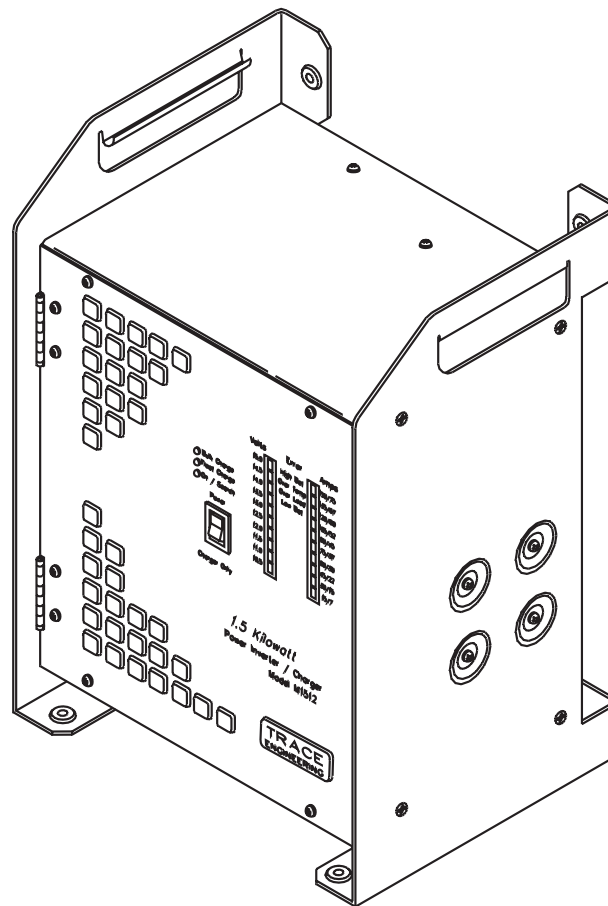




Owners Manual

Version 1.1a

Models
M1512
M1512E
M1524
M1524E



INST25

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Part #830-1

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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 battery terminal covers (with hardware);

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.

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IMPORTANT SAFETY INSTRUCTIONS

SAVE THESE INSTRUCTIONS

This manual contains important safety and operating instructions as prescribed by ANSI/UL specifications for inverters used in marine and RV applications. This manual covers inverter/charger models: M1512 and M1524.

These models are ETL listed to UL1236, UL458 and meets ABYC standards for marine use. Both are listed to UL458 for RV/Motor home use.

General Precautions

- 1.** Before using the charger/inverter, read all instructions and cautionary markings on (1) the charger/inverter and (2) the batteries.
- 2.** CAUTION- To reduce risk of injury, charge only deep cycle lead acid, lead antimony, lead calcium and gel cell type rechargeable batteries. Other types of batteries may burst causing personal injury and damage. Do not use battery charger for charging dry-cell batteries that are commonly used with household appliances. These batteries may burst and cause injury to persons and damage property.
- 3.** Do not expose charger/inverter to rain, snow or moisture.
- 4.** Use of an attachment not recommended or sold by TRACE ENGINEERING may result in a risk of fire, electric shock, or injury to persons.
- 5.** Make sure wiring is located so that it will not be stepped on, tripped over, or otherwise subjected to damage or stress.
- 6.** Do not operate the charger/inverter with bad wiring - replace immediately.
- 7.** Do not operate charger/inverter if it has received a sharp blow, been dropped, or otherwise damaged in any way. Take it to a qualified service center for inspection and test.
- 8.** Do not disassemble the charger/inverter; take it to a qualified service center when service or repair is required. Incorrect re-assembly may result in a risk of electric shock or fire.
- 9.** To reduce risk of electric shock, disconnect all wiring before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.

- 10. WARNING - WORKING IN VICINITY OF A LEAD ACID BATTERY IS DANGEROUS. BATTERIES GENERATE EXPLOSIVE GASES DURING NORMAL OPERATION.**
- 11. NEVER** charge a frozen battery.
- 12.** If necessary to remove battery from vehicle to charge, always remove grounded terminal first. Make sure all accessories in the vehicle are off, so as not to cause an arc.
- 13.** Be sure area around battery is well ventilated while battery is being charged. Gas can be forcefully blown away by using a piece of cardboard or other nonmetallic material as a fan.
- 14.** Clean battery terminals. Do not allow corrosion to come in contact with eyes.
- 15.** Add distilled water in each cell until battery acid reaches level specified by battery manufacturer. This helps purge excessive gas from cells. Do not over-fill. For a battery without cell caps, carefully follow manufacturer's recharging instructions.
- 16.** Study all battery manufacturer's specific precautions such as removing cell caps while recharging and recommended rates of charge.
- 17. FOLLOW THESE STEPS WHEN BATTERY IS OUTSIDE VEHICLE. A SPARK NEAR THE BATTERY MAY CAUSE BATTERY EXPLOSION. TO REDUCE RISK OF A SPARK NEAR BATTERY:**
- A.** Check polarity of battery posts. POSITIVE (POS,P,+) battery post usually has a larger diameter than NEGATIVE (NEG,N,-) post.
 - B.** Attach an insulated battery cable at least 24 in. long to the NEGATIVE (NEG,N,-) post. Size in accordance with chart on pg. 27.
 - C.** Connect POSITIVE (RED) charger battery cable terminal to the POSITIVE (POS,P,+) post of battery.
 - D.** Position yourself at the free end of cable as far away from battery as possible, then connect NEGATIVE (BLACK) charger battery cable to the charger.
 - E.** Do not face battery when making final connection.
 - F.** When disconnecting charger, always do so in reverse sequence of connecting procedure, and break first connection while as far away from battery as practical.

- 18.** EXTERNAL CONNECTIONS TO CHARGER SHALL COMPLY WITH THE UNITED STATES COAST GUARD ELECTRICAL REGULATIONS (33CFR1833, SUB PART 1).
- 19.** No terminals or lugs are required for hook-up of the AC wiring. AC wiring should be 12 (AWG) gauge 90 degree C copper wire. Units supplied with the optional STANDBY feature should use 8 (AWG) gauge 90 degree C copper wire. Battery cables must be rated for 105 degree C and should be 2/0 (AWG) gauge (welding cable). A crimped and soldered lug with a 5/16 hole attached to the battery cable is required for connection to the inverter/charger.
- 20.** Torque all AC wiring connections to 20 inch pounds. Torque all DC cable connections to 12 foot pounds.
- 21.** Symbols used in this manual and on the inverter/charger are:
- 22.** Tools required to make AC wiring connections: Wire strippers 1/2", (13MM) open end wrench or socket, Philips screw driver #2, Slotted screw driver 1/4" (6MM) blade.
- 23.** This inverter/charger is intended to be used with a battery supply of nominal voltage that matches the last two digits of the inverter model number, e.g., 12 volt with a M1512.



Chassis



AC Output



AC Input



Phase

- 24.** Instructions for wall or ceiling mounting: See mounting instruction section of this manual. For battery installation and maintenance: read the manufacturer's installation and maintenance instructions prior to operating.
- 25.** No AC or DC disconnect switch is provided as an integral part of this unit. Both AC and DC disconnects must be provided as part of the system installation. See SYSTEM SAFETY WIRING REQUIREMENTS section of this manual.
- 26.** No over current protection for the battery supply is provided as an integral part of this unit. Over current protection of the battery cables must be provided as part of the system installation. See SYSTEM SAFETY WIRING REQUIREMENTS section of this manual.

27. No over current protection for the AC output wiring is provided as an integral part of this unit. Over current protection of the AC output wiring must be provided as part of the system installation. See SYSTEM SAFETY WIRING REQUIREMENTS section of this manual.

28. GROUNDING INSTRUCTIONS - This battery charger should be connected to a grounded , metal, permanent wiring system; or an equipment -grounding conductor should be run with circuit conductors and connected to equipment-grounding terminal or lead on battery charger. Connections to battery charger should comply with all local codes and ordinances.

PERSONAL PRECAUTIONS

- 1.** Someone should be within range of your voice or close enough to come to your aid when you work near lead-acid batteries.
- 2.** Have plenty of fresh water and soap nearby in case battery acid contacts skin, clothing, or eyes.
- 3.** Wear complete eye protection and clothing protection. avoid touching eyes while working near batteries.
- 4.** If battery acid contacts skin or clothing, wash immediately with soap and water. If acid enters eye, immediately flood eye with running cold water for at least 10 minutes and get medical attention immediately.
- 5.** NEVER smoke or allow a spark or flame in vicinity of battery or engine.
- 6.** Be extra cautious to reduce the risk of dropping a metal tool onto batteries. It might spark or short-circuit batteries or other electrical parts that may cause an explosion.
- 7.** Remove personal metal items such as rings, bracelets, necklaces, and watches when working with a lead-acid battery. A lead-acid battery can produce a short-circuit current high enough to weld a ring or the like to metal, causing a severe burn.

Product Overview

The Model M1512, M1524 and the 230 vac “E” versions are microprocessor controlled power inverter’s with built-in battery chargers and automatic transfer circuitry. The inverter is a modified square wave design tailored to the requirements of the boating and RV users. Tight voltage and frequency regulation, substantial surge power, high efficiency and comprehensive protection circuitry characterize the design.

The battery charger uses a three stage charging technique that ensures rapid charging without battery gassing. Transferring to and from battery charging mode is done automatically. When shore power is present the unit charges batteries and passes the shore power thru to its AC output. If shore power fails the unit returns to inverter operation. Transfer time is typically fast enough to support computers.

Additionally, many advance features are standard.

- Adjustable energy saving Search Mode.
- Current compensated protection against battery over-discharge.
- Adjustable transfer voltage.
- Adjustable charge rate.
- Charger only operation so that power failure will not deplete the batteries.
- Adjustable automatic charge rate reduction to limit AC input current.
- LED volt and amp meters. Amp meters measure charge rate and inverter consumption.
- Automatic return to operation after most error conditions.
- Synchronous rectification battery charger topology for cooler operation.
- Selectable Gel or liquid electrolyte battery charger settings.
- Temperature compensated charger with sensor.
- Automatic return to operation after low battery condition with the resumption of AC power.

We at Trace Engineering sincerely thank you for choosing our products and trust that you will be completely satisfied with them.

Inverter Operation

Self Test

When first connected to batteries, the inverter initiates a self test. The cooling fan runs momentarily and the internal speaker chirps. During this time the **Bulk Charge**, **Float Charge** and **On / Search** LED's light. This is followed by the **Volts** and **Amps** LED's meters lighting sequentially from the bottom to the top. Once this is completed, the unit is ready to be turned on with the **Power / Charger Only** switch.

