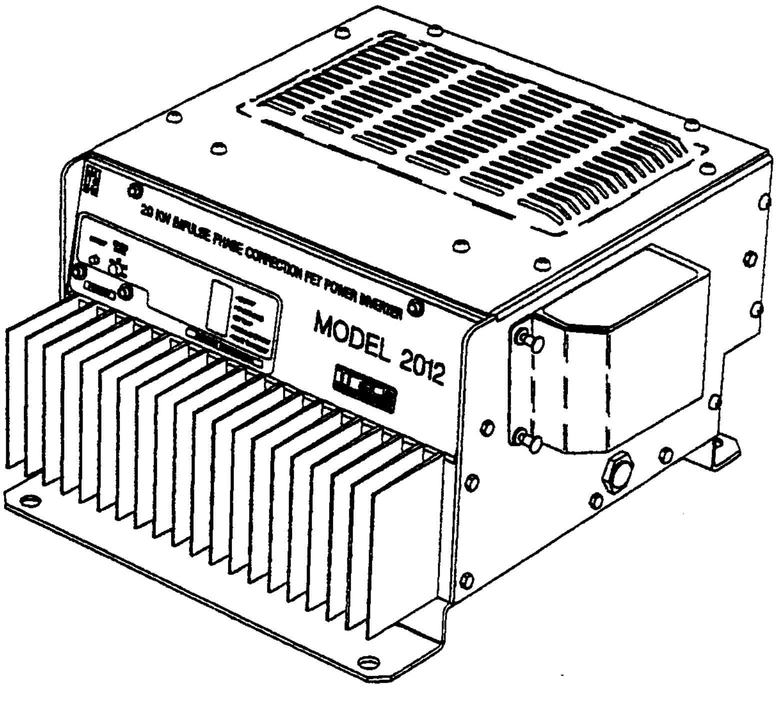
Owner's Manual

V 1.0

2012 Series Inverters

3-Stage Charger



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Front Panel

Shown below is the front panel for the standard inverter without the optional battery charger. The front panel for inverters with the optional battery charger is shown in the chapter *Standby Option.*

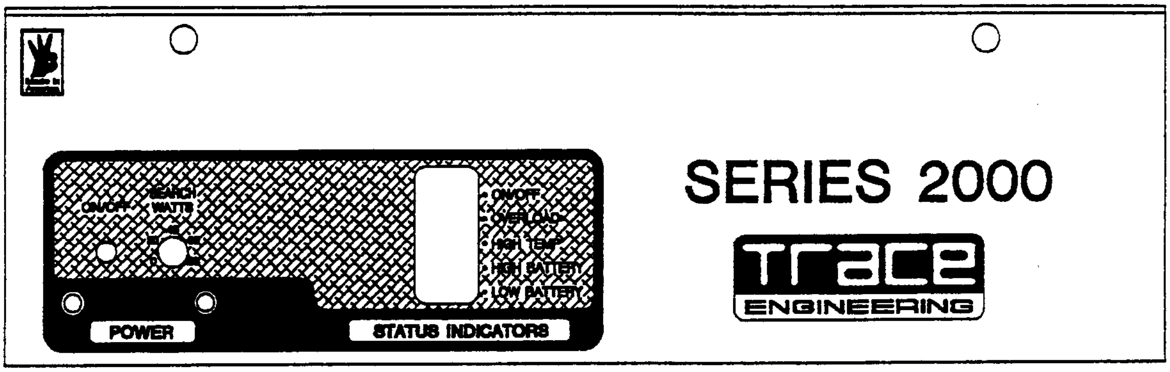


Figure 1, Front Panel for Standard Inverter

Two controls are provided with the standard unit. Located on the left of the panel is the momentary On/Off switch. Next to it is the SEARCH WATTS control used for adjusting the sensitivity of the search mode circuit. Behind the Lexan front panel, on the main circuit board there is a vertical row of five LED's (light emitting diodes). The top LED indicates a change in on/off status. The remaining four report on any activation of the protection circuits.

Startup

When first connected to batteries, the inverter will be in the off state. Whenever the batteries are connected, the momentary power switch must be pressed once to turn the inverter on. Subsequently pressing the on/off switch alternately turns the inverter on and off. An amber LED indicator lamp will light only while the power switch is pressed to acknowledge the unit has changed states.

Search Mode Control

The Series 2000 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 connected. 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. Turning the control full counter-clockwise defeats the search mode feature.

Example: With the SEARCH WATTS control set at 40, 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 the inverter is used as an uninterruptable power supply the search mode function should be defeated.

The inverter makes a ticking sound when in the search mode. At full output voltage it makes a steady humming sound.

A neon nightlite can be used 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 at 40 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 at 30 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 then this combinnation 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.

Protection Circuitry

The inverter will **automatically** restart itself from the following overload conditions: low battery, high battery, shorted output, over current, over temperature.

The inverter will turn itself off and need to be **manually** restarted under the following conditions: (1) if it is put to the ultimate test and has it's AC output connected to public power; (2) if an attempt is made to start a very large motor; (3) if it encounters a load large enough to enable the protection circuit and reduce the output wave form for approximately 15 seconds (a prolonged short circuit).

Indicator Lamps

There are 5 LED indicator lamps on the **Series 2000** units that monitor the inverter's operation. These LED's are viewed thru the lexan front cover and are located slightly to the left of center. The **On/Off** LED is amber. The rest are red. The standby option adds three more LED's on the right side of the front panel. Their operation is explained in the battery charger chapter.

- **On/Off** - This LED lights momentarily when the power switch is pressed to acknowledge that the inverter has either turned on or off depending on its previous state. It does not stay lit. On the standby model (with optional internal battery charger) the ON/OFF switch also activates the battery charger function.

- **Overload** - This LED lights when the load being run demands more current than the inverter can safely supply. If the lamp is on while a load is running, it implies a reduced output voltage. Since the protection circuit is temperature compensated, a large load that runs satisfactorily when the unit is cold may begin to trip the protection circuit and light the overload lamp when the inverter is warm. If an overload condition exists for more than 20 to 30 seconds, the inverter will turn itself off. To restart the inverter, press on/off switch once.

- **Over Temperature** - This LED indicates an over-temp condition. If the temperature of the power transformer or the heat sink rises above its designed operating limits, the inverter will shut off and automatically restart after a sufficient cooling period.

- **Low Battery** - In order to protect itself, the inverter shuts down and lights this LED when battery voltage falls below the low battery protection point for more than 3 seconds. The unit resets itself after the voltage rises above this point. (See specifications section for these voltages.)

  Note: When a Standby model inverter is shut down due to a low battery condition, the battery charger will also be disabled. 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.

  Note: There is a Battery Protector option available with adjustable low battery cutout. This optional circuit looks at both current draw <u>and</u> battery voltage in performing its battery protection function.

- **High Battery** - If battery voltage rises above the high voltage protection point, the inverter shuts down and lights this LED. When the voltage has dropped to a safe level, it restarts. (See specifications section for these voltages.)

Theory of Operation

Waveform

The output waveform of the inverter is referred to as a modified sinewave. 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.

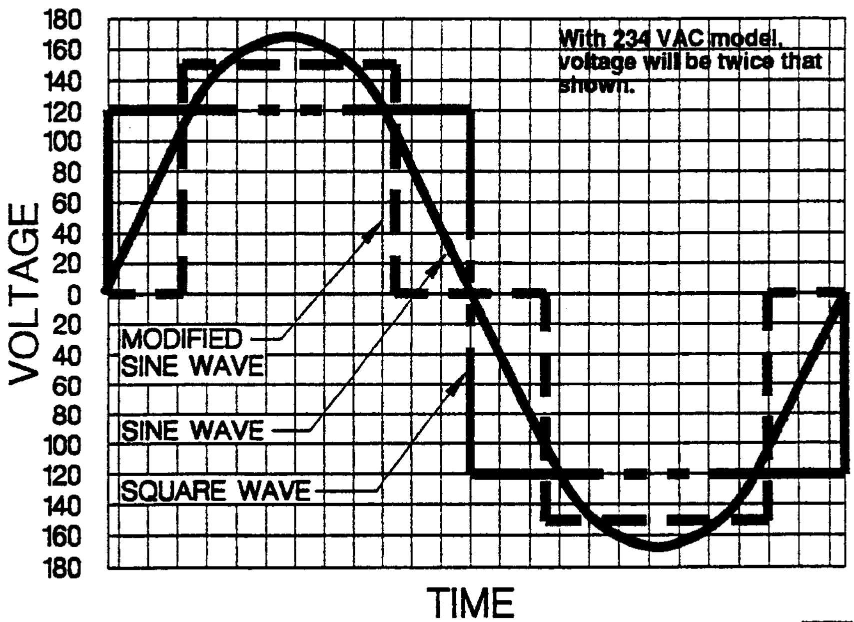


Figure 2, Comparison of Output Waveforms

The waveform could be more accurately described as a pulse- width modified squarewave. The accompanying *Figure 2* shows the relationships between squarewave, sinewave and modified sinewave 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.

Standby Option

Front Panel

Shown below is the front panel for units with the internal battery charger option.

