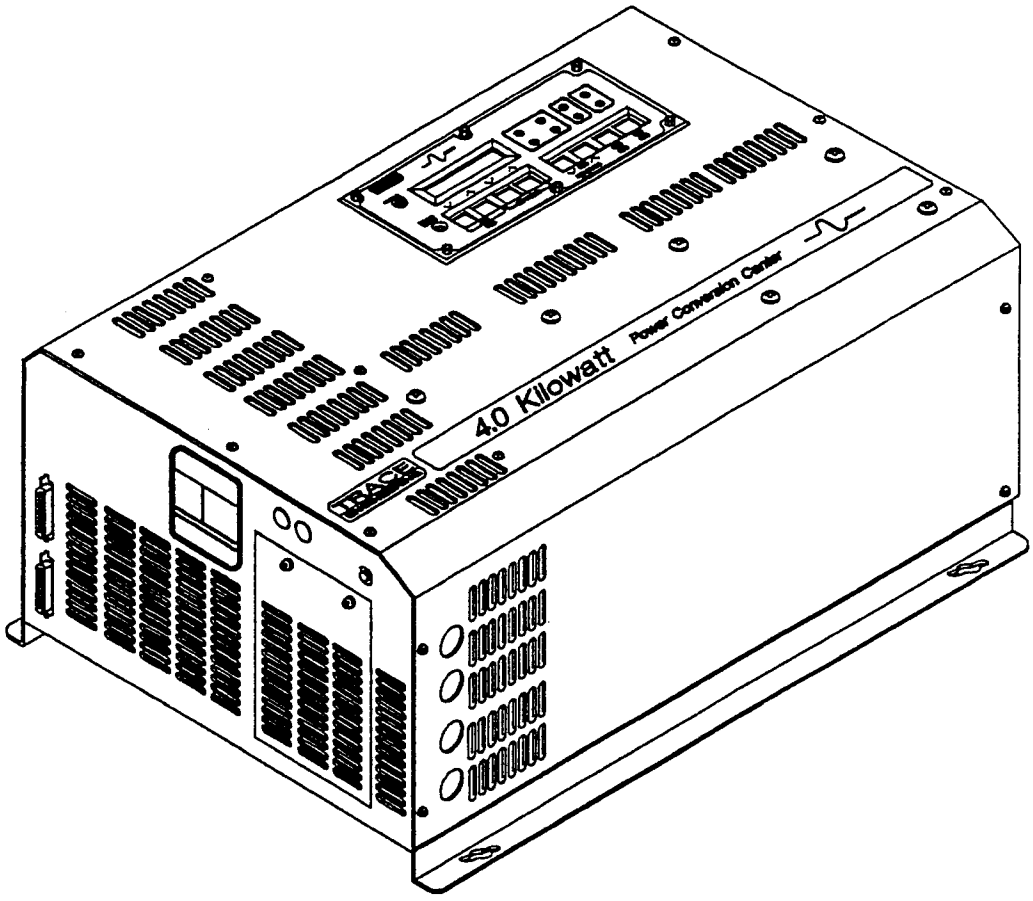
Owner's Manual

Version 2

SW4024
SW4048
Inverters



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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 residential applications. This manual covers Trace Engineering model numbers SW4024 and SW4048, sine-wave series for use in Residential and Commercial applications.

The Sinewave Series inverter is ETL listed to the general UL specification 1741, Power Conditioning Units for use in Residential Photovoltaic Power Systems.

General Precautions

1. Before using the inverter/charger, read all instructions and cautionary markings on (1) the inverter/charger and (2) the batteries.

2. CAUTION- To reduce risk of injury, charge only deep cycle lead acid, lead antimony, lead calcium and gel cell or nickel type rechargeable batteries. Other types of batteries may burst, causing personal injury and damage.

3. Do not expose inverter/charger to rain, snow or moisture of any type.

4. Do not disassemble the inverter/charger; 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.

5. To reduce risk of electric shock, disconnect all wiring before attempting any maintenance or cleaning. Turning off controls will not reduce this risk.

6. WARNING - WORKING IN VICINITY OF A LEAD ACID BATTERY IS DANGEROUS. BATTERIES GENERATE EXPLOSIVE GASES DURING NORMAL OPERATION. Provide ventilation to outdoors from the battery compartment.