Front Panel Controls and LED Indicators

Front Panel

Shown below are the M1512's front panel controls and indicator lights . The Model M1524's are similar with only the voltage and amperage values changed. The LED's provide information about the unit when it is in either its inverter or battery charging mode of operation.

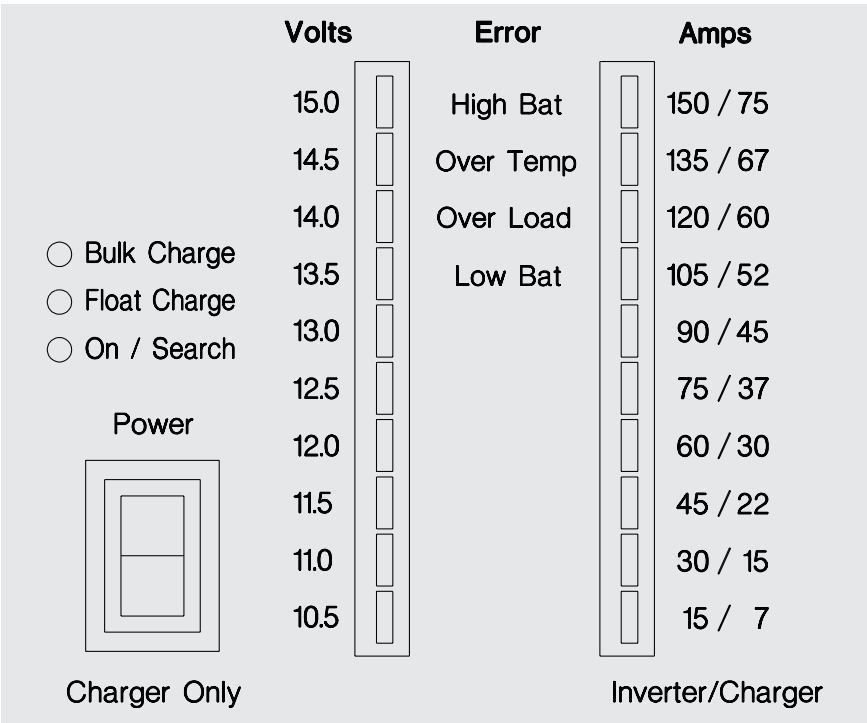


Figure 1, Front Panel Controls

Power / Charger Only Switch

The **Power / Charger Only** control is a momentary rocker switch. Momentary switches do not remain depressed after use. It is used to turn the inverter/charger mode on and off. Its also, used to turn the charger only mode on and off. When the unit is first connected to batteries it executes a self test. Upon completion the unit is off.

Turning on to Inverter/charger mode

If the inverter is off - press the momentary switch to the **POWER** position.

Turning on to Charger Only mode

If the inverter is off - press the momentary switch to the **CHARGER ONLY** position.

This position allows the unit to operate as a battery charger only. Power is passed thru the unit from AC input to AC output. However, if power fails the unit will not invert and deliver power to its AC output.

Turning the unit off

If the unit is in inverter/charger mode - press Power. If the unit is in Charger Only mode - press Charger Only. In order to change from inverter/charger mode to charger only mode or vice versa the unit must first be turned off.

On / Search LED

This green LED indicator lights when the unit is in the inverter mode (not charging batteries). When the inverter is in its search mode the LED will blink. While the inverter is delivering full output voltage the LED is on solid.

Error Indicators

The top four LED's of the vertical row of LED's that comprise the **AMPS** meter are used to indicate error conditions. The appropriate LED will flash if a condition unsafe for inverter or charger operation exists. Additionally, the **On / Search** LED will blink and the buzzer will beep. The volt meter continues to operate under error conditions.

- **High Bat-** High battery voltage turns the unit off immediately. When battery voltage falls to a safe level, the inverter returns automatically to operation.
- **Over Temp-** The unit monitors the temperature of its transformer and power devices. The Over Temp is activated if either approach their design limits. A ten second warning is provided before shutdown. After the temperatures fall the inverter returns automatically to operation.
- **Overload-** Overload occurs when the inverter is asked to deliver too much power or the output is short circuited. Overload protection is

instantaneous. If the over-current condition lasts for less than 10 seconds the unit will automatically resume operation. It will have to be manually restarted if it is a prolonged overload that lasts longer than 10 seconds.

- **Low Bat**- When a low battery condition occurs the unit provides a ten second warning before interrupting operation. Once the unit has turned itself off to protect the batteries, it will return to operation when either AC is available at its input terminals or it is manually restarted.

Note: The battery charger control circuit operates from battery voltage. If battery voltage falls below 7 volts neither the charger nor inverter will operate. In this situation, a small charge from a stand-alone charger will be required to bring the battery to a high enough voltage for the inverter/charger to resume operation.

Circuit Board Controls

Shown below are the M1512's circuit board controls, jumpers, accessory jacks and low battery alarm terminals. These are accessed by opening the front panel door. The door is opened by removing the four Phillips-head screws that secure it. The circuit board is attached to the back side of the door. The first three controls on the upper left hand corner are used to adjust inverter features. The remaining two are used for battery charging and are discussed in that section of the manual.

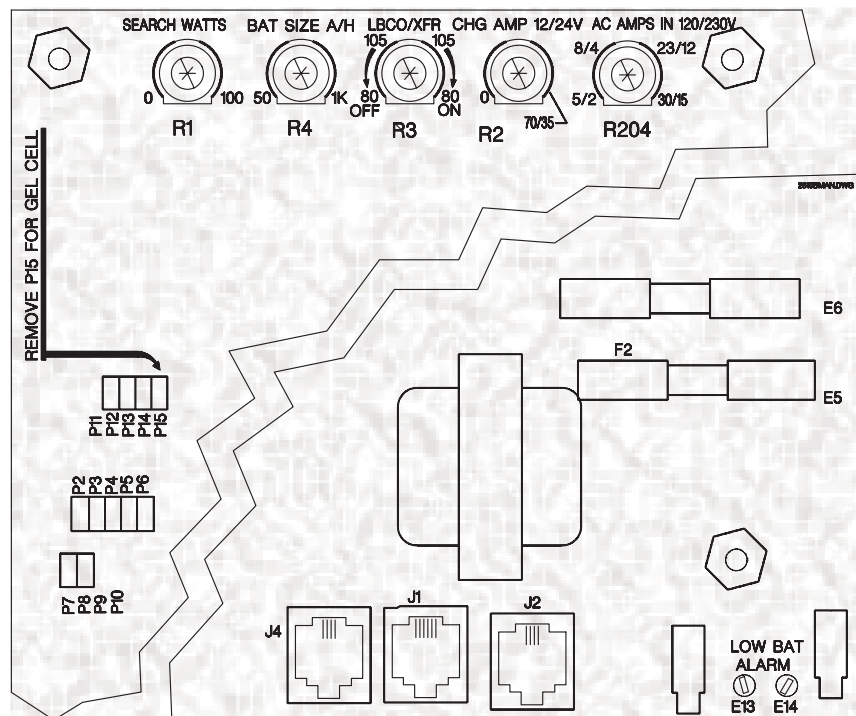


Figure 2, Circuit Board Controls

Search Watts

The **SEARCH WATTS** control is used for adjusting the sensitivity of the search mode circuit.

The M1512 and M1524 inverters feature an adjustable search mode circuit. It minimizes power drain by reducing the inverter's output to small test pulses when there is no load turned on. These pulses are used to detect the presence of a load. When a load is detected the inverters's output goes to full voltage. The sensitivity of the detection threshold is adjustable. Turning the **SEARCH WATTS** control clockwise decreases the sensitivity (bigger loads are required for the inverter to return to normal operation). Turning the control full counter-clockwise defeats the search mode feature.

Example: With the **SEARCH WATTS** control 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 state. If the sensitivity is increased by setting the control to 10, a 20 watt load will bring the inverter out of the search mode, while a 5 watt load will not.

When in the search mode, the green **On / Search** LED will blink and the inverter will make a ticking sound. At full output voltage, the **On / Search** LED will burn steadily and the inverter will make a steady humming sound. When the inverter is used as an uninterruptable power supply the search mode function should be defeated.

A neon nightlite can also be used as a good indicator to determine if the inverter is in search mode. Simply plug the light into any AC outlet. When the inverter is in the search mode the light will blink. If the inverter is running a load, the light will be solid.

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

Example A: If the **SEARCH WATTS** control 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 cold. When the light gets bright the filaments heat up and the light becomes a 30 watt load. Since this is below the control setting of 40, the inverter will not detect it and the light will go out. And so on and so forth.

Example B: If the **SEARCH WATTS** control is set to detect a 30 watt load and a 40 watt florescent 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 florescent tube ionizes,

Example C: There are some appliances that draw power even though they are turned off. TV's with instant on circuits, microwave ovens with digital displays and VCR's 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 outlet. Use an extension cord with a rocker switch, a switch at the outlet or the appropriate circuit breaker.

BAT SIZE A/H

The **BAT SIZE A/H** control is used to inform the inverter's microprocessor of the battery bank size. This allows the inverter to make better "over-discharge protection" and battery charging decisions. Battery bank size is adjustable from 50 to 1000 amp hrs.

LBCO/XFR

This cryptic and tricky control provides two different functions. When the dial is set to the left side the LBCO feature is disabled. When the dial is set to the right side the LBCO feature is enabled. Transfer voltage (the XFR part) is the other feature controlled by this dial. With the dial set to either the left or right side, transfer voltage can be adjusted from 80 to 105 VAC (on 230 VAC models 155 to 200 VAC).

LBCO (Low Battery Cut-out)

The LBCO feature provides battery over-discharge protection. This circuit is unique to Trace Inverters. It monitors both the current being drawn by the inverter and the battery voltage. Battery voltage alone is not an accurate indicator of battery condition. The internal resistance of a battery causes its output voltage to drop when the battery is delivering current. The smaller the battery the greater the voltage drop for a given load. This battery voltage drop due to load is not an indicator of the battery's state of charge. The Trace "load compensated" circuit uses information about the battery bank size, temperature and the load current to derive a corrected battery voltage. If the circuit determines that the battery condition is low, the inverter turns off and will reset when AC power is input to the inverter or the unit is manually restarted.