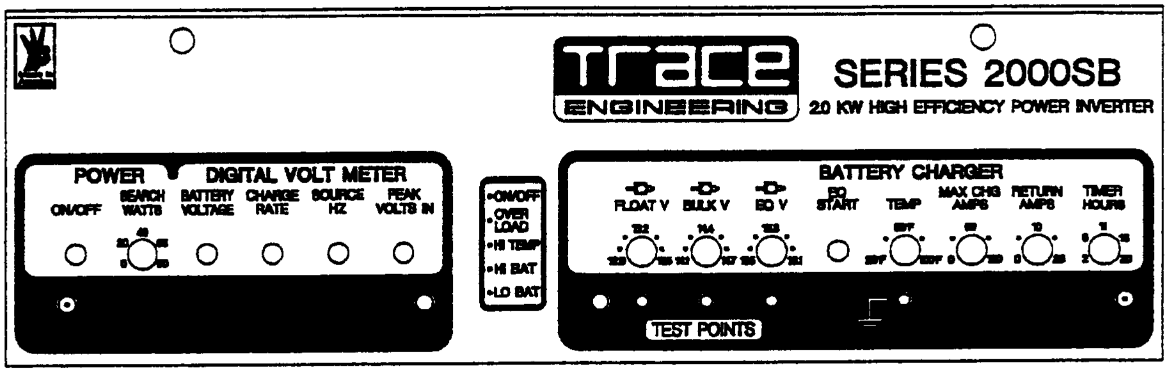


Figure 3, Front Panel for Standby Models

Front panel shown reflects voltages for the model 2012SB

Units with the standby option have four additional momentary switches on the left side of the front cover. These are for the Digital Voltmeter option. If your unit is not equipped with the DVM option, these switches are not functional. The right side of the front panel has seven adjustable controls for setting battery charger parameters. There is a recessed momentary switch for initiating an equalization charge. Also provided on the front panel are three test and one ground point for the precise adjustment of voltage settings.

Operation

The standby option adds an internal battery charger and automatic transfer relay. This 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 (eg, shore power or generator) must be supplied to the inverter in order to allow it to operate as battery charger. When the unit is operating as a charger, it's AC output is powered by the external source (i.e. generator or public power).

The inverter automatically becomes a battery charger whenever AC power is delivered to its AC inputs. There is a 15 second time delay from the time the inverter senses that AC is present at its input and 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.

30 Amps is the maximum power that can be handled by the inverter's internal wiring and transfer relay. During heavy charging, up to 20 amps (10 amps with 220-240 VAC models) may be consumed by the charger, leaving the remainder available for external loads. By reducing the charge rate, more current can be made available for external loads.

Transfer Switching Speed

When switching from charger to inverter mode, the inverter will "soft start" the load, tapering up to full voltage. The "soft start" time is about 1/2 second. Note: because of this soft-start feature, standby models should NOT be used for uninterruptable power supplies (UPS).

When switching from inverter to standby, the inverter waits approximately 15 seconds to ensure the AC source is stable (generator up to speed) and then makes the transfer in approximately 40 milliseconds.

Digital Voltmeter Option

This option is only available with standby models. It can be factory or user installed.

Digital Voltmeter Functions

- **Battery Voltage** - Reads average battery voltage while in standby or inverter mode. Operates with the inverter on or off.

- **Charge Rate** - Reads average battery charge rate in amps.

- **Source Hz** - Reads the frequency of the external AC source which is supplying the power to charge the batteries (public power or generator).

- **Peak Volts In** - In order for the battery charger to deliver its rated current, it must be supplied with sufficient peak AC volts. If the source voltage is sinusoidal then the peak voltage is 1.41 time the input voltage. If the peak voltage is above 200 volts (120 VAC models only), the meter will read "OFL". This condition is dangerous to household electronic appliances - TV's, VCR's, stereo's, etc. Correct this problem at the generator.

Installation By User

Disconnect the battery just in case you drop a mounting screw. Touch the heat sink with your finger to eliminate any static charge. Remove the lexan front cover and set it to the side carefully. Orient the DVM board so the digital readout is at the top. The female connector on the DVM board aligns with the vertical row of pins located 3 inches from the left edge of the mother board. Notice the 4 standoffs that you will be fastening the DVM board to. Align the connectors carefully, then gently press the DVM board onto the main PC board. Check again to see that you have aligned the connector properly - the holes on the DVM circuit board should match the standoffs on the mother board. Using the 4- #4 Phillips head screws supplied, fasten the board in place. There are holes in the heat sink that are positioned in line with the standoffs. They will accept a slender screw driver. Replace the front cover. Reconnect the battery - CAREFULLY! Don't be surprised when an arc is drawn as you make the connections.

Battery Charger (standby option only)

Overview of Battery Charger Operation

The charger is a powerful and sophisticated constant current, voltage limited design that normally operates in three stages. During the initial, "Bulk Charge" stage, the unit charges at a constant current causing the battery voltage to rise. A constant voltage, "Absorption" stage begins after the battery voltage reaches the bulk charge voltage. During this second phase, the charge rate is gradually reduced holding the battery voltage constant. The third, or "Float" stage is initiated when the current required to hold the batteries at the bulk charge voltage has tapered to a low level. At this point, the battery voltage is allowed to fall to a float voltage, where it is maintained until another charge cycle is initiated.

Users well rounded in batteries and battery charging can optimize charger operation through fine tuning of the many user adjustable charge controls. Most userw will want to accept factory default settings.

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).

Battery Charger Controls

A comprehensive set of controls are provided with the Standby Option's internal battery charger. This makes it possible for qualified users to tailor the charging characteristics for various types of batteries, environments and special situations.

If this array of controls seems formidable, remember that for most applications the factory settings will provide you with the advantages of the charger's advanced features. Resetting the charger to the factory positions is easily accomplished by turning all controls to their 12 O'clock position.

Max Chg Amps

This sets the maximum charge rate in amps. The highest charge rate recommended is determined by dividing the battery's amp hour capacity by a factor between 3 and 5 (3 for gel cell - 5 for lead acid). Setting the MAX CHG AMPS 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 amps X 24 hours = 600 amp/hrs.

The charger may thermally cycle when charging at levels above 75% of the maximum charge rate for extended times. If this occurs the unit turns off until it cools and then automatically restarts. It is recommended that the fan cooling option (ACTC) be installed in applications requiring high continuous charge rates.

Bulk V

This sets the maximum voltage (bulk charge 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. Sealed batteries are usually set to the higher voltage, while non-sealed batteries are set to the lower.

Return Amps

This setting is used by the charger to determine when it should change to the float stage. Normal setting is from 2% to 6% of the battery capacity, i.e. a 200 amp battery bank would call for a setting of 4 to 12 amps.

Note that the charger will also deliver current to drive any external DC loads that may be connected during the charge cycle. The current requirements of the DC loads could keep the charge rate from falling to a low enough level to initiate the float stage. If significant DC loads are anticipated during charging, the RETURN AMPS setting can be set higher to compensate.

Float V

This control sets the float voltage, i.e. the voltage at which the batteries will be maintained after they have been charged. The factory setting is based on 2.2 VDC per cell or 13.2 VDC for a 12 VDC battery. This is the recommended setting for sealed and non-sealed batteries.

Timer Hours

TIMER HOURS is a safety feature that ensures that abnormal conditions will not cause the charger to hold the batteries at high voltages for prolonged periods of time. The range of adjustment is 2 to 20 hours.This control limits the maximum amount of time that the charger is allowed to hold the batteries at the bulk charge voltage. It also sets the maximum duration of the equalize mode. Timing in equalize mode begins once the batteries reach the bulk charge voltage.

EQ Start

This momentary switch initiates the equalization cycle. During equalization, charging continues until the batteries reach the voltage setting of the EQ VOLTAGE control. Once this voltage is attained, equalization is terminated and the charging voltage falls to the float voltage. Equalization will also be terminated on a time basis if the voltage remains above the Bulk Voltage level for the time indicated on the TIMER HOURS control. Equalization can be manually terminated by pressing the EQ START.

Caution: DC loads should be disconnected from the batteries during equalization to protect appliances from high battery voltage.

If batteries are being used on a daily basis they should be equalized every one to two months.

The battery voltage will rise higher than the high battery protection threshold during equalization. This will light the high battery protection LED. It is not harmful to the inverter. The high battery protection inhibits the output of the inverter (not the charger) to eliminate the possibility of damage to AC loads if the inverter were operated at very high battery voltages. If the optional RC/2 remote control is installed it will indicate an error condition by flashing its indicator lamp.

EQ Voltage

This control sets the termination voltage for battery equalization cycle.

Temp

The optimum voltage for the various charging stages is temperature dependent. As temperature decreases the proper voltages for each charge stage need to be increased. All charge voltage settings can be rescaled for ambient temperature. Adjustment is made by simply setting the TEMP control to the temperature of the environment where the batteries are stored. For the technically minded, the compensation slope based on cell voltage is -2.17 mv per degree F. per cell.

The front panel markings for BULK V , FLOAT V and EQ V points will correspond to the actual control voltages **only** when the TEMP control is set at 60^0 F. When the TEMP control is varied from the 60^0F. norm, the temperature compensation circuitry automatically rescales the control voltage points, and the front panel settings no longer reflect the actual voltages used by the charger to progress through its charge stages. The actual control voltage can be read (in cell voltage) at the TEST POINTS.

For example: with a 12 VDC inverter, if the FLOAT V is set at 13.2 VDC and the TEMP is set to 40 degrees, the actual float voltage will be 13.46 F. This is derived as follows: 13.2 + 6 [(-20) X (-.00217)].

Charge Indicator LED's

Three LED indicators are located on the front panel for monitoring battery charger status.

- **Yellow LED** - Located above the BULK V control, this LED indicates that the charger is on. If no other battery charger LED's are lit, it also indicates that the charger is in the Bulk Charge Stage.

- **Green LED** - Located above the FLOAT V control, this LED indicates that the charger is in the Float Stage.

- **Red LED** - Located above the EQ V control, this LED indicates that the charger is in the Equalize Stage.

Test Points

Access to three test points and one ground point are provided on the front panel. These may be used with an accurate voltmeter for precisely setting the float, bulk and equalize voltages. The test points are located below their respective voltage controls.

To use the test points, the ground/negative/black voltmeter probe is placed at the ground point and the positive/red probe is placed at the position for the desired voltage. Readings at these points are in cell voltage and include the effects of the temperature compensation circuit. They will correspond to the dial scale only when the TEMP control is set at 60^0F.

Theory of Operation

The battery charger in standby models normally charges in three stages - bulk, absorption and float - to provide rapid and complete charge cycles without undue battery gassing. A manually operated equalize stage is provided for periodic battery maintenance.

Stage One - Constant Current/Bulk Charge

This stage is initiated in two ways:

- When AC is applied to the AC input of the inverter.
- When the battery voltage is less than the float voltage by at least .040 volts times the number of cells. In a 12 VDC system this is .240 volts.

Example: With FOAT V set to 13.2 and TEMP set to 60^0F., a 12 volt inverter will shift from Float to Bulk stage at 12.96 volts.

Stage one charges the batteries at a constant current. The level of charge for this phase is set using the MAX CHG AMPS control on the front panel. The constant current phase is terminated when the batteries reach the bulk charge voltage. During this stage only the yellow LED is lit.

Installation of the Fan Cooling Option (ACTC) is recommended if the charger is to be used at settings above 70% of maximum charge rate capability for extended periods of time. High charge rates may cause sufficient temperature increases to activate the thermal protection circuitry. This will shut the charger off until it has cooled, at which time it will automatically restart. The technical section of this manual provides a graph showing charge rate verses time.

Caution: Do not charge your batteries at higher voltages and/or currents than their manufacturers recommend. This is a very powerful charger. If used incorrectly it may damage your batteries.

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 (234V AC power has a peak voltage of 330).

It takes a powerful AC generator set to maintain the full 164 volt peak while delivering the current necessary to operate the charger at its maximum rate (typically 6kw). Smaller generators will have the tops of their wave form 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.

Stage Two - Constant Voltage/Absorption

Absorption is initiated when the Bulk Voltage setting is reached. At this point the charge current begins to taper off at whatever rate is required to hold the voltage constant. Only the yellow LED is lit during this stage . 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 RETURN AMPS setting, the voltage is allowed to fall to the FLOAT V (float voltage) setting - 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. An adjustable 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 RETURNS AMPS setting before the TIMER HOURS setting is reached..

Stage Three - Float Voltage

The purpose of stage three is to maintain the batteries at a voltage that will not gas the batteries. The charger remains in the float stage until either the charger is turned off or the battery voltage falls below the float voltage. During this stage the yellow and green LED's are lit.

Note: If sufficient DC loads are placed on the battery, the charger will deliver currents up to the Max Charge setting while maintaining the float voltage.

Equalization Stage

Periodically it is advantageous to charge the batteries to a voltage high enough to gas the batteries. This removes the lead sulfate from the plates and stirs up the electrolyte that tends to stratify during normal operation. The equalize stage is initiated manually by pressing the EQ button on the front panel. During this stage the yellow and red LED's are lit. When the battery voltage reaches the Bulk Charge Voltage, the timer protection circuit is engaged. The EQ stage is terminated in one of three ways.

- The batteries reaches the EQ Voltage setting as determined by the front panel control.

- The battery voltage has been above the Bulk Charge Voltage for a period of time equal to the time as set on the front panel TIMER HOURS control.

- Pressing the EQ START control.

The battery voltage will rise higher than the high battery protection threshold during equalization. This will light the high battery protection LED. It is not harmful to the inverter. The high battery protection inhibits the output of the inverter (not the charger) to eliminate the possibility of damage to AC loads if the inverter were operated at very high battery voltages. If the optional RC/2 remote control is installed it will indicate an error by flashing its indicator LED.

Batteries

Batteries come in different sizes, types, amp hours, voltages and chemistries. There are nearly as many descriptions of exactly how batteries should be charged as there are people willing to offer explanations. 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 far better maintained than the majority.

During equalization the battery voltage will rise above the inverter's high battery protection threshold. This will light the high battery protection LED. This will not harm the inverter. It only prohibits the inverter (not the charger) from operating at battery voltages that could be harmful to AC loads. If the RC/2 remote control is being used, its light will blink indicating an error condition.

Selection of Battery Type

Car Batteries

These are designed for high cranking power, but not deep cycling. Don't use them. It does not hurt the inverter - they simply will not last long in a deep cycle application. The way they are rated should give you a good indication of their intended use. "Cold Cranking Amps" is a measure of the amperage output that can be sustained for 30 seconds.

Telephone Company Batteries

Second-hand telephone batteries are oftentimes available at far below original cost. They are sometimes used in remote homes successfully. Typically lead calcium in design - therefore, should not be cycled such that less than 80% of their amp/hr rating remains before recharging. Keep this in mind when evaluating their amp/hr to cost ratio.

Deep Cycle Batteries

This is the type of battery best suited for use with inverters. They are designed to have the majority of their capacity used before being recharged. They are available in many sizes and types.

- Non-Sealed Batteries

  Non-sealed types have battery caps. The caps are removed periodically to check the level of electrolyte. When it is low, distilled water is added.

  The most common and inexpensive of this type is the "golf cart" battery. It is a 6 volt design typically rated at 220 amp/hr, and cost about $70-$80.

  Many systems use Trojan L16's. These are 350 amp/hr, 6 volts, and distributed by Interstate Batteries at a list of about $185. They are 17 inches in height which may be troublesome in RV or marine installations.

  8D batteries are available with either cranking or deep cycle construction. Since they are most commonly used to start truck engines, you should make sure you purchase the deep cycle version. Rolls and Surette make a very rugged but expensive 8D (800 deep cycles claimed). The 8D is typically rated at 220 amp/hrs at 12 volts.

  If battery requirements are large, industrial grade 2 volt batteries are suitable. This is the type of battery used in fork lifts and submarines.

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 which allows the batteries to be mounted in any position. The advantages are no maintenance, long life (800 cycles claimed) and low self discharge. The disadvantage is high initial cost. Typically $450 to $500 for an 8D.

While there are many manufactures of quality non-sealed batteries, there are only a few manufactures of gel cells. Sonnenschein, marketed as Prevailer, and the Dynasty by Johnson Controls are two.

NiCad

This charger is optimized for use with lead acid batteries and will **not** perform satifactorally with NiCad batteries.

Maintenance

If you have read the section "Theory of Operation", you already have a good idea of the stages of battery charging that combine to promote fast charging and ensure long battery life. Basically, there are four charger related considerations to properly care for your batteries.

- **Charge Rate** - The maximum safe charge rate is related to the size of your batteries. The battery bank capacity in amp/hours divided by 5 is appropriate for non-sealed batteries. Some gel cells can be charged at a rate as high as amp/hours divided by 3. Use the MAX CHG AMPS control to make this setting.

- **Charge Voltage** - The normal range based on cell voltage is 2.367 to 2.4 VDC. For a 12 VDC battery this is 14.2 to 14.4 VDC. Sealed batteries are usually set to the higher figure, while non-sealed batteries are set to the lower. Use the BULK V control.

- **Float Voltage** - The batteries experience less gassing if they are maintained at a lower voltage than the voltage level at which they are charged. Both sealed and non-sealed batteries can be set to a float charge of 2.2 VDC per cell. This is 13.2 for a 12 VDC battery. Use the FLOAT V control.

- **Equalization (Non-Sealed Batteries Only)** - Every month or two batteries may need to be "equalized." (A fancy term for over-charged.) Since the individual battery cells are not exactly identical, some may still have sulfate on their plates after a complete charge cycle. Or, if the batteries never receive a full charge, all plates will have sulfate left on them. If the sulfate remains on the plates for an extended period of time, it will harden and seal off a percentage of the plate area, reducing the capacity of the battery. By equalizing the batteries, all the sulfate is removed from the plates. Additionally, the gassing that results stirs up the electrolyte which tends to stratify. Stratification concentrates the sulfuric acid in the bottom of the cell while the top becomes watery. This corrodes the plates. To start the Equalization cycle simply press the EQ control. Caution: DC loads should be disconnected before equalization to protect appliances from high battery voltage.

- **Temperature Compensation** - Temperature affects the optimum voltage values for the different charge stages. The TEMP control can be used to fine tune these voltages. Set it to the average ambient temperature that the batteries experience. Typically this control will be set seasonally.

Note that voltage settings on the dials will correspond to actual control voltages used by the charger only when the TEMP dial is set to 60^{0}F. Adjusting the TEMP dial rescales all control voltages.

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/hrs are known, size the batteries at approximately twice this amount. Doubling the expected amp/hr usage ensures that the batteries will not be overly discharged.

To compute total amp/hrs usage, the amp/hr requirements of each appliance that is to be used are determined and then added together. *Table 1* in the tables section, page 45, 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 X 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/hrs. 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 often marked with their starting current rather than their running 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 4.

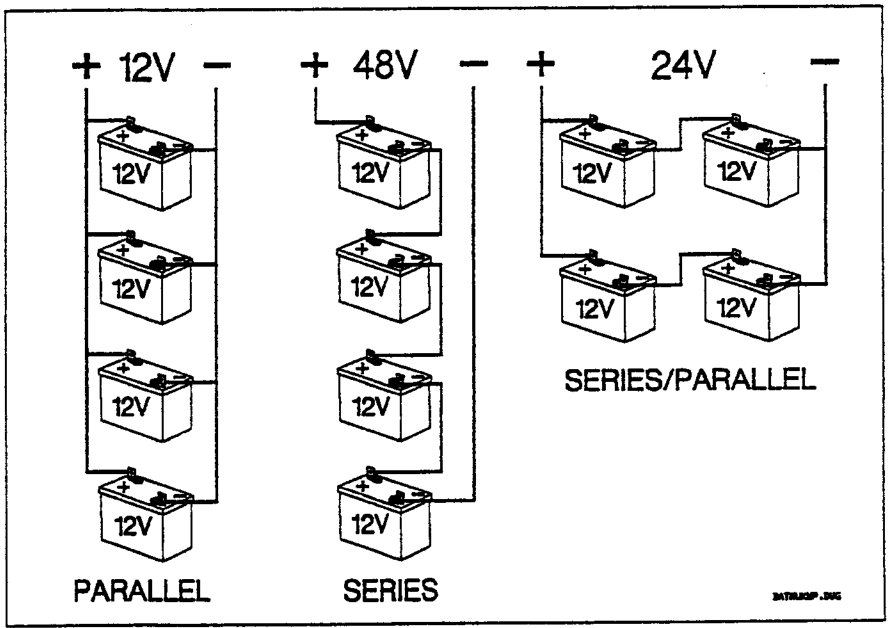


Figure 4, Connecting Multiple Batteries

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 device. There are nearly 50,000 silicon junctions in its output devices and integrated circuits. The crystal oscillator runs at 4 megahertz. The drive circuitry timing is accurate to a thoousandth of a second. Genetically speaking, it is a cousin to stereo equipment, television sets or computers. Steps have been taken to improve tolerance to hostile environments. Circuit boards are covered with a protective coating. All electro-mechanical connections use special non-oxidizing compound. Metal components are plated and fasteners are stainless steel. 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.

It is in your best interests to install the inverter in a dry, protected location away form sources of high temperature.

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 the relay in the standby model.

Do not mount the inverter in a closed container. To operate at high power for sustained periods of time, unrestricted air flow is required to cool the heat sink. Without it, the protection circuitry will activate thus reducing the power available.

The inverter may be mounted on a vertical or horizontal surface, in any orientation using the four grommeted holes on the bottom flanges. However, the best continuous power performance will be attained by mounting it on a shelf with its heat sink near the edge.

In RV and marine 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 Connections

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

A five station external terminal block is provided to make the AC connections. The terminal block is located on the right-hand side of the inverter. A cover box for the terminal block is shipped separately in the shipping box. On standard models, the terminal block is used only for hardwiring the inverter's AC output. With the standby option, the terminal strip is also used to hardwire the AC input. Consult your local code for proper wire sizes, connectors, conduit, etc. For 120 VAC units, we recommend 12 gauge for the standard model and 10 gauge for units with the standby option. For 220-240 VAC units, 14 gauge and 10 gauge are recommend. *Table 2* in the tables section gives conversions from U.S. to metric wire sizes.

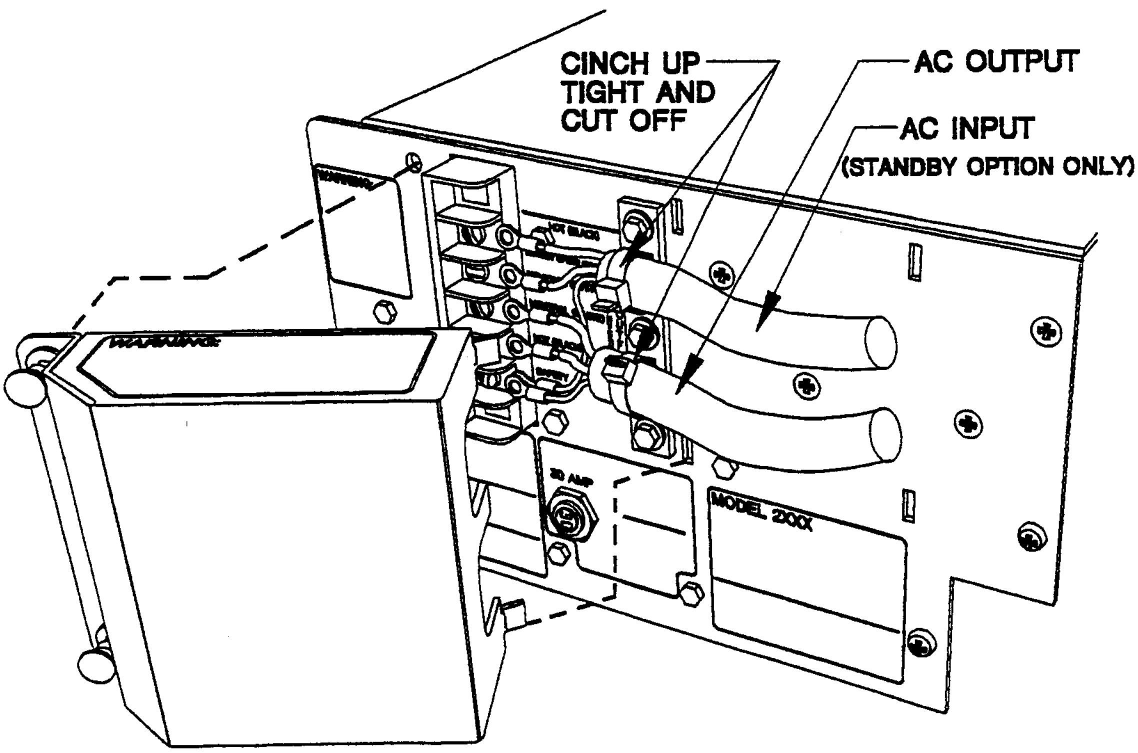


Figure 5, Hardwire Terminal

Disconnect the inverter from the battery. Crimp and solder the spade terminals supplied to the AC leads. Feed the wires thru the wire ties on the side of the inverter. See *Figure 5*. Following the wiring guide on the side of the chassis, connect the hot(black), neutral (white) and safety (green) wires to the terminal block and tighten securely. Tighten the wire ties by pulling on their ends until the loop fits snugly about the wires. Trim the end(s) of the wire tie(s). The cover box for the terminal strip has two tabs that face to the back of the inverter. Insert these tabs into the rectangular slots on the inverter's side and press on the plastic fasteners to lock the cover in place.

Note that chassis ground is connected to battery negative. This is a negative ground system. Do not use this inverter in a positive ground system.

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.

On standby models the installation should ensure that the inverter's AC output is, at no time, connected to its AC input.

Review the installation diagrams included before you start making connections.

Battery Connections

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 it's **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 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.

Coe your battery cables with colored tape or heat shrink tubing. Cable ends musthave crimped and soldered copper ring terminals.

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.

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

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

Battery Cable Sizing

Battery cables cannot be too large. 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 of Minimum Recommended Battery Cable Size
Cable Length

Model	Under 5 ft	5 to 10 ft	10 to 20 ft
2012	00	0000	0000
2524	0	00	0000
2232	1	0	000
2236	2	0	00
2248	4	1	0

DC Overcurrent Protection and Disconnects

Trace inverter's sophisticated internal overcurrent protection circuitry will not protect against external DC faults. Therefore, we recommend that protection be provided in the DC positive line between the inverter and the battery. Listed are three methods that will protect the DC cables and provide a means of disconnecting the battery. The device(s) used should be as close to the battery as practical.

1 - Minimum 250 amp rated knife switch with series wired fuse sized as follows:

12 Volt	FRN-R-250 to 350	36 Volt	FRN-R-80 to 100
24 Volt	FRN-R-150 to 200	48 Volt	FRN-R-60 to 75
32 Volt	FRN-R100 to 125		

2 - Enclosed safety switch with built in fuse sized as in (1) above.

SF400-T Ananda Power Technologies, Inc.
14618 Tyler Foote Road #143 Nevada City, Ca 95959
Tel 916 292-3834 Fax 916 292-3330

3 - DC rated circuit breaker sized as follows:

12 Volt "ITE" FD62B225 "Heinemann Series GJ" 250 amp curve 3
24 Volt "ITE" FD62B150 "Heinemann Series GJ" 150 amp curve 3
32 Volt "ITE" ED21B100 "Heinemann Series GJ" 100 amp curve 3
36 Volt "ITE" ED21B080 "Heinemann Series GJ" 100 amp curve 3
48 Volt "ITE" ED21B070 "Heinemann Series GJ" 100 amp curve 3

If you cannot locate these devices at a local electrical supply house, contact:

Industrial Controls Supply Co.
22410-70th Ave West Unit 6
Mountlake Terrace, Wa 98043
Tel 206 771-6344 Fax 206 775-8901

Installation Diagrams

A. Installation Using Plugs

Figure 9 shows a simple and fool-proof installation. This would typically be used in an RV that presently has a power cord that plugs into the shore power or the generator.

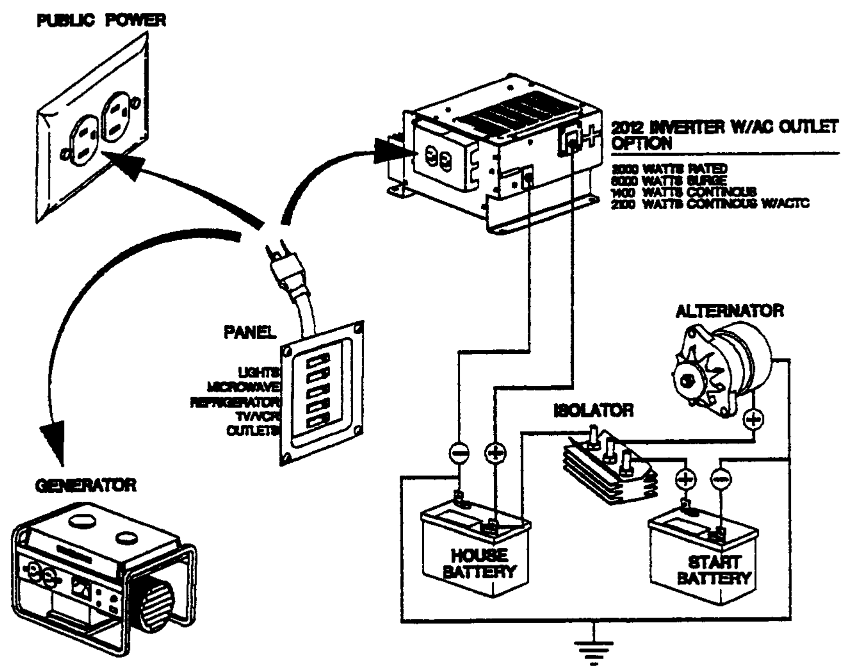


Figure 6, Installation Using Plug-In

The power from the generator is terminated in a junction box with an AC receptacle. Similarly, the power from the inverter is terminated in a junction box (figure 6 show an inverter with the optional AC outlet cover). The shore power plug is simply plugged into the appropriate outlet.

B. Standby Inverter 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:

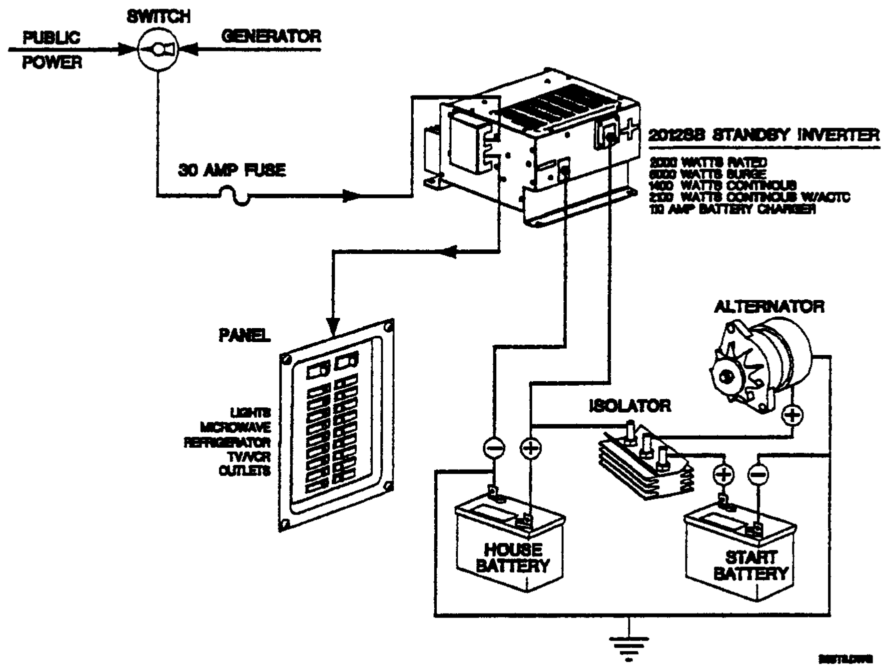


Figure 7, Standby Inverter without Sub-Panel

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 30 amp AC input breaker. Of this 30 amps as much as 20 may be consumed by the battery charger if it is charging heavily. This would leave only 10 amps available for external loads.

The above configuration is acceptable, <u>but not recommended</u>. Diagram "C" is preferable in that it isolates the inverter from inappropriate loads.

C. Standby Inverter with Two AC Panels

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.

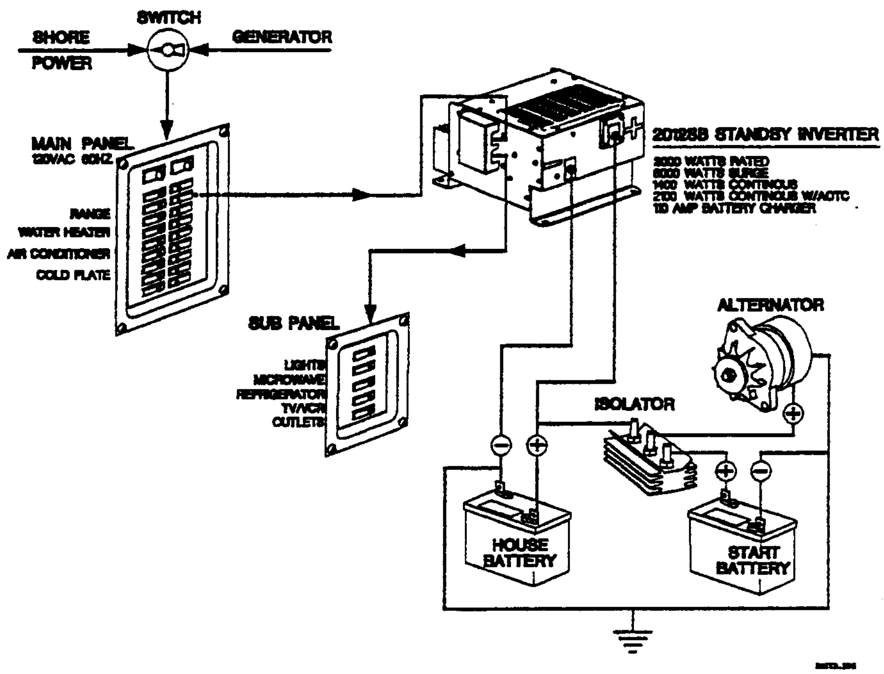


Figure 8, Standby Inverter with AC Sub-Panel

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.

The maximum current that can be used by the combination of sub-panel and battery charger is 30 amps. Of this 30 amps as much as 20 may be consumed by the battery charger if it is charging heavily. This would leave only 10 amps available for loads in the sub panel.

D. Standby Inverter with Two AC Panels and Solar Array

This installation is similar to Figure 7 on the previous page except that a solar array and wind generator are included.

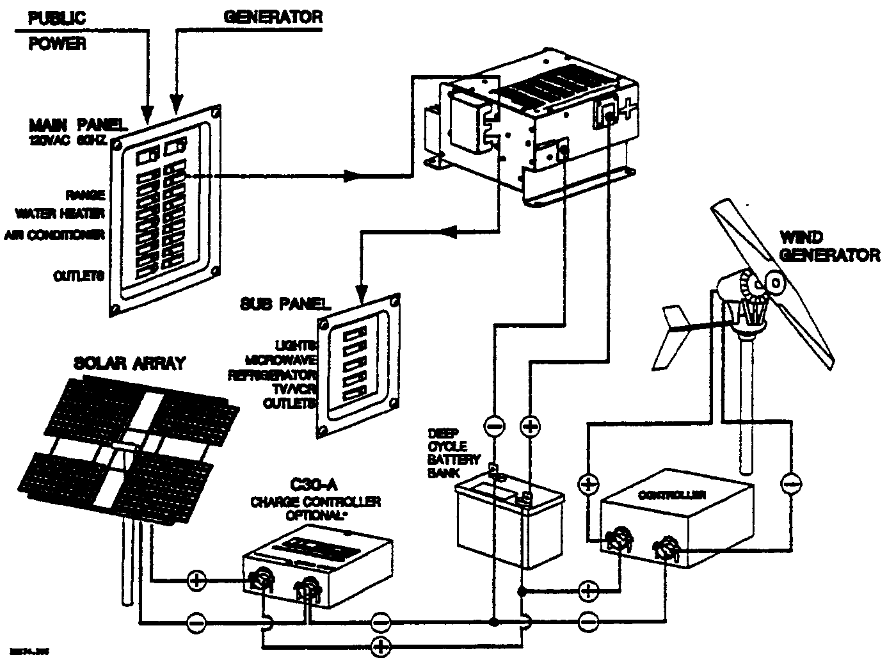


Figure 9, Standby Unit with AC Sub-panel and Solar Panels

E. Inverter with Single AC Panel and External Relay

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. The diagram below is simple, automatic and meets this requirement. Keep in mind that with only one AC panel encompassing all loads, the inverter could be connected to loads which are greater that it can run. For this reason, it is an acceptable, but not a recommended configuration.

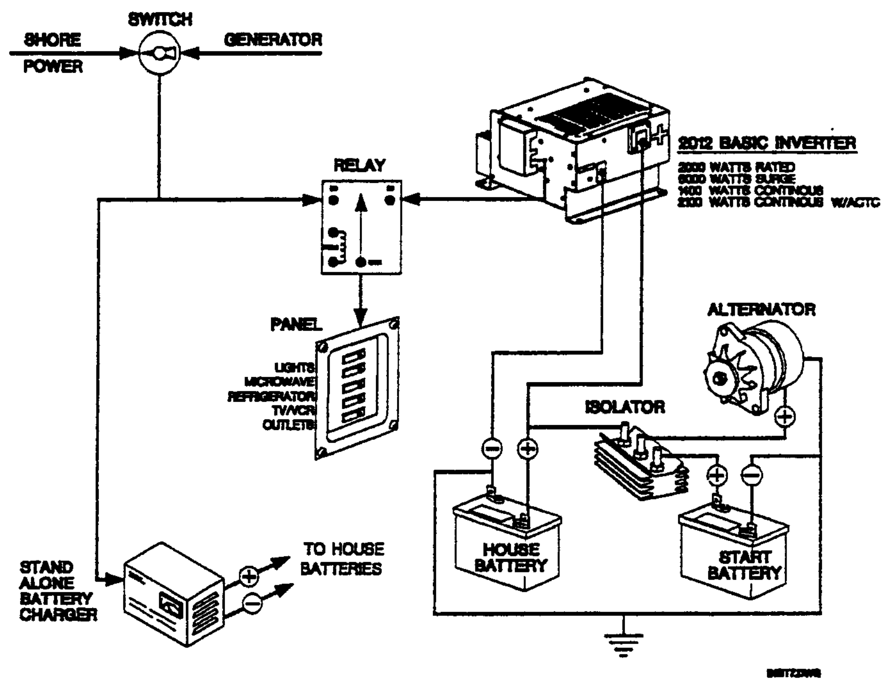


Figure 10, Single AC Panel with Exteral Relay

F. Inverter with Two AC Panels and External Relay

This is the recommended configuration for installing an inverter without the built-in battery charger. It operates in the following manner. When there is power available at the main panel, the 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.

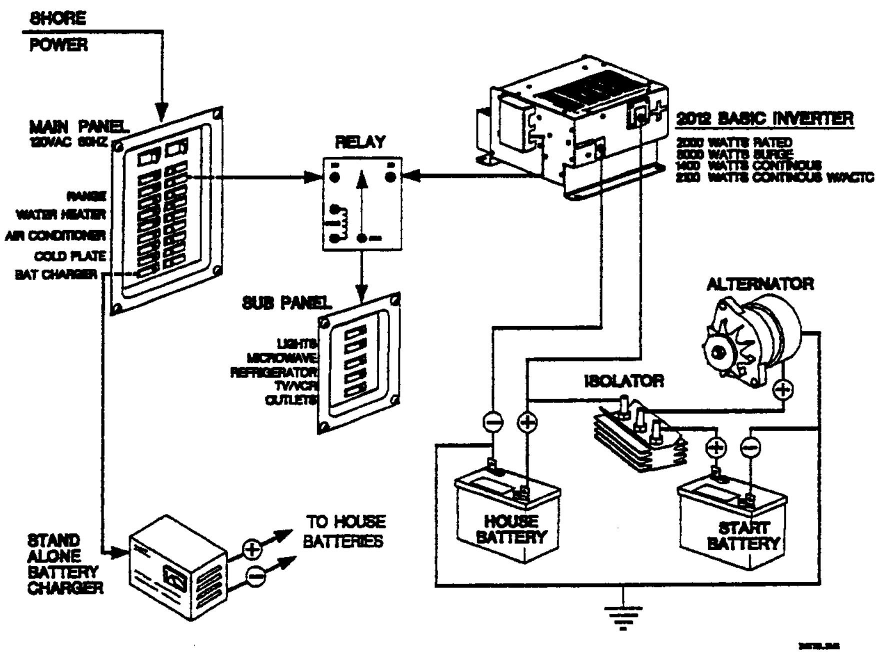


Figure 11, Sub-Panel with External Relay

This installation automatically ensures that public or generator AC power is never routed to the output of the inverter. This setup also ensures that the inverter will only be connected to appropriately sized loads.

G. External Transfer Relay Details

Using a transfer relay allows the AC panel to be automatically connected to the output of the inverter or the generator.

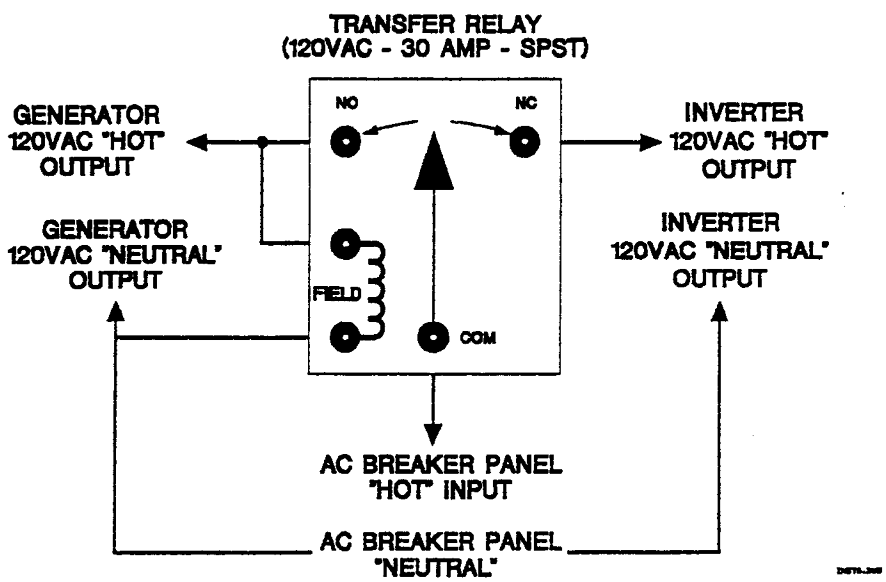


Figure 12, External Transfer Relay

The proper relay to use is described as single pole - double throw - 30 amp - 117 VAC. These relays are commonly available at electrical supply outlets for a cost of about $14.00. Pre-wired relays enclosed in electrical panel boxes are also available thru system suppliers. These range in price from $75 to $250.

H. Standby Inverter with External Relay

This configuration may be desirable when the amount of power available from the generator is greater than the 30 amp rating of the inverter's internal relay.

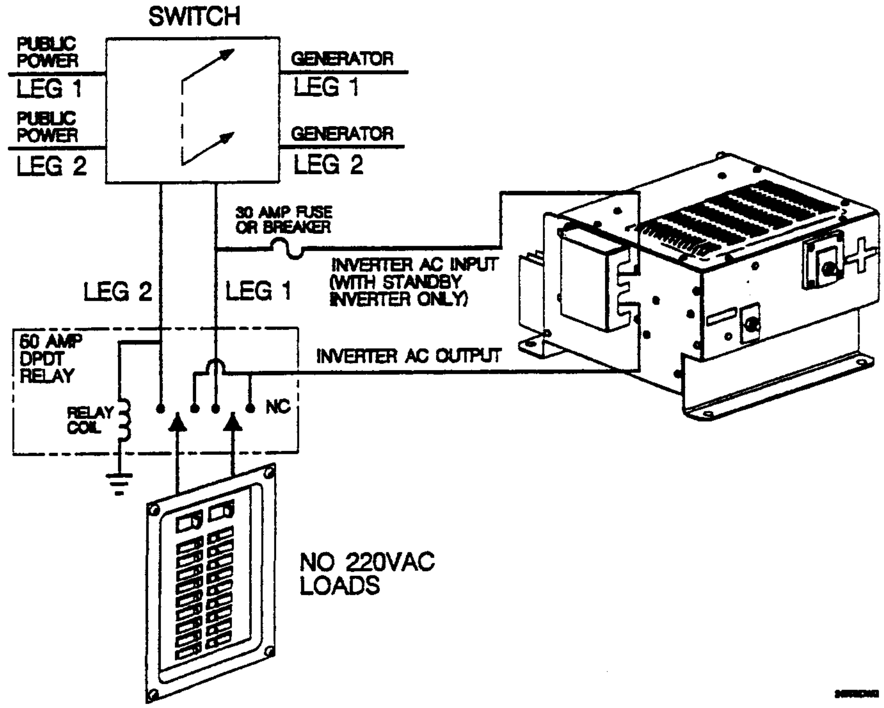


Figure 13, Generator with External Relay

When the AC panel is being run by the generator, leg 1 and leg 2 of the generator are connected independently to the two halves of the AC panel. When the inverter is operating, both sides of the AC panel are automatically connected together.

Do not use this system if there are 220 VAC loads

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. The return current of an inductive load is making its second pass thru the inverter. Whenever current is run thru transformers and semiconductors, some is wasted as heat. Therefore, inductive loads are run less efficiently.

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, eg. compressors and pumps. The largest motor of this type that the inverter will run varies from 1/3 to 3/4 hp. 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. Universal motors are generally easier to start. The inverter may start up to 2.5 hp universal motors. 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 20 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 called "Search Mode Control" for ways to solve this problem.

- **Florescent 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 programed to remain at full output voltage. See the section "Using the Programing Switches".

- **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. Since this cycling happens quickly it can be mistaken for a problem with the inverter.

Medical Equipment

Trace Engineering inverters were not designed to power either life supporting or life saving equipment. Do so only at your own risk.

Technical Information

Design Goals

To achieve high efficiency levels, the inverter design must attack power transfer losses from multiple sources.

<u>**Efficiency**</u>

The primary types of power transfer losses must be minimized in order to run efficiently.

- **Transformer Loss-** Transformer design and construction have a considerable effect on inverter efficiency. The characteristics that make a transformer efficient at high power make it inefficient at low power. Trace transformer designs favor high power efficiency, and use sophisticated search mode circuitry to maintain efficiency at low power. Special winding techniques - previously used only in very high power equipment - are employed to further enhance high power performance.

- **Transistor Loss** - The FET's (field effect transistors) used in the output stage act like resistors. The more FET's that are put in parallel, the lower their effective resistance. The lower the resistance, the lower the losses. Trace 2000 series inverters use 36 power FET's in their output stage - about double the number used in competing products. The signal that is used to turn them on and off is important to efficiency as well as reliability. The FET's should be driven on and off very quickly with the proper voltage to optimize their characteristics. A regulated switching power supply is dedicated to the output stage for this purpose.

- **Connector Loss-** All connections are tin plated copper to copper with a one square inch surface area. All primary currents are carried in copper bus bars to minimize losses and corrosion problems.

- **Reactive Loads** - These loads present special requirements to an inverter. The current flow is out of phase with its voltage waveform. The trailing current waveform must be properly handled or the performance of the inverter will be seriously degraded. Trace's **"impulse phase correction"** circuitry returns most of this current back to the load where it does useful work.

<u>**High Power**</u>

The ingredients for high power are a subset of those for high efficiency. High power is high efficiency at high current. Attaining maximum performance requires protection circuitry that allows full use of the FET's safe operating area. To do this, the control circuitry monitors temperature, current and time. The transformer's low DC resistance, the low "on" resistance of the FET's, and the smart protection circuitry combine to generate substantial power from the Series 2000's small package.

In order to run loads that require more start power than run power, the inverter must be able to deliver power well beyond its continuous rating for a short period of time. This is the so-called "surge power". Its value is often determined by a company's marketing department. This is partly because there are no standards for surge power, and partly because it cannot be represented by a simple or single number. Trace 2000 series inverters can start any load that is on the edge of their time versus power envelope. Which is to say, it will start anything that it can run for at least a few minutes.

Reliability

Achieving reliability requires synthesizing a carefully controlled drive circuit design, extensive protection circuitry and sound construction techniques. A description of the drive circuit design is beyond the scope of this manual, but has been touched upon in the above discussion of efficiency.

Trace protection circuitry monitors the following conditions: low battery, high battery, short circuit, over current, reverse output voltage and temperature. Low battery voltage is not harmful to the inverter but could damage the batteries. High battery voltage is not harmful to the inverter either, but would result in high peak output voltages which could damage electronic equipment if the inverter did not automatically shut down. Over current protection is triggered when load demands exceed the safe operating area of the transistors. Reverse output voltage protection guards the unit from accidental connection of the inverter output to public power. Limited lightning protection is supplied by surge protection devices in the secondary.

Temperature protection is provided by solid state temperature sensors located on the heat sink and transformer. The power that a semiconductor can deliver is in part dependent upon its temperature. Therefore, the protection scheme adjusts the protection parameters linearly according to temperature. This utilizes the full capability of the FET's. If either sensor exceeds a threshold (heatsink-80 deg.C, transformer-110 deg.C) the inverter shuts down.

Trace construction methods employ Motorola's "tight packaging technique". This refers not to the size of the unit, but rather the concept of keeping all drive signal paths as short as possible. Consistent performance and superior reliability are assured by minimizing the use of wires and locating nearly all circuitry contained on one double -sided, thru-hole plated printed circuit board.

MODEL 2012 SPECIFICATIONS - US 60 hz

Rated Power @ 20 deg.C	3000 watts for 10 minutes 2000 watts for 30 minutes 1400 watts continuous
Surge Power	6000 watts incandescent lights
Motor Starting Current	45 RMS amps with 12 VDC battery
Efficiency	Over 90% from 60 to 1400 watts
Input current	.028 amps / .33 watts in search mode .600 amps idling with search mode defeated 190 amps at rated power 950 amps short circuit
Load sensing (watts)	Adjustable from 5 to 80 watts, or defeated
Input voltage	10.8 to 15.2 to maintain regulated output voltage 8.8 to 10.8 non-regulated output voltage Below 8.8 -15.2 subject to inverter shutdown with auto reset
Output voltage regulation	120 VAC +/- 2 volts
Frequency regulation	Crystal controlled - +/- .04%
Power factor	All conditions allowed (-1 to 1)
Wave form	Modified sine wave, dynamic impulse phase correction for inductive loads
Reverse polarity	1800 amp maximum
Output protection	Passive and dynamic energy push back absorbers Transient/surge absorber
Protection circuitry (with auto reset)	
High battery	above 15.2V with (with auto reset) return below 14.8V
Low battery	below 9V for 3 sec.
Overcurrent	instantaneous limiting with linear temperature compensation
Environmental Characteristics	
Operating ambient temperature	0 C to +60 C
Non-operating ambient temperature	-55 C to +75 C
Altitude operating	to 15,000 ft.
Altitude non-operating	to 50,000 ft
Dimensions	Height 6.75", width 11.5", depth 12.5"
Weight	39 lbs.

MODEL 2012 SPECIFICATIONS - International 50 hz

Rated Power @ 20 deg.C	3000 watts for 8 minutes 1700 watts for 30 minutes 1200 watts continuous
Surge Power	5500 watts incandescent lights
Motor Starting Current	42 RMS amps with 12 VDC battery
Efficiency	Over 90% from 60 to 1300 watts
Input current	.028 amps / .33 watts in search mode .600 amps idling with search mode defeated 190 amps at rated power 950 amps short circuit
Load sensing (watts)	Adjustable from 5 to 80 watts, or defeated
Input voltage	10.8 to 15.2 to maintain regulated output voltage 8.8 to 10.8 non-regulated output voltage Below 8.8 -15.2 subject to inverter shutdown with auto reset
Output voltage regulation	230 VAC +/- 4 volts - Europe 240 VAC +/- 4 volts - Australia, UK
Frequency regulation	Crystal controlled - +/- .04%
Power factor	All conditions allowed (-1 to 1)
Wave form	Modified sine wave, dynamic impulse phase correction for inductive loads
Reverse polarity	1800 amp maximum
Output protection	Passive and dynamic energy push back absorbers Transient/surge absorber
Protection circuitry (with auto reset)	
High battery	above 15.2V with (with auto reset) return below 14.8V
Low battery	below 9V for 3 sec.
Overcurrent	instantaneous limiting with linear temperature compensation
Environmental Characteristics	
Operating ambient temperature	0 C to +60 C
Non-operating ambient temperature	-55 C to +75 C
Altitude operating	to 15,000 ft.
Altitude non-operating	to 50,000 ft
Dimensions	Height 6.75", width 11.5", depth 12.5"
Weight	39 lbs.

Standby Option Specifications (12 VDC Models)

Charge rates	Adjustable from 0 to 120 amps
Charge voltage	Adjustable from 14.1 to 14.7 VDC
Float Voltage	Adjustable from 12.9 to 13.5 VDC
Equalize Voltage	Adjustable from 15.5 to 16.1 VDC
Return amps	Adjustable from 0 to 20
Charge timer	Adjustable from 2 to 20 hours
Temperature compensation	Adjustable from 20 F. to 120 F. - -3.9 mv/deg. C
Transfer relay	1 hp 30 amp
AC input circuit breaker	30 amps
Power Consumption	.011 amps / .13 watts

Digital Volt Meter Option Specifications

Frequency	40 to 70 Hz +/- 3 digits
Battery Voltage	9 to 16 volts - +/- 3 digits
Peak Voltage	100 to 199 volts - +/- 2%
Charge Rate	0 to 20 amps - +/- 10%
	20 to 80 amps - +/- 5%
	80 to 120 amps - +/- 10%

All specifications subject to change without notice.

Options

The Series 2000 inverters are designed to accommodate a wide range of options. All, except the standby option , may be installed by the user. The standby option can only be retrofitted by the factory.

Standby option (SB) - Allows the inverter to operate as a multiple stage battery charger and includes an automatic transfer relay. Extensive controls allow the battery charger to be adjusted for specific requirements.

Digital Voltmeter (12DVM) - Reads peak AC input voltage, battery voltage, charge rate, and AC source frequency.

Remote Control (RC2000/12) - Provides a remote panel with an On/Off switch and digital voltmeter that reads the same functions as the DVM option. Status indicator lights show On/Off, search mode, error condition and AC present.

Remote Control (RC/2) - Provides an on/off switch and LED that indicates on, off, search mode and overload conditions.

Battery Protector (LBCO/12) - Monitors battery voltage and current being drawn by the inverter to determine if the inverter should be shut down to protect the batteries.

Stacking Interface (SI/B) - Allows two units to be connected in parallel for twice the power output.

Turbocharger (ACTC) - Temperature activated fan cooling kit that increases the continuous power rating by 400 watts. It is also useful if the inverter is installed in an area with restricted ventilation.

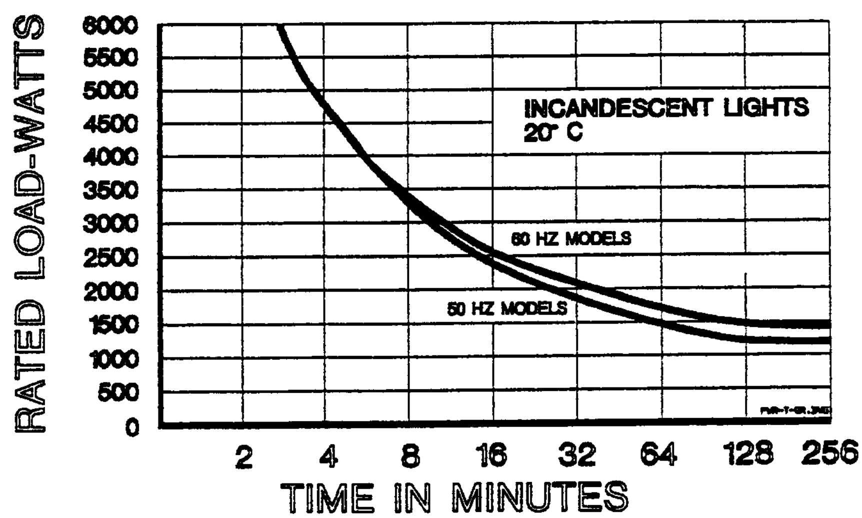
Battery Cables (BC5) & (BC10) - 4/0 flexible 4000 strand cables. Color coded with crimped and soldered copper terminals. Two 5 foot or two 10 foot lengths.

Note: When options are to be used with 220 to 240 volt models add a /E to the option designation. For example: ACTC/E.

Performance Graphs

Power vs. Time

Loads presented to the inverter are seldom constant. Turn on/Startup causes load surges, load coombinations to change as appliances come on and drop off. In order to provide maximum utility, TRACE inverters are allowed to operate beyond their continuous power ratings for limited time periods. The graph shows how loads that are larger than the inverter can sustain continuously, can still operate for useful time duration.



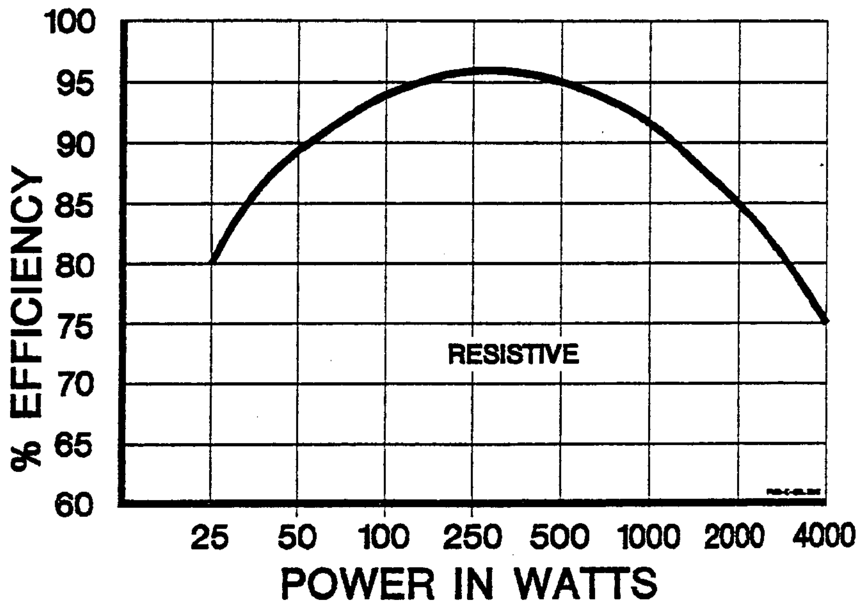
Graph 1, Power vs Time

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, than the inverter can dissipate, its ability to operate becomes time limited. The accompanying graph indicates how long the inverter can operate at different power levels.

This graph assumes an ambient operating temperature of 20^0 C and resistive loads. Inductive loads (motors, fluorescent lights) and/or elevated ambient temperatures will reduce the time that the inverter can operate at a particular power 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 efficiency losses.



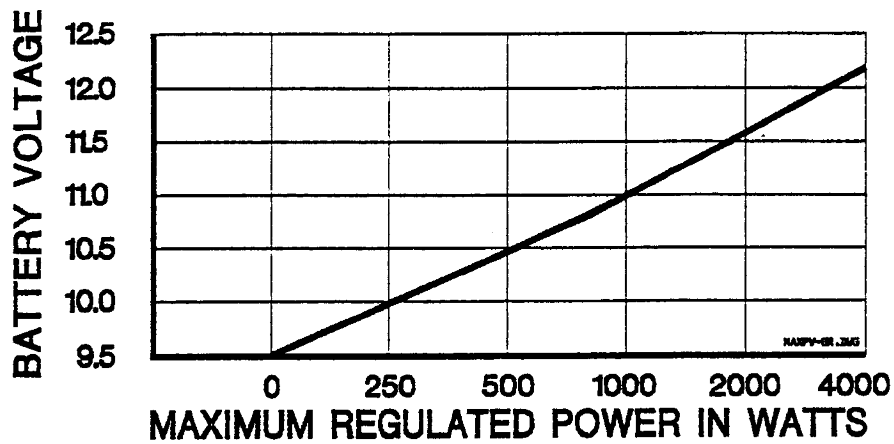
Graph 2, Power vs Efficiency

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 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..

Maximum 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 squarewave output. The area above the line represents regulated output. The area below the line shows unregulated operating conditions.

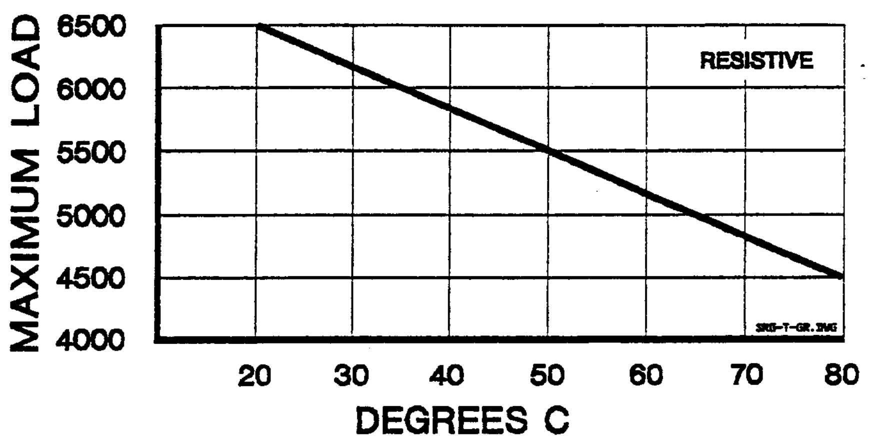


Graph 3, Battery Voltage vs Maximum Regulated Power

As the battery voltage is reduced, the maximum regulated power the inverter can produce decreases.

Maximum Load vs Temperature

The current protection circuit is temperature compensated, ie, the maximum sized load that the inverter can run changes with temperature. As the temperature of the power devices (FET's) increases, the maximum allowable current is reduced. When the available current is reduced, the maximum size load the inverter can run is reduced.

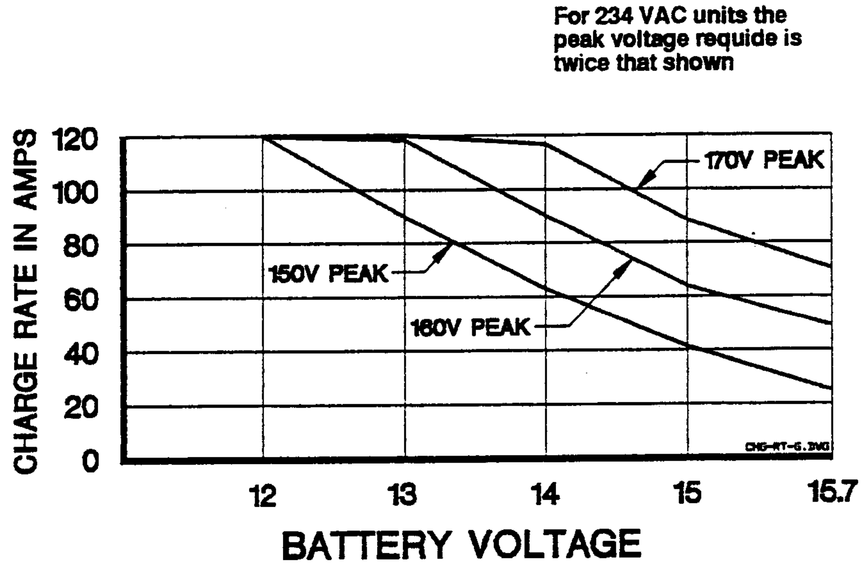


Graph 4, Maximum Load vs Temperature

The graph above shows the effect FET temperature has on maximum possible loads. While the graph shows loads up to 6000 watts, the inverter will run out of regulation well below this level. Included in the manual is a graph depicting maximum regulated power vs battery voltage.

Charge Rate vs Peak Input Voltage

The performance of the battery charger is dependent upon the peak voltage available. This graph demonstrates the effect that peak AC voltage has upon the inverter's maximum charge rate capabilities.



Graph 5, Charge Rate vs Peak AC Voltage

In order to meet its ratings, 164 peak volts are required. A battery charger uses only the top portion of the input sinewave. Therefore, small variations in peak voltage result in large variations in the amount of the waveform that the charger has to work with. Standard public power of 117V has a peak voltage of 164V.

TABLES

Table 1 - Watts out vs. Time vs. Battery Drain

Watts	Appliance	Time in Minutes: 5	15	30	60	120
30	Stereo	.3	.7	1.4	2.5	5.0
60	B&W TV	.5	1.4	2.7	5.4	9.1
100	Color TV	.8	2.7	4.5	9.1	18.1
200	Computer	1.5	4.5	9.0	18.1	36.3
400	Blender	3.0	9.0	18.1	36.3	72.5
800	Skil Saw	6.0	18.1	36.3	72.5	145.0
1000	Toaster	7.6	22.5	45.3	90.1	180.2
1200	Microwave	9.3	27.8	55.6	111.1	222.2
1800	Hot Plate	14.5	43.5	87.1	174.2	348.4
		Amp/Hours				

Notes:

If the current draw at 120 VAC is known, then the battery amperage at 12 VDC will be 10 times the AC amperage. For 240 VAC loads, the battery amperage will be 20 times the AC amperage.

Motors are often marked with their starting current rather than their running current.

Refrigerators and ice makers typically run about 1/3 of the time and draw about 3.0 amps at 120 VAC. Therefore, their average battery current draw is about 10 amps (3.0 X 10 X 1/3).

Table 2. U.S. (AWG) to Metric Wire Size Conversion

AGW	Diameter/mm	Area/mm^2
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

Limited Warranty

Trace Engineering Company warrants its power products against defects in material and workmanship for a period of two (2) years from date of purchase and extends this warrantyto all purchasers or owners of the product during the warranty period. Trace Engineering does not warrant its products against any and all defects: (1) Arising out of material or workmanship not provided or furnished 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 or 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 EXPRESS 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 (2) YEARS FROM THE DATE OF PURCHASE BY THE ORIGINAL RETAIL PURCHASER.

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

TO VALIDATE your warranty, the warranty card must be filled out and mailed to Trace Engineering within ten (10) days from the date of purchase. It is also advised that you 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 inquires made to Trace Engineering must include the model and serial number of the product in question. Be sure to fill in the model and serial number in the space provided below and keep this portion of the warranty card in a safe place for future reference.

WARRANTY SERVICE must be performed ONLY AT AN AUTHORIZED TRACE SERVICE CENTER, OR AT THE TRACE ENGINEERING FACTORY. It is recommended that advance notice be given to the repair facility 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 thru the mail. Be sure to include in the package:

1. Complete return shipping address (P.O. Box numbers are not acceptable) and telephone number where yoou can be reached during working 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, operation 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 number below and retain for your files:

TRACE ENGINEERING

Model ______________

Serial Number ______________

Date of purchase ______________

DETACH THIS PAGE AND MAIL TO TRACE ENGINEERING

Warranty Information

Model including options ______________________________

Serial Number ______________________________

Purchase Date ____________ Phone No ____________

Owner's Name ______________________________

Address ______________________________

City ______________ State _____ Zip ________

Where will the product be used?

- ☐ Primary home
- ☐ Cabin / Vacation Home
- ☐ Pleasure boat
- ☐ Commercial boat
- ☐ RV, motorhome, trailer
- ☐ General office
- ☐ Computer, telephone system
- ☐ Mobile equipment

Type of product use (check all that apply).

- ☐ Commercial power backup
- ☐ Altermative energy (solar, wind, water)
- ☐ Primary source of AC power

Where did you learn of Trace products?

- ☐ Magazine ad
- ☐ Magazine article
- ☐ Dealer
- ☐ Catalog
- ☐ Friend
- ☐ ______________

Comments about the product you purchased: ______________

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TRACE ENGINEERING 5916 - 195th Street N.E., Arlington, WA 98223 Phone: (360) 435-8826 Fax: (360) 435-2229

visit our website at: www.traceengineering.com