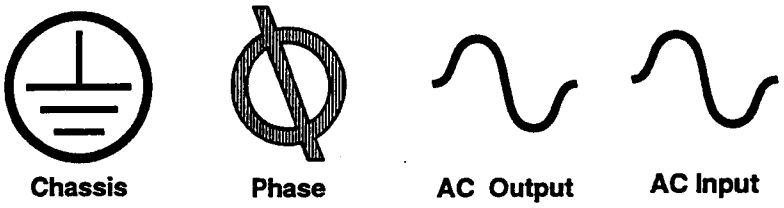
7. NEVER charge a frozen battery.

8. No terminals or lugs are required for hook-up of the AC wiring. AC wiring should be no less than 10 (AWG) gauge copper wire rate at 90 degree C. Battery cables must be rated for 105 degree Celsius and should be no less than 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.

9. Torque all AC wiring connections to 20 inch pounds. Torque all DC cable connections to 12 foot pounds.

   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 could cause an explosion.

10. Symbols used in this manual and on the inverter/charger are:



11. Tools required to make AC wiring connections: Wire strippers, 1/2" (13MM) open-end wrench or socket, Phillips screw driver #2, Slotted screw driver 1/4" (6MM) blade.

12. 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.. 24 volt with a SW4024.

13. Instructions for wall mounting: See mounting instruction section of this manual. **NOTE**: Do not use the keyhole mounting slots. For battery installation and maintenance: read the manufacturer's installation and maintenance instructions prior to operating.

14. 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.

15. No overcurrent 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.

16. 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.

17. GROUNDING INSTRUCTIONS - This battery charger should be connected to a grounded, metal, permanent wiring system. Connections to inverter 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. Baking soda neutralizes battery acid (lead acid batteries) also.

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.

Introduction

Congratulations! You are the proud owner of the finest inverter on the market today - and one very complex piece of equipment. The Trace Engineering Sine-wave inverter has many features and capabilities previously either non-existent, or found only in separate products.

With proper installation, the unit will typically work satisfactorily for stand-alone applications straight out of the box using factory settings. To fully utilize the unit's generator interactive, or utility interactive capabilities, it is necessary to understand the way the unit thinks and tailor operation via the user menu. This manual will provide the necessary information. However, it is recommended that you consult with your authorized dealer to ensure correct installation and maximum utilization of this product's numerous features. If you do not understand any aspect of installation and your authorized dealer/installer is not available, please contact Trace Engineering for assistance.

As a minimum, you should read the operation sections that relate to your type of installation. Then read the chapter on using the control menu. Focus on the menu items that relate to your type of installation and make the appropriate selections and adjustments. Installation diagrams are provided for various applications.

The Operation Characteristics chapter explains how the unit works in each of its different modes. The Control Panel chapter explains the user control menu. This menu enables features and adjusts operating parameters.

This is a long manual and much of it is fairly technical. If you are an insomniac, properly used, this manual is guaranteed to provide several good nights of sleep.

Overview

Operation Characteristics

The model SW4024 and model SW4048 Power Conversion Centers can operate in one or more of the following modes:

- Stand-alone 4KW sine wave inverter.
- 120 (60 amp model SW4048) amp, low current distortion battery charger.
- Inverter/charger with automatic transfer.
- UPS Standby with maximum 32 millisecond transfer time.
- Utility interactive wherein excess power is sold to the grid.
- Utility interactive wherein stored battery power is sold to the grid.
- Peak load shaving with onboard clock to set inverter operation times.
- Generator support - in which the inverter switches from charger mode - to assist the generator in starting large loads. Selectable generator support voltage and current threshold..

Numerous features are provided to enhance and customize the inverter's operation while in its different operational modes:

- Automatic generator start and stop.
- Three stage battery charging with adjustable charge parameters.
- Battery temperature sensor for scaling charge parameters to temperature changes.
- Adjustable sell back current for utility interactive mode.
- AC inputs for utility and generator sources with utility priority.
- Three independently set voltage controlled relays.

Inverter Mode

Waveform

The inverter makes a stepped approximation to a sine wave. The number of steps typically varies from 34 to 52 per cycle. Lower battery voltage and/or higher power increases the number of steps. Distortion varies from 3% to 5%. The minimum battery voltage at which the inverter will regulate at rated power is 22 VDC. The internal protection circuitry is set at 78 AC amps.

Search Mode Control

During inverter operation an adjustable search mode circuit is available. It minimizes power drain by reducing the inverter's output to pulses of a single cycle. The spacing of these pulses is a menu adjustable item. These pulses are used to detect the presence of a load. When a load is detected the inverter's output goes to full voltage. The sensitivity of the detection threshold, the spacing of the pulses and the delay time until search mode is resumed, are all adjustable.

The yellow inverter LED indicates inverter status.

- In search mode the LED blinks.
- In inverter mode with full output voltage the LED is solid.
- When the unit is in charger mode the LED is off.

Search Mode is activated by selection *AUTO* from the *ON/OFF MENU*. The ON/OFF MENU is accessed by pressing the ON/OFF *MENU* button.

Setting Search Mode Watts

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 in the search mode, the yellow inverter LED will blink and the inverter will make a ticking sound. At full output voltage, the yellow power 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 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 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. TVs with instant on circuits, microwave ovens with digital displays and VCRs are examples. These loads present a dilemma. If the sensitivity is set higher than the combination of these loads, then an auxiliary load must be used to bring the inverter out of the search mode before the appliances can be turned on. If the sensitivity is set lower than this combination of loads, the loads will be left on and will put an additional drain on the batteries. (Three such 15 watt loads would amount to an additional 45 amp/hours per 24 hours in a 24 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.

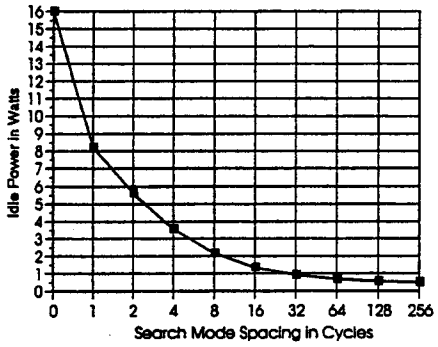


Figure 1, Search Spacing vs. Idle Power

Setting Search Mode Spacing

Search spacing is calibrated in cycles. Therefore, to test once each second, set *search spacing* to 60. To test for loads once each 1/2 second, set to 30. The available range is 3 to 255. While in search mode there is no voltage regulation.

Setting Search Off Delay

Search off delay determines the length of time that the inverter waits once it has detected no load before initiating search mode. The available range is 0 to 255. Calibration is in cycles. A setting of 240 gives a 4 second delay.

Low Battery Cut Out

The unit is provided with automatic shut down in the event of low battery. Both the current being drawn by the inverter and the battery voltage are monitored. 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 bat-

tery's state of charge. The Trace "current compensated" circuit uses information about the battery bank size and the load current to derive a corrected battery voltage. If the circuit determines that the battery condition is low, the inverter turns off after a 2 miniute delay. Three condition will return the unit to operation:

- Power is applied to the inverter AC input
- Unit is manually restarted.
- Battery voltage rises above the *SET LOW BATTERY CUT IN VDC* value.

Menu Adjustable Inverter Parameters

- *OFF SRCH ON CHG*
- *SEARCH WATTS*
- *SEARCH SPACING*
- *SEARCH OFF DELAY*
- *SET LOW BATTERY CUT OUT VDC*
- *SET LOW BATTERY CUT IN VDC*
- *SET LBCO AMP/VDC 100 200 400 800* - This setting asks "How many DC amps must your system deliver to cause a 1 VDC drop in the combination of batteries and cables?". The choice is between 100, 200, 400 and 800 amps. The factory default is 400.

Battery Charger Mode

AC Characteristics

The charger is a very powerful low current distortion design. Power is drawn over the full AC cycle. The result is little distortion of the AC waveform and good performance with low AC voltage and generators.

Charging Method

The charging cycle uses 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 at the bulk charge voltage. 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 (*BULK DONE AMPS AC*). At this point, the battery voltage is allowed to fall to the float voltage, where it is maintained until another charge cycle is initiated. A new charge cycle is initiated after AC failure and at the time set in the *BULK CHARGE TRIGGER TIMER* menu item.

As a safety feature, the bulk charge stage is timed. Should there be DC loads on the battery, the charge current during the bulk charge stage may not fall to a low enough level to initiate the change to float stage. This would cause undesirable gassing of the batteries. The max charge time parameter limits the amount of time that the charger will remain in bulk charge stage.

Charger Only Operation

When the On/Off menu is set to CHG the unit operates as a charger only. This is useful for unattended operation where power failure would drain the batteries.

Menu Adjustable Charger Parameters

- *OFF SRCH ON CHG* - menu heading
- *FLOAT VOLTAGE* - menu item
- *BULK CHARGE VOLTAGE* - menu item
- *SET MAX CHARGE AMPS AC* - this number is AC amps drawn by the charger when charging. (DC amps is approximately 5 times greater.)
- *BULK DONE AMPS AC* - menu item
- *MAX CHARGE TIME* - menu item

Inverter/Charger Mode

Operating Modes

There are two schemes available for determining when the unit transfers from inverter operation to charger operation and back.

Transfering Upon Availablity of AC Power

When AC power is supplied to either or both of the AC HOT IN 1 and AC HOT IN 2 inputs, the unit will automatically transfer from inverter mode to battery charger mode. Before transferring, the inverter checks to see if the AC input voltage is within tolerance. If AC voltage is acceptable, the inverter synchronizes its output to the AC source. The AC source is then connected directly to the inverter's AC output. There is no transfer time interruption.

This is the default mode and is set by selecting *FLT* (float) in the *GRID USAGE MENU.*

Transfering Based on Battery Voltage

If *LBX* (low battery transfer) is selected in the *GRID USAGE MENU,* the decision to transfer to and from charger mode will be based upon the battery voltage. With *LBX* enabled the *SET LOW BATTERY CUT IN VDC* and *SET LOW BATTERY TRANSFER VDC* determine the transfer voltages. At the transfer voltage, grid power is engaged and charging commences. At the cut in voltage, inverter operation resumes.

The battery voltage is current compensated so that large loads are less likely to falsely indicate low battery condition.

AC Input Connections

AC HOT IN 1 is the priority input. It is to be used with utility power. Frequency tolerance is 58.5 to 62 Hz. Transfer delay is 28 seconds. With *SELL* enabled transfer time is 90 seconds.

AC HOT IN 2 is for use with a generator. With this input there is a 30 second (default) delay before transfer. This delay gives the generator time to stabilize before being loaded. Frequency tolerance is 53 to 67 Hz

DO NOT connect AC 1 and AC 2 to a 240 VAC system. This will not work unless 2 (two) SW4024's are stacked in series.

Using Both Inputs

When both utility power and a generator are connected, the unit charges from AC HOT IN 1- the priority input. If utility power fails, the inverter supports the

load and the generator is instructed to start as required by battery voltage(see section on Automatic Generator Starting). The inverter synchronizes with the generator and then transfers output power to it. When utility power returns, the unit disconnects the generator (if it's still running), instructs it to turn off, synchronizes and reconnects to utility power.

Transfer Time

Normally there is no transfer time. However, if the utility fails instantaneously and in a shorted condition, the inverter will see an overload (since it is running everything that is connected to the grid). The unit turns off and waits for the relay to open. After the relay opens, operation resumes one cyle later. This requires a 32 milliseconds.

Menu Adjustable Inverter/Charger Parameters

- *GEN WARMUP DELAY TIME* - menu item

Generator Interactive Mode

In Brief

The factory default settings are configured to operate the unit as an inverter/charger connected to a generator. Factory default activates generator support when generator output exceeds 30 amps.

- Connect generator AC power out to the unit's AC HOT 2 input and NEUTRAL IN 2 terminals.
- Connect AC loads to the unit's AC HOT OUT and NEUTRAL OUT terminals.
- Set battery charger parameters (if the factory defaults listed in the technical section are not satisfactory).
- Set *GEN SIZE AMPS AC* located in the *AC INPUTS* menu heading, to that of the generator's AC breaker or output capability. This allows the generator overload and generator support features to function correctly.
- Set *GEN LOWER LIMIT VAC located in the AC INPUTS* menu heading, to the lowest voltage that the generator will be allowed to operate without automatic support from the inverter. Keep in mind that when the inverter supports the generator is uses power from the batteries. Therefore, the generator could be running and the batteries being discharged.
- Set *GEN UPPER LIMIT VAC located in the AC INPUTS* menu heading, to the highest voltage that the generator will be allowed to operate without being considered out of tolerance. At this voltage the unit will disconnect to protect AC loads.

Generator Overload Protection

The charger is very powerful and without limits could overload a small generator. Therefore, the charger has circuitry that will keep it from overloading its source of AC power. If AC charge current combined with load current exceed the settings in the *GEN SIZE AMPS AC* menu, the charge rate will be automatically reduced to keep currents from tripping the generator's breaker. In fact, if the load is large enough, the unit will stop charging completely and draw power from the batteries to support the load.

Generator Support

When the amount of amperage demanded by the AC loads is greater than the *GEN SIZE AMPS AC* setting, the inverter's power is added to that of the generator's. The unit attempts to hold the current drawn from the generator at the setting of the *GEN SIZE AMPS AC.* This allows the generator to start larger loads than it could normally.

Generator support is also available if AC voltage falls below the *SET GEN LOWER LIMIT VAC.* In this case the unit will assist the generator at the *SET GEN LOWER LIMIT VAC* voltage setting as long as there is power flowing from the generator to the load.

Automatic Generator Start and Stop

Extensive control of automatic generator operation is available thru the items under the menu headings ***GEN AUTO START SETUP, GEN STARTING DETAILS, GEN RUNNING DETAILS*** and ***GENERATOR TIMER.*** The generator can be set to start on low battery and/or AC high amps. A lock out period can be set that restricts the generator from starting during defined hours of the day. A "*Must Start Bat Volts*" parameter is available to override the lock-out time. Menu items are also provided to customize the start sequence.

Two types of relay actions are available:

- The terminals marked **RELAY 7 COIL** provide contacts that remain closed during generator run time.
- The terminals marked **RELAY 8 STARTER** provide contacts that remain closed only during generator starting.

Menu Adjustable Generator Interactive Parameters

- *GEN SIZE AMPS AC*
- *SET GEN LOWER LIMIT VAC*
- *SET GEN UPPER LIMIT VAC*

GEN AUTO START SETUP Menu Heading

- AUTO START LOAD AMPS - sets the load amps that when exceeded will start the generator.
- *AUTO START BAT VOLTS* - sets a battery voltage that will trigger generator start.
- *AUTO START DELAY MIN* - sets the length of time in minutes that the battery is allowed to be at or below the *AUTO START BAT VOLTS* or the load bigger than the *AUTOSTART LOAD AMPS* before initiating gen-start.
- *MUST START BAT VOLTS* - sets a battery voltage that will override *GENERATOR QUIET TIMER* settings and trigger generator start.

***GEN STARTING DETAILS* Menu Heading**

- *GEN WARM UP SECONDS* - sets the length of time after the generator starts that the charger waits before connecting to it.
- *MAX CRANKING SECONDS*
- *MAX STARTING ATTEMPTS* - sets the number of times the inverter will try to start the generator.

***GEN RUNNING DETAILS* Menu heading**

- *START RUN TIME* - Sets a time at which the generator will automatically start.
- *END RUN TIME* - Sets a time at which the generator will automatically stop.
- *START QUIET TIME* - Sets the beginning time for a period during which the generator is not allowed to run.
- *END QUIET TIME* - Sets the ending time for a period during which the generator is not allowed to run.

UPS Mode (uninterruptable power supply)

In Brief

With a 32 millisecond worst case transfer time, this unit makes an excellent UPS system for all but the most demanding applications. Computer magazines have demonstrated that 100 milliseconds is typically fast enough to hold up todays personal computers. With voltage or frequency irregularities, there is no transfer time.

- Connect utility AC power to the unit's AC HOT 1 input and NEUTRAL IN 1 terminals.
- Connect AC loads to the unit's AC HOT OUT and NEUTRAL OUT terminals.

- Set battery charger parameters if the factory defaults listed in the technical section are not satisfactory. For UPS applications, lower charge rates with their lower AC requirements may be desirable.
- Set *GRID SIZE AMPS AC* - located in the *AC INPUTS* menu heading - (See Line Support, below).

Line Support

In addition to fast transfer time, the unit will support grid in the event unintended loads threaten to trip the AC breaker. If the amount of power demanded by the AC loads is accidentally greater than the *GRID SIZE AMPS AC* setting, the inverter will contribute power to the system.

Line Conditioning

The inverter's output waveform is safe for running all equipment. No filtering or conditioning is required. The AC power that is passed thru the inverter is conditioned. The natural action of the unit when charging or maintaining batteries smooths the AC source's wave form. "Surge arrestors" are still useful for high frequency voltage spikes.

Using *SLT* Mode (Silent Mode)

In *SLT* mode the batteries are charged only once a day, at a time prescribed in the *BULK CHARGE TRIGGER TIMER* menu. During the rest of the day the charger is turned off. If the grid fails, the inverter runs. When power returns, the batteries will be re-charged. The advantage of *SLT* mode is silent operation. The disadvantage of *SLT* mode is that the units natural line conditioning capability is not available unless the unit is charging.

When using this mode, a time must be selected from the *BULK CHARGE TRIGGER TIMER* menu. If the timer is defeated by setting it to 00:00, no charging will take place without a grid failure. The time is set usiing the *START BULK TIME.* menu item located under the *BULK CHARGE TRIGGER TIMER* menu. The default setting is 21:00.

Battery Requirements

UPS requirements are, usually, of a shorter duration than most alternative energy applications. Typically, batteries are rated at 20 hours. This means that a 100 amp hour battery can deliver 5 amp hours for 20 hours. It cannot deliver 100 amp hours for 1 hour. Battery manufactures should have derating curves for their products.

Menu Adjustable UPS Parameters

- *SLT* - Silent Mode selected in the *GRID USAGE MODE* menu
- *BULK CHARGE TRIGGER TIMER* - used in conjuction with the silent (*SLT*) mode
- *SET GRIDSIZE AMPS AC* - set to the size of the AC breaker feeding the units AC INPUT 1.

Utility Interactive Mode

Overview

This mode is used to sell power to the utilities. It is simple to set the unit up to accomplish this. However, this type of installation is so new, that not all utility companies have formalized their regulations for acceptable installation. Regulations will vary from one utility to another. The utility companies have a right and a need to be careful about how power is fed into their system. **Utility inter-tie should be done with the assistance of your dealer and must be done with the approval of the local utility company.**

Note: Since a utility interactive installation requires an understanding of your local utility code, no installation diagrams or details are included in this manual.

Battery Requirements

Batteries are required for utility inter-tie operation. The batteries can be small, if there is no requirement for back-up power in the event of utility failure. Two thousand watt/hours is sufficient (100 amp/hours at 24 volts is 2400 watt hours).

Theory of Operation

When the *SELL* item is highlighted in the *GRID USAGE MODE* menu, the unit moves excess power from the batteries to the grid. In *SELL* mode, the unit is simply a battery charger that is capable of executing its three stage charging cycle even if it requires pulling the battery voltage down. To pull battery voltage down, power is taken from the batteries and put on the grid. The unit is more accurately described as a utility interactive battery charger. This means that battery voltages are properly maintained whenever utility, or grid power is connected.

In a solar array configuration, a charge controller is not needed when the unit is operational and utility is connected. If the unit were turned off, or utility power were to fail, the batteries could quickly be over-charged. One of the unit's voltage controlled relays could be used to protect the batteries in the event of utility

failure. It would be programmed to open a relay from solar panels at a battery voltage above the bulk charge voltage setting of the charger.

Protection Circuitry

In utility interactive mode the unit is capable of detecting three types of failures.

- **Grid shorted** - Normally if power fails, the inverter will be trying to supply power for the entire neighborhood. This condition looks like a short circuit to the inverter and causes it to disconnect from grid.
- **Grid open** - The inverter can tell when there is no current being delivered to the grid and it will disconnect.
- **Islanding** - This occurs when the grid has failed and the "neighborhood" that the inverter is powering requires the same amount of power that is being supplied to the systems's batteries. The islanding detection circuit checks grid condition cycle by cycle. Typically, disconnect is achieved in a few cycles.

Menu Adjustable Utility Interactive Parameters

- *SET GRID SIZE AMPS AC* - sets the maximum amount of AC amps allowed to be fed back to the grid or takern from the grid.
- *SELL* - enabled from the *GRID USAGE MODE* menu.
- *SET MAX SELL AMPS AC* - the maximum current allowed to be sold

Load Displacement Modes

In Brief

The purpose of these modes is to shift the time at which public power is used. This is accomplished by charging the batteries at a favorable time and then using the power later. There are two strategies available for accomplishing this. One is passive in that the inverter simply disconnects from public power during a specific period of the day. The other will actively discharge the batteries into the grid and is, therefore, utility interactive.

Passive Strategy

In order to disconnect from grid during a specific period of the day and operate only as an inverter, a window of time is created in which charging is allowed. The following settings accomplish this:

- *GRID USAGE MODE* menu is set to *FLT*

- *START CHARGE TIME* in the *GRID USAGE TIMER* menu is set to the time the unit connects to grid. Which is the beginning of the time the charger is allow to run and the end of the inverter only time.
- *END CHARGE TIME* in the *GRID USAