

Trace
ENGINEERING®

MARINER

I N V E R T E R / C H A R G E R

Owner's Manual



Part Number 3506
October 27, 1998

Packaging Materials

Thank you for choosing Trace Engineering products to meet your alternative-energy power needs. We make every effort to ensure that your inverter/charger packaging includes the following materials:

Owner's Manual;

Red\Black\Green battery terminal covers (with hardware);

AC terminal cover (with hardware);

AC Warning Decal;

Trace bumper sticker;

If any of the above listed materials are missing from your package, or if it is unsatisfactory in any manner, please call Customer Service at (360) 435-8826 or fax this page with your comments to (360) 435-2229.

Model Number: _____

Serial Number: _____

Purchase Date: _____

Comments: _____

Thank you for choosing Trace Engineering to meet your independent power needs. Check out our web site at www.traceengineering.com for more information and answers to your FAQ's.

Table of Contents

INTRODUCING THE MARINER	1
IMPORTANT SAFETY INSTRUCTIONS	3
GENERAL PRECAUTIONS	3
PERSONAL PRECAUTIONS	5
FEATURES.....	7
PROTECTION CIRCUITRY	7
<i>Automatic Low Battery Cut Out</i>	<i>7</i>
<i>Automatic High Battery Cut Out</i>	<i>7</i>
<i>High Temperature Cut Out</i>	<i>7</i>
<i>Over Current Cut Out.....</i>	<i>8</i>
<i>Battery Type Optimization</i>	<i>8</i>
<i>Charge Rate Regulation</i>	<i>8</i>
<i>Shore Power Amps Monitoring.....</i>	<i>9</i>
<i>VAC Dropout.....</i>	<i>9</i>
SEARCH MODE CIRCUITRY	9
IMPULSE PHASE CORRECTION.....	10
TRUE RMS VOLTAGE REGULATION	10
CRYSTAL CONTROLLED TIME BASE	11
STAND-BY BATTERY CHARGER.....	11
TRANSFER SWITCHING SPEED	11
AUTOMATIC INVERTER TO CHARGER TRANSITION	11
UNIT IDENTIFICATION.....	13
MODEL IDENTIFICATION.....	13
SERIAL NUMBER.....	14
CONTROLS & INDICATORS.....	15
QUICK INSTALL	19
DC CABLING	19
AC-IN CABLING	21
AC-OUT CABLING.....	22
WRAP UP	22
INSTALLATION.....	23
SAFETY INSTRUCTIONS	23
LOCATING THE INVERTER	24
VENTILATION	24
MOUNTING	25
OVERVIEW OF MARINE AC AND DC SYSTEMS	25
<i>Terminology</i>	<i>25</i>

<i>Typical Marine AC and DC Electrical System</i>	26
DC CABLING.....	27
<i>Battery Cable Sizing</i>	27
<i>Battery Cable Inductance</i>	27
<i>DC Over Current Protection</i>	28
<i>DC Conductors</i>	29
<i>DC Cabling Connections</i>	29
<i>DC Negative Ground Cable Connection</i>	31
<i>Installation Procedure</i>	31
AC WIRING.....	33
<i>AC and DC Wiring Separation</i>	34
<i>AC Wire Connections</i>	34
<i>AC Disconnect Device</i>	34
<i>Ground Fault Interrupting Outlets (GFCI's)</i>	34
<i>Neutral-to-Ground Switching</i>	35
<i>Disabling Neutral Ground Switching</i>	37
<i>Installation Procedure</i>	39
<i>Wrap-up</i>	41
OPERATION	43
BATTERIES	45
TERMINOLOGY	45
TYPES	46
<i>Starting Batteries</i>	46
<i>Deep-Cycle Batteries</i>	46
<i>Sealed Gel Cell</i>	46
ENVIRONMENT	47
<i>Location</i>	47
<i>Enclosures</i>	47
<i>Temperature</i>	47
BATTERY BANK SIZING	48
<i>Estimating Battery Requirements</i>	48
<i>Battery Bank Sizing Example & Worksheet</i>	49
MONTHLY MAINTENANCE	51
<i>Preparation</i>	51
<i>Attire</i>	51
<i>Tools</i>	51
<i>Equipment</i>	52
<i>Supplies</i>	52
<i>Procedure</i>	52
<i>Battery Enclosure and Batteries</i>	52
<i>Terminals & Lugs</i>	52
<i>Cables</i>	53
CABLING & HOOK-UP CONFIGURATIONS.....	53
<i>Parallel Connection</i>	54
<i>Series Connection</i>	54

<i>Series – Parallel Connection</i>	55
THREE-STAGE BATTERY CHARGER	56
CHARGING PROFILE	56
CHARGER AC REQUIREMENTS	58
THEORY OF INVERTER OPERATION	59
WAVEFORM	59
REGULATION	60
APPLICATIONS	61
RESISTIVE LOADS	61
INDUCTIVE LOADS	61
PROBLEM LOADS	62
OPTIONS	65
THE RC6 REMOTE CONTROL	65
THE RC7 REMOTE CONTROL	66
BATTERY TEMPERATURE SENSOR (BTS)	67
BATTERY CABLES	67
APPENDIX A: TROUBLESHOOTING	69
APPENDIX B: OTHER PRODUCTS FROM TRACE ENGINEERING	71
APPENDIX C: REFERENCE TABLES & GRAPHS	73
TYPICAL POWER CONSUMPTION OF COMMON APPLIANCES	73
ENGLISH TO METRIC WIRE CONVERSION CHART	74
RECOMMENDED BATTERY CABLE SIZE (IN FREE AIR)	74
RECOMMENDED MINIMUM AC WIRE SIZES	75
MAXIMUM AMPERAGE FOR CONDUCTORS UNDER 50 VOLTS AT 105°C	75
COMMON BATTERY CHARGING RATES	76
MARINER CHARGING GRAPH	76
MARINER EFFICIENCY CURVE	77
MARINER PERFORMANCE GRAPH	77
TYPICAL DC INSTALLATION DIAGRAM	78
TYPICAL AC INSTALLATION DIAGRAM	78
APPENDIX D: SPECIFICATIONS	79
APPENDIX E: DIMENSIONS	81
APPENDIX F: LIMITED WARRANTY	83
APPENDIX G: LIFE SUPPORT POLICY	87
INDEX	89

TABLE OF FIGURES

<i>Figure 1, Identification Placard.....</i>	<i>14</i>
<i>Figure 2, Controls and Indicators.....</i>	<i>15</i>
<i>Figure 3, Typical DC Wiring Diagram.....</i>	<i>20</i>
<i>Figure 4, Typical AC Wiring Diagram</i>	<i>22</i>
<i>Figure 5, Power Output Versus Temperature</i>	<i>24</i>
<i>Figure 6, Typical AC & DC System</i>	<i>26</i>
<i>Figure 7, Battery to Inverter Cable Connection</i>	<i>30</i>
<i>Figure 8, Typical DC Wiring Diagram.....</i>	<i>32</i>
<i>Figure 9, Neutral-to-Ground Switching without external AC source</i>	<i>35</i>
<i>Figure 10, Neutral-to-Ground Switching with External AC</i>	<i>36</i>
<i>Figure 11, Disabling Neutral-to-Ground Switching</i>	<i>37</i>
<i>Figure 12, AC Terminal Block.....</i>	<i>39</i>
<i>Figure 13, Typical AC Wiring Diagram</i>	<i>40</i>
<i>Figure 14, Three-Stage Charging Profile</i>	<i>56</i>
<i>Figure 15, RC6 Remote Control Faceplate Display</i>	<i>65</i>
<i>Figure 16, RC7 Remote Control Faceplate.....</i>	<i>66</i>

TABLE OF TABLES

<i>Table 1, Recommended Maximum Charging Rates</i>	<i>8</i>
<i>Table 2, DC Cable Sizing in Free Air.....</i>	<i>19</i>
<i>Table 3, Recommended Minimum AC Wire Sizes</i>	<i>21</i>
<i>Table 4, Recommended Battery Cable Size (In free air)</i>	<i>27</i>
<i>Table 5, Maximum Fuse Rating in Free Air.....</i>	<i>28</i>
<i>Table 6, Maximum Amperage for Conductors Under 50 Volts at 105°C.....</i>	<i>29</i>
<i>Table 7 Flexible Cable for Marine Applications.....</i>	<i>33</i>
<i>Table 8, Conductors for Marine Applications.....</i>	<i>33</i>
<i>Table 9, Recommended Minimum AC Wire Sizes</i>	<i>34</i>
<i>Table 10, Typical Appliance Watts.....</i>	<i>50</i>
<i>Table 11, Bulk and Float Setpoints</i>	<i>58</i>

Introducing the Mariner

The Mariner inverter/chargers are specially designed for after market installation in recreational vehicles.

The Mariner inverter/chargers feature:

- ✓ Easy installation
- ✓ 2000, 2500, or 3000 watt continuous power output
- ✓ Automatic three-stage battery charging
- ✓ Over-current, over-temperature, and high/low battery voltage protection
- ✓ ETL listed to UL 458 standards
- ✓ 2-year limited warranty
- ✓ Front-panel wiring terminals for maximum accessibility
- ✓ Optional RC6 remote On/Off, voltmeter, ammeter, charge status and error indicator
- ✓ Optional full-function, programmable RC7 remote control provides digital metering and user configuration
- ✓ Adjustable charging rate and battery type selection
- ✓ Adjustable power-saving search mode
- ✓ Automatic battery temperature compensation (with battery temperature sensor [BTS] option).

IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS

This manual contains important safety and operating instructions as prescribed by UL specifications for inverters used in marine applications. This manual covers inverters and inverter/chargers models: M2012, M2512, and M3012 Mariner inverter/chargers. The entire Mariner Series of inverters is ETL listed to the general UL specification #458.

General Precautions

1. Before using the inverter/charger, read all instructions and cautionary markings on (1) the inverter/charger, (2) the batteries, and (3) all appropriate sections of this instruction manual.
2. **CAUTION** - To reduce risk of injury, charge only deep-cycle lead acid, lead antimony, lead calcium, gel cell, or absorbed mat type rechargeable batteries. Other types of batteries may burst, causing personal injury and damage.
3. Do not expose inverter/charger to rain, snow or liquids of any type. The inverter is designed for interior mounting only. Protect the inverter from splashing when used in marine applications.
4. Do not disassemble the inverter/charger; take it to a qualified Trace Engineering Service Center when service or repair is required. Incorrect re-assembly may result in a risk of electric shock or fire.
5. To reduce risk of electric shock, disconnect all wiring before attempting any maintenance or cleaning. Turning off the inverter will not reduce this risk.
6. **WARNING - RISK OF EXPLOSIVE GASES**

WORKING IN VICINITY OF A LEAD ACID BATTERY MAY BE DANGEROUS. BATTERIES GENERATE EXPLOSIVE GASES DURING NORMAL OPERATION. FOR THIS REASON, IT IS OF UTMOST IMPORTANCE THAT EACH TIME BEFORE SERVICING EQUIPMENT IN THE VICINITY OF THE BATTERY, YOU READ THIS MANUAL AND FOLLOW THE INSTRUCTIONS EXACTLY.

Provide ventilation to outdoors from the battery compartment. The battery enclosure should be designed to prevent accumulation and concentration of hydrogen gas in "pockets" at the top of the compartment. Vent the battery compartment from the highest point. A sloped lid can also be used to direct the flow to the vent opening location.

To reduce the risk of battery explosion, follow these instructions and those published by battery manufacturer and any manufacturer of any equipment you intend to use in the vicinity of batteries. Review cautionary markings on these products and all other products being used.

IMPORTANT SAFETY INSTRUCTIONS

7. No terminals or lugs are required for hook-up of the AC wiring. AC wiring must be no less than 10 AWG (5.3 mm²) copper wire and rated for 75°C or higher. Battery cables must be rated for 75°C or higher and should be no less than the minimum size wire recommended by this manual. Crimped and sealed copper ring terminal lugs with a 5/16" hole should be used to connect the battery cables to the DC terminals of the inverter/charger. Soldered and crimped cable lugs are also acceptable. Solder shall not be the sole means of mechanical connection in any circuit [ABYC E-9.16(k)] unless the solder contact length exceeds 1.5 times the diameter of the conductor. See section *Batteries and Chargers* for correct battery cable size and length for your application.
8. Torque all AC wiring connections to 15-20 inch-pounds. Torque all DC cable connections to 10-12 foot-pounds.
9. **CAUTION:** To reduce the risk of fire, use only input circuits provided with the correct ampere branch circuit protection in accordance with the National Electric Code, ANSI/ NFPA70
10. Use the correct tools to make AC/DC wiring connections: wire strippers, ½" (13mm) open-end wrench or socket, Phillips screw driver #2, and ¼" flat blade screwdriver (6mm).
11. This inverter/charger should be used with a battery supply of 12-volts DC nominal voltage.
12. Do not install this inverter/charger on or near flammable materials (plywood, chemicals, gasoline, etc.).
13. The unit is designed for mounting on a flat surface only. Do not mount on a bulkhead or hang inverted.
14. 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. See *Installation* section on Page 23 of this manual.
15. 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. See *Installation* section of this manual.
16. No overcurrent protection for the AC output wiring is provided as an integral part of this inverter. Over-current protection of the AC output wiring must be provided as part of the system installation. See the *Installation* section of this manual.
17. DC GROUNDING INSTRUCTIONS - This inverter/charger should be connected to a grounded, permanent wiring system. For most installations, the negative battery conductor should be bonded to the vessel safety-grounding conductor (green wire) as per ABYC standard E-8.5 and E-9.20. Connection of the green DC negative ground terminal on the side of the inverter to the DC load center negative bus (connected in turn to the engine negative terminal) will create the battery negative to vessel safety ground. All installations should comply with Federal regulations.

Connect and disconnect DC output connections only after setting the inverter switches to the Off position and removing AC shorepower cord from the shorepower connector, or after opening the AC disconnect device.

IMPORTANT SAFETY INSTRUCTIONS

18. EXTERNAL CONNECTIONS TO THE UNIT SHALL COMPLY WITH THE UNITED STATES COAST GUARD ELECTRICAL REGULATIONS (33 CFR 183, SUB PART I).
19. AC GROUNDING INSTRUCTIONS – The inverter/charger includes neutral-to-ground switching for the AC electrical system. The AC system in marine installations must have the neutral physically isolated from the ground throughout the load distribution powered by the inverter.

Personal Precautions

1. Someone should be within range of your voice to come to your aid when you work near batteries.
2. Have plenty of fresh water and soap nearby in the event that battery acid contacts skin, clothing, or eyes.
3. Wear complete eye protection and clothing protection. Avoid touching eyes while working near batteries. Wash your hands when done.
4. If battery acid contacts skin or clothing, wash immediately with soap and water. If acid enters eyes, immediately flood eyes with running cool water for at least 15 minutes and get medical attention immediately.
5. Baking soda neutralizes lead acid battery electrolyte. Vinegar neutralizes spilled NiCad and NiFe battery electrolyte. Keep a supply on hand in the area of the batteries.
6. **NEVER** smoke or allow a spark or flame in vicinity of a battery or generator.
7. Be extra cautious when working with metal tools on and around batteries. It could short-circuit the batteries or other electrical parts, producing a spark that could cause an explosion.
8. Remove personal metal items such as rings, bracelets, necklaces and watches when working with a battery. A battery can produce a short-circuit current high enough to weld a ring, or the like, to metal causing severe burns.
9. **Never** attempt to charge a frozen battery.
10. If a remote or automatic generator-start system is used, disable the automatic starting circuit, and/or disconnect the generator from its starting battery while servicing to prevent accidental starting during servicing.
11. If necessary to remove any batteries, always remove the grounded terminal from the battery first. Make sure all accessories are off, so as not to cause an arc.
12. Be sure area around battery is well ventilated.

IMPORTANT SAFETY INSTRUCTIONS

13. Clean battery terminals. Be careful to keep corrosion from coming in contact with eyes.
14. Study all battery manufacturer's specific precautions (such as removing or not removing cell caps while charging) and recommended rates of charge.
15. Add ONLY distilled water in each cell until battery acid reaches level specified by battery manufacturer. This helps purge excessive gas from cells. Do not overfill. For a battery without cell caps, carefully follow manufacturer's recharging instructions.

FEATURES

Features

All Mariner inverters include extensive protection circuitry, Search Sense Mode, Impulse Phase Correction, true RMS voltage regulation, crystal-controlled timing, three-stage battery charging, and an internal AC transfer relay.

Protection Circuitry

The inverter is protected from high-battery voltage, low-battery voltage, over-heating, and over-current conditions. When the inverter senses one of these situations, it will protect itself by disconnecting from the loads, and will signal an error condition by a red flashing of the LED indicator.

The low-battery cutout, high-battery shut down, and over-temperature protection circuitry resets automatically. If an over-current condition continues for more than 20 seconds, the inverter will shutdown and must be reset with the power button. If the error condition is remedied before the 20-second period has elapsed, the inverter will automatically reset.

Automatic Low Battery Cut Out

The Mariner inverter/charger protects your batteries from damage caused by over-discharging by automatically shutting itself off when battery voltage falls to a preset level. This feature is called the Low Battery Cut Out (*Auto LBCO*). Your Mariner inverter/charger comes from the factory with the *Auto LBCO* enabled; LBCO voltage is set at 11.1 volts. You can adjust the cutoff voltage to 8.5 volts (*Auto LBCO* disabled) using the optional RC7 remote control. See *The RC7 Remote Control* section on Page 66 for more information about the configuring LBCO.

Automatic High Battery Cut Out

When battery voltage rises above 15.6 volts, the inverter shuts down to protect electronics that may be operating off of it (high battery voltage results in high AC peak voltage). The inverter automatically resumes operating when battery voltage drops below 15.6 volts. High battery voltage can occur *only* through using an unregulated charging source, such as an unregulated solar or other DC generator or alternator. To remedy this problem, disconnect any external charging sources.

High Temperature Cut Out

The inverter is protected from overheating due to excessive loading or charging. When the internal temperature of the inverter exceeds its design limits, the inverter will disconnect itself and shut down. After a sufficient cooling period, the inverter will automatically reset and resume operation. Some causes of high internal temperatures include excessive loading, high ambient temperatures, inadequate ventilation, and an inoperative cooling fan. To remedy, reduce loads or reduce ambient temperatures by relocating, insulating, and/or ventilating the inverter enclosure (See the section on Page 23 for more information).

FEATURES

Over Current Cut Out

Mariner inverter/chargers are protected from over-current conditions. When the load being run demands more current than the inverter can safely supply, the inverter will momentarily shutdown, turn off if it encounters an over-current condition for approximately 20 seconds (a prolonged short-circuit) or if the AC output is connected to another AC power source (shorepower or generator).

Battery Type Optimization

Mariner inverter/chargers are designed to prevent damage to and extend the useful life of your batteries by regulating the charging voltage and duration. To do this, the inverter/charger must be configured for the type of batteries in the system. The Mariner is pre-configured for optimum charging of gel-cell type batteries at 14.1 volts in bulk charging mode, and 13.5 volts in float charging mode. For liquid lead-acid batteries, you can reset the Mariner using the RC7 remote control to bulk charge at 14.5 volts and float charge at 13.4 volts. For a complete discussion of batteries and battery charging techniques, see the *Batteries* and the *Three-Stage Battery Charger* sections of this manual.

Charge Rate Regulation

Batteries can overheat if the charge rate is too high. The Mariner inverter/charger protects your batteries by enabling you to limit the charge rate using the RC7 remote control. The charge rate is set at the factory to 100% of maximum, which may be up to 140 amps depending upon the model you have purchased (see *Appendix D: Specifications* to determine the maximum possible charge rate for your model). For smaller battery banks, this may be too high.

The highest charge rate recommended is determined by dividing the battery bank's amp hour capacity by a factor of three or five (3 for gel cell - 5 for lead acid).

Table 1, Recommended Maximum Charging Rates

Battery Capacity in Amphours	Recommended Maximum Charge Rate in Amps	
	Gel Cell Lead-Acid	Liquid Lead-Acid
125	40	25
250	20	50
500	140	100

Setting the charge rate at the highest recommended level is best when the objective is to charge the batteries as quickly as possible. A much lower setting can be used in installations where AC power is typically available for periods of several hours. There is more than sufficient time for a 400-amphour battery bank to be recharged in 24 hours at a 25-amp setting.

Example: 25 amps X 24 hours = 600 amp/hrs.

FEATURES

Caution: Excessively high charge rates can overheat a battery. If battery bank capacity is low, set the battery charge rate to the minimum setting.

Shore Power Amps Monitoring

Mariner models monitor the current drawn by the built-in charger and any AC loads. These current requirements may exceed the amperage rating of the shore power circuit breaker. To prevent unnecessary tripping of this circuit breaker, the inverter limits the current draw to a maximum between five and 30 amps, set by using the RC7 remote control. Shore power amps is pre-set at the factory to a maximum of 25 amps.

VAC Dropout

Mariner model inverter/chargers monitor the voltage of the AC power passing through to the charger and AC loads. When AC voltage falls below a pre-set level, the inverter automatically transfers from AC power to DC power. This dropout voltage is factory pre-set to 40 volts. You can re-set this voltage from 40 to 100 volts using the RC7 remote control. Using a lower voltage results in less frequent transfers from AC to DC power, but may cause undesirable operation of some AC loads, including brown-outs and damage.

Search Mode Circuitry

Mariner inverters feature circuitry that minimizes power drain by reducing the inverter's output to small test pulses when there is no load connected to the inverter. These pulses are used to detect the presence of a load. When a load is detected the inverter's output goes to full voltage. The sensitivity of the detection threshold is adjustable from about five watts to 40 watts using the RC7 remote control. This feature is defeated (turned Off) at the factory and can only be activated using the RC7 remote control.

Example: With the threshold set to detect a 40 watt load, a 50 watt load will bring the unit to full output voltage. However, a 30-watt load will leave the inverter in its energy saving Search Mode. If sensitivity is increased (by setting the control to 10), a 20 watt load will bring the inverter out of the search mode, while a five-watt load will not.

When in the search mode, the green Power LED will blink. At full output voltage, the LED will remain lit. When the inverter is used as an un-interruptable power supply, the search mode function should be defeated. A neon nightlight can be used as a good indicator to determine if the inverter is in search mode. Simply plug the light into any AC outlet connected to the inverter's output. When the inverter is in the search mode the light will blink. If the inverter is running a load, the light will be on continuously.

Exceptions: (Murphy's Law) Unfortunately, things don't always work the way the manual says they will.

Example A: If the threshold is set to detect a 40-watt load and a 30-watt incandescent light is turned on, the inverter will detect the light. The light is a bigger load than 40 watts when its filaments are

FEATURES

cold. When the light gets hot it becomes a 30-watt load. Since this is below threshold of 40-watts, the inverter will not detect it and the light will go out. This will cause the light to cycle repeatedly.

Example B: If the threshold is set to detect a 30-watt load and a 40-watt fluorescent light is turned on, the inverter will not detect the light. The light presents a smaller load than 30 watts until the gas in the fluorescent tube ionizes.

Example C: There are some appliances that draw power even though they are turned off. TVs with instant on circuitry microwave ovens with digital displays and VCRs are examples. These loads present a dilemma. If the sensitivity is set higher than the combination of these loads, then an auxiliary load must be used to bring the inverter out of the search mode before the appliances can be turned on. If the sensitivity is set lower than this combination of loads, the loads will be left on and will put an additional drain on the batteries. Three such 15-watt loads would amount to an additional 90 amp/hours per 24 hours in a 12 VDC system.

One solution is to turn these items off at the wall. Use an extension cord with a rocker switch, a switch at the outlet, or the appropriate circuit breaker. Another solution might be to place all these phantom loads on a separate circuit with its own disconnect.

This circuit determines how much power the inverter draws when there are no loads. The inverter's transition from the no load state to full output voltage is fast, eliminating delays when operating devices such as hand tools. Additionally, the threshold sensitivity of the search mode is user adjustable (with the optional RC7 remote control), and it may be disabled.

Impulse Phase Correction

This circuitry improves the shape of the output waveform while the inverter is running reactive loads. It allows the inverter to closely duplicate the characteristics of standard public power. With this design approach, the limitations of the modified sine wave format are largely overcome. The primary benefit is realized when the inverter is running induction motors and fluorescent lights. Induction motors are commonly used to run drill presses, fans, and bandsaws.

When an inductive load is driven, it tries to return a large portion of the energy that it has received. This returned energy can be thought of as going 'backwards' through the household wiring to the motor, giving the motor an extra push and making it run smoothly. Impulse phase correction provides a similar path for this 'backwards' energy. The Mariner line of inverter/chargers will run small motors at full speed, start larger ones, and run both efficiently.

True RMS Voltage Regulation

With battery voltages from 11 to 15 VDC and power levels up to the continuous power rating, the inverter will deliver true RMS regulated power. This insures that while battery voltages and power levels change, the inverter will deliver the correct output voltage.

FEATURES

Crystal Controlled Time Base

Proper frequency regulation is assured with the use of a crystal. Battery voltage and power have no effect on the inverter's operating frequency.

Stand-by Battery Charger

The Stand-by feature includes an internal battery charger and automatic transfer relay. This allows the unit to operate as a battery charger or an inverter (but not at the same time). An external source of AC power (i.e. shore power or generator) must be supplied to the inverter's AC input to allow it to operate as a battery charger. When the unit is operating as a charger its AC output is powered by the external AC source. See the *Three-Stage Battery Charger* section beginning on Page 56 for an in-depth description of this charger.

Transfer Switching Speed

While this inverter is not designed specifically to operate as an un-interruptable power supply (UPS), its transfer time is normally fast enough to hold up computers in the event of a power outage. Transfer time is a maximum of 32 milliseconds (two 60Hz AC cycles). Success as UPS will vary with computer models, and cannot be guaranteed. If this is an issue, buy a small, dedicated UPS for the specific application.

Automatic Inverter to Charger Transition

The inverter automatically becomes a battery charger whenever AC power is supplied to its AC inputs. There is a minimum 20-second time delay from the time the inverter senses that AC is present at its input to when the transfer is made. This delay is built in to provide time for a generator to spin-up to a stable voltage and avoid relay chattering. The inverter's AC input is internally connected to the inverter's AC output while in the battery charger mode. The maximum power that can be handled by the inverter's internal wiring and transfer relay is 30 amps.

UNIT IDENTIFICATION

Unit Identification

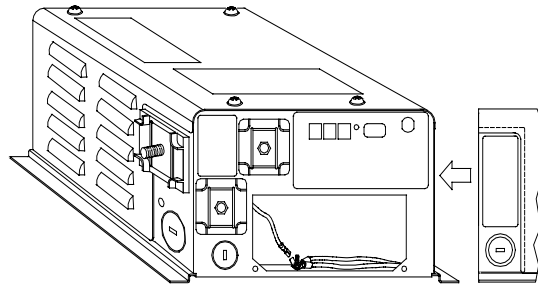
This section describes the marking and location of the model and serial number for Mariner inverterchargers. Use this section to determine the type and model of your inverter/charger.

Model Identification

Trace Engineering inverters are specifically designed to meet the growing demand for high-reliability, high-quality inverters and chargers for alternative energy systems and marine applications. This manual covers the Mariner inverters with various options and configurations. To determine the model and features of your inverter, check the model number found on the identification placard on the side of the inverter.

Consider the following unit with a M2012 model number:

M	20	12
<i>Model</i>	<i>Power</i>	<i>Input Voltage</i>



Model: The first letter indicates the model, in this case the Mariner Series. Mariner inverters are designed for installations in vessels. They are housed in a white enclosure and employ neutral-to-ground switching.

Power: The first and second positions in the model number indicate the continuous AC power output in hundreds of watts. Power levels available include 2000, 2500, and 3000 watts. In the example above, 20 would stand for a 2000-watt (2kW), continuous-output inverter.

Input Voltage: The number (12) following the power rating indicates an inverter/charger that is designed to convert 12VDC input to 120VAC output, and charge 12VDC batteries when powered by 120VAC.

Serial Number

The unit identification placard on the right side panel of the inverter/charger will show the serial number, model number, listings, ratings, and date of manufacture.

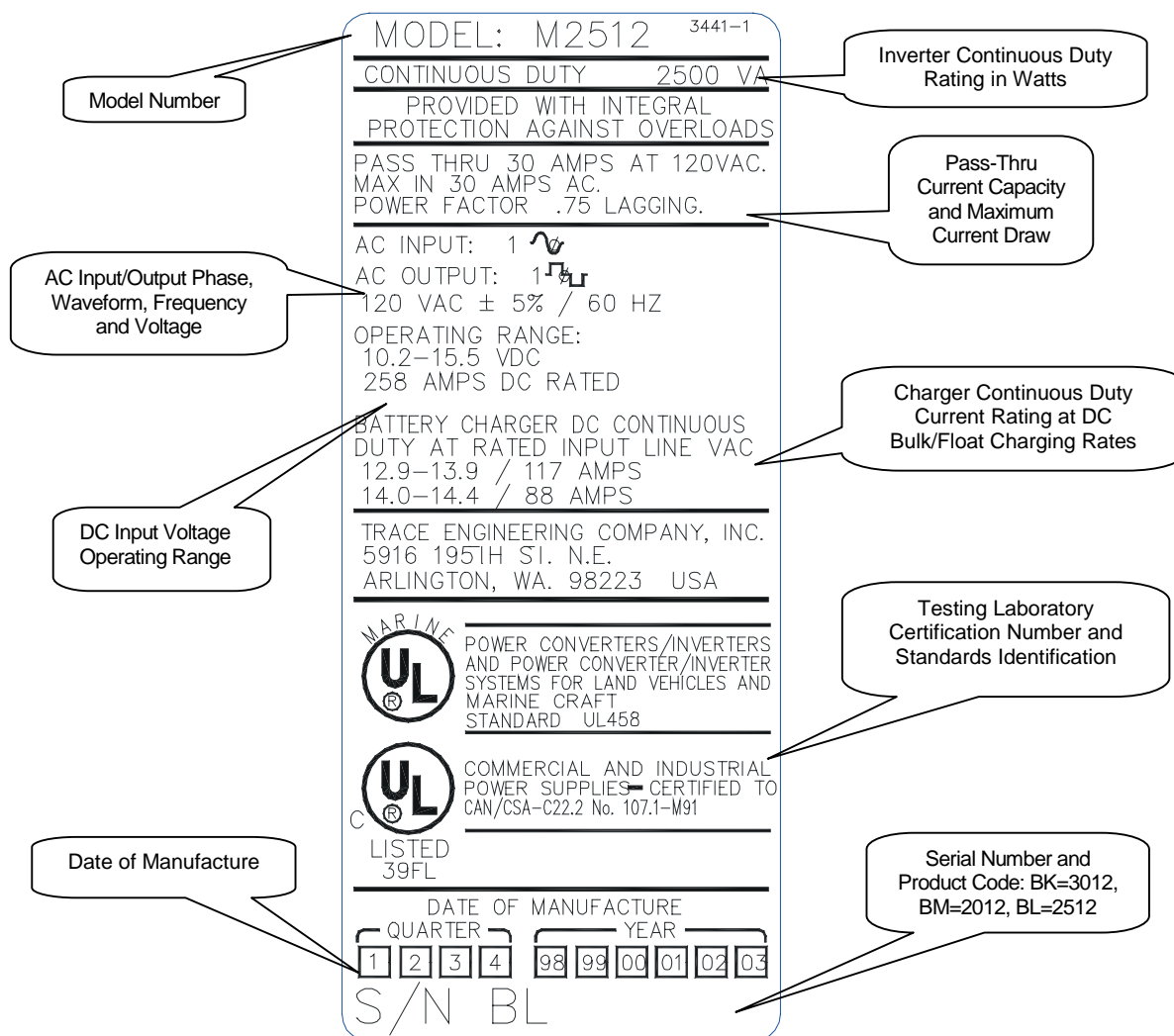


Figure 1, Identification Placard

Controls & Indicators

The Mariner inverter/chargers feature a two-position On/Off rocker switch, tri-color status indicator, battery temperature sensor (BTS) port, remote control port, and a charger circuit breaker on the front panel.

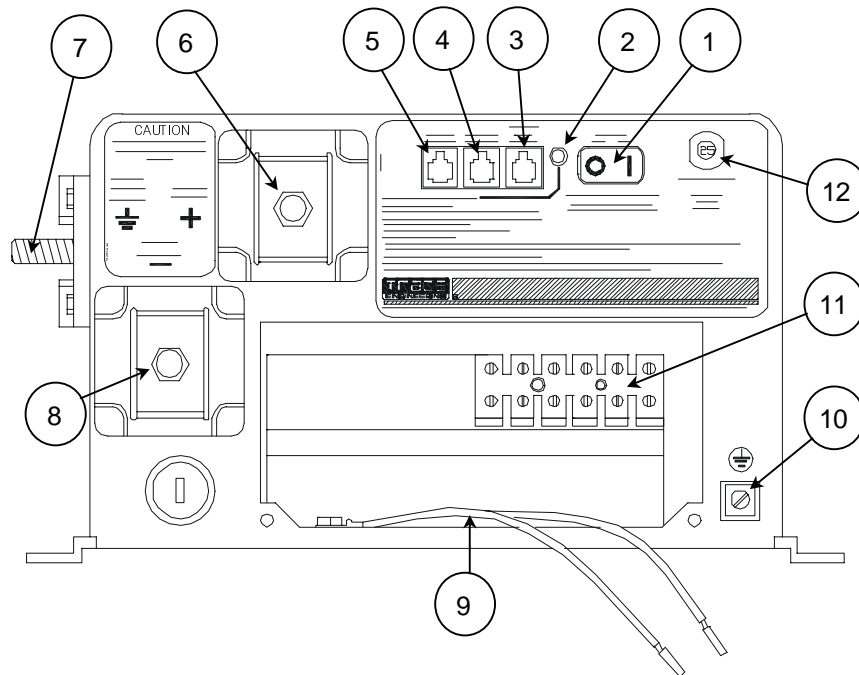


Figure 2, Controls and Indicators

1. On/Off Switch: Turns the inverter on or off.

ON: the inverter transforms 12-volt direct current from the batteries into 120-volt, 60 Hz alternating current whenever AC current is not present at the AC Input Hot 1 terminal.

When 120-volt AC is present at the AC Input Hot 1 terminal, the inverter will pass the current through to any AC loads connected to the inverter, and the standby battery charger will charge the batteries.

OFF: the inverter will not create AC power from the batteries, but will pass through AC current when it is present at the AC Input Hot 1 terminal. The standby battery charger will charge the batteries regardless of the position of the On/Off switch.

CONTROLS & INDICATORS

NOTE:

The three-stage standby battery charger is always “On”. Whenever AC power is present at the AC Input Hot 1 terminal, the charger will charge the batteries connected to the battery positive and battery negative terminals. The On/Off switch has no effect upon the charger.

2. LED Indicator

All Mariner inverter/chargers feature a tri-color LED on the front panel that will light green, orange, or red to indicate the operating mode, battery or charger status, or an error condition.

Green:

Solid: inverter is providing AC power from the batteries

Slow Flashing: (once each second) inverter is in search mode

Fast Flashing: (four times each second) charger is charging in Float mode at 13.5 volts, the factory setting for gel cell batteries. Float mode for liquid lead-acid batteries is 13.4 volts, configured using the RC7 remote control. See the *Three-Stage Battery Charger* section on Page 56 for a complete description of three-stage battery charging, and on Page 66, *The RC7 Remote Control* section.

Orange

Solid: charger is in Bulk mode, the initial charging mode. Bulk mode for gel cell batteries is set at the factory at 14.1 volts. Bulk mode voltage for liquid lead-acid batteries is set at 14.5 volts. Use the RC7 remote control to configure the inverter for liquid lead-acid batteries.

Flashing: charger is in Absorption charge. In Absorption stage, the charger maintains the Bulk voltage at up to the maximum charge rate for 90 minutes.

CONTROLS & INDICATORS

Red

Solid: an over-current event has occurred. Too many loads on the unit (excessive current demand) cause an over-current condition. When this occurs, the inverter/charger instantaneously detaches from the loads. If, after a ten-second delay, the current demand on the unit is not excessive, the unit will automatically resume inverting. If the current demand remains excessive, the unit will shut itself off and must be manually restarted by turning the unit Off, then On again.

Flashing: (followed by a five-second pause) an error condition has occurred

Once = battery voltage is below Low Battery CutOut factory setting of 11.1 volts (see *Protection Circuitry* section on Page 7 for a description of LBCO). The inverter will automatically restart when battery voltage rises to 12.5 volts.

Twice = battery voltage is over 15.6 volts and inverter has shut down (see Page 7). The inverter will automatically resume operating when battery voltage has dropped below 15.6 volts.

Three = inverter is overheating and has shut off to protect itself. Reduce loads or provide adequate ventilation. The inverter will automatically restart when cool.

Four = a charger fault has occurred. Return unit to an authorized Trace Service Center for servicing.

Five or more: Not used with the Mariner Series inverter/chargers.

3. **BTS Port:** An optional battery temperature sensor (BTS) can be plugged in at the RJ-11 four-conductor connector. The BTS provides information that enables the three-stage standby battery charger to “fine tune” the battery charge rates for better charging performance, greater efficiency and longer life.

4. **Stacking Port** (not used). The Mariner Series are not stackable.

5. **Remote Control Port:** The Mariner can be controlled up to 50 feet from the unit by plugging in a remote control (RC6 or RC7). See the *Options* section for a complete description of the RC6 and RC7 remote controls.

- The RC6 reports DC voltage, charging or inverter current, and turns the inverter on and off.
- The RC7 is a full function, programmable remote control with backlit LCD, battery capacity and other meters.

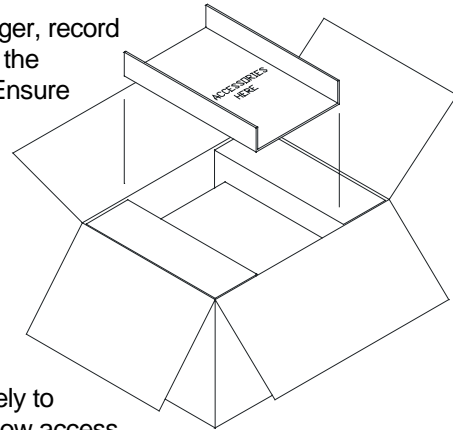
CONTROLS & INDICATORS

6. **Battery Positive Terminal** from house batteries
7. **DC Ground Bus Terminal** to DC Negative bus of DC load center
8. **Battery Negative Terminal** from house batteries
9. **AC Safety Grounding Wires:** to AC ground bus of AC load center from AC source ground
10. **DC Safety Grounding Bus Terminal** (green wire) to engine negative terminal or its DC ground bus.
11. **AC Terminal Block:** AC Hot 1 and Neutral from AC Source to AC subpanel
12. **Charger Circuit Breaker:** 25 amps in the M2012 and M2512, 30 amps in the M3012. Press breaker to reset.

Quick Install

Marine electricians with experience installing inverters may follow the installation instructions in this section. This section assumes knowledge of current ABYC standards, applicable Federal regulations, and safe working practices. For all others, the following *Installation* chapter describes ABYC standards, Federal regulations, and safe working practices.

Unpacking – Before beginning, unpack the inverter/charger, record the serial number on the inside cover of this book and on the warranty card. Retain packing materials for future use. Ensure that all components listed on the Packaging Materials sheet are included. If any components are missing, please call Customer Service at (360) 435-8826.



Mounting and Location – Mount the unit securely in a horizontal position in a clean, dry, ventilated enclosure. Do not mount the unit in the same enclosure as vented or maintenance-free vented batteries. Do not mount the unit in the engine room of gasoline-fueled vessels. Install appropriate strain-reliefs and conduit. Bolt the unit securely to deck, shelf, or bulkhead. Allow adequate clearance to allow access to the front panel. On U.S vessels, installations must conform to the requirements of 33 CFR 183.410.

DC Cabling

Determine the correct DC cable to use (also see *Table 5, Maximum Fuse Rating in Free Air* on Page 28) for the inverter model and length of run for your specific application from the table below:

Table 2, DC Cable Sizing in Free Air

Inverter Model #	Typical DC Amps	1 to 3 feet One Way	3 to 5 ft One Way	5 to 10 ft One Way
M2012	200 Amps	00	0000	0000
M2512	250 Amps	0000	0000	0000
M3012	300 Amps	0000	0000	0000

- Ensure that the On/Off switch on the front panel of the inverter is in the Off position before you begin the installation.

QUICK INSTALL

- Connect a cable from battery or battery bank positive terminal to the battery positive (red) terminal of the inverter. Federal regulations (33 CFR 183.455) and ABYC standards (E-9.10) require an overcurrent device (fuse or circuit breaker) in this conductor. Install a DC fuse (Trace part number TFBXXX) or circuit breaker within 72-inches of the battery terminal in this cable.
- Connect an appropriate sized cable from the DC source negative terminal to the negative (black) terminal on the inverter.
- Connect a cable from the DC Negative Bus Terminal (green terminal) on the inverter to the DC negative bus in the vessel's DC distribution center. Torque all terminals to 12 foot-pounds.
- Connect a conductor from the DC Grounding terminal (chassis ground) on the front of the inverter to the DC Grounding bus ('green wire'), which is connected to the engine negative terminal. Do not connect to the DC Load Center Negative bus.
- Connect the DC negative conductor from all DC loads to the DC negative bus of the DC load center or distribution center. This enables the inverter's Fuel Gauge feature. Never connect DC negative conductors to the DC Grounding Bus (green wire) as this bus is not intended as a conductor, except in the event of current leakage.

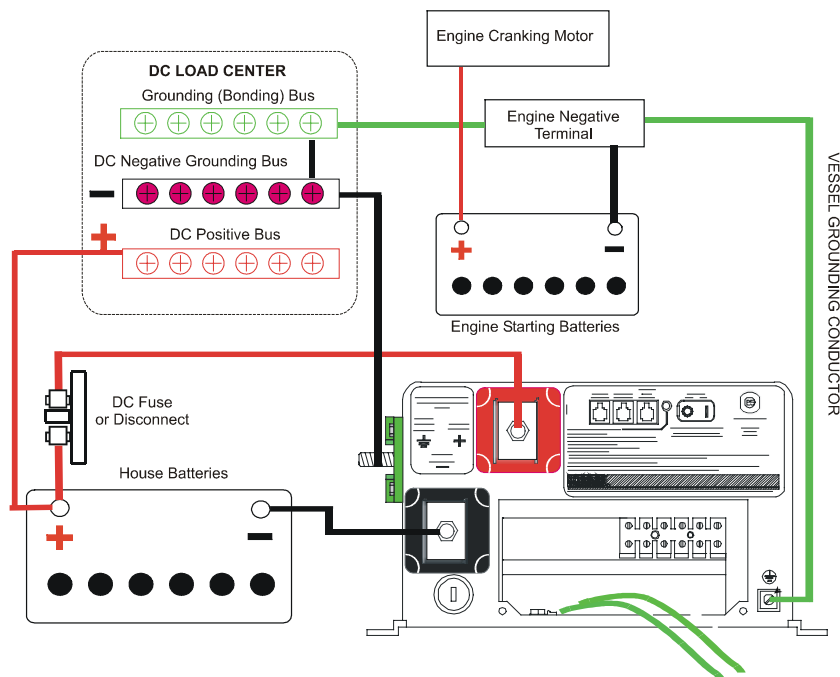


Figure 3, Typical DC Wiring Diagram

QUICK INSTALL

AC-In Cabling

Disconnect all AC sources before beginning. This includes shorepower, inverter, or generator. Disable generator autostart feature if vessel is so equipped. Use the appropriate size AC cabling as determined by the following table:

Table 3, Recommended Minimum AC Wire Sizes

Inverter Model	120 VAC Input	120 VAC Output
M2012	10 AWG	12 AWG
M2512	8 AWG	10 AWG
M3012	8 AWG	10 AWG

! Caution:

This inverter/charger includes neutral-to-ground switching for the AC electrical system. In marine installations, the AC neutral must be physically isolated from the ground throughout the load distribution that is powered by the inverter.

- Remove the knockout from the front or either side of the inverter chassis and install a strain relief or conduit in which to route the AC cabling in and out.
- Connect the black wire from an appropriately sized three-conductor AC cable from the hot side of the AC source selector switch and/or disconnect device to the terminal labeled "AC Input Hot 1" on the inverter. Never connect both shorepower and generator power to the inverter at the same time. ABYC standards require a disconnect switch within 10 feet of the shore power inlet connector.
- Connect the white wire from the neutral side of the AC source to the terminal labeled "AC Input Neutral" on the inverter.
- Connect the green wire from the ground of the AC source to one of the two green wires (AC Safety Ground) bolted to the chassis of the inverter/charger.

QUICK INSTALL

AC-Out Cabling

- Connect the black wire of a three-conductor AC cable between the terminal marked “AC Output Hot 1” on the inverter to the hot bus of your AC load center or AC sub-panel.
- Connect the white wire from the terminal marked “AC Output Neutral” to the neutral bus of your AC load center or sub-panel.
- Connect the remaining green wire bolted to the chassis of the inverter to the safety ground bus of the AC load center or sub-panel. Install the AC terminal cover with the screws provided.

Wrap up

- Secure all cables with wire ties or other non-conductive fasteners to prevent chafing or damage from movement and vibration. Use strain relief's, grommets, or conduit to prevent damage to the wiring where it passes through bulkheads or any apertures. Tighten all connections to 10-15 foot pounds. Install the red, green, and black inverter battery terminal covers.
- Affix the "Warning...Vessel is equipped with a DC to AC power inverter..." decal to the AC load center or sub-panel powered by the inverter.
- Check to see that the inverter front panel switch is in the “Off” position, then reconnect to the AC power source.
- Turn the inverter to the “On” position and check inverter operation (See *Operation* section).

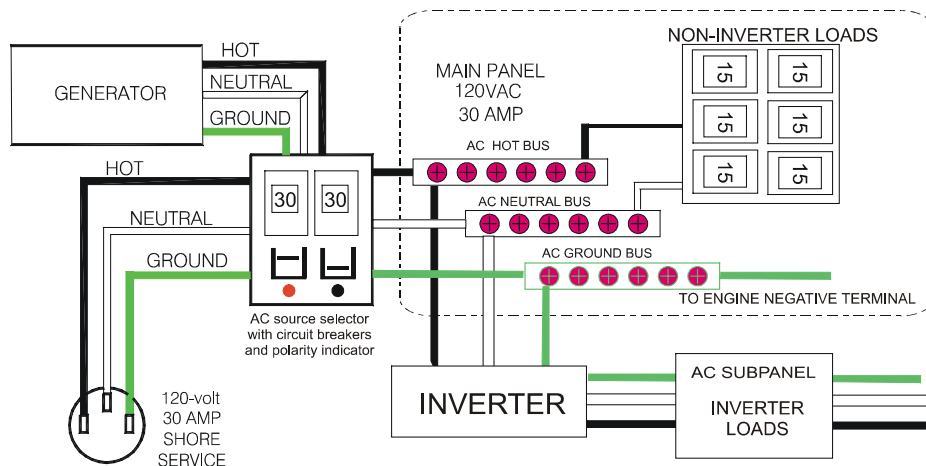


Figure 4, Typical AC Wiring Diagram

INSTALLATION

Installation

This section describes the requirements and recommendations for installing the Mariner inverter/charger. These are only guidelines. The National Electrical Code (NEC), American Boat and Yacht Council (ABYC), and the Code of Federal Regulations (CFR's) are the controlling authorities. Their standards and regulations are described here in general for your convenience, and are not represented as comprehensive or complete. For comprehensive and complete official standards and regulations, write the addresses listed below:

Title 33, Part 183: Code of Federal Regulations
Superintendent of Documents,
POB 371 954
Pittsburgh, PA 15250-7954
202-512-1800 or FAX 202 512 2250

ABYC, Incorporated
Standards and Recommended Practices for Small Craft
3069 Solomon's Island Road,
Edgewater, MD 21037-1416.
410 956 1050 or FAX 410-956-2737.

NFPA - National Fire Protection Association
National Electrical Code Handbook
One Batterymarch Park,
PO Box 9101
Quincy, MA 02269-9101
617-770-3000.

Safety Instructions

The Mariner inverter/charger is not ignition protected and may not be located in an engine compartment with gasoline-fueled engines under any circumstances. It is ETL listed to UL Standard 458 "*Power Converters/Inverters and Power Converter/Inverter Systems for Land Vehicles and Marine Crafts*" and Canadian CSA-C22.7 No. 107.1-M91, and conforms to ABYC standards A-20 "*Battery Charging Devices*" and A-25 "*Power Inverters*."

Before beginning the installation of the Mariner inverter/charger, read all instructions. Disconnect any and all sources of AC and DC power to prevent accidental shock. Disable and secure any and all AC and DC disconnect devices and automatic generator starting devices.

INSTALLATION

Locating the Inverter

Locate the inverter as close to the batteries as possible in order to keep the battery cable length short. However, do not locate the inverter above the batteries or in the same compartment as vented batteries. Batteries generate hydrogen sulfide gas, which is very corrosive to electronic equipment and everything else. They also generate hydrogen and oxygen. If accumulated, this mixture will ignite by an arc caused by the connecting of battery cables or the switching of a relay. Mounting the inverter in a ventilated enclosure with sealed batteries is acceptable.

ABYC A-25

Inverters shall be installed in a ventilated, dry, accessible location where ambient temperature will not exceed 122 °F (50°C), away from heat sources such as dry engine exhaust and other heat producing devices. Inverters shall not be installed directly over batteries. Controls shall be readily accessible. Inverters shall be securely fastened to bulkheads or other vessel structural parts. The base of the unit shall be at least two feet above normal bilge water, or protected so it is not subject to bilge splash. Protection shall be provided from falling objects or drippage.

Ventilation

Installation of the inverter in a properly ventilated enclosure is necessary for efficient operation of the unit. Installation in an enclosure that is too tight or poorly ventilated will result in lower peak power output, reduced surge capability, and potentially shorter inverter life. This is due to the inverter reaching its thermal shutdown point sooner than normal from lack of ventilation.

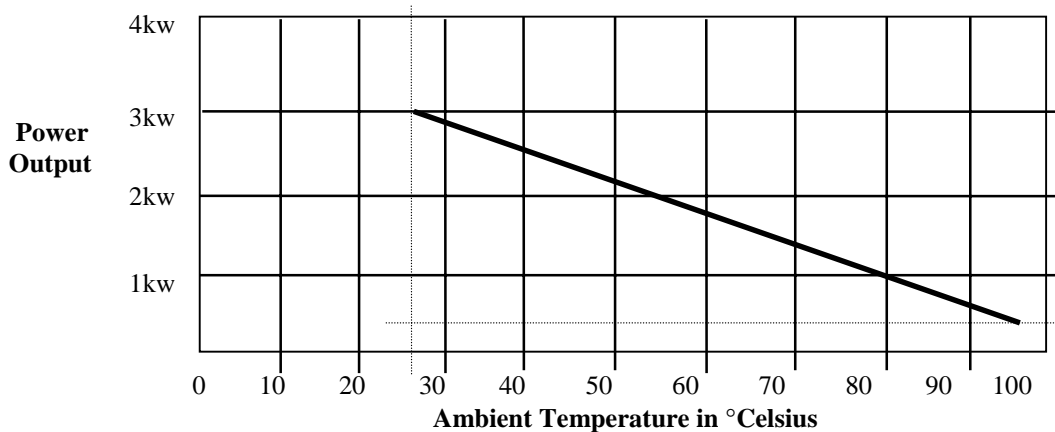


Figure 5, Power Output Versus Temperature

Figure 5, *Power Output Versus Temperature* shows the output capabilities of the M3012 inverter/charger, which is dependent on the ambient temperature in the enclosure where the inverter is located. The dark line represents the maximum power that may be expected from the inverter for

INSTALLATION

a given ambient temperature. Testing has shown that the volume of the enclosure is not as important as the overall ventilation. As long as a minimum airspace of 1 ½ - inches is maintained around the sides of the inverter, and three inches at the back of the inverter with the cooling fan, adequate ventilation should be maintained. Because the top of a Mariner chassis is not vented, clearance between the enclosure and the top of the inverter is not relevant. A fresh air intake opening should be provided directly to the fan if possible, and an exhaust port directly opposite that will allow cool outside air to flow through the inverter and back out of the enclosure.

Mounting

The inverter must be mounted on a horizontal surface. The purpose of this requirement is to orient the inverter so that it has no openings that will allow sparks or ignition sources to be ejected in the event of an internal fire. Secure the inverter to a shelf or deck to prevent movement during rough seas. Place flexible washers on the mounting screws or bolts between the shelf or deck and the inverter chassis to reduce vibration from the propulsion system while underway.

Overview of Marine AC and DC Systems

This section defines terms commonly used in marine electrical systems, and describes typical AC and DC marine systems. This is a brief overview. For more information regarding marine electrical systems, refer to the following publications: *Boat Owner's Electrical Manual*, 2nd Ed. 1995 by Nigel Calder and *12-volt Bible for Boats* by Miner Brotherton, or *Boat Owner's Illustrated Handbook of Wiring* by Charlie Wing.

Terminology

The following terms are derived from ABYC Standard E-9:

AC Grounding Conductor: A conductor, not normally carrying current, used to connect the metallic non-current-carrying parts of electrical equipment to the AC system and Engine Negative Terminal or its bus and to the shore AC grounding conductor through the shore power cable.

DC Grounded Conductor: A current-carrying conductor connected to the side of the source which is intentionally maintained at boat ground potential (DC negative ground bus).

DC Grounding (Bonding) Conductor: A normally non current-carrying conductor used to connect metallic non current-carrying parts of DC devices to the Engine Negative Terminal or its bus for the purpose of minimizing stray current corrosion.

Engine Negative Terminal: The point on the engine at which the negative battery terminal is connected (with the Mariner inverter, this connection is made to the DC Ground bus).

Ground: Refers to the potential of the earth's surface. The boat's ground is established by a conductive connection (intentional or accidental) with the earth, including any conductive part of the wetted surface of the hull.

INSTALLATION

Ground Fault Circuit Interrupter (GFCI): A device that functions to de-energize a circuit or portion thereof when a current to ground exceeds some predetermined value that is less than that required to operate the overcurrent protective device of the supply circuit. GFCI's are intended to protect people from electrical shock.

Typical Marine AC and DC Electrical System

The diagram below is intended to graphically illustrate a typical AC and DC electrical system commonly found on vessels. This diagram is not intended as a guide for wiring a boat, but only as an informational and instructional aid. Not all vessels will be equipped with all of the components shown, nor does the illustration include all equipment that may be found on a vessel.

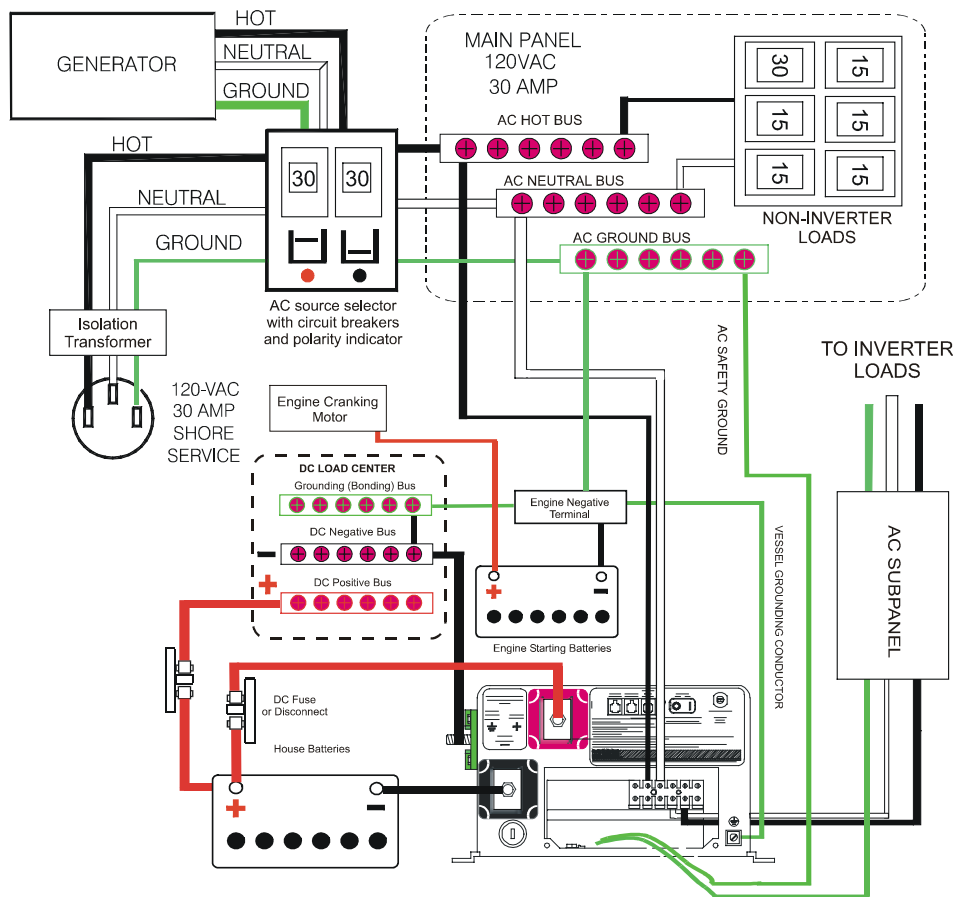


Figure 6, Typical AC & DC System

INSTALLATION

DC Cabling

This section describes DC cabling requirements and recommendations including cable sizing, DC conductor ampacity ratings, overcurrent devices, terminals and lugs, and DC negative terminal connections.

Battery Cable Sizing

The bigger the battery cables the better. Undersized cables result in additional stress on the inverter, lower efficiency, reduced surge power and lower peak output voltage. Don't use cables that are too small in diameter. The following table gives recommended cable sizes for the various cable-run lengths and inverter voltages.

Table 4, Recommended Battery Cable Size (In free air)

Inverter Model #	Typical DC Amps	1 to 3 feet One Way	3 to 5 ft One Way	5 to 10 ft One Way
M2012	200 Amps	00	0000	0000
M2512	250 Amps	0000	0000	0000
M3012	300 Amps	0000	0000	0000

The term "free air" is defined by the NEC as the cabling not being enclosed in conduit or raceway. Enclosed cables have a substantially lower continuous current carrying ability due to heating factors.

Battery Cable Inductance

When current passes through a conductor, a magnetic field is set up around the conductor. As this magnetic field builds, it induces voltage in any conductor that is close by, which induces a voltage in the original conductor. The voltage induced into the original conductor is called self-inductance, and tends to oppose the current that produced it. Induced voltage changes cause ripple in the battery cables that must be absorbed or filtered by the filter capacitors in the inverter. This ripple will lead to eventual premature breakdown of the filter capacitors and performance loss in the inverter.

When a distance separates positive and negative battery cables, they have much more inductance than if they are close together. When cables are separated, the magnetic fields add together and increase the inductance of the battery cables. With only a foot of distance between the battery cables, the inductance almost doubles. At four feet between cables the inductance is nearly three times the inductance of cables adjacent to one another.

In addition to the problems mentioned, the induced current opposes the applied current (battery current) which directly causes a loss of inverter performance as greatly reduced efficiency.

INSTALLATION

To avoid this problem, route your positive and negative DC cables in parallel, as close together as possible. Secure the cables against movement with clamps or straps every 18 inches. Avoid routing conductors near heat sources such as dry exhaust or furnace piping. Avoid chafing sources such as steering cables, engine shafts, and throttle connections.

ABYC E-9.16

Conduit, tape, raceways or other protection shall protect conductors exposed to physical damage. Conductors passing through bulkheads or other structural members shall be protected to minimize insulation damage such as chafing. Conductors shall be supported throughout their length, or shall be secured at least every 18 inches by non-metallic clamps or metal straps or clamps with smooth, rounded edges and an insulating material to prevent damage to the cable. Wiring shall be installed in such a manner that magnetic loops in the area of the compass and magnetically sensitive devices are avoided. Junction boxes and other enclosures in which electrical connections are made shall be weatherproof or installed in a protected location. No more than four conductors shall be secured to any one terminal stud. Twist-on connectors (wire nuts) shall not be used. Solder shall not be the sole means of mechanical connection in any circuit.

DC Over Current Protection

For safety and to comply with regulations, battery over-current protection is required. Fuses and disconnects must be sized to protect the wiring in the system. The fuse is required to blow before the wire reaches its maximum current carrying capability. The ABYC and Federal Regulations (CFRs) require a fuse or breaker within 7-inches of the current source (unless the conductor is attached to the battery terminal itself, then it must be within 72 inches) and rated to match the cable's ampacity at 75° C to protect the cables. The NEC also allows rounding up to the next fuse size from the cable rating, i.e. 150-amp cable size rounds up to a 175-amp fuse size. See the table on Page 69 to determine the proper fuse size for the cables you are using.

These installation parts are not supplied as part of the inverter. However, Trace Engineering offers a DC-rated class T fuse and safety-covered fuse block that are compatible with the Mariner inverter. The fuses are available in 110, 200, 300, and 400 amp sizes. Contact your Trace dealer to order; see the *Options* section of this manual for more information.

Table 5, Maximum Fuse Rating in Free Air

Cable Size	Rating in Free Air	Maximum Fuse Size	Trace Part Number
00 AWG	265 amps maximum	300 Amp	TBF300
0000 AWG	360 amps maximum	400 Amp	TBF400

INSTALLATION

DC Conductors

ABYC standards include minimum DC conductor size ratings for how much amperage each size wire can carry. The maximum allowable current-carrying ability of each size conductor is listed in the following table.

Table 6, Maximum Amperage for Conductors Under 50 Volts at 105°C

AWG Wire Size	Metric Wire Size	Amperage Outside Engine Spaces	Amperage in Engine Spaces
18	.8	20	17
16	1	25	21.3
14	2	35	29.8
12	3	45	38.3
10	5	60	51
8	8	80	68
6	13	120	102
4	19	160	136
2	32	210	18.5
0	50	285	242.3
00	62	330	280.5
000	81	385	327.3
0000	103	445	378.3

DC Cabling Connections

Color-code your battery cables with colored tape or heat shrink tubing. The standard is **red** for positive (+) and **black** for negative (-).

Cables must have soldered and crimped, or crimped copper compression lugs unless aluminum mechanical lugs are used. Soldered connections alone are not acceptable. We suggest using high quality, UL-listed Trace Engineering battery cables. These cables are available in a specific assortment of sizes from 1 ½ to 10 feet, and in 2/0 or 4/0 AWG. They are color-coded and have pressure crimped, sealed ring terminals. Contact your Trace dealer to order.

Figure 7, Battery to Inverter Cable Connection illustrates proper connections for the Mariner inverter/chargers. Points of caution are:

- ✓ **Do not** connect the battery negative (-) cable to the vessel safety ground; connect it to the battery negative terminal of the inverter.
- ✓ **Do not** connect equipment DC negatives to the safety ground, connect only to the negative bus of the DC load center.

INSTALLATION

These connections are necessary in order for the RC7 remote control fuel gauge to work properly. Use either copper compression ring terminals or aluminum mechanical lugs.

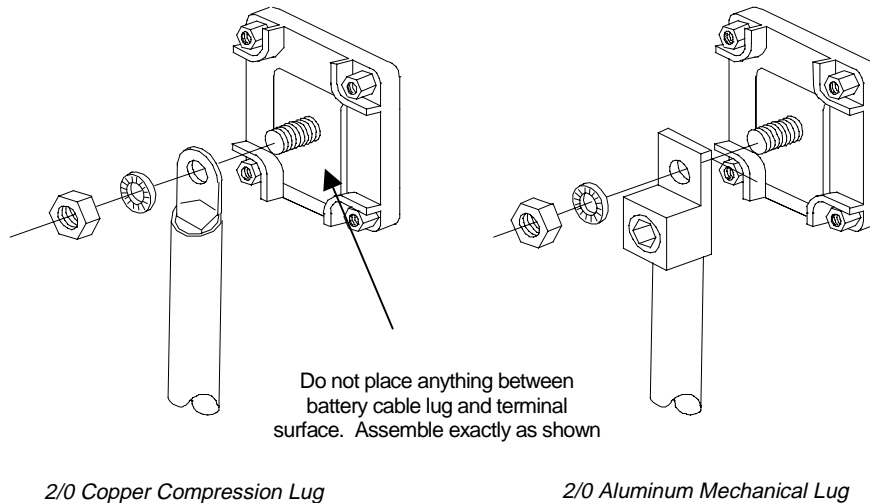


Figure 7, Battery to Inverter Cable Connection

Copper Compression Lugs: Commonly available at hardware, welding, and auto parts retailers, compression lugs must be crimped onto each cable using an appropriate crimping tool. These lugs are not available from Trace Engineering. Suggested sources and part numbers are:

Hollingsworth, Pompano Beach, FL 305-979-2050

Part #	Description
TL3061	2/0 Ring Terminal
TL3062	4/0 Ring Terminal
H40	8 AWG to 250MCM Air-Operated Crimping Tool

Thomas & Betts

K973	2/0 Ring Terminal
M973	4/0 Ring Terminal
RJ737	2/0 Insulated Ring Terminal
RL737	4/0 Insulated Ring Terminal
TBM6	Hand Operated Crimping Tool (order dies separately)

Dies:	#11809 for crimping	2/0 non-insulated lugs
	#11811	4/0 non-insulated lugs
	#11826	2/0 insulated lugs
	#11828	4/0 insulated lugs

INSTALLATION

Mechanical Lugs: Aluminum mechanical lugs are available from electrical hardware suppliers and do not require crimping. Suggested sources and part numbers are:

Part #	Description
ILSCO	
TA-2/0	2/0 Lug
TA-250 (preferred)	250 MCM Lug
Thomas & Betts	
62205	2/0 Lug
62212	250 MCM Lug
Panduit	
LAMA2/0-14	2/0 Lug
LAMA250-56.	250 MCM Lug

DC Negative Ground Cable Connection

The Trace Mariner inverter/chargers have a third battery terminal labeled "DC Ground Bus" (the green terminal on the left side of the unit). The purpose of this third terminal is to route all DC load current into and out of the battery bank through the internal shunt of the inverter. The internal shunt is connected between the inverter's black battery negative terminal and the green DC Ground Bus terminal of the inverter.

Because all DC loads in a vessel are generally connected to a common DC negative bus and not directly to the battery negative (in a negative ground system), all DC current in the system will at some point pass through the bus and then into the battery bank. If the inverter is in this loop, the net current flow is easily monitored. Thus, the RC7 remote control's battery fuel gauge feature is possible. You may connect the system without going through the inverter's DC Ground Bus terminal, but the RC7's fuel gauge feature will not work properly.

Installation Procedure

Determine the correct size battery cable to use for your installation (see *Table 2, DC Cable Sizing in Free Air* on Page 19). Connect a cable from the battery positive terminal to the battery positive (red) terminal on the inverter. Install an over-current device (fuse or circuit breaker) within 72-inches of the battery in this cable (within 7-inches is preferable). Connect a cable from the negative battery terminal to the negative (black) terminal on the inverter. If these cables penetrate a bulkhead, seal the opening through which the cables pass with a grommet or other device to prevent chafing and leakage of fluids or vapors.

Observe Battery Polarity! Place the battery cable ring terminals over the stud and directly against the inverter's battery terminals. A 'snap' caused by arching may occur-this is normal. Red is positive (+), Black is negative (-) Use a 1/2-inch wrench or socket to tighten the 5/16 SAE nut to 10-15 foot/pounds. Do not place anything between the flat part of the inverter terminal and the battery cable ring terminal or overheating may occur. Do not apply any type of anti-oxidant paste to terminals until after the battery cable wiring is tightened to 10–15 foot-pounds!

INSTALLATION

Caution! This inverter is not reverse polarity protected! If the positive terminal of the battery is connected to the negative terminal of the inverter, the result is failure of the unit. This type of failure is very obvious and is not covered under warranty. Double check when making battery connections!

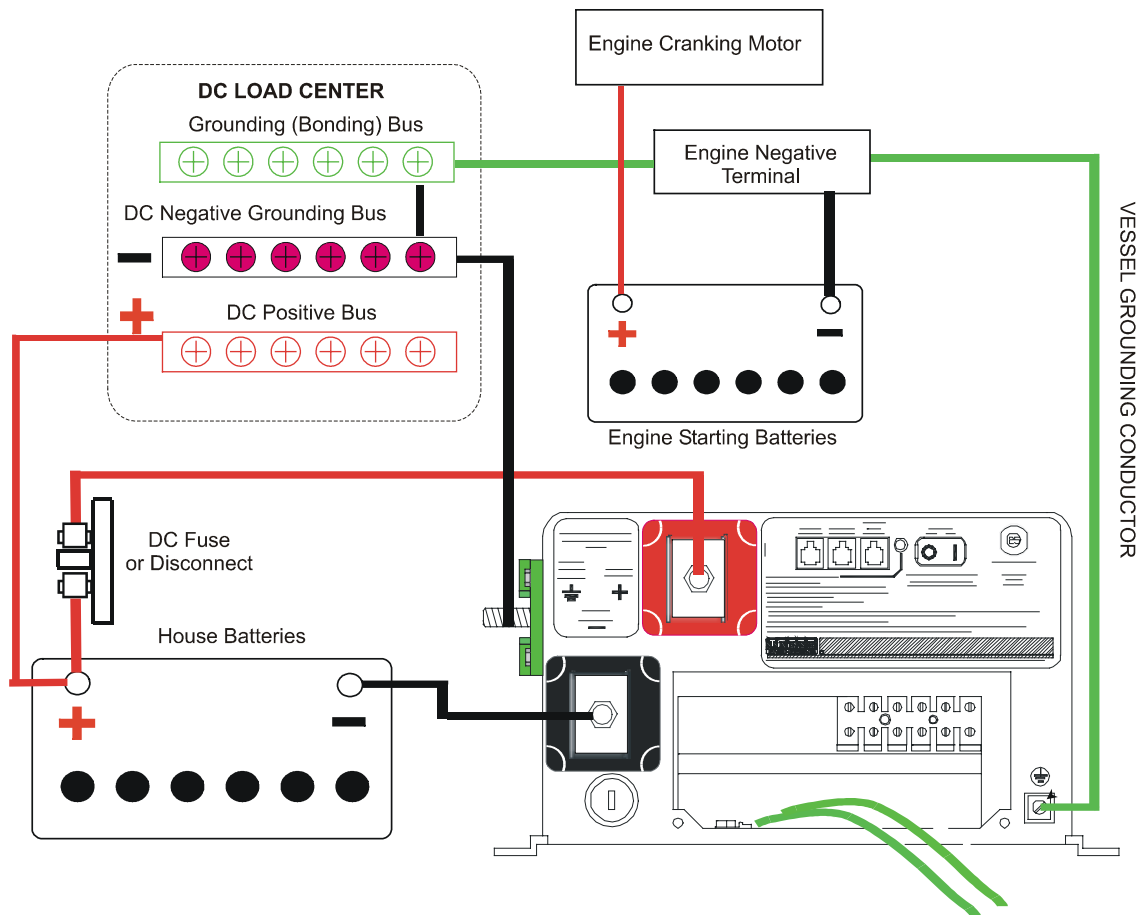


Figure 8, Typical DC Wiring Diagram

INSTALLATION

AC Wiring

This sections describes AC wiring requirements and recommendations including cable sizing, flexible cable, marine conductors, overcurrent devices, GFCI's, hookup procedure, and neutral-to-ground switching.

UL, ABYC and Federal Regulations define the standards for AC installation wiring in vessel applications. Never use Romex TM type single-strand cable. Use only multi-strand conductors of the type listed in the following tables. Temperature ratings shown assume the routing of wires above bilge water in locations protected from dripping and exposure to weather, spray, and oil.

Table 7 Flexible Cable for Marine Applications

Type	Description	Temperature Rating
SO	Hard Service Cord, Oil Resistant Compound	60°C and up (140° F and up)
ST	Hard Service Cord, Thermoplastic	60°C and up (140° F and up)
STO,SEO	Hard Service Cord, Oil Resistant Thermoplastic	60°C and up (140° F and up)
SJO	Junior Hard Service, Oil Resistant Compound	60°C and up (140° F and up)
SJT	Junior Hard Service, Thermoplastic	60°C and up (140° F and up)
SJTO	Junior Hard Service, Oil Resistant Thermoplastic	60°C and up (140° F and up)

Table 8, Conductors for Marine Applications

Type	Description	Temperature Rating
THW	Moisture and Heat Resistant Thermoplastic	75°C (167° F)
TW	Moisture Resistant Thermoplastic	60°C (140° F)
HWN	Moisture and Heat Resistant Thermoplastic	75°C (167° F)
XHHW	Moisture and Heat Resistant, Cross-linked Synthetic Polymer	90°C (194° F)
AWM	Moisture, Heat and Oil Resistant Thermoplastic, Thermosetting	105°C (221° F)
UL 1426	Boat Cable	105°C (221° F)

INSTALLATION

AC and DC Wiring Separation

Do not mix AC and DC wiring in the same conduit or panel. A separate conduit should be used for each. Induced current in the DC conductors could cause confusion with the inverter's microprocessor. Where DC wiring must cross AC or vice-versa, make the wires at the crossing point 90° to one another. Consult code for details of DC and AC wiring in vicinity to one another.

AC Wire Connections

The AC terminals are located on the front panel of the inverter chassis. A six-station terminal block is provided to make the AC connections. The terminal block is used to hardwire the AC input and AC output. All terminals are labeled on the inverter. Table 9 "*Recommended Minimum AC Wire Sizes*" on Page 34 gives suggestions for wire sizing.

Table 9, Recommended Minimum AC Wire Sizes

Inverter Model	120 VAC Input	120 VAC Output
M2012	10 AWG	12 AWG
M2512	8 AWG	10 AWG
M3012	8 AWG	10 AWG

AC Disconnect Device

Standards and regulations require an external disconnect switch in the AC input wiring circuit. AC breakers will meet this requirement. If the vessel is equipped with a generator, an AC source selector switch (such as Blue Sea Systems' part number 8032) is required. This particular switch also includes circuit breakers that protect both the ungrounded current-carrying conductor (Hot 1) and the grounded current-carrying conductor (Neutral). Also included are polarity indicators and a Power On indicator, all of which are required by ABYC standards (polarity indicator is not required if an isolation or polarity transformer is installed). The AC disconnect device must be located within 10 feet of the shorepower entry, measured along the cable. The power On indicator should be located at the AC load center.

Ground Fault Interrupting Outlets (GFCI's)

Trace Engineering has tested the following GFCI's and found them to work satisfactorily with our inverters:

LEVITON	6599
PASS & SEYMOR	1591RI 4A957
ACE Hardware	ACE 33238

INSTALLATION

GFCI's may be used on single-phase 120-volt AC circuits only if the system has a polarity indicator as the AC disconnect device. Some GFCI's will nuisance trip when used with a modified square wave inverter. Trial is the only way to tell for sure. On the above listed types, continued nuisance tripping is usually a result of a wiring problem in the inverter AC output system. Leakage currents present somewhere in the AC system are causing the GFCI to trip. Make a careful review of the AC wiring layout in your system and look for possible unwanted ground paths. An error in wiring of the neutral-ground switching system is a good place to start troubleshooting. Be sure that the AC output neutral is isolated from the ground. A multimeter may be handy in this troubleshooting procedure.

Neutral-to-Ground Switching

All of the Mariner Series units employ neutral-to-ground switching as required by the NEC (National Electric Code). The purpose for this requirement is to ensure that the neutral conductor in a three-wire system is "bonded" or connected to ground **at only one point**. This prevents a voltage difference from developing between the shorepower neutral and the vessel' neutral, which may cause an electric shock. When the unit is operating as an inverter, the AC output neutral is connected to the chassis ground by an internal relay, creating the bond within the inverter. When operating from an external AC power source the internal relay in the inverter opens and removes the ground from the neutral conductor and allows the "bond" to be provided by the external AC source.

The diagram on the below graphically describes the ground switching system in the inverter for a unit operating as an inverter and feeding the AC sub-panel.

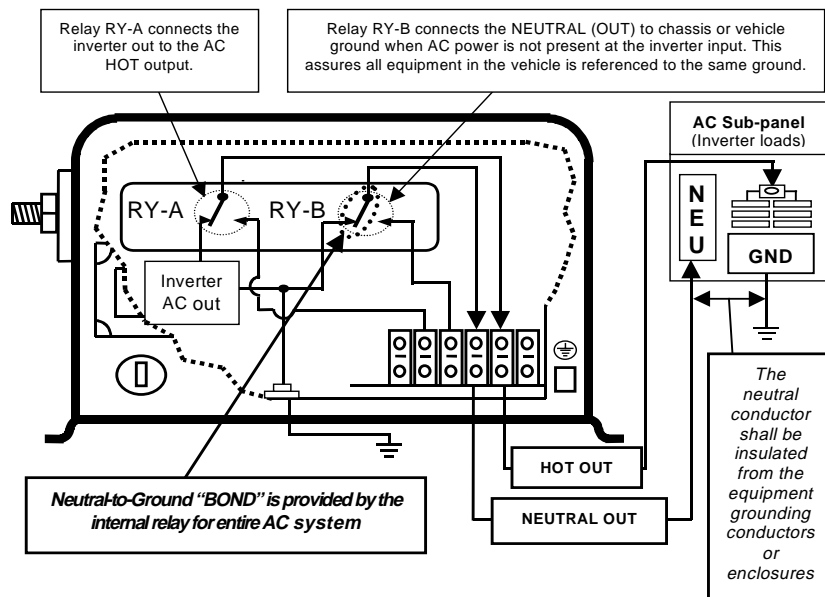


Figure 9, Neutral-to-Ground Switching without external AC source

INSTALLATION

For this system to work, the AC *output* neutral of the inverter *must* be isolated from the ground of the system (usually the green wire). When in the inverter mode, the neutral ground switching relay will automatically connect (bond) the output neutral to ground, and when in charger/pass-through mode, the ground and neutrals will be bonded to one another at the AC source (generator or shore power).

The diagram below graphically describes the ground switching system in the inverter for a unit connected to an external AC source (generator, grid etc.) and passing the AC power through the inverter to the AC sub-panel.

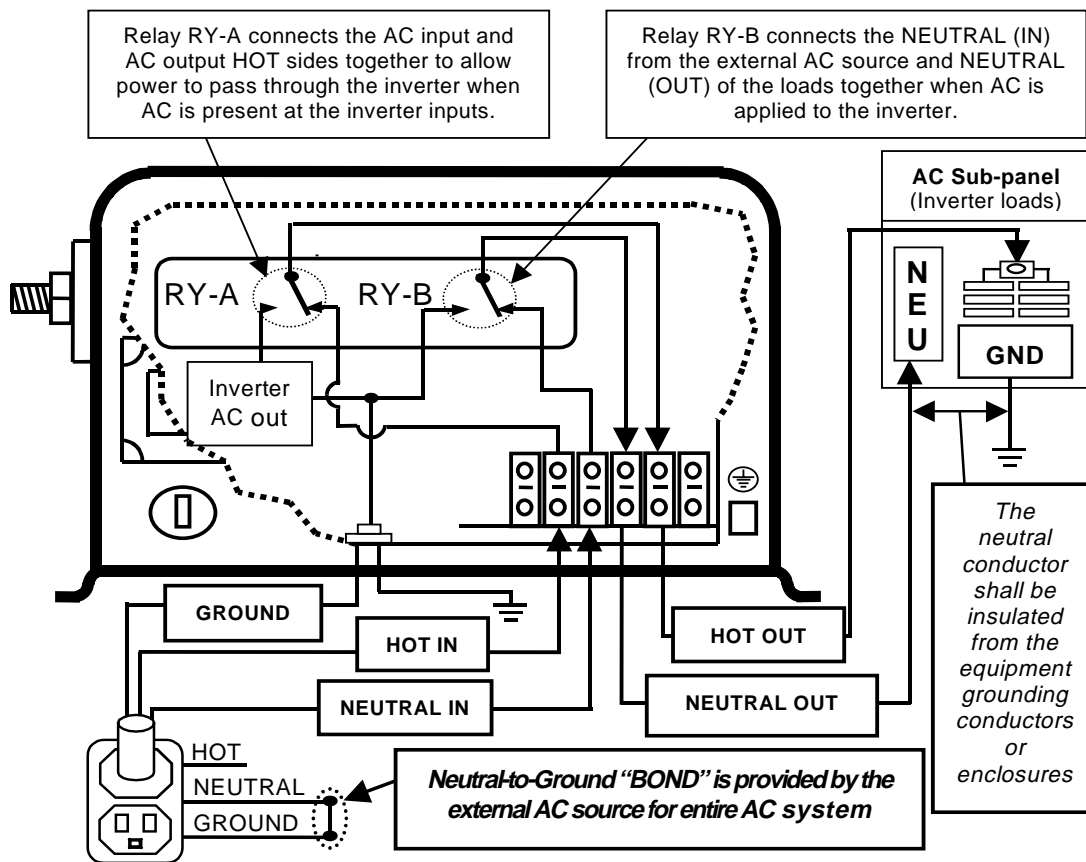


Figure 10, Neutral-to-Ground Switching with External AC

INSTALLATION

If no neutral to ground switching were employed in an inverter there would be one neutral tied to the AC sub-panel and the other neutral to the vessel's ground. The two different ground points would now form a current carrying conductor with the vessel's grounding conductor ('green wire') acting as the "wire" between the two different ground points. This means any ground point in the vessel becomes a potential current carrying conductor, which could result in electrical shock. This ground loop could also be a cause for nuisance tripping of any GFCI's (Ground Fault Circuit Interrupter).

Disabling Neutral Ground Switching

Mariner inverters employ neutral-to-ground switching. In some countries, this may not be used. In Canada, this feature **must** be disabled before installation. Check local code if you are not sure whether you must disable the neutral ground switching feature.

Note: Connect the chassis ground to the vehicle chassis even if ground switching has been disabled. Disabling the ground switching is very simple if precautions are taken and these steps followed:

1. If the inverter is already installed, disconnect any AC sources (If any are present)
2. Disconnect the battery(s) from the inverter.
3. Remove the AC terminal block cover on the front of the inverter.
4. Locate the green wire that runs from the circuit board to the chassis ground bolt as shown in the figure below. Disconnect this wire and wrap the terminal end with insulating tape.

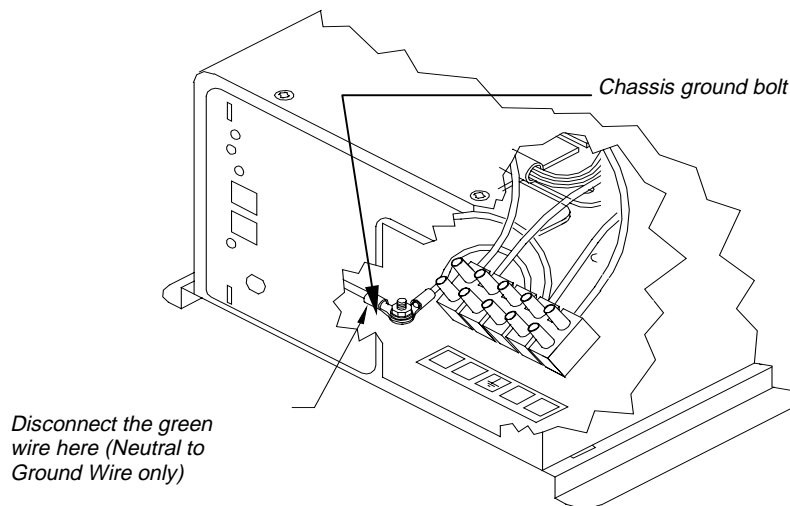


Figure 11, Disabling Neutral-to-Ground Switching

INSTALLATION

5. Do not cut the green wire that goes from the connector block to the DC grounding conductor.
6. Replace the AC terminal block cover and reconnect the battery(s) and the AC sources.

ABYC A-25.6

The neutral for AC power sources shall be grounded only at the following points:

- 1) the shore power neutral is grounded only through the shore power cable and not grounded on board the boat;
- 2) the inverter neutral shall be grounded at the inverter;
- 3) on systems using an isolation transformer or a polarization transformer, the inverter neutral (and the transformer secondary neutral) may be grounded at the AC main grounding bus instead of at the inverter.

Excerpts from "The Green Wire Controversy" by Robert Loeser from *Practical Sailor*, November 15, 1991:

"The three most common errors boat owners make are:

1). Connecting the grounded neutral (white wire) to the grounding wire (green wire)... If the shore-grounded neutral conductor is grounded on the boat by connecting the green and the white wires, underwater metallic hardware on the boat (propellers, shafts, outdrives, metallic through-hulls) becomes a current-carrying ground return path....In essence, the current radiates from the boat and creates a field of significant size, usually behind the boat. Anyone swimming in that field is in serious trouble...the voltage stops the swimmer's muscles from working, with the result that the swimmer quickly drowns.

2) Omitting (or cutting) the green grounding wire connection to the engine. As far as corrosion is concerned, cutting the green wire will work. But...the alternating current loses its return path for leakage. Anyone who goes into the water when the boat is at dock could be killed. And indeed this has happened several times in recent years.

3) Using equipment that requires both alternating and direct current [battery chargers, dual-voltage lights, refrigerators], which is not specifically designed for use in a marine environment. If AC leaks into the DC system, the current will automatically travel to the engine and the underwater hardware. This is true whether the green wire is connected to the engine or not.

Making these mistakes can be very serious, if not disastrous...."

INSTALLATION

Installation Procedure

1. Disconnect the inverter from the battery bank (if already connected), by either removing the DC fuse or opening the DC disconnect. Disconnect the shorepower conductor. Disable the automatic generator start device (if so equipped). Check to see if any AC or DC power is present (use a multimeter if necessary).
2. Determine which knockout(s) will be utilized and remove them from the inverter. Install strain relief in the inverter knockout holes. These require a 1" strain relief available at hardware stores or building supply centers. Using appropriate conduit connectors (if using conduit), fasten the conduit to the inverter. Feed all AC wiring through the conduit and into the inverter AC terminal block (located on the front of the inverter). Be sure to leave yourself extra wire to work with. You need at least two sets of three conductor wiring, one for AC Hot, neutral, and ground into the inverter, and another for AC hot, neutral and ground out of the inverter to the loads. Torque all AC terminals to 10 to 15 inch-pounds.

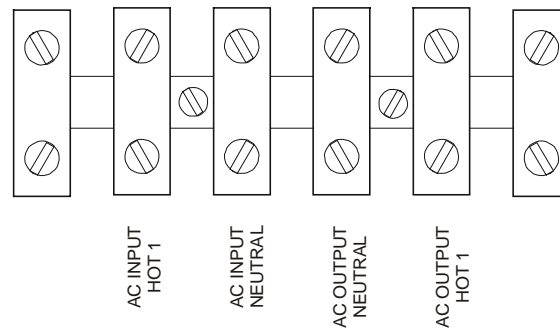


Figure 12, AC Terminal Block

ABYC E-8.15

All connections normally carrying current shall be made in enclosures to protect against shock hazards. Unused openings in boxes, cabinets and enclosures shall be closed. Current-carrying conductors shall be routed as high as practicable above the bilge water level and other areas where water may accumulate.

Conductors which may be exposed to physical damage shall be protected by self-draining loom, conduit, tape, raceways or other equivalent protection. Conductors passing through bulkheads or structural members shall be protected to minimize insulation damage such as chafing. Conductors shall also be routed clear of sources of chafing such as steering cable and linkages, engine shafts and control connections. Twist-on connectors (wire nuts) shall not be used. No more than four conductors shall be secured to any one terminal stud.

INSTALLATION

Following the wiring guide shown below, connect the hot (black) and neutral (white) wires from the AC source to the respectively labeled terminals on the inverter's AC terminal block. The ground (green) should be connected to the terminal stud labeled "ground" bolted to the floor of the chassis. Repeat the procedure for the AC wiring going to the AC sub-panel which will power the loads, except connect these wires to the terminals labeled AC out.

3. Inspect all wiring for proper installation and then replace the cover using the two 6/32nds screws and lock washers to secure it.

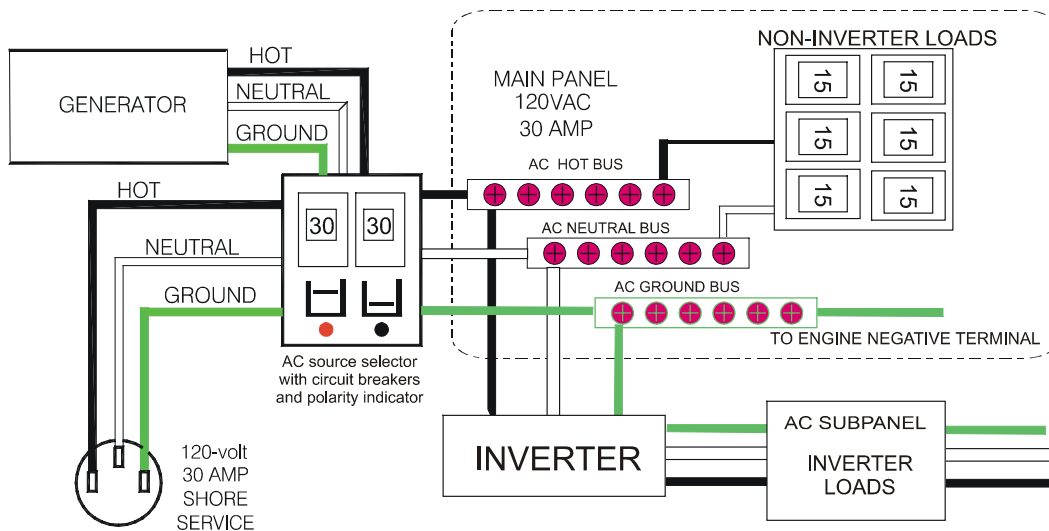


Figure 13, Typical AC Wiring Diagram

! Important Precaution

The output side of the inverter's AC wiring should at no time be connected to any AC power source. This condition is far worse than a short circuit. If the unit survives this condition, it will shut down until corrections are made.

AC output must be isolated from ground to comply with the NEC requirement for neutral-ground switching. This is easiest to do at the sub-panel by isolating the neutral connector block from the frame of the subpanel with an appropriate insulator.

I N S T A L L A T I O N

Wrap-up

- Install the cover over the AC terminal block and secure with the two screws provided.
- Affix the "Warning...Vessel is equipped with a DC to AC power inverter..." decal to the AC load center or sub-panel powered by the inverter.
- Check to see that the inverter front panel switch is in the "Off" position, then reconnect shorepower.
- Turn the inverter to the "On" position and check inverter operations.

Operation

Once the AC and DC wiring have been installed and connected, take a moment to go back over all connections and make sure they are secure and in the proper terminal(s).

Important! Before proceeding...

If the system utilizes liquid lead-acid type batteries instead of sealed gel-cell type, you will need to use the RC7 remote control to change the set-up for battery type from gel-cell to liquid lead-acid. If you don't know which battery type you have, use the gel-cell setting just to be safe, and then contact the battery manufacturer.

1. Check to see that the inverter is turned off, then apply battery (DC) power to it. Ensure that all wiring has been installed properly. Next, turn on the battery bank DC disconnect or connect the proper fuse inline to the battery to complete the battery circuit. When done, the inverter will go through a start-up self test. This will include the fan running, and relays opening and closing.

If the inverter does not come on or go through the start-up self test, check all connections. Check the inverter's DC voltage on the positive (+) and negative (–) terminals. If the DC voltage is low or if the battery bank needs to be charged, skip Step Two and go directly to Step Three.

2. Turn the inverter power switch to the "On" (|) position. The inverter should run a load with no AC connected (battery only). Place a load on the inverter (plug in a light or other load to an outlet the inverter is powering), and make sure it works.
3. Apply shore power. The charger should charge the battery bank. To charge your batteries, connect shore power to the inverter by plugging in the shore power cord and turning on the shore power breaker. After a minimum 20 seconds delay, the light on the front of the inverter should indicate it is in one of the three charge stages (bulk, absorption, or float). This indicates the charger is working properly. If you have an RC6 or RC7 remote control, it should indicate which charge stage the inverter is currently in. Any AC loads powered by the inverter should also work at this point since a portion of the shore power is passed through the inverter to power the loads. The delay before connecting is provided while the inverter is "sampling" the shore power to see that it is within acceptable frequency and voltage limits. This delay also allows time for a generator to spin up to a stable operating condition before connecting to the inverter. In this manner relay chatter is reduced.

OPERATION

4. Disconnect shore power. Take away the shore power by turning the shore power breaker off, or unplugging the shore power. The inverter should transfer to inverter mode immediately. This will be indicated by a clicking sound as the internal transfer relays change position. The inverter will begin to “buzz” as it takes power from the batteries and uses it to power the loads. The loads should continue to operate uninterrupted.

The above steps will complete a functional test of the inverter. If all areas pass, the inverter is ready for use. If any area fails, figure out why before proceeding. The troubleshooting guide in the appendix will help you solve problems you encounter. If any of the inverter's internal setpoints are to be adjusted, consult the booklet included with the RC7 remote control.

Batteries

This section of the manual is included to help you better understand the factors involved with battery charging, care, and maintenance, by discussing the physical make-up and characteristics of chemical storage batteries. This is not intended to be an exhaustive discussion of battery types, but simply a guideline. The manufacturer of each specific battery is the best authority as to its use and care.

Batteries come in different sizes, types, amp-hours, voltages and chemistries. It is not possible here to discuss all aspects in detail. However, there are basic guidelines you can follow that will help in battery selection and ensure that your batteries are better maintained than the majority.

Terminology

A description of battery charger operation requires the use of terms with which you may not be familiar. The following terms appear in the description of batteries and battery charger operation.

- ✓ **Electrolyte:** Typically a mixture of water and sulfuric acid, it is commonly referred to as battery acid.
- ✓ **Plates:** Originally made of lead, now fabricated from lead oxide. Plates connect to the battery terminals and provide a structure for the chemicals that create current. There are several plates in each cell, each insulated from the other by separators.
- ✓ **Sulfating:** As a battery discharges, its plates become covered with lead sulfate. During 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 will not remove it. This reduces the effective plate area and the battery's capacity.
- ✓ **Stratification:** Over time, a battery's electrolyte (liquid) tends to separate. The electrolyte at the top of the battery becomes watery while at the bottom it becomes more acidic. This effect is corrosive to the plates.
- ✓ **Deep Cycle:** A deep cycle occurs when a battery is discharged to less than 20% of its capacity (80% depth-of-discharge).
- ✓ **Temperature Compensation:** Peak available battery voltage is temperature dependent. As ambient temperatures fall, the proper voltage for each charge stage needs to be increased. An optional temperature-probe (BTS) automatically re-scales charge-voltage settings to compensate for ambient temperatures. The compensation slope based on cell voltage is -2.17mv per degree Fahrenheit per cell (30mv per degree Celsius) for lead-acid batteries.

BATTERIES

Types

There are two principal types of batteries: starting and deep-cycle. There are several different types of battery chemistries including liquid lead-acid, nickel-iron (NiFe), nickel-cadmium (NiCad), alkaline, and gel-cell. Batteries are either sealed or vented.

Starting Batteries

Starting batteries are designed for high cranking power, but not deep cycling. Do not use them with your inverter. They do not hurt the inverter but they simply will not last long in a deep-cycle application. The way they are rated should give a good indication of their intended use: "Cold Cranking Amps", a measure of the amperage output that can be sustained for 30 seconds. Starting batteries use lots of thin plates to maximize the surface area of the battery. This allows very high starting current but lets the plates warp when the battery is cycled.

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 type is the non-sealed, liquid electrolyte battery. Non-sealed types have battery caps. The caps should be removed at least monthly to check the level of electrolyte. When a cell is low, only distilled water should be added. The electrolyte level should be checked monthly and topped up if needed after recharging.

The most common deep-cycle batteries are the types used with boats and motor homes. They are 12-volt batteries rated at 80 to 100 amp-hours. Often the deep cycle claim is over-stated. They do have greater capacity than a car battery, but are not recommended.

Another popular and inexpensive battery of this type is the "golf car" (T-105 or CG220) battery. Rated at 220 amp-hours, these six-volt batteries can be discharged repeatedly to 80% of their capacity without being damaged. This is the minimum quality of battery that should be used with the Mariner inverter in normal applications.

Some systems use the L16 type of battery. These are 6-volt batteries rated at 350 amp-hours and are available from a number of manufacturers. They are 17 inches in height and weigh up to 130 pounds each - which may be troublesome in installations.

Type 8D batteries are available in either cranking or deep-cycle construction. The deep cycle versions are 12-volt batteries rated at 200 amp-hours or so. Since they are most commonly used to start truck engines, you should make sure you purchase the deep cycle version. Type 4D batteries are very similar in construction, but somewhat smaller.

Sealed Gel Cell

Another type of battery construction is the sealed gel-cell. They don't use battery caps. The electrolyte is in the form of a gel rather than a liquid. This allows the batteries to be mounted in any

BATTERIES

position without spilling. The advantages are no maintenance (to the battery itself, the system will still require routine maintenance), long life (800 cycles claimed) and low self-discharge. The disadvantage is high initial cost and the possibility of damage from overcharging.

While there are many manufacturers of quality non-sealed batteries, there are only a few manufacturers of suitable gel-cells. Don't confuse sealed batteries with maintenance free batteries. The latter is typically a standard liquid electrolyte type battery 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 may be used in inverter applications.

Environment

For long life and good performance, batteries need to be located in protected enclosures insulated from extremes in temperature. These environmental factors are discussed in the following sections.

Location

Batteries should be located in an accessible location with access to the battery caps and terminals. At least six inches of clearance above is recommended. They must be located as close as possible to the inverter, but can not limit the access to the inverter and the inverter's over-current protection device. Do not locate the inverter in the same space as the batteries, unless the batteries are of the sealed 'gel-cell' type.

The over-current protection device must be located per code within 72 inches of the battery installation, and must be covered to prevent possibility of discharging material in the event of a short circuit.

Enclosures

Batteries must be protected inside a ventilated enclosure. The enclosure should be ventilated to the outdoors from the highest point to prevent accumulation of hydrogen gasses 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. For most systems, a one-inch diameter vent pipe from the top of the enclosure is adequate to prevent accumulation of hydrogen.

Temperature

The effective capacity of a battery is reduced when cold. This phenomenon is more significant with lead-acid type batteries compared to 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 back-up source (usually a generator). This should be considered when designing the system. If extremely cold temperatures are expected at the location of a system, either a heated equipment room or alkaline batteries should be considered.

BATTERIES

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 the individual battery cells are more consistent, preventing unequal charging which can cause battery failure (some cells will be overcharged while others are undercharged).

The batteries should also be protected from high temperature as well. This can be caused by high ambient temperatures, solar heating of the battery enclosure, or heat released by a closely located generator. High battery temperatures will result 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

Batteries are the inverter's fuel tank. The greater amp-hour capacity of the batteries, the longer the inverter can operate before recharging is necessary. An undersized battery bank results in reduced battery life and disappointing system performance.

Batteries should not be discharged more than 50% of their capacity on a regular basis. Under extreme conditions cycling to a discharge level of 80% is acceptable. Totally discharging a battery may result in permanent damage and reduced life.

Estimating Battery Requirements

In order to determine the proper battery bank size, it is necessary 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-hours usage, the amp-hour requirements of each appliance that is to be used are determined and then added together.

You can compute your battery requirements using the nameplate rating of your appliances. The critical formula is $WATTS = VOLTS \times AMPS$. Divide the wattage of your load by the battery voltage to determine the amperage the load will draw from the batteries. If the AC current is known, then the battery amperage will be:

$$(AC \text{ volts} \times AC \text{ current}) / \text{Battery Bank Voltage} \times 1.2 \text{ (efficiency loss)} = DC \text{ amps (Battery amps)}$$

Multiply the amperage a load requires by the number of hours the load will operate and you have, reasonably enough, amp-hours.

Motors are normally marked with their running current rather than their starting current. Starting current may be three to six times running current. Manufacturer literature may provide more

BATTERIES

accurate information compared to the motor nameplate. If large motors will be started, increase the battery size to allow for the high demand start-ups require.

Battery Bank Sizing Example & Worksheet

Complete the steps that follow to calculate your battery bank capacity. No two installations will require exactly the same battery bank capacity. The example that follows will provide a guideline for determining your needs. Read through the example and then complete the worksheet on the following page.

Step 1: Multiply the number of hours (or fractions of hours) you will use the appliance each day by the wattage of each appliance. Total these *Daily Watt-Hours* to determine your *Daily Energy Required*;

Step 2: Multiply the *Daily Energy Required* by the number of anticipated days of autonomy (days between charging, usually one to five) to determine your *Rough Battery Estimate* (example used three);

AC Appliance	Hours of Daily Usage	Appliance Watts	Daily Watt-Hours Used
Microwave	0.5	600	300
Lights (x4)	6	40	240
Hair Dryer	0.75	750	563
Television	4	100	400
Washer/Dryer	1	375	375
STEP 1	Usage X Watt Hours = Total Watts		1878
STEP 2	Days of Autonomy X Total Watts		5634
STEP 3	Safe Battery Size (watt-hours)		13522
STEP 4	Amp-Hours Required		1127
INVERTER	Minimum Inverter Size Required		2000

Step 3: Multiply your *Rough Battery Estimate* (Step 2) by two. This allows for a maximum 50% normal battery discharge and an additional 50% for emergency situations. Multiply this figure by 1.2 to allow for an efficiency of 80%. This number is your *Safe Battery Size* in watt-hours.

Step 4: Convert Safe Battery Size in watt-hours to amp-hours. The formula is Safe Battery Size (Step 3) divided by DC system voltage (example used 12-volts). This is the Amp-Hours Required each day from your battery bank without recharging.

Inverter: This is the minimum inverter size required. Add together the appliances that will run at the same time from Column 3 (Appliance Watts, listed above). You will need an inverter with this many watts or more.

BATTERIES

Worksheet

AC Appliance	Hours of Daily Usage	Appliance Watts	Daily Watt Hours
Microwave			
Lights (x4)			
Hair Dryer			
Television			
Washer/Dryer			
STEP 1	Daily Energy Required		
STEP 2	Rough Battery Estimate		
STEP 3	Safe Battery Size (watt-hours)		
STEP 4	Amp-Hours Required		
INVERTER	Minimum Inverter Size Required		

Table 10, Typical Appliance Watts

Typical Appliance Watts			
Appliance	Watts	Appliance	Watts
One FL Light	10	Blender	400
Computer	350	Toaster	1000
Television	100-500	Hot Plate	1800
Microwave	600	Washer/Dryer	375-1000

BATTERIES

Monthly Maintenance

At a minimum, check the level of the electrolyte in each battery cell once a month (for non-sealed batteries). It should be above the top of the plates, but not completely full. Most batteries have a plastic cup that, when full, just touches the electrolyte. Don't overfill the batteries or the electrolyte will spill out of the batteries when they are being charged. Refill the batteries with distilled water only - "spring" water and regular tap water may have high levels of minerals. These can poison the battery chemistry and reduce battery life.

It is also good to periodically check the battery connections for tightness and corrosion. If any corrosion is found, disconnect the cables and carefully clean with a mild solution of baking soda and water. *Do not allow the solution to enter the battery.* Rinse the top of the battery with clean water when finished.

To reduce the amount of corrosion on the battery terminals, coat them with anti-corrosion grease or liquid neoprene (liquid electrical tape) available from automotive parts stores or battery suppliers. Do not apply anything between the terminal and the cable lugs. The connection should be metal to metal. Apply the protective material only after the bolts have been tightened.

Warning: use caution when working with metal tools around batteries. Do not allow any metal object to come into contact with both battery terminals at the same time. Battery explosion or failure can occur.

Dirty batteries may leak current, and tend to run warmer. Cleaning the batteries, when necessary, is easy and safe when the instructions presented here are followed.

Preparation

You will need appropriate attire, a few tools, and some equipment and supplies on hand. Read over the list and gather what you need before you begin.

Attire

Appropriate attire might include old clothes, rubber boots or old shoes. Battery acid is very corrosive and will dissolve most textiles within a few days after exposure, so wear something you can live without just in case you splash some on yourself. Be sure to wear rubber gloves and eye protection.

Tools

- ½-inch or 9/16 wrench as required, or an equivalent socket and ratchet
- adjustable and/or locking pliers
- torque wrench (suggested, not required)
- soft-bristled brush (discarded toothbrushes work just fine)

BATTERIES

- 6-inch scrub brush
- Inexpensive ½ inch chip brush or soldering brush

Equipment

- Water hose with spray nozzle or 5-gallon watering bucket
- Empty spray bottle
- Old clothing
- Eye protection
- Rubber gloves

Supplies

- Baking soda or vinegar (for use with NiCad batteries only), always keep a supply on hand in the event of a spill
- Water (a hose is best; a five-gallon watering bucket if a hose is not available)
- Hand cleaner or soap
- Towel
- When cleaning or tightening cables only: liquid neoprene or white lithium grease (available at auto, RV, and marine stores)

Procedure

Review the Safety Precautions section of this booklet before you begin, then turn the disconnect switches for the batteries you are cleaning to the Off position.

Battery Enclosure and Batteries

Mix a four-ounce box of baking soda with a gallon of fresh water and fill spray bottle. Spray 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

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

BATTERIES

cable must be removed for cleaning. When it is necessary to detach a battery cable from the battery, turn the DC disconnect switches to the 'Off' position. Using the appropriate tool, remove the Negative battery cable first and install it last.

Use a toothbrush (or other soft bristle brush) and baking soda to remove any stubborn residue. Sprinkle the baking soda directly on the area and scrub with a wet toothbrush, adding water as required, then rinse.

Reconnect the battery cable terminals to the battery lugs and tighten to approximately 10 to 15 foot-pounds using the torque wrench. If you do not have a torque wrench, use the appropriate tool to tighten the bolts reasonably snug. Do not over-tighten.

After tightening the cables, evenly coat all the exposed metal surfaces of the battery terminals and lugs with liquid neoprene, which will cure to form an airtight protective layer. If liquid neoprene is not available, use a light coating of white lithium grease or other sealant. Don't let anything come between the mating surfaces of the lugs and terminals.

Cables

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

Cabling & Hook-up Configurations

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

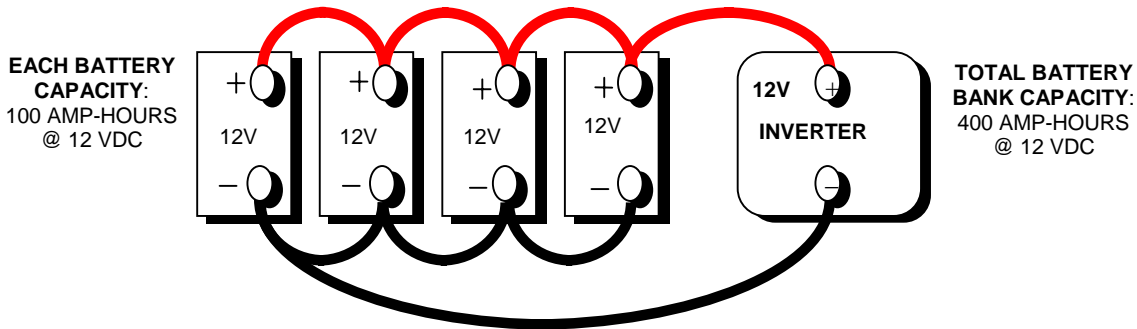
It is usually preferable to first connect the batteries in series and then in parallel when connecting smaller batteries together. The best configuration is to connect the batteries both in series and parallel - a configuration often called "cross-tying". This requires additional cables but reduces imbalances in the battery and can improve the overall performance. Consult your battery supplier for more information regarding the hook-up configuration required for your system.

Connect several smaller batteries together when creating a battery bank of substantial size. There are three ways to do this. Batteries can be connected in parallel, series, or series - parallel.

BATTERIES

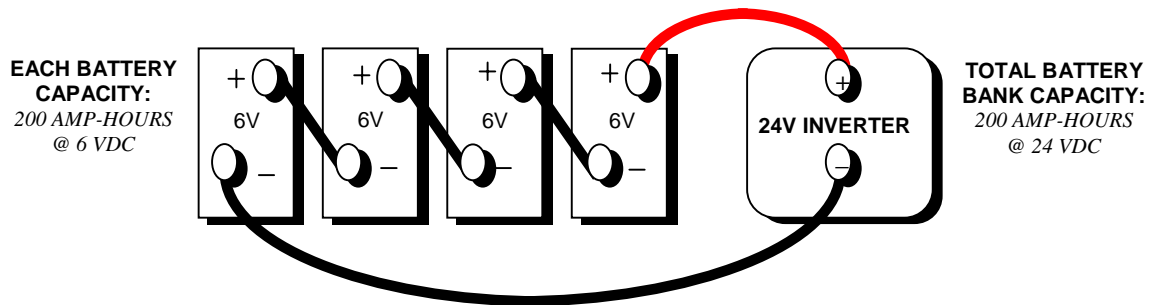
Parallel Connection

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 have the same voltage as a single battery, but an amp/hour rating equal to the sum of the individual batteries. This is usually only done with 12-volt battery-inverter systems.



Series Connection

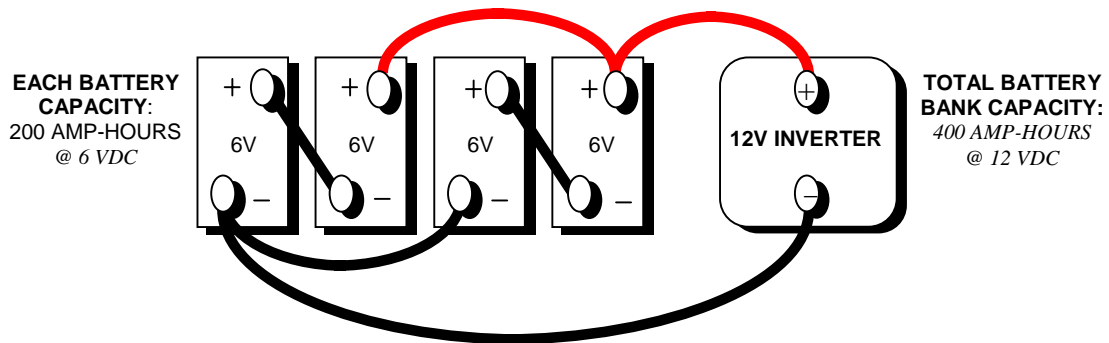
When batteries are connected with the positive terminal of one to the negative terminal of the next, they are connected in series. In a series configuration, the battery bank has the same amp/hour rating of a single battery, but an overall voltage equal to the sum of the individual batteries.



BATTERIES

Series – Parallel Connection

When pairs of batteries are connected in series and parallel, the result is an increase in both the voltage and the capacity of the total battery bank. This creates a larger, higher-voltage battery bank out of several smaller, lower-voltage batteries – a common practice in battery/inverter systems. In the illustration, each battery in the bank has 100 amp-hours capacity at 6 VDC. The advantage is the battery bank will have 400 amp-hours capacity at 12 VDC.



! CAUTION:

Batteries can produce extremely high currents if they are short-circuited. Be very careful when working around them. Read the important safety instructions at the start of this manual and the battery supplier's precautions before installing the inverter and batteries.

THREE-STAGE BATTERY CHARGER

Three-Stage Battery Charger

The Mariner inverter/charger has a fully functional three-stage battery charger. Anytime an acceptable (within frequency and voltage parameters) AC source is presented to the unit, it will charge the batteries connected to it. The On/Off switch on the inverter does not control the charger portion of the unit. When AC is present the charger will charge the battery bank regardless of the position of the inverter's On/Off switch.

AC is fed into the inverter's AC input and the transformer steps the high voltage AC down to lower voltage AC. This power is rectified and fed to the battery bank to charge it. The charger is fully regulated, and protection systems prevent abuse of the battery bank due to overcharge, over-temp, and/or charger failures

Charging Profile

The battery charger in the Trace Mariner inverters charges in three stages - **BULK**, **ABSORPTION**, and **FLOAT** - to provide rapid and complete charge cycles without undue battery gassing. The figure below shows how DC voltage and current change with time through the different charge stages.

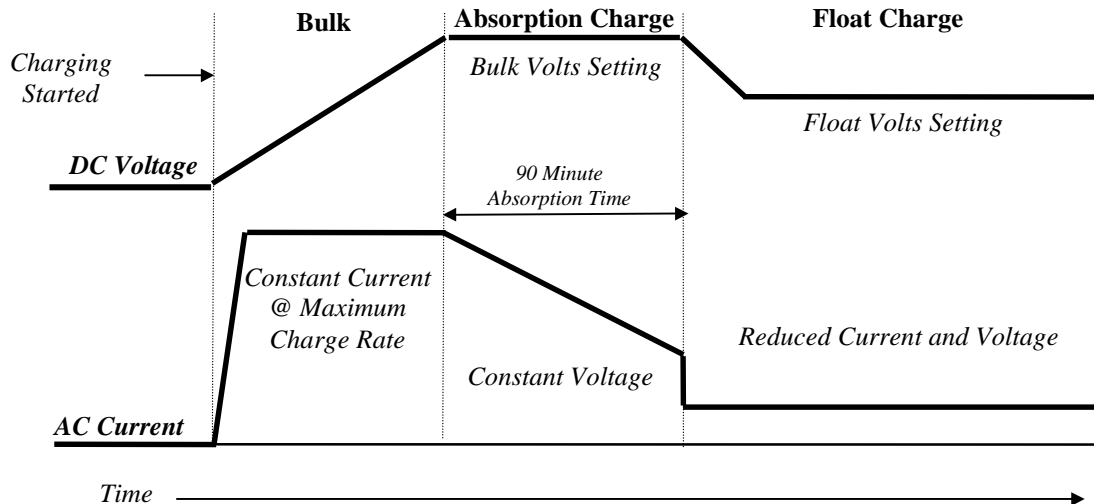


Figure 14, Three-Stage Charging Profile

THREE-STAGE BATTERY CHARGER

Bulk Voltage - This is the maximum voltage the batteries will reach during a normal charging cycle. The normal range is 2.35 to 2.42 volts per cell. For a 12 VDC battery (6 cells) this is 14.1 to 14.5 volts. Liquid electrolyte batteries are charged to a higher voltage, while gel-cell batteries have a lower voltage.

This stage is initiated when AC is applied to the AC input of the inverter, if battery voltage is less than 12.6 volts. It is terminated when the batteries reach the Bulk Charge Voltage. During this stage the charger LED glows steady orange. Stage One charges the batteries at a constant current. The level of charge for this phase can be adjusted using the RC7 remote control.

Absorption - During this part of the charge cycle, the batteries are held at the bulk voltage and accept whatever current is required to maintain this voltage. This ensures full charging, "topping" off the batteries. At this point the charge current begins to taper off and the charger LED blinks orange.

As the charge cycle progresses, the current required to hold the battery voltage constant gradually reduces. After ninety minutes of absorption charging, the voltage is allowed to fall to the float voltage setting — Stage Three.

Note

If there are DC loads on the batteries, the voltage may never rise to a level high enough to initiate the Absorption stage.

Float Voltage - This is the voltage at which the batteries will be maintained after they have been charged. A range of 13.4 -13.5 volts for 12-volt systems is appropriate for most sealed and non-sealed batteries. 13.5 volts is an appropriate setpoint for gel-cell batteries, and 13.4 volts is common for liquid lead-acid types.

When AC is connected to the inverter/charger, and battery voltage is 12.6 volts or higher, the charge will skip Bulk and Absorption modes and go directly into Float mode. The charger remains in the float stage until the unit loses AC input power (i.e. generator or shore power). During this stage, the charger flashes green about four times per second. The purpose of stage three is to maintain the batteries at a voltage that will hold full charge but not gas the batteries.

Note

When DC loads are placed on the battery, the charger will deliver currents up to the Maximum Charge Rate setting while maintaining the float voltage.

THREE-STAGE BATTERY CHARGER

Table 11, Bulk and Float Setpoints

Typical Bulk & Float Setpoints for Lead-Acid Batteries		
Battery Type	Bulk Volts	Float Volts
Gelled Lead-Acid (sealed)	14.1 volts	13.5 volts
Liquid Lead-Acid (non-sealed)	14.5 volts	13.4 volts

Charger AC Requirements

The maximum charge rate of the battery charger is dependent upon the peak AC voltage available. Since the battery charger uses only the top portion of the input sine wave, small variations in peak voltage results in large variations in the amount of energy to the charger. This charger's output is rated on the basis of shorepower input, which typically has a peak voltage of 164 volts (230 volt AC power has a peak of 330 volts). Peak voltage may be inadequate at older marina's, on individual docks, and from other AC sources.

It takes a powerful AC generator to maintain the full 164-volt peak while delivering the current necessary to operate the charger at its maximum rate (typically 5KW for 2500 VA models and 6 kW for 3000 VA models). Smaller generators will have the tops of their waveform clipped under such loads. Running at these reduced peak voltages will not harm the charger, but it will limit the maximum charge rate. Large auxiliary AC loads may exacerbate this problem.

Theory of Inverter Operation

The Trace Mariner inverter/chargers utilize a low frequency power transformer-based design. This design takes low voltage direct current from a DC source (usually a battery bank) and produces higher voltage power. High efficiency is achieved by utilizing top quality field effect transistor switches (FET's) in an "H-bridge" configuration, as well as in-house designed and manufactured power transformers.

The theory behind inverter operation is to "chop" the DC power up into pulses via the transistor switches. These pulses are then applied to a power transformer which steps the low voltage DC pulses up to higher voltage AC. In the Mariner inverter, this process is overseen by an onboard microcomputer. The computer is also responsible for the monitoring and charging of the battery bank, as well as monitoring and protecting the inverter/charger against damage from heat, over current, and other potentially hazardous situations.

Waveform

The output waveform of the inverter is referred to as a modified sine wave. This waveform is suitable for a wide variety of applications such as induction motors (i.e. refrigerators, drill presses), resistive loads (i.e. heaters, toasters), and universal motors (i.e. hand tools, vacuum cleaners), as well as microwave ovens and computers. The modified sine wave waveform could be more accurately described as a pulse width modulated square wave. The accompanying figure shows the relationships between square wave, sine wave and modified sine wave formats.

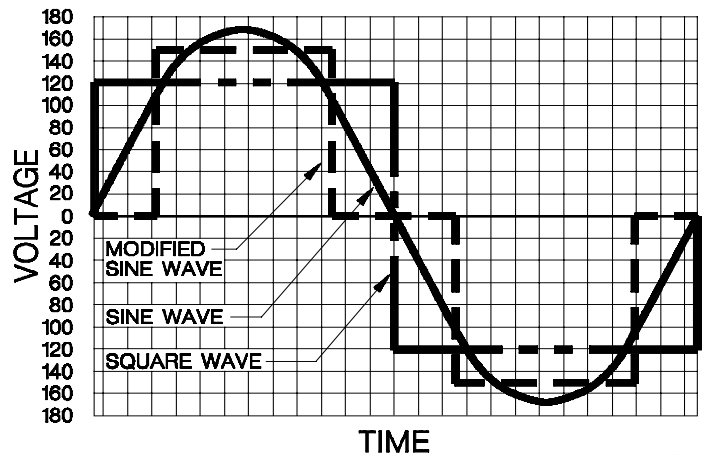


Figure 12, Comparison of Output Waveforms

THEORY OF INVERTER OPERATION

Regulation

An advantage of a modified square wave compared to a square wave is the ability to regulate Root Mean Square (RMS) voltage by means of varying the pulse width, and off time periods. The pulse width variation method of regulation is referred to as pulse width modulation or PWM.

RMS regulation should keep the area inside the waveform equal at all times. Since the peak voltage, or pulse height, is a product of battery voltage and transformer ratio, when the peak voltage increases (Figure 12), the area inside the pulse will increase if the pulse width remains the same. With a pure square wave inverter nothing can be done about this RMS voltage increase, but with a modified sine wave inverter PWM control allows the width of the pulse to be narrowed. This maintains a constant area inside the waveform and thus a constant RMS voltage is maintained.

Conversely, if the battery voltage decreases, the RMS voltage will also decrease if the pulse width remains the same. In this situation, RMS voltage regulation may be achieved by increasing the pulse width (shown below).

Increase and decrease of pulse width is accomplished by controlling the on-and-off time of the inverter's transistor switches. Realistically, there is a point where the zero time is no longer present as the pulse width is increased, and an essentially square wave develops. Beyond this point the RMS voltage becomes unregulated.

Shaded Area is equal for all three scenarios so RMS voltage is equal.

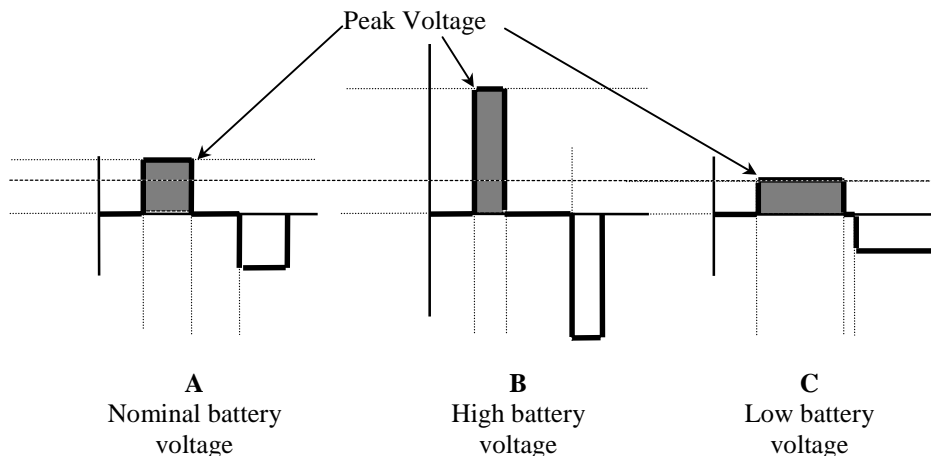


Figure 13, RMS Voltage Regulation

Applications

AC loads on the inverter differ in the way they perform. There are different types of loads: resistive loads, inductive loads, and problem loads.

Resistive Loads

These are the loads that the inverter finds the simplest and most efficient to drive. Voltage and current are in phase, or, in this case, in step with one another. Resistive loads usually generate heat in order to accomplish their tasks. Toasters, coffee pots and incandescent lights are typical resistive loads. Larger resistive loads—such as electric stoves and water heaters—are usually impractical to run off an inverter due to their high current requirements. Even though the inverter can most likely accommodate the load, the size of battery bank required would be impractical.

Inductive Loads

Any device that has a coil of wire in it probably has an inductive load characteristic. Most electronics have transformers (TV's, stereos, etc.) and are therefore inductive. Typically, the most inductive loads are motors. The most difficult load for the inverter to drive will be the largest motor it manages to start. With inductive loads, the rise in voltage applied to the load is not accompanied by a simultaneous rise in current. The current is delayed. The length of the delay is a measure of inductance. The current makes up for its slow start by continuing to flow after the inverter stops delivering a voltage signal. How the inverter handles current that is delivered to it while it is essentially "turned off", affects its efficiency and "friendliness" with inductive loads. The best place for this out-of-phase current is in the load. Trace's "impulse phase correction" circuitry routes it there.

Inductive loads, by their nature, require more current to operate than a resistive load of the same wattage rating, regardless of whether power is being supplied by an inverter, a generator, or utility power (the grid).

Induction motors (motors without brushes) require two to six times their running current on start-up. The most demanding are those that start under load, e.g., compressors and pumps. Of the capacitor start motors (typical in drill presses, band saws, etc.), the largest you may expect to run is ½ to 1 hp (depending on inverter size and surge power capability). Universal motors are generally easier to start. Since motor characteristics vary, only testing will determine if a specific load can be started and how long it can be run.

If a motor fails to start within a few seconds, or it begins to lose power after running for a time, it should be turned off. When the inverter attempts to start a load that is greater than it can handle, it will turn itself off after about 10 seconds.

APPLICATIONS

Problem Loads

Trace Engineering inverters can drive nearly every type of load. However, there are special situations in which inverters may behave differently than public power. Trace has provided the following knowledge as guidelines only. Trace does not guarantee that your experiences with any particular product will duplicate ours whether good or bad. Manufacturers change the topologies of circuits routinely, in an effort to save money and at the same time improve a product. This means that a product we list as working or not working with a modified square wave inverter may react conversely to our findings in your situation. Trace assumes no responsibility for failure of a particular product in your application! It is up to you to decide to and to test a given product with your specific system. We do not endorse any product in particular.

Very small loads - If the power consumed by a device is less than the threshold of the search mode circuitry, it will not run. See the section *Search Sense* for ways to solve this problem. Most likely the solution will be to defeat the search mode feature.

Fluorescent lights & power supplies - Some devices when scanned by search sense circuitry cannot be detected. Small fluorescent lights are the most common example. (Try altering the plug polarity by turning the plug over). Some computers and sophisticated electronics have power supplies that do not present a load until line voltage is available. When this occurs, each unit waits for the other to begin. To drive these loads either a small companion load must be used to bring the inverter out of its search mode, or the inverter may be programmed to remain at full output voltage by defeating the search mode feature. See the section *Search Sense*.

Microwave ovens- Microwave ovens are sensitive to peak output voltage. The higher the voltage, the faster they cook. Inverter peak output voltage is dependent on battery voltage and load size. The high power demanded by a full sized microwave drops the peak voltage several volts due to internal losses. Therefore, the time needed to cook food will be increased if battery voltage is low. Some microwave ovens may not operate at all. Try it before you buy it.

Clocks- The inverter's crystal controlled oscillator keeps the frequency accurate to within a few seconds a day. However, external loads in the system may alter the inverter's output waveform causing clocks to run at different speeds. This may result in periods during which clocks keep time and then mysteriously do not. Most clocks do not draw enough power to trigger the load sensing circuit. In order to operate without other loads present, the load sensing will have to be defeated (See section on *Search Sense*). Clock accuracy is also affected by the accuracy of the generator. The best solution is to buy a battery-operated clock, or a clock that is not dependent on line frequency or voltage. Any clock with a crystal controlled oscillator will probably work just fine.

Searching- If the amount of power a load draws decreases after it turns on, and if this "on" load is less than the load sensing threshold, it will be turned alternately on and off by the inverter. Incandescent light bulbs may present this problem when the search threshold is set near the wattage rating of the bulb.

APPLICATIONS

Dimmer switches- Most dimmer switches lose their ability to dim the lights and operate either fully on or off. Trace has had reports of success with the 600 watt, 120 VAC Leviton slide dimmer switches (Leviton P/N-6621). These have been reported as working reliably every time with a modified square wave output inverter.

Rechargeable devices- Sears "First Alert"™ flashlights fail when charged by the inverter. "Skil"™ rechargeable products are questionable. "Makita"™ products work well. When first using a rechargeable device, monitor its temperature for 10 minutes to ensure that it does not become abnormally hot. That will be your indicator that it should not be used with the inverter. Trace has found that "Black & Decker"™ Dustbusters and Spotlights work well.

Laser printers- While many laser products are presently operating from Trace Engineering inverters, and we have personally run a Texas Instruments Microlaser and HP IIP, we have had reports of an HP III and a MacIntosh Laser Writer failing under inverter power. We, therefore, do not recommend the use of laser printers. Hewlett Packard ink jet printers seem to work well with modified square wave inverters. Should you wish to try and run your own laser printer, do so at your own risk. The manufacturer will probably not honor the warranty if they figure out it failed under any power source other than public power.

Electronics- AM radios will pick up noise, especially on the lower portion of their band. Inexpensive tape recorders are likely to pick up a buzz. Large loads should not be started while a computer is operating off the inverter. If a load is large enough to require "soft starting" it will "crash" the computer, causing it to "reboot".

Computers - Computers may 'crash' if large loads are started while the inverter is operating. The inverter output voltage may fall briefly, allowing computers to fall. Large motors may generate voltage spikes that are not completely suppressed by the inverter's internal voltage transient suppression circuit. Surge arrestors and similar devices design to guard computers from voltage spikes or fluctuations will not work correctly with the inverter's output waveform. Don't use them.

OPTIONS

Options

Options available for the Mariner inverter/charger include a choice of remote controls, and a battery temperature control.

The RC6 Remote Control

The optional RC6 remote control unit duplicates the Power On/Off Switch on the Mariner inverter/charger. It connects directly to the port labeled Remote Control on the front of the inverter, using standard phone cable and jacks. Use the included Trace remote cable because it's a high quality cable. The wire is custom-made and tinned along its entire length for weather and corrosion resistance.

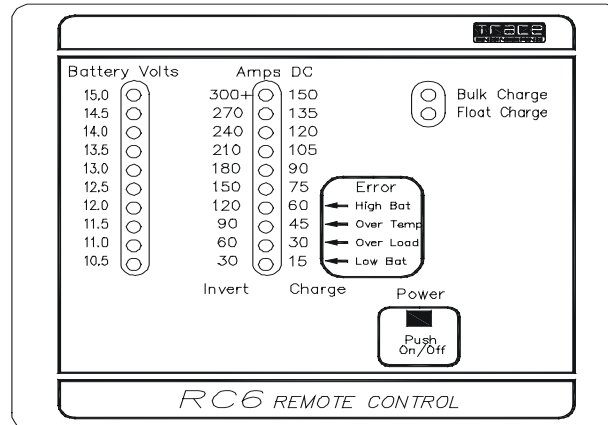


Figure 15, RC6 Remote Control Faceplate Display

The front panel of the RC6 shows the status of several different modes of the inverter, and monitors the inverter's output. The lighted bar graph on the far left shows battery voltage from 10.5-15 volts. The bar graph in the middle of the panel indicates DC amps in either the inverter or charger modes and will automatically switch between these modes as the inverter changes modes. The four error lights on the lower right of this graph use the bottom four LED's of the amperage scale to indicate four different error conditions: High battery, Low battery, Over temp, and Over load. One of these

OPTIONS

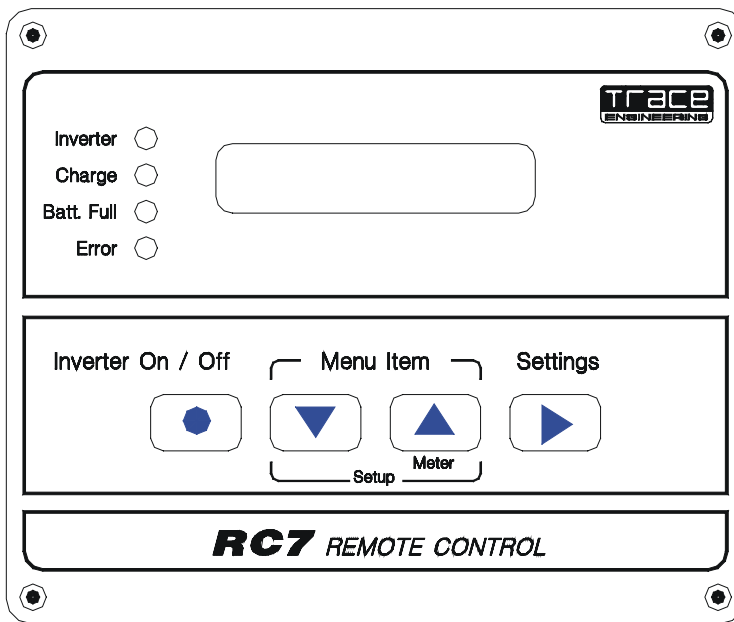
four lights will blink when an error condition occurs. The Bulk Charge or Float Charge lights will light to indicate the inverter is in either the bulk or float stage of the charging process.

In order for the inverter to recognize the RC6, it must be powered up with the RC6 already plugged in. If the RC6 is plugged in while the inverter is operating, it will not be recognized. In this situation simply turn the inverter power switch off and then back on.

The RC7 Remote Control

The optional RC7 remote control has the ability to communicate with and adjust settings in the Mariner. It connects into the port labeled Remote Control on the front panel of the inverter using the included remote connection cable. Only one remote control at any given time may be plugged into the inverter. Use the cable supplied with the RC7 rather than standard phone cable because it is high quality cable. It is tinned along its entire length for corrosion and weather resistance.

Figure 16 , RC7 Remote Control Faceplate



OPTIONS

The RC7 displays its information on a LCD screen and has multiple modes. A menu tree accompanies the RC7 to help navigate the RC7's many features. The RC7 is the only way to change the setpoints of the inverter. Once the desired changes have been made, the RC7 may be unplugged and these changes will be retained, even if the inverter is completely powered down. When the RC7 is connected to the inverter, the inverter's status LED still operates normally. Installation and operating instructions are included with the RC7.

Battery Temperature Sensor (BTS)

An optional plug-in external battery-temperature sensor (BTS) automatically fine-tunes the charging process of the charger. When the temperature sensor is installed, the inverter/charger adjusts the *BULK* and *FLOAT* charge voltage. A BTS is shown below.



If the temperature sensor is **NOT** installed, charger configuration must be manually set.

Install the BTS on the side of the battery below the electrolyte level. It is best if the sensor is placed between batteries and if the batteries are placed in an insulated box to reduce the influence of the ambient temperature outside the battery enclosure. Ventilate the battery box at the highest point to prevent hydrogen accumulation.

The BTS provided may be extended beyond the standard 15 feet by an additional 20 feet using standard phone cables with RJ-11 plugs. However, locating your batteries 35 feet from the inverter exceeds the recommended distance and requires heavier battery cables.

Battery Cables

Trace Engineering UL listed battery cables are available from Trace Engineering authorized dealers in various lengths to ensure maximum power transfer between the inverter and batteries. They are available in two sizes: 2/0 and 4/0. Cable lengths include 1½, 3, 5, and 10 feet for both sizes. A 4/0 cable length of 15 feet is also available. All Trace Engineering cables have red or black color-coding, and sealed, crimped ring terminal ends.

APPENDIX A: TROUBLESHOOTING

Appendix A: Troubleshooting

<u>Symptoms</u>	<u>Problem</u>	<u>Remedy</u>
No power output and no warning LED's	Unit is Off, or battery voltage is too low	Turn unit On, check the battery voltage, fuses, or breakers and cable connections
No power output and LED indicator is flashing green	Load too small for search mode circuit to detect	Reduce search threshold or defeat search mode
No power output and warning LED flashes red	Low battery voltage = 1 flash High battery voltage = 2 flash High ambient temperature = 3 flash	Check the battery voltage at the inverter's terminals
Power output is low and inverter turns loads on and off	Low battery	Check condition of batteries and recharge
	Loose or corroded battery connections	Check and clean all connections
	Loose AC output connections	Check all AC output connections
Inverter clicks every 20 seconds LED is solid green	Output of inverter wired back to its own input	Check for proper AC input & output wiring
Charger is inoperative	AC input voltage does not match inverter spec	Check AC input for proper voltage and frequency for your model
	Charger controls improperly set	Refer to owner's manual for proper setting
LED flashing red 4 times	Charger Fault has occurred.	Have inverter serviced
Low charge rate	Low peak AC input voltage (164 volts peak required for full charger output)	Use larger generator, speed up generator check AC input wiring cable too small or too long adjust charge rate,
	AC current output of generator too small to handle load	Reduce charge amps setting or reduce passthrough loads
Low AC output voltage	Measuring with the wrong type voltmeter (displays 80-100VAC)	Voltmeter must be a true RMS reading meter (most are not).
Low surge power	Weak batteries, battery cables too small or too long	Refer to cable and battery recommendations in owner's manual

APPENDIX B: OTHER PRODUCTS FROM TRACE ENGINEERING

Appendix B: Other Products from Trace Engineering

SW SERIES SINEWAVE INVERTER

A high power sinewave inverter/charger, the SW Series features low current distortion charger, temperature compensation, series operation, fast transfer time, line tie capability, generator support, generator start and user controlled auxiliary relays.

C40 MULTI-PURPOSE CONTROLLER

The C40 is a 40-amp solar charge controller, DC load controller, or DC diversion regulator. The unit works with 12, 24, or 48 volts systems and is rated at 40-amp continuous capacity. Other features of the C40 are field adjustable setpoints, temperature compensation and protection, electronic overload protection with manual or auto-reset ability, optional LCD meter, and an optional temp compensation sensor.

C12 CHARGE CONTROLLER

The C-12 is a 12 amp 3 stage solar charge controller, DC load, and automatic lighting control center. The C12 is fully protected against overload, short-circuit, and reverse polarity. It is ideal for controlling lighting systems as it uses a PV array as an electric eye to "see" when it is dark, so it knows when to turn on the lights! Automatic reset, battery over discharge and overcharge protection, two-stage lightning protection and surge suppression, and optional temp compensation sensor are a few of the features of the C12.

SW AND DR SERIES POWER PANEL SYSTEMS

Pre-assembled complete power panels featuring the SW or DR series inverters are now available. Each panel is complete and complies with all codes (it is ETL listed). All you do is connect to the battery and hook up AC loads. An AC system bypass allows AC loads to operate while the inverter is locked out for servicing.

TM500 BATTERY STATUS MONITOR

The Trace TM500 battery status monitor features seven data-monitoring functions and two alarms that monitor battery state of charge, real-time amps, total charging amps, total load amps, days since fully charged, cumulative amp-hours, recharge alarm and full charge indicator. Mounts up to 50 feet from the batteries. Easily configured for liquid lead-acid or gel cell batteries. Works with 12, 24, or 48-volt systems.

Contact your Trace Engineering dealer for details on any of the above products.

Appendix C: Reference Tables & Graphs

Typical Power Consumption of Common Appliances

		TIME IN MINUTES					
APPLIANCE	WATTS	5	15	30	60	120	240
Single PL Light	10	.1	.3	.7	1.3	2.7	5.3
B & W TV	50	.4	1	2	4	8	17
Computer	100	1	2	4	8	17	34
Color TV	200	2	4	8	17	34	67
Blender	400	3	8	17	34	67	133
Skil Saw	800	6	17	34	67	133	266
Toaster	1000	8	23	46	93	185	370
Microwave	1200	10	28	57	114	227	455
Hot Plate	1800	15	44	88	176	353	706
		AMP-HOURS					

If the current draw at 120 VAC is known, then the battery amperage at 12VDC will be 10 times the AC amperage divided by the efficiency (90% in this table).

Motors are normally marked with their running rather than their starting current. Starting current can be five times running current. Keep this in mind when sizing a motor into a system.

Refrigerators and icemakers typically run about 1/3 of the time. Therefore, their average battery current draw is 1/3 what their amp rating would indicate.

APPENDIX C: REFERENCE TABLES & GRAPHS

English to Metric Wire Conversion Chart

AWG	Diameter/mm	Area/mm ²	DC Resistance / 1000ft
14	1.628	2.082	3.14
12	2.052	3.308	1.98
10	2.588	5.261	1.24
8	3.264	8.367	0.778
6	4.115	13.299	0.491
4	5.189	21.147	0.308
2	6.543	33.624	0.194
1	7.348	42.406	0.154
0 (1/0)	8.525	53.482	0.122
00 (2/0)	9.266	67.433	0.0967
000 (3/0)	10.404	85.014	0.0766
0000 (4/0)	11.684	107.219	0.0608

Recommended Battery Cable Size (In free air)

Inverter Model #	Typical DC Amps	1 to 3 feet One Way	3 to 5 ft One Way	5 to 10 ft One Way
M2012	200 Amps	00	0000	0000
M2512	250 Amps	0000	0000	0000
M3012	300 Amps	0000	0000	0000

"Free air" is defined by the NEC as cabling that is not enclosed in conduit or a raceway. Cables enclosed in raceways or conduits have substantially lower continuous current carrying ability due to heating factors.

APPENDIX C: REFERENCE TABLES & GRAPHS

Maximum Fuse Rating in Free Air

Cable Size	Rating in Free Air	Maximum Fuse Size	Trace Part Number
00 AWG	265 amps maximum	300 Amp	TBF300
0000 AWG	360 amps maximum	400 Amp	TBF400

Recommended Minimum AC Wire Sizes

Inverter Model	120 VAC Input	120 VAC Output
M2012	10 AWG	12 AWG
M2512	8 AWG	10 AWG
M3012	8 AWG	10 AWG

Maximum Amperage for Conductors Under 50 Volts at 105°C

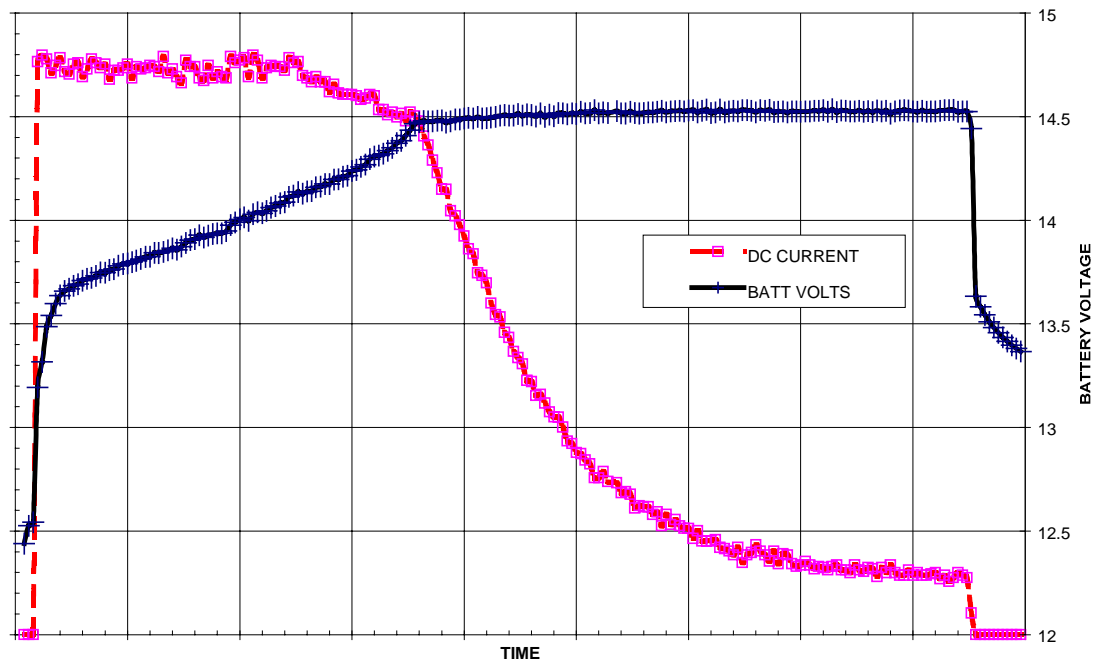
AWG Wire Size	Metric Wire Size	Amperage Outside Engine Spaces	Amperage in Engine Spaces
18	.8	20	17
16	1	25	21.3
14	2	35	29.8
12	3	45	38.3
10	5	60	51
8	8	80	68
6	13	120	102
4	19	160	136
2	32	210	18.5
0	50	285	242.3
00	62	330	280.5
000	81	385	327.3
0000	103	445	378.3

APPENDIX C: REFERENCE TABLES & GRAPHS

Common Battery Charging Rates

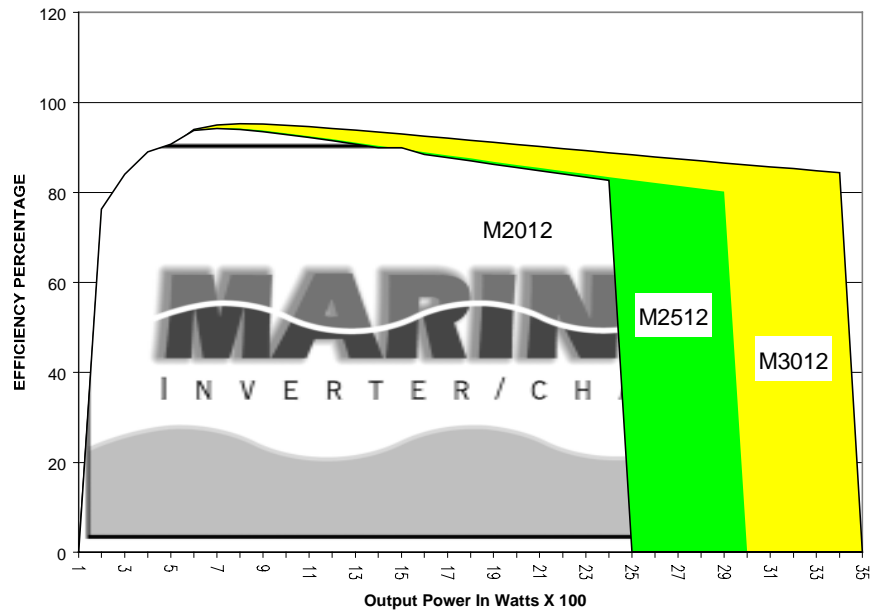
Typical BULK and FLOAT Setpoints for Common Battery Types (12 VDC System)		
Battery Type	Bulk Volts	Float Volts
Gelled Lead-Acid (sealed)	14.1 volts	13.5 volts
Liquid Lead-Acid (not-sealed)	14.5 volts	13.4 volts

Mariner Charging Graph

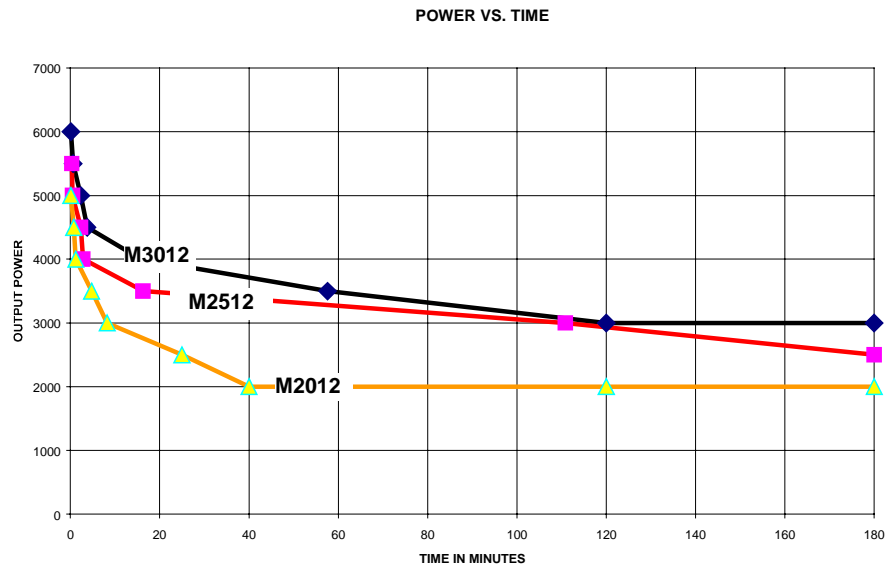


APPENDIX C: REFERENCE TABLES & GRAPHS

Mariner Efficiency Curve

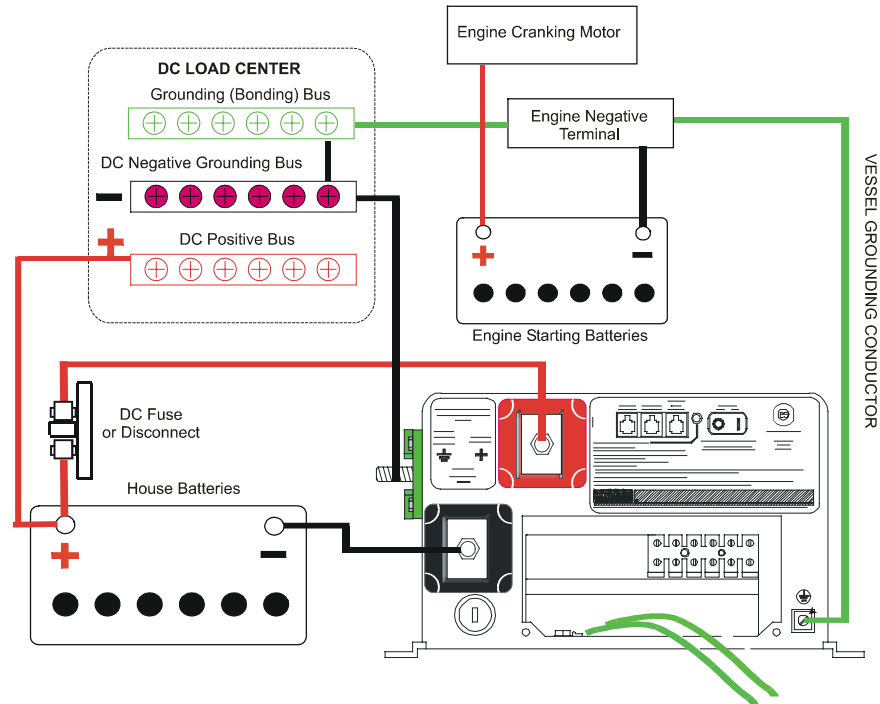


Mariner Performance Graph

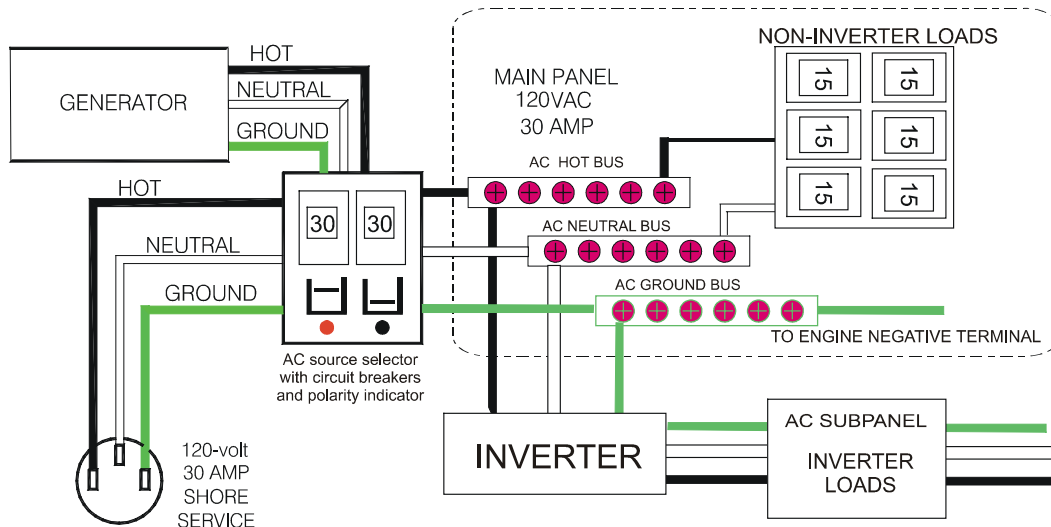


APPENDIX C: REFERENCE TABLES & GRAPHS

Typical DC Installation Diagram



Typical AC Installation Diagram



APPENDIX D: SPECIFICATIONS

Appendix D: Specifications

MODEL	M2012	M2512	M3012
Continuous Power @ 25°C	2000 VA	2500 VA	3000 VA
Maximum AC Current			
1 millisecond Peak *	44 amps	48 amps	52 amps
Efficiency (Maximum)	94%	94%	94%
Adjustable Charge Rate†	10-100 amps	12-120 amps	14-140 amps
Unit Weight	45lbs (20.5kg)	50lbs (22.7kg)	60lbs (27.2kg)

DC Input Current Consumption

Search Mode	0.055 amps	0.070 amps	0.080 amps
Full Voltage (search defeated)	0.550 amps	0.600 amps	0.650 amps
At Rated Power	200 amps	250 amps	300 amps
Short Circuit	600 amps	800 amps	900 amps

The following specifications apply to all models:

Nominal Input Voltage	12VDC
Input Voltage Range	10.2-15.5VDC
Auto Low Battery Protection (LBCO)∞	11.1VAC or defeated
Voltage Regulation- Maximum	±5%
Voltage Regulation- Typical	±2.5%
Output Waveform	Modified Sine Wave
Power Factor allowed	-1 to +1
Frequency Regulation	60Hz ± .04%
Standard Output Voltage	120 VAC
Adjustable Load Sensing∞	5 to 40 Watts or defeated
Forced Air Cooling	Automatic Variable Speed Fan
Automatic Transfer Relay	30 amps at 120VAC
Charging Profiles∞	2 (liquid lead acid or gel cell)
Battery Charging Program	3-stage: Bulk, Float, Absorption
Battery Temperature Compensation (BTS)	Optional: BTS/15 (15 foot cable included)
Remote Control	Optional: RC6- Bargraph Volt/Ammeter On/Off RC7- Full Function LED Display

* All power and charging specifications based on 25°C ambient temperature.

† Minimum AC input requires 164 VAC peak for full battery charger output. Some generators are unable to produce this voltage under required load.

∞ RC7 remote control required to change settings

Dimensions	13.15" x 7.25" x 14.3" 33.3cm x 18cm x 35.2cm
------------	--

Mounting	Shelf mount only
----------	------------------

Environmental Characteristics

Operating Ambient Temperature	0°C to +50°C
Non-operating Temperature	-55°C to +75°C
Maximum operating altitude	15,000 feet
Altitude Non-operating	50,000 feet

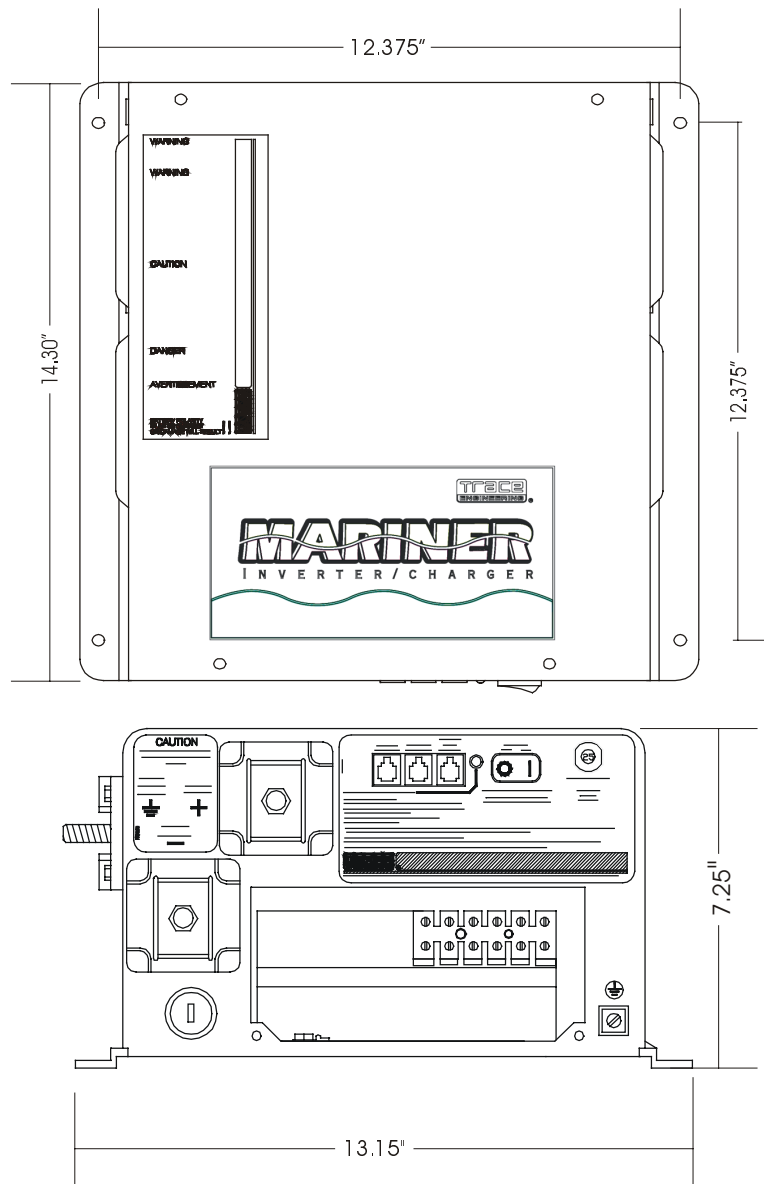
Factory Default Settings

Search Sense	Defeated
Auto Low Battery CutOff	On (11.1 volts DC)
Battery Capacity	250 amphotours
Battery Type	gel cell
Charge Rate	100% of maximum
VAC dropout	40 VAC
Shorepower Amps	25

All Specifications Subject to Change without Notice

APPENDIX E: DIMENSIONS

Appendix E: Dimensions



Note: terminals and covers add 1 1/2" to length

Appendix F: Limited Warranty

Trace Engineering Company warrants the Mariner Series inverter/charger against defects in materials and workmanship for a period of two (2) years from the date of purchase and extends this warranty to all purchasers or owners of the product during the warranty period.

Trace Engineering Company does not warrant its products from any and all defects:

- (1) arising out of material or workmanship not provided by Trace Engineering, or
- (2) resulting from abnormal use of the product or use in violation of the instructions, or
- (3) in products repaired or serviced by other than Trace Engineering repair facilities, or
- (4) in components, parts, or products expressly warranted by another manufacturer.

Trace Engineering agrees to supply all parts and labor or repair or replace defects covered by this warranty with parts or products of original or improved design, at its option, if the defective product is returned to any Trace Engineering authorized warranty repair facility or to the Trace Engineering factory in the original packaging, with all transportation costs and full insurance paid by the purchaser or owner.

ALL REMEDIES AND THE MEASURE OF DAMAGES ARE LIMITED TO THE ABOVE. TRACE ENGINEERING SHALL IN NO EVENT BE LIABLE FOR CONSEQUENTIAL, INCIDENTAL, CONTINGENT OR SPECIAL DAMAGES, EVEN IF TRACE ENGINEERING HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. ANY AND ALL OTHER WARRANTIES EXPRESSED OR IMPLIED ARISING BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE, OR OTHERWISE, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN DURATION TO A PERIOD OF TWO (2) YEARS FROM THE DATE OF PURCHASE.

SOME STATES DO NOT ALLOW LIMITATIONS ON HOW LONG AN IMPLIED WARRANTY LASTS, OR THE EXCLUSION OF INCIDENTAL OR CONSEQUENTIAL DAMAGE. SO THE ABOVE LIMITATIONS MAY NOT APPLY TO YOU. THIS WARRANTY GIVES YOU SPECIFIC LEGAL RIGHTS. YOU MAY ALSO HAVE OTHER RIGHTS WHICH VARY FROM STATE TO STATE.

Warranty Procedure

Complete the warranty card and mail it to Trace Engineering within 10 days from the date of purchase. KEEP YOUR BILL OF SALE as proof of purchase, should any difficulties arise concerning the registration of the warranty card.

WARRANTY REGISTRATION is tracked by model and serial numbers only, not by owner's name. Therefore, any correspondence or inquiries made to Trace Engineering must include the model and serial number of the product in question.

WARRANTY SERVICE must be performed ONLY AT AN AUTHORIZED TRACE SERVICE CENTER, OR AT THE TRACE ENGINEERING FACTORY. Notify the repair facility before shipping to avoid the possibility of needless shipment. UNAUTHORIZED SERVICE PERFORMED ON ANY TRACE PRODUCT WILL VOID THE EXISTING FACTORY WARRANTY ON THAT PRODUCT.

FACTORY SERVICE: If you wish your Trace Engineering product to be serviced at the factory, it must be shipped FULLY INSURED *IN THE ORIGINAL PACKAGING* OR EQUIVALENT; this warranty will not cover repairs on products damaged through improper packaging. If possible, avoid sending products through the mail.

Note: Before returning any equipment to Trace Engineering, call our Warranty Coordinator and request a Return Merchandise Authorization (RMA) number. Be sure to have the serial number of the equipment handy.

Ship To:

**Trace Engineering Company, Inc.
Attn: Service Department. RMA#
5916 195th ST. NE
Arlington, WA 98223
Phone: (360) 435-8826
(Warranty Coordinator)**

Be sure to include in the package:

1. Complete return shipping address (PO Box numbers are not acceptable) and telephone number where you can be reached during work hours.
2. A detailed description of any problems experienced, including the make and model numbers of any other equipment in the system, types and sizes of loads, operating environment, time of unit operation and temperature.
3. A copy of your proof of purchase (purchase receipt).

APPENDIX F: LIMITED WARRANTY

Repaired products will be returned freight C.O.D. unless sufficient return shipment funds are included with the unit.

Products sent to the factory from outside the U.S. MUST include return freight funds, and sender is fully responsible for all customs documents, duties, tariffs, and deposits.

Record the model and serial numbers on the sheet and retain for your files.

Appendix G: Life Support Policy

As a general policy, Trace Engineering, Inc. does not recommend the use of any of its products in life support applications where failure or malfunction of the Trace Engineering product can be reasonably expected to cause failure of the life support device or to significantly affect its safety or effectiveness. Trace Engineering, Inc. does not recommend the use of any of its products in direct patient care. Trace Engineering, Inc. will not knowingly sell its products for use in such applications unless it receives in writing assurances satisfactory to Trace Engineering, Inc. that (a) the risks of injury or damage have been minimized, (b) the customer assumes all such risks, and the liability of Trace Engineering, Inc. is adequately protected under the circumstances.

Examples of devices considered to be life support devices are neonatal oxygen analyzers, nerve stimulators (whether used for anesthesia, pain relief, or other purposes), autotransfusion devices, blood pumps, defibrillators, arrhythmia detectors and alarms, pacemakers, hemodialysis systems, peritoneal dialysis systems, neonatal ventilator incubators, ventilators for both adults and infants, anesthesia ventilators, and infusion pumps as well as any other devices designated as "critical" by the U.S. FDA.

INDEX

Index

A

absorption	
charging	57
ABYC	
A-20	23
A-25	23
A-25.6	38
defined	23
E-8.15	39
E-8.5 & 9.20	4
E-9	25
E-9.10	20
E-9.16	28
E-9.16(k)	4
AC Connections	34
AC input neutral	36
AC output neutral	35, 36
AC safety ground	18
AC Terminal Block	18
AC Wiring	33
ACE Hardware	34
alkaline	
batteries	47
AM radios	63
ambient temperature	25
applied current	27
autotransfusion devices	87
AWG	53
American Welding Gauge	29

B

Baking Soda	
neutralizer	5
bar graph	
RC6 remote control	65
Battery Cable Sizing	27
battery cables	67
Battery Charger	
peak voltage required	58
Battery Enclosures	47
Battery Location	47
Battery negative terminal	18
Battery plates	45
Battery Polarity	31
Battery Positive Terminal	18

Battery Temperature	47
Battery Temperature Sensor (BTS)	67
battery terminal	45
breakers	34
BTS Port	17
bulk voltage	
charge	57

C

CFR	
183.410	19
183.455	20
defined	23
Charge Rate	79
Charger Circuit Breaker	18
chassis ground	29, 31, 35, 37. See DC
grounding terminal	
clock accuracy	62
clocks	62
compressors	61
computers - use with inverter	11
conduit	34
conduit connectors	39
Controls & Indicators	15
Copper Compression Lugs	
described	30
Customer Service	
telephone number	19

D

DC Grounding terminal	
chassis ground	20
deep cycle	45
deep cycle battery	46
dimmer switches	63
Disabling Neutral Ground Switching	37
disconnect switch	34
distilled water	
and batteries	51

E

efficiency	61, 73
electrolyte	45, 46, 51, 57
defined	45
Environmental Characteristics	80

INDEX

error condition
 LED indication 17
estimating battery requirements 48

F

Factory Default Settings 80
FET..... *See* field effect transistor
field effect transistor switches..... 59
float voltage 57
Fluorescent lights 62
Free Air..... 27
Fuel Gauge..... 20
fuse size 28

G

generator 47, 48, 57, 61
 spin up 43
generator requirements 58
GFCI's 35
ground
 equipment..... 18
Ground Cable Connection 31
Ground Fault Interrupting Outlets 34
ground switching..... 35, 37

H

Hand Crimping Tool..... 30
hemodialysis..... 87
Hollingsworth..... 30
hydrogen..... 47
hydrogen sulfide gas 24

I

identification placard
 defined..... 14
Impulse Phase Correction 10
incubators..... 87
Induced current..... 34
inductance 27
induction motors 10, 61
Inductive Loads 61
infusion pump 87
Input Voltage 13
Inverter Operation
 theory..... 59
Inverter to Charger Transition..... 11

K

knockout(s)..... 39

L

Laser Printers 63
lead acid 8
lead acid batteries 8, 47, 57, 79
lead acid, neutralizer 5
LED Indicator..... 16
LEVITON 34
life support devices..... 87
Life Support Policy..... 87

M

Maintenance
 batteries..... 51
maintenance free
 batteries..... 47
Mechanical Lugs..... 31
microwave ovens..... 10
Model Identification 13
Model Type..... 13
modified sine wave 59, 60
motors
 capacitor start 61
Mounting..... 25
Murphy's Law 9

N

National Electric Code 35
NEC
 defined..... 23
neonatal ventilator 87
neoprene
 liquid 51
nerve stimulators 87
neutral ground switching..... 35, 37
neutral wire 40
neutral-ground switching
 error 35
Neutral-to-Ground Switching 35
nuisance trip 35

O

On/Off Switch
 operation..... 15
Operation..... 43

INDEX

output capabilities24
Over Current Protection28
overcurrent.....7
over-current
 LED indication.....17
over-current device31
overload7
overtemp7
oxygen analyzers87

P

parallel53, 54
parallel connection54
PASS & SEYMOR.....34
pass through15
peak output voltage.....27, 62
peritoneal dialysis87
Plates45
Power LED9
Power levels.....13
power supplies62
Precautions3, 5
Problem Loads62
pulse width modulated square waveSee
 waveforms
pumps61, 87
PWMsee waveforms. see

Q

Quick Install19

R

RC6 Remote Control.....65
RC7 Remote Control.....66
Rechargeable Devices63
Regulation.....60
Remote Control Port17
repair procedure.....85
Resistive Loads.....61
reverse polarity32
ripple27
RMS.....60
RMS- Root Mean Square.....69
root mean square60
running current.....48, 61

S

Sealed Gel Cell Battery.....46

search mode
 nightlite.....9
Search Mode.....9
self test.....43
 described43
Serial Number14
series29, 53, 54, 65
Series – Parallel Connection
 described55
Series Connection
 described54
sine wave See waveforms
Specifications.....79
square wave..... See waveforms
Stacking Port.....17
Starting Batteries46
starting current46, 48
status LED7, 67
Stratification45
Sulfating45
surge power27, 61

T

T fuse
 DC rated.....28
Temperature Compensation45
terminal block.....34
Thomas & Betts30
Torque
 wire connections39
Transfer Switching Speed.....11
transfer time11
Troubleshooting69
True RMS Voltage Regulation10

U

UL 4583, 23, 28
uninterruptable power supply
 UPS.....9
UPS
 uninterruptable power supply11

V

vehicle chassis.....29
Vehicle Chassis Ground Terminal.....18
Ventilation24
Vinegar
 electrolyte, neutralizer5
voltage

INDEX

bulk.....	57	Warranty Procedure	85
		waveform(s).....	59
		Wiring Separation	34
	W		
Warranty.....	83		