If control is set between 7:00 and 11:00 o'clock the LBCO feature is disabled. When set between 1:00 and 5:00 o'clock the LBCO feature is enabled. If the over discharge circuit is defeated the inverter itself is protected from low battery voltage conditions by an additional protection circuit.

Turnoff voltage is compensated to 1.83 v per cell.

Transfer Voltage

When shore power fails or falls to a low level, the unit changes from battery charger mode to inverter mode. The shore power voltage point at which the inverter decides to change modes is called the transfer voltage. It is adjustable from 80 to 105 VAC. The adjustment is made by rotating the dial between 7:00 and 11:00 o'clock if the LBCO is defeated. The adjustment is made by rotating the dial between 1:00 and 5:00 o'clock if the LBCO is enabled.

Higher voltage setting result in slightly faster transfer times. Lower settings are less likely to cause a transfer due to voltage fluctuations.

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. Induction motors (i.e. refrigerators, drill presses), resistive loads (i.e. heaters, toasters), universal motors (i.e. hand tools, vacuum cleaners) as well as microwave ovens and computers are all suitable loads.

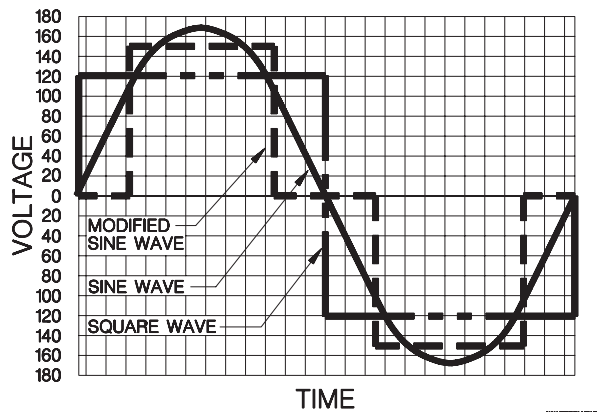


Figure 3, Modified Sine Wave

The waveform could be more accurately described as a pulse width modified square wave. The accompanying *Figure 2* shows the relationships between square wave, sine wave and modified sine wave formats.

Regulation

The inverter is RMS voltage regulated. RMS regulation ensures that resistive loads will always have the same amount of power delivered to them as battery voltage changes. Regulation is achieved by varying the width of each pulse. Peak voltage is the product of the battery voltage times the turns ratio of the inverter's power transformer and is therefore not regulated.

Battery Charger

Theory of Operation

Inverter to Charger Transition

The internal battery charger and automatic transfer relay allows the unit to operate as either a battery charger or inverter (but not both at the same time). An external source of AC power (e.g., shore power or generator) must be supplied to the inverter's AC input in order to allow it to operate as a battery charger. When the unit is operating as a charger, it's AC output is powered by the external source (i.e. generator or shore power).

The inverter automatically becomes a battery charger whenever AC power is delivered to its AC inputs. There is a 40 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. While in the battery charger mode the inverter's AC input is internally connected to the inverter's AC output. The maximum power that can be handled by the inverter's internal wiring and transfer relay is 30 amps. During heavy charging a maximum of 12 amps is consumed by the charger. If the total current required by the loads and the charger exceeds 30 amps, the charger will automatically reduce its charge rate to maintain the 30 amp limit.

Models with 230 VAC output have a 20 amp maximum thru-put current. The charger draws a maximum of 6 amps.

Transfer Switching Speed

While this inverter is not designed specifically as an uninterruptable power supply (UPS) system, its transfer time is normally fast enough to hold up computers. The transfer time is a maximum of 16 milliseconds.

When switching from inverter to charger, the inverter waits approximately 40 seconds to ensure the AC source is stable (generator up to speed).

PC Magazine has run tests that indicated a transfer time of 100 milliseconds will normally hold up the present generation of PC's.

Battery Terminology

A description of the battery charger operation requires the use of terms with which you may not be familiar. The following terms will be referred to in the description of the 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, they are now made of lead oxide. Plates are the part of the battery that collects current and are connected to the terminals. There are several plates in each cell, each insulated from the other by separators.
- **Sulfating**- As a battery discharges, its plates are progressively covered with lead sulfate. During recharging, the lead sulfate is removed from 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 effective plate area and the battery capacity is diminished.
- **Stratification**- Over time the batteries' 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 has been discharged such that less than 20% of its capacity remains (80% discharge).
- **Temperature Compensation**The optimum voltage is temperature dependent. As temperature decreases the proper voltage for each charge stage needs to be increased. The temperature probe will automatically re-scale charge voltage settings for ambient temperature. The compensation slope based on cell voltage is -2.17 mv per degree F. per cell.

Charger Terminology

- **Bulk Voltage**- This is the maximum voltage at which the batteries will be charged during a normal charging cycle. The normal range is 2.367 to 2.4 volts per cell. For a 12 VDC battery (6 cells) this is 14.2 to 14.4. Liquid electrolyte batteries are usually set to the higher voltage, while gel cell batteries are set to the lower.
- **Float Voltage**- This is the voltage at which the batteries will be maintained after they have been charged. A range of 13.2 - 13.4 is appropriate for most sealed and non-sealed batteries.
- **Absorption Stage** 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.

Three Stage Battery Charging

The battery charger normally charges in three stages - bulk, absorption and float. This provides rapid and complete charge cycles without excess battery gassing.

Stage One - Constant Current/Bulk Charge

This stage is initiated when AC is applied to the AC input of the inverter.

Stage one charges the batteries at a constant current. The constant current phase is terminated when the batteries reach the bulk charge voltage. During this stage the **Bulk Charge** LED glows yellow.

Stage Two - Constant Voltage/Absorption

Absorption is initiated when the bulk voltage is reached. At this point the charge current begins to taper off at whatever rate is required to hold the voltage constant. During this stage the **Bulk Charge** LED is lit. The absorption phase is terminated in one of two ways.

- 1 - Normally, as the charge cycle progresses, the current required to hold the battery voltage constant gradually reduces. When this current equals the programmed return amps setting, the voltage is allowed to fall to the float voltage - stage three.
- 2 - If there are DC loads on the batteries, the current may never fall to a level low enough to initiate the float voltage stage. A timer is used to ensure that the battery voltage does not remain indefinitely at the Bulk Charge Voltage. The timing circuit is activated by the onset of stage two. It terminates stage two if the charge current does not reach the return amps value setting within 12 hours.

Stage Three - Float Voltage

The purpose of stage three is to maintain the batteries at a voltage that will hold full charge but not gas the batteries. The charger remains in the float stage until the charger is turned on. During this stage the Charger LED glows green.

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.

Battery Charger Controls and LED Indicators

Two LED's on the front panel report on the activity of the battery charger (see *Figure 1*). There are two dials on the circuit board on the inside of the front panel door that relate to battery charging rate (see *Figure 2*). The circuit board also has jumper settings for liquid electrolyte or gel batteries, a jack for the temperature sensor and low battery alarm terminals.

Bulk Charge LED

The yellow **Bulk Charge** LED is lit when the charger is in bulk or absorption mode.

Float Charge LED

The green **Float Charge** LED is lit when the charger is in floating the batteries. This is the maintenance mode.

Adjusting Charger Rate

The **CHG AMP** control on the circuit board (see figure 2) sets the maximum charge rate in amps. The highest charge rate recommended is determined by dividing the battery bank's amp hour capacity by a factor between 3 and 5 (3 for gel cell - 5 for lead acid). Setting the **CHG AMP** control 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. For example: there is more than sufficient time for a 400 amp/hr battery bank to be recharged in 24 hours at a 25 amp setting - $25 \text{ amps} \times 24 \text{ hours} = 600 \text{ amp/hrs}$.

AC AMPS IN - Setting the Level of Maximum Input Amps

This unit has a feature that automatically reduces the amount of power the battery charger draws to keep the maximum AC input current from exceeding a user selectable level. The control is mounted on the circuit board (see *Figure 2*) and is labeled **AC AMPS IN**. Domestic models are adjustable from 5 to 30 amps. Export 230 VAC models can be adjusted from 2 to 15 amps.

Circuit Board Fuses

Fuse **F1** on the circuit board is for the pass thru current and could need replacement. Fuse **F2** is for the battery charger current only. If it fails the unit will require factory service.

WARNING: The unit is rated for a maximum pass thru current of 30 amps (export models 20 amps). Protection is provided by a slow blow fuse. If the fuse fails the unit will continue to operate as a battery charger, but will not deliver any power to its AC output from either shore power or when operating in inverter mode. A spare fuse is taped to the inside of the unit.

Temperature Compensation

Temperature affects the optimum voltage values for the different charge stages. If your batteries are being used in an environment with large temperature variation and particularly if the batteries remain on float the majority of the time

(UPS systems), using the temperature compensation probe is will extend battery life. This sensor has cabling that plugs into the inverter battery sense connector. The sensor, itself, attaches directly to the battery. It automatically adjusts the charger's float and bulk charge voltages to accommodate changes in battery temperature.

The temp sensor is connected to jack **J2** on the circuit board (see *Figure 2*, and *Figure 4*). *Figure 4*, shows the correct cable routing. The sensor itself is attached to a battery using double sided tape. The tape is on the sensor from the factory.

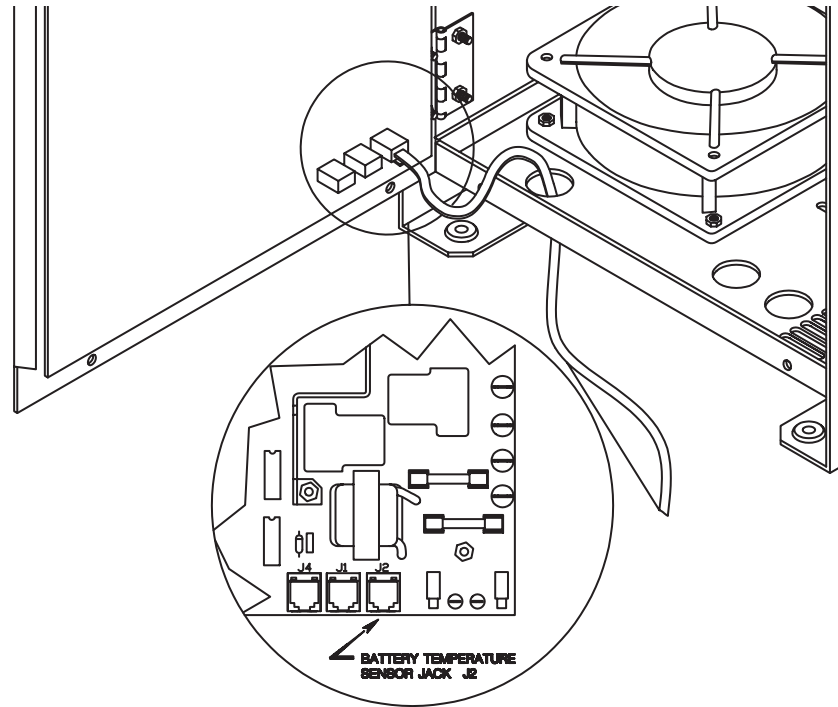


Figure 4, Battery Temp Sensor Installation

Selecting Battery Types

The microprocessor has parameters for charging liquid electrolyte or gel cell batteries. the factory setting is for the typical liquid electrolyte battery. In order to change to gel cell parameters the jumper label P15 is removed. Jumper P15 is located on the circuit board (see *Figure 2*).

Generator Requirements

The maximum charge rate of the battery charger is dependent upon the peak AC voltage available. Because a battery charger uses only the top portion of the input sine wave, small variations in peak voltage result in large variations in the amount of energy to the charger. This charger's output is rated on the basis of public power input which has a peak voltage of 164V (230V AC power has a peak voltage of 330).

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 2.5 KW for 1500 watt 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.

Batteries

Sizing

Batteries are the inverter's fuel tank. The larger 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.

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/hrs usage, the amp hour requirements of each appliance that is to be used are determined and then added together. *Table 1 and 2* in the tables section provides a means of figuring the amp hours drawn by various types and sizes of loads. Use the table as follows: (1) enter on the left with the row of the appropriate appliance or wattage (2) enter from the top with the column of the length of time the appliance will be run between charge cycles, (3) the intersection of row and column provides the amp hours that will be consumed.

Follow this procedure for each item you want to use with the inverter. Add the resulting amp hour requirements. The minimum properly sized battery bank will be double this amount.

If you haven't forgotten your high school algebra you may wish to 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. Multiply the amperage times the hours and you have, reasonably enough, amp hours. Remember that periods of time less than an hour will be fractions (10 minutes is 1/6 of an hour).

Notes: If the AC current is known, then, the battery amperage will be: *AC current times AC voltage divided by the battery voltage.*

Motors are normally marked with their running current rather than their starting current. Starting current may be 3 to 6 times running current.

Hook-up Configurations

Battery banks of substantial size are generally created by connecting several batteries together. There are three ways to do this. Batteries may be connected in series, parallel or series/parallel.

Series Connection

When batteries are connected with the plus terminal of one to the minus of the next, they are in series. A group of batteries in series has the amp/hour rating of a single battery but a voltage rating equal to the sum of the individual batteries voltages.

Parallel Connection

Batteries are connected in parallel when all the positive terminals of a group of batteries are connected and, then, all the negative terminals are connected. In parallel, batteries have the voltage of a single battery and an amp/hour rating equal to the sum of the individual batteries.

Series Parallel Connection

As the name implies, both of the above techniques are used in combination. See *Figure 5*.

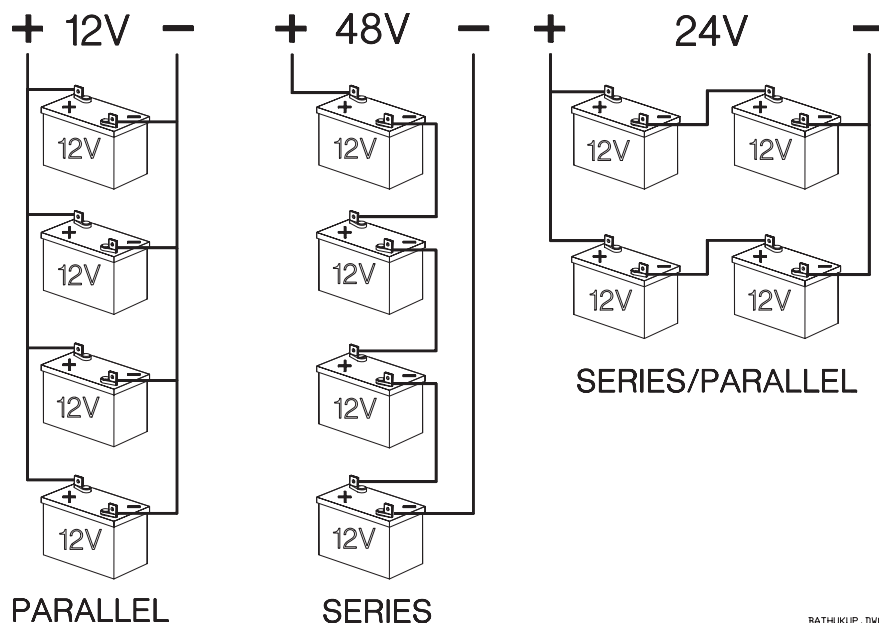


Figure 5, Battery Configurations

Installation

Environment

Inverters are sophisticated electronic devices and should be treated accordingly. When selecting the operating environment for the inverter, don't think of it in the same terms as other equipment that works with it, e.g. batteries, diesel generators, motor generators, washing machines etc. It is a highly complex micro-processor controlled device. There are nearly 500,000 silicon junctions in its output devices and integrated circuits. The crystal oscillator runs at 4 megahertz. The drive circuitry timing is accurate to a thousandth of a second. Genetically speaking, it is a cousin to stereo equipment, television sets or computers. The use of conformal coated circuit boards, plated copper buss bars, powder coated metal components, and stainless steel fasteners improves tolerance to hostile environments. However, in a condensing environment (one in which humidity and/or temperature change cause water to form on components) all the ingredients for electrolysis are present - water, electricity and metals. In a condensing environment the life expectancy of the inverter is indeterminate and the warranty is voided.

Caution: It is in your best interests to install the inverter in a dry, protected location away from sources of high temperature and moisture. Although the chassis has been specifically designed to reduce to possibility of water entering the unit, exposure to saltwater is particularly destructive and potentially hazardous.

Locate the inverter as close to the batteries as possible in order to keep the batteries cables short. However, do **not** locate the inverter in the same compartment as the batteries. Batteries generate hydrogen sulfide gas which is very corrosive to electronics equipment - and everything else. They also generate hydrogen and oxygen. If accumulated, this mixture could be ignited by an arc caused by the connecting of battery cables or the switching of a relay.

Do not mount the inverter in a closed container. To operate at high power for sustained periods of time, unrestricted air flow is required. Without it, the protection circuitry will activate and reduce the maximum power available.

The inverter may be mounted on a vertical or horizontal surface using the holes on the chassis flanges. In mobile installations it is advantageous to mount the inverter so that it is isolated from vibration.

Treat the inverter as you would any fine piece of electronic equipment.

AC Wiring

Overview

The National Electrical Code (NEC) defines the standards for AC and DC installation wiring in marine and RV applications, but there are still many installation variables. Most are determined by the level of automatic switching desired, the amount of external AC power to be switched.

The fundamental difference between Marine and residential use is the technique used for grounding on the AC side. Residential systems are always “polarized” - Neutral connected to safety ground - at the AC panel, never at the inverter. Marine systems are polarized on the dock at the shore power panel (not on the boat) when AC is supplied by shore power. When shore power is disconnected, system polarity can only come from the AC source on the boat. This could be the inverter or generator. On Trace Marine inverters, the AC output is polarized (safety ground connected to neutral) when the unit is operating as an inverter, and non-polarized (neutral not connected to safety ground) when operating as a charger.

Here is another way to look at this grounding difference between Marine and residential applications. In a residence, the AC neutral is always earth grounded at the panel. In a boat, the AC panel’s ground to neutral is lost when shore power is disconnected. It must be made by the new AC source if the system is to remain polarized.

Note: RV installations are similar to boat installations in respect to shore power connection, but RV industry standards do not deal with the ground switching issue. “E” models do not incorporate this feature.

Shore Power Connection to Boat’s Main AC Panel and Grounding System.

Wiring from the shore power input receptacle should be connected to like wire buses in the boat’s main AC panel, i.e., black to black, white to white and green to green. (Note: the hot and neutral wires may first go through a selector switch to allow choice between alternate AC sources, e.g., generator and shore power.)

The green safety ground bus should always be connected to the boat’s DC grounding system as a safety measure to provide protection against faults & leakage while the boat is connected to shore power. This ground connection, while providing an important safety feature, also introduces the risk of galvanic corrosion and/or electrolysis.

Note that this risk is present in any boat with a shore power connection, whether or not it has inverters or generators on board. One of two methods are typically used to maintain the ground switching safety feature while greatly reducing (if not eliminating) the risk of corrosion/electrolysis.

1 - Galvanic Isolator Method

“Galvanic Isolators” (aka “Zinc Savers” or “Green Wire Interrupters”) are relatively inexpensive devices that will provide effective electrolysis/corrosion protection on most non-metallic hull boats. They are wired between the safety ground (Green) wire of the shore power input and the safety ground bus of the boat’s main AC panel. Galvanic isolators establish a low voltage block (1.5-2.0volts) that will pass a 110 volt fault, but effectively stop typical low voltage corrosion/electrolysis currents.

2 - Isolation Transformer Method

Isolation transformers are a more expensive solution to the corrosion/electrolysis problem, and are typically used on metallic hull boats. They totally eliminate hardwire connections between shore power and the boat’s AC wiring system, replacing them instead with induced connections through transformers. Since corrosion/electrolysis is based on DC current flow, and since transformers do not pass dc current, the problem is eliminated.

Galvanic Corrosion and Electrolysis

Galvanic corrosion is typically a salt water problem. Electrolysis can be a salt or fresh water problem.

Galvanic Corrosion is caused by components in the boat’s electrical distribution system which form a natural battery when they are immersed in water and connected by an electrical conductor. EXAMPLE: Boat A with bronze propeller is tied at the dock next to Boat B with an aluminum outdrive. These dissimilar metals are immersed in salt water (a good electrolyte) and connected together electrically by the green safety ground on the shore power connection. Absent a “galvanic isolator” or “isolation transformer,” the aluminum outdrive will disappear in short order!

Electrolysis (aka “stray current corrosion”) is caused by an “impressed voltage” — an outside source of voltage — applied to the DC grounding system. Usually this outside source is a leakage fault in a neighboring boat’s wiring.

Connection of Shipboard Sources of AC Power to the Boat’s Wiring System.

When AC on the boat is being supplied by shore power, the system is polarized (neutral connected to safety ground) on the dock. Consequently, neutral and safety ground should not be connected anywhere on the boat when shore power is present. When AC is being supplied by a source on the boat, i.e., inverter or generator, the system can be polarized or non-polarized. Arguments can (and have) been made for both.

In either case, the wiring connections of an inverter follow the same general guidelines as a generator, with the notable exception that inverters require connection to both the AC and the DC wiring systems for their sources of energy.

Figure 7 on Page 25 diagrams the installation wiring for the M1500 series inverters in a polarized system.

The Case for “Polarized” (Grounded Neutral) Systems

The American Boat and Yacht Council (ABYC) recommends that a boat’s AC system be “polarized” when the inverter or generator is operating. They follow the general rule that neutral and safety ground should be connected at the AC source whether that source be inverter, generator or shore power. Their underlying purpose is to establish a specification that maximizes the possibility that a circuit breaker will activate if a hot-wire-to-ground fault occurs. Their recommended system requires that the neutral/safety ground connection at the inverter or generator be enabled when the source of AC is on the boat, and disabled when shore power is connected. The Trace M1500 series inverters have a relay that does this automatically. This feature is not used in “E” models.

The Case for “Non-Polarized” (Floating Output) Systems

We are not aware of any recognized standards in the U.S. that favor a non-polarized system. However, the Canadian and European marine communities seem to favor non-polarized systems. Even in the U.S., it is a common practice for marine electricians to install non-polarized systems. Those that verbalize a reason offer these explanations:

- The safety risks of a boat’s AC system are far greater when the boat is connected to shore power than when operating away from the dock.
- With a non-polarized system you can touch either hot leg and not receive a shock. You would have to touch both hot legs, or touch one hot leg when the other hot leg was shorted to ground (via a fault) to receive a shock.
- A non-polarized system essentially requires two faults to exist to present a safety hazard.
- In a polarized system, if you touch a hot wire while in contact with the water, you will be shocked. In a non-polarized system you won’t.
- Why complicate a system that is inherently quite safe and increase the risk of improper installation and lessened reliability?

Our Position

In keeping with ABYC standards for marine installations, the M1500 series inverters were designed with automatic ground switching to polarize the inverter’s AC output when operating in inverter mode. These inverters are also well-suited to RV applications. However, Trace Engineering believes that both polarized and non-polarized systems can be safe in a Marine/RV application if done properly. We recommend that if a non-polarized system is used, a fault monitoring device (indicator lights, alarms, etc.) should be employed to warn the boat operator of an unsafe condition requiring attention.

Caution: Do not use either the Model M1512 or M1524 inverters in residential or commercial applications where the AC neutral is grounded at the main panel. Trace residential/ commercial series (without ground switching) is the proper choice for these applications.

AC Connections

Installation should be done by a qualified electrician. Consult local code for the proper wire sizes, connectors and conduit.

Inside the unit a four station external terminal block is provided to make the AC connections. A label that defines which positions are used for the AC inputs and AC outputs is located near the terminal block. **HOT IN** and **NEU IN** are the wires that come from the shore power or generator (usually via a main panel box). **HOT OUT** and **NEU OUT** wiring leads to the loads (usually via a sub panel box).

Consult your local code for proper wire sizes, connectors, conduit, etc. For 120 VAC units, we recommend 10 gauge. For 230 VAC units we recommend 12 gauge. Code requires that an external disconnect switch be used in the AC input wiring circuit. The AC breakers in a sub panel will meet this requirement.

Review the installation diagrams included before you start making connections.

Step 1 - Open the front panel door by removing the 4 Phillips head 6/32 screws.

Step 2 - Disconnect the inverter from the battery.

Step 3 - Feed the wires thru the bottom of the inverter. See Figure 6.

Step 4 - Following the wiring guide near the terminal block, connect the hot (black), neutral (white) and safety (green) wires to the terminal block and tighten securely.

Step 5 - The safety wire is connected to the large terminal at the back right hand corner of the chassis. The terminal is large enough to hold 00 gauge wire. Code requires that the safety ground be able to handle the same current as the battery cable. The safety wire is connected from the ground terminal to the battery negative terminal.

Step 6 - Install the Temp Sensor and make any desired adjustments. See the previous chapters for information on setting inverter and battery charger parameters as well as **Temp Sensor** installation.

Step 7 - Secure the door.

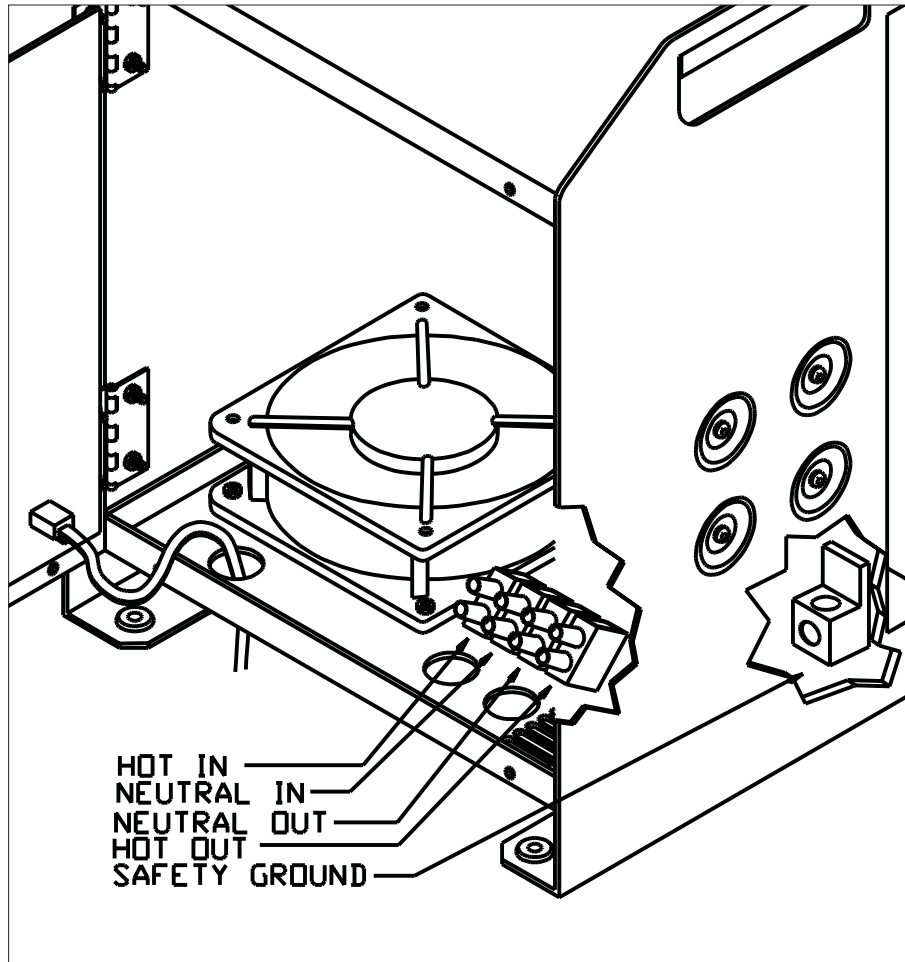


Figure 6, AC Wiring Hookup

Important Precautions

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

Ground Fault Interrupting Outlets (GFI's)

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

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

AC Wiring Diagram

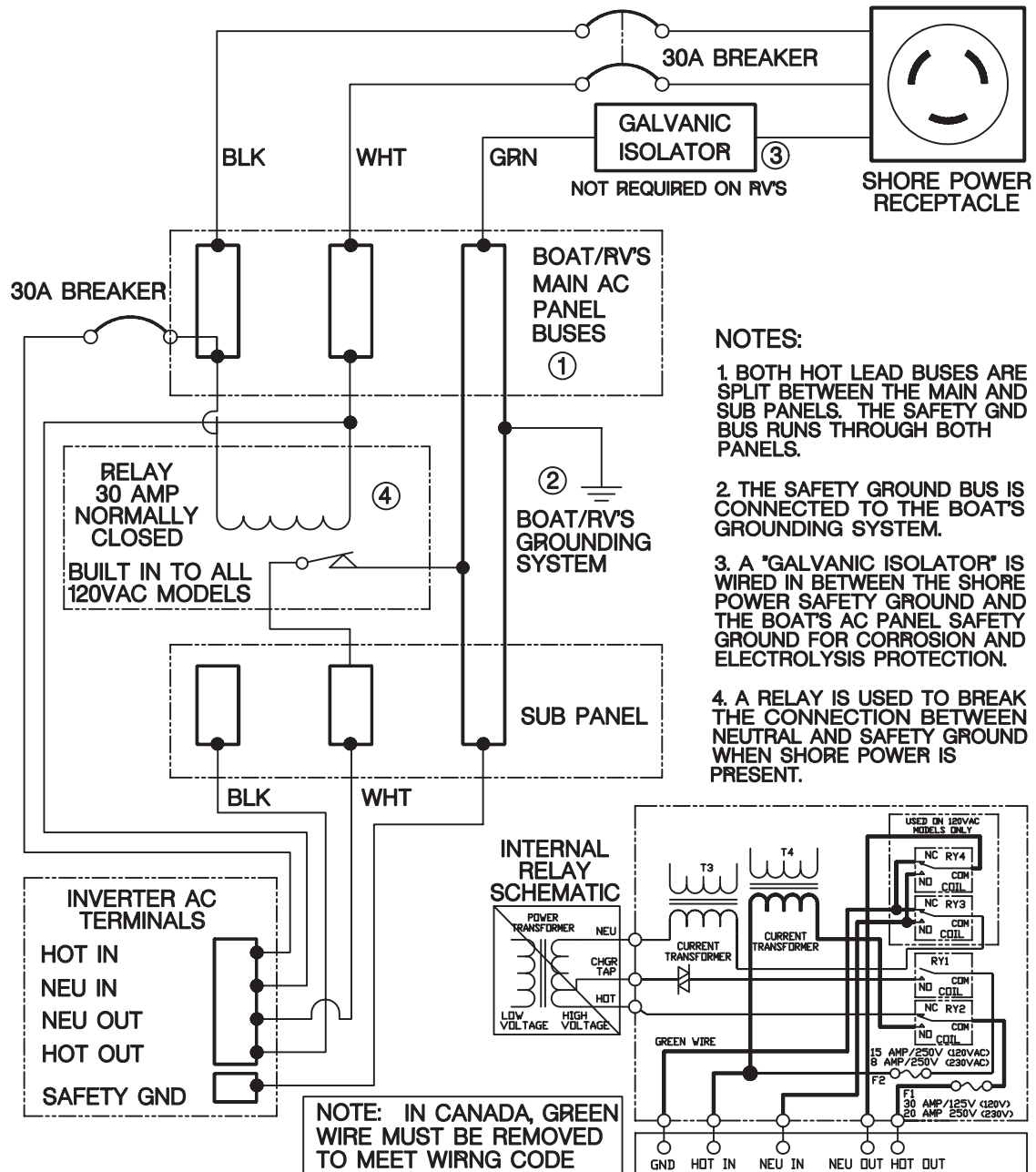


Figure 7, AC Wiring and Transfer Schematic

DC Wiring

Safety Instructions

THIS INVERTER IS NOT REVERSE POLARITY PROTECTED. If the positive terminal of the battery is connected to the negative terminal of the inverter and vice versa, the result will be instantaneous failure of nearly every power FET. To compound your misfortune, this type of failure is very obvious, and is **not covered under the warranty**. So, pay close attention and double-check when making the battery connections.

The inverter's maximum peak current requirements are high. If battery cables are too small and/or connections are loose, efficiency and maximum output power are degraded. Small cables or loose connections can also cause dangerous overheating of the wire and/or terminals.

Make the battery cables as large and as short as possible. Tape or run the battery cables together. This reduces the inductance of the wire resulting in a better waveform and less current in the inverter's filter capacitors.

Code your battery cables with colored tape or heat shrink tubing. Cable ends must have crimped and soldered copper ring terminals.

DC Disconnect

In order to comply with the UL 458 safety standard a UL approved form of battery disconnect is required. These installation parts are not supplied by Trace Engineering. They may be obtained from your dealer, electrical supply houses or:

Industrial Controls Supply Company
22410 70th Ave West Unit 6
Mountlake Terrace, Wa. 98043
Phone (206) 771-6344
Fax (206) 775-8901

Ananda Power Technologies, Inc.
14618 Tyler Foote Rd.
Nevada City, CA 95959
Phone (916) 292-3834
Fax (916) 292-3330

Battery Cable Connection

The battery connections are located inside the unit. The red positive terminal is on the back of the unit and the black negative terminal is positioned on the right side.

Use 1/2" socket wrench and a six inch extension.

Observe Battery Polarity!

Step 1 - Disconnect the AC to the unit at the breaker panel.

Step 2- Lead the positive battery cable thru the appropriate hole in the bottom of the unit and attach it to the positive terminal on the back of the unit. Place the ring terminal over the bolt and directly against the inverter's copper terminal. Tighten the 5/16 nut to 10-15 ft./lbs.

Step 3- Lead the negative battery cable thru the appropriate hole in the bottom of the unit and attach it to the negative terminal on the right hand side of the unit. Place the ring terminal over the bolt and directly against the inverter's copper terminal. Tighten the 5/16 nut to 10-15 ft./lbs.

Note: Connecting the battery cables to the inverter battery terminals will cause an arc - usually accompanied by a "snap". This is normal - don't let it scare you.

Never disconnect the battery cables while the inverter is delivering power or battery charger is operating. Always turn the unit off first.

Battery Cable Sizing

The bigger the battery cables the better. Under sized 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 and degrade the efficiency that we have worked so hard to achieve and you have paid so much to own. The following table gives recommended cable sizes for various cable run lengths and inverter voltages.

Table 1 - Minimum Recommended Battery Cable Size

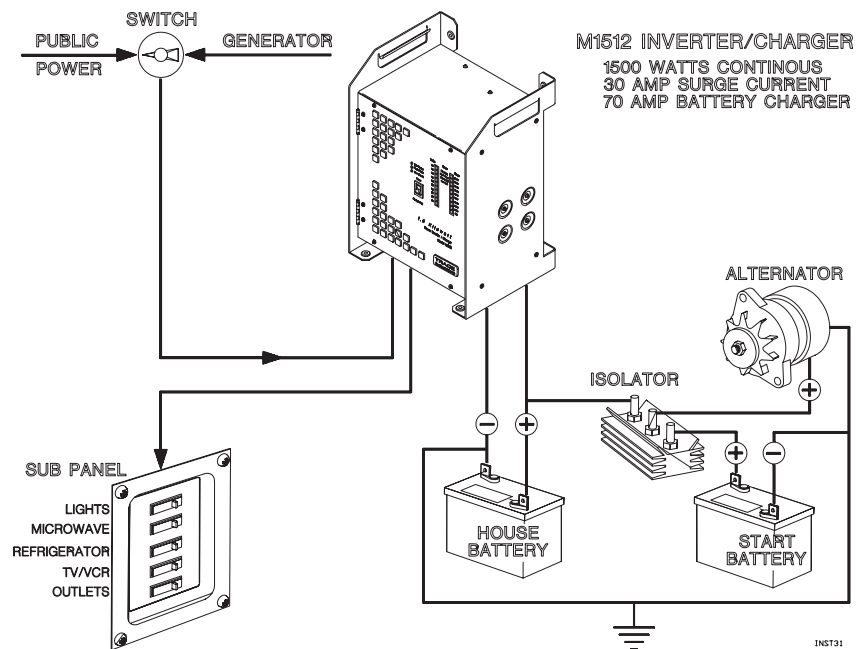
| Model | Cable Length | | |
|-------|--------------|------------|-------------|
| | Under 5 ft | 5 to 10 ft | 10 to 20 ft |
| M1512 | 00 | 000 | 0000 |
| M1524 | 0 | 00 | 000 |

WARNING !! Battery cables that are very small will melt and burn the first time the inverter is asked to produce high power.

Installation Diagrams

A. Installation with Single AC Panel

In all installations it is important to ensure that AC power from any source (generator, public power) is never fed to the inverter's AC output. With the standby option, it is essential that the inverter's AC output is not fed to its AC input. The diagram below is simple and meets these requirements. However, there are two precautions to keep in mind:



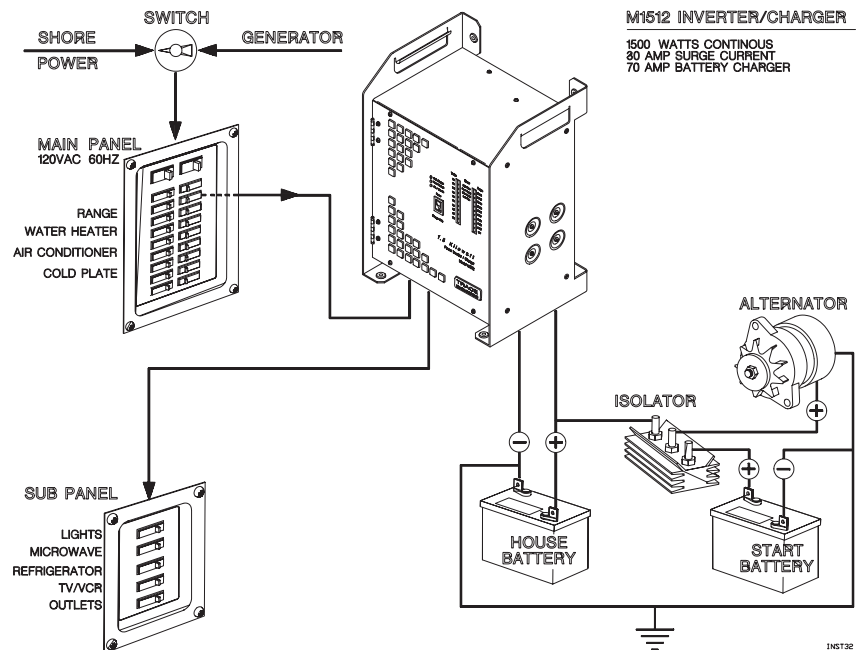
Figure, 8

- 1) With only one AC panel encompassing **all** loads, the inverter could be connected to loads which are greater that it can run.
- 2) The maximum system current is limited by the inverter's two 30-amp AC input breakers. One breaker provides 30 amps of pass-thru current, the other may supply up to 20 amps to the charger.

The above configuration is acceptable, but not recommended. Figure 9 is preferable in that it isolates the inverter from inappropriate loads.

B. Installation with AC Sub Panel

This is the recommended configuration for installing an inverter with the built-in battery charger. It operates in the following manner. When there is power available at the main panel, the inverter's automatic transfer relay closes, connecting the main panel to the sub-panel. When there is no AC present at the main panel, the relay opens and the sub-panel is fed AC power generated by the inverter.



Figure, 9

This installation automatically ensures that public or generator AC power is never routed to the output of the inverter. The inverter's AC output cannot be fed to its input. Additionally, the inverter will only be connected to appropriately sized loads that are dedicated to the sub-panel.

C. Installation with External Relay

This configuration may be desirable when the pass thru current required is greater than 30 amp maximum that the inverter's internal relay can control.

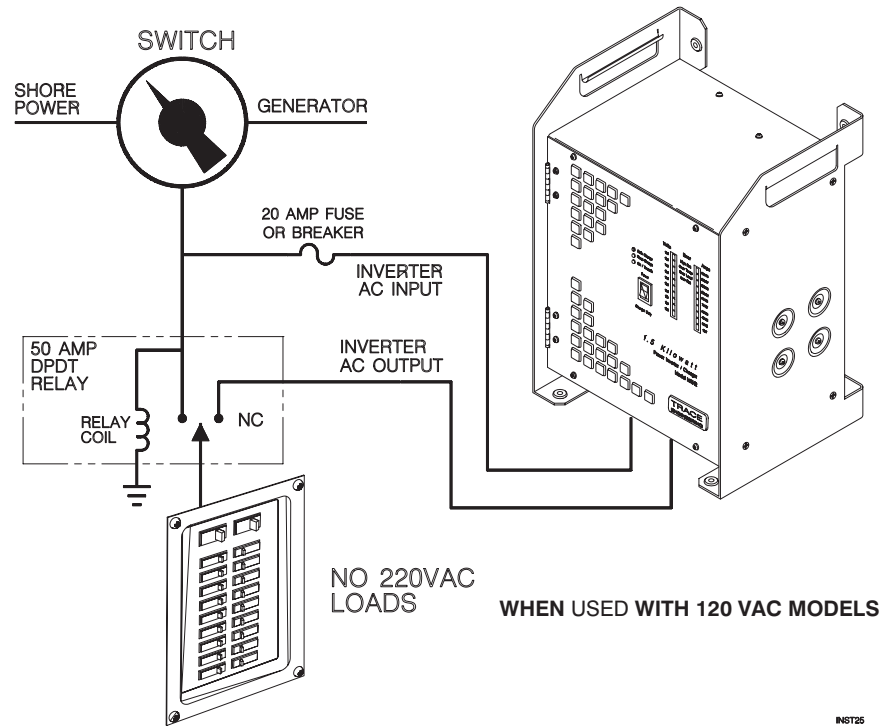
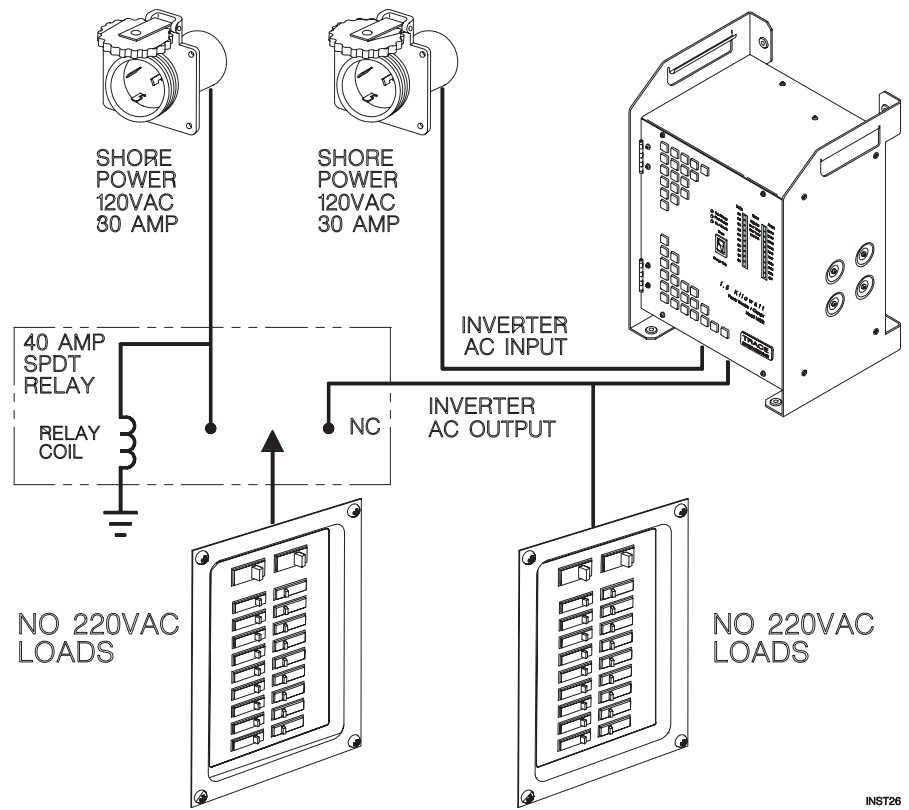


Figure 10

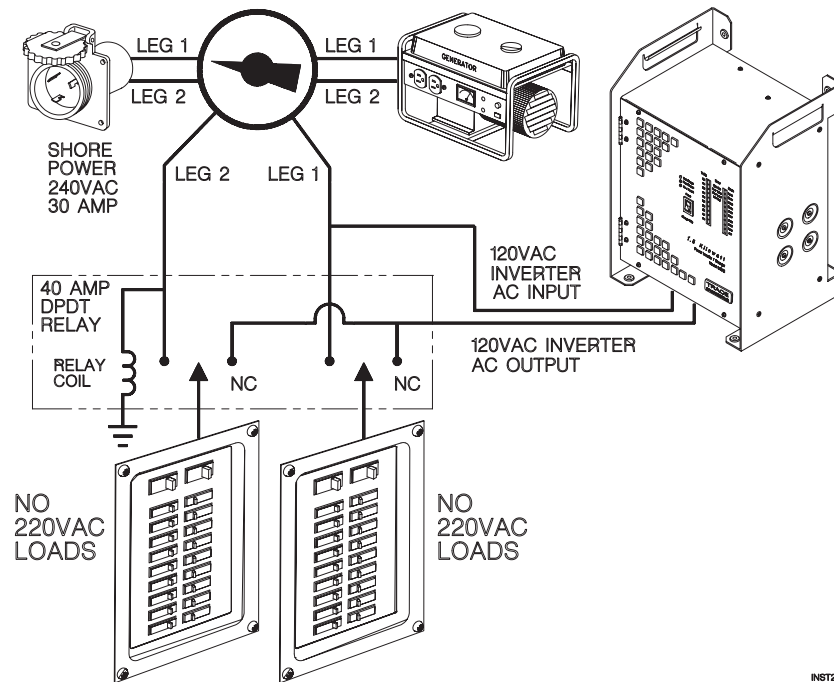
D. Installation with External Relay



INST26

Figure, 11

E. Installation with External Relay



INST27

Figure 12

Trouble Shooting Guide

| <u>Symptoms</u> | <u>Problem</u> | <u>Remedy</u> |
|---|--|---|
| No power output and no warning LED's | Battery voltage at the inverter's terminals is too high or low | Check the battery condition |
| Buzzer on | Battery over discharge protection circuit on | Disable circuit |
| | Load too small for Search Mode circuit to detect | Reduce search threshold setting or defeat the Search Mode |
| | ComPort Accessories are improperly installed | Re-install or remove options from the ComPort |
| No power output and warning LED's "ON", Buzzer on | High or Low Battery LED "ON" | Check the battery voltage at the inverter terminals |
| | Overload LED is "ON" | Remove loads from the inverter and restart |
| | High Temp LED is "ON" | Remove loads and let the inverter- cool down before re-starting |
| Power output is low and inverter turns loads on and off | Low battery | Check charge and condition of batteries |
| | Loose or corroded battery connections | Check and clean all connections |
| | Loose AC output connections | Check all AC output connections |
| Inverter turns off when external power is applied | Output of inverter wired back to the input | Check for proper AC input and output wiring |
| Charger is inoperative or intermittent | AC input voltage does not match inverter spec | Check AC input for proper voltage and frequency of your model |
| | Charger controls improperly set | Refer to Owner's Manual for proper setting of battery charger parameters |
| Low charge rate | Low <u>peak</u> AC input voltage (164 volts peak required for full charger output) | Use larger generator, speed up generator, check AC input wiring size, adjust charge rate, cable too small or too long |
| Low AC output voltage | Measuring with the wrong type voltmeter | Voltmeter must be 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 |
| Charger operative but no inverter or pass thru current | Blown fuse | Replace circuit board fuse with extra taped to inside of chassis |

Applications

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. Even if the inverter could 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 you manage 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, and 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 grid.

Induction motors (motors without brushes) require 2 to 6 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 1 to 1.5 hp with the 2500 watt models and 1/2 to 1 hp with 1500 watt models. 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.

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.

- **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 on search mode operation for ways to solve this problem.
- **Fluorescent lights & power supplies** Some devices when scanned by the load sensor cannot be detected. Small fluorescent lights are the most common example. (Try altering the plug polarity-turn 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. See the section search mode operation.
- **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 will drop the peak voltage several volts due to internal losses. Therefore, the time needed to cook food will be increased if battery voltage is low.
- **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 Mode Control.)
- **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.
- **Ceiling Fans**- Most large diameter, slow turning fans run correctly, but generate more noise than they would connected to public power. The high speed type fans operate normally.
- **Dimmer Switches**- Most dimmer switches lose their ability to dim the lights and operate either fully on or off.
- **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.
- **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.

- **Electronics-** AM radios will pick up noise, especially on the lower half 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.
- **Low Battery Dropout** The inverter will turn off to protect itself if your battery bank cannot deliver the necessary amperage to drive a particular load without falling below the low voltage protection point for three seconds. With the inverter off, the battery voltage will rise and then it will resume operation.

Technical Information

Model M1512 and M1524 Specifications

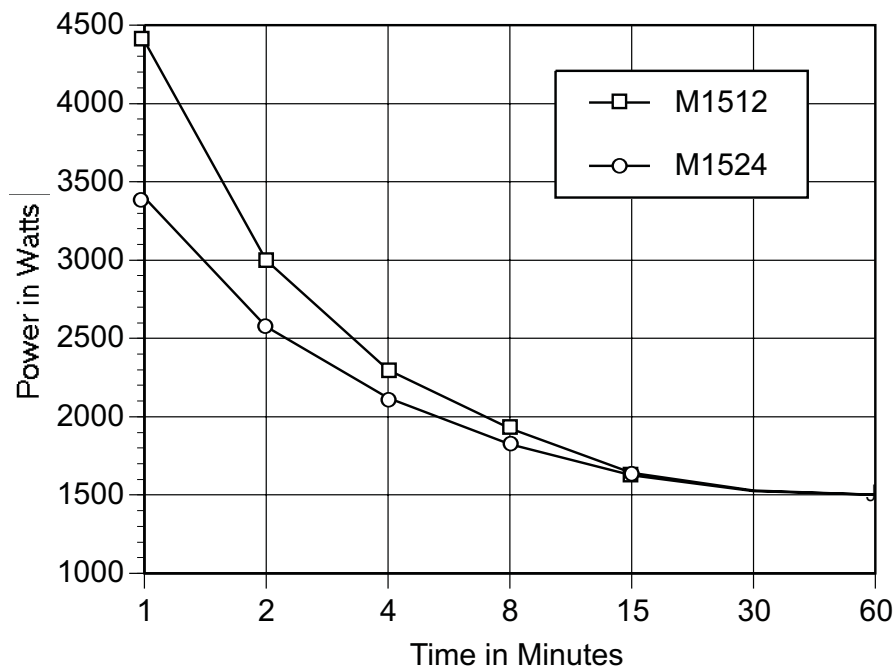
| MODEL. | M1512 (Export) | M1524 (Export) |
|--|-----------------------------|-----------------|
| Continuous Power @ 20° C. | 1500 watts | 1500 watts |
| Surge Power. | 3500 watts | 4500 watts |
| Efficiency (maximum) | 94% | 95% |
| Input Current | | |
| Search Mode | .045 amps | .030 amps |
| Full Voltage | .600 amps | .300 amps. |
| Rated Power. | 140 amps | 70 amps |
| Short Circuit. | 400 amps | 280 amps |
| Nominal Input Voltage | 12 vdc | 24 vdc |
| Input Voltage Range | 8.5 to 16.0 vdc | 17 to 32 vdc |
| Voltage Regulation | +/- 4% | +/- 4% |
| Waveform | modified sine | modified sine |
| Power Factor Allowed | -1 to 1 | -1 to 1 |
| Frequency Regulation. | +/- .04% | +/- .04% |
| Output Voltage | 120 vac (230 VAC) | 120 vac (230 |
| VAC) | | |
| Adjustable Load Sensing | 5 to 100 watts | 5 to 100 watts |
| Automatic Low Battery Protection | 11 vdc or defeated | 22 vdc or de- |
| feated | | |
| Forced Air Cooling. | thermally activated | thermally acti- |
| vated. | | |
| Automatic Transfer Relay. | 30 amp (20 amp) | 30 amp (20 amp) |
| Adjustable Charge Rate | 0 to 70 amps | 0 to 35 amps |
| Number of Charging Profiles | 2 | 2 |
| Three Stage Charging | yes | yes |
| Temperature Compensation Probe | standard | standard |
| Remote Control | optional | optional |
| Environmental Characteristics | | |
| Operating Ambient Temperature. . . . | 0°C to +60°C | 0°C to +60°C |
| Non-operating Ambient Temp | -55°C to +75°C | -55°C to +75°C |
| Altitude Operating | 15,000 ft | 15,000 ft |
| Altitude Non-operating | 50,000 ft | 50,000 ft |
| Weight. | 35 lbs | 35 lbs |
| Dimensions | H 14.4" X W 10.6" X D 8.25" | |
| Mounting | bulkhead | bulkhead |

Performance Graphs

Load Capacity vs. Time

Loads presented to the inverter are seldom constant. Typically, large loads are operated for only short periods of time. In order to provide the maximum utility, TRACE inverters are allowed to operate at power levels that exceed their continuous power ratings. This graph shows how loads that are larger than the inverter can sustain continuously can be operated for useful periods of time.

The length of time that the inverter can operate at high power is limited by temperature. When large loads are run, the inverter's temperature increases. At the point where more heat is created in the inverter than can be dissipated, its ability to operate becomes time limited. The accompanying graph represents the relationship between size of load and the time it can be operated by a M1500 series inverter.

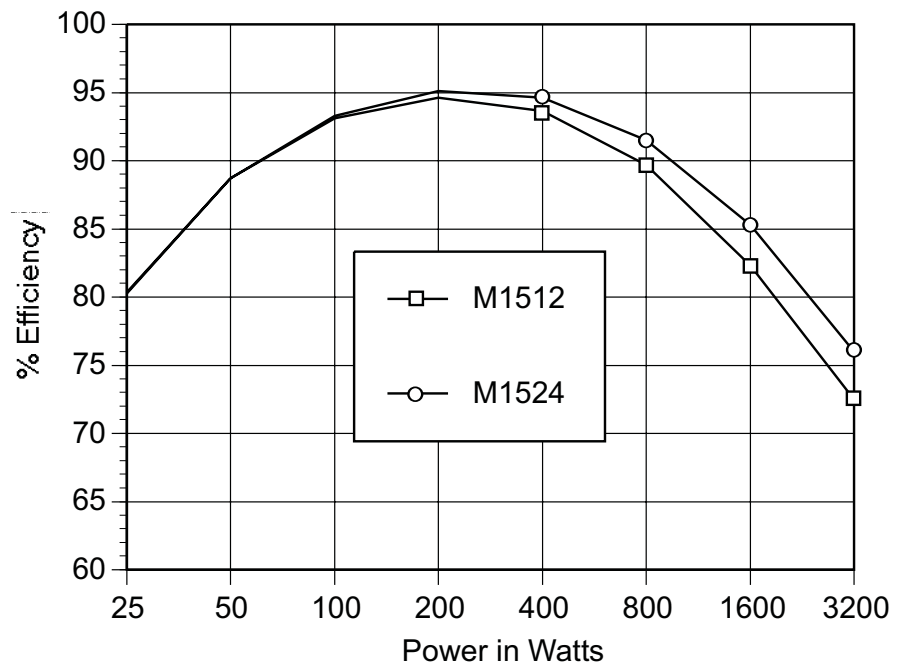


This graph assumes an ambient operating temperature of 20⁰ C and resistive loads. Reactive loads (motors, florescent lights) and/or elevated ambient temperatures will reduce the time that the inverter can operate at a particular load level.

Power vs. Efficiency

There are two primary types of losses that combine to create the efficiency curve. The first is the energy that is required to operate the inverter at full output voltage while delivering no current. This is the idle power. At low power levels it is the largest contributor to inefficiency.

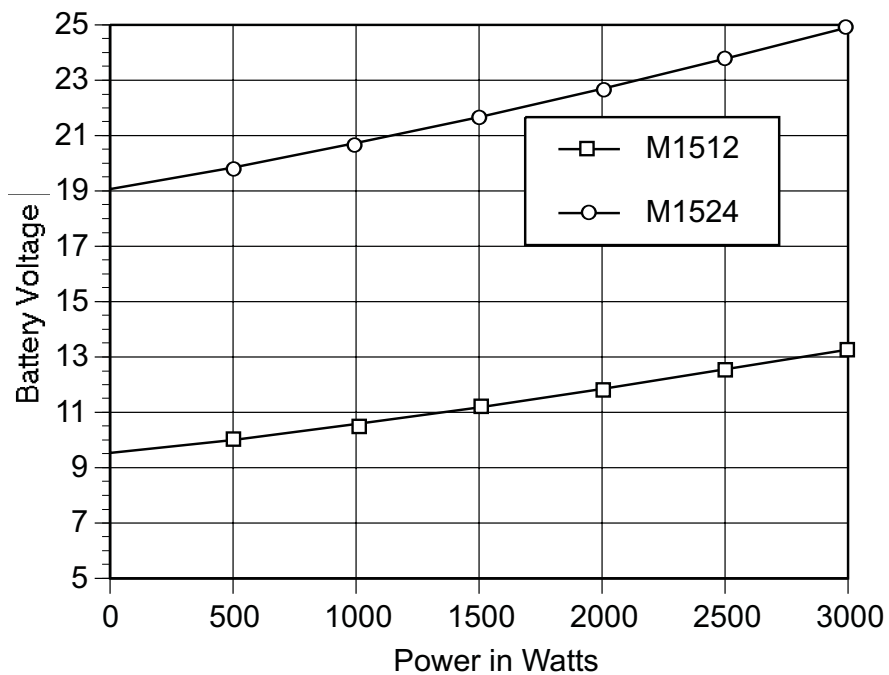
The second and largest source of loss is a result of the resistance in the transformer and power devices. The power lost here is proportional to the square of the output power. For Example, losses at 2000 watts will be four times higher than losses at 1000 watts.



This graph above represents the inverter's efficiency while operating resistive loads. Inductive loads such as motors are run less efficiently due to the impact of power factor losses.

Max Regulated Power vs. Battery Voltage

The inverter regulates RMS voltage by changing the width of its output waveform. The graph below defines the points at which the combination of power and battery voltage results in square wave output. The area above the line represents regulated output. The area below the line shows unregulated operating conditions.



As the battery voltage is reduced, the maximum regulated power the inverter can produce decreases. Note that battery voltage is specified as “cell voltage.” To get system voltage, multiply by six for a twelve volt system, twelve for a twenty-four volt system.

Tables

Typical Battery Draw of Common Appliances

Table 2, Model M1512 - 12 volt inverters

| Appliance | Watts | Time in Minutes | | | | | |
|-----------------|-------|-----------------|----|----|-----|-----|-----|
| | | 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.

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

Table 3, Model M1524

| Appliance | Watts | Time in Minutes | | | | | |
|-----------------|-------|-----------------|----|----|----|-----|-----|
| | | 5 | 15 | 30 | 60 | 120 | 240 |
| Single PL Light | 10 | .06 | .2 | .3 | .7 | 1.3 | 2.7 |
| B & W TV | 50 | .2 | .6 | 1 | 2 | 4 | 8 |
| Computer | 100 | .4 | 1 | 2 | 4 | 8 | 17 |
| Color TV | 200 | 1 | 2 | 4 | 8 | 17 | 34 |
| Blender | 400 | 2 | 4 | 8 | 17 | 34 | 67 |
| Skil Saw | 800 | 3 | 8 | 17 | 34 | 67 | 133 |
| Toaster | 1000 | 4 | 11 | 23 | 46 | 93 | 185 |
| Microwave | 1200 | 5 | 14 | 28 | 57 | 114 | 227 |
| Hot Plate | 1800 | 8 | 22 | 44 | 88 | 177 | 353 |
| | | Amp Hours | | | | | |

If the current draw at 120 VAC is known, then the battery amperage at 24VDC will be 5 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.

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

Table 4, English to Metric Wire Conversion

| AGW | Diameter/mm | Area/mm² |
|-------------|--------------------|----------------------------|
| 14 | 1.628 | 2.082 |
| 12 | 2.052 | 3.308 |
| 10 | 2.588 | 5.261 |
| 8 | 3.264 | 8.367 |
| 6 | 4.115 | 13.299 |
| 4 | 5.189 | 21.147 |
| 2 | 6.543 | 33.624 |
| 1 | 7.348 | 42.406 |
| 0 | 8.525 | 53.482 |
| 00 | 9.266 | 67.433 |
| 000 | 10.404 | 85.014 |
| 0000 | 11.684 | 107.219 |

Model 1512 and M1524 Options

Remote control

Remote control panel with ON/OFF switch and LED indicator. Available soon.

Other Products available from Trace Engineering

Model SW4024 sine wave Inverter

Continuous 4000 watt sine wave inverter/charger. Features low current distortion charger, temperature compensation, series operation, fast transfer time, line tie capability, generator support, generator start and user controlled auxiliary relays.

30A Solar Charge Controller

Controls the charge received by the batteries from a solar array. It is rated at 30 amp capacity and has box terminals that will accept up to #4 AWG wire. The C-30A also features self-configuration for 12 or 24 volt VDC systems. An automatic disconnect feature prevents battery drain by disconnecting the solar array under low light conditions.

C30 Load Controller

The C30 can be manually set to operate at 12 or 24 volts as either a charge controller or DC load disconnect. As a charge controller, both high battery disconnect and low battery re-connect levels are user adjustable. As a load controller, both high battery re-connect and low battery disconnect are adjustable. The C30 is rated at 30 amps and uses box terminals that will accept up to #4 AWG wire.

Battery cables

Are available from Trace in various lengths to ensure maximum power from the inverter and batteries.

Limited 2 Year Warranty

Trace Engineering Company warrants its power products 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 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).

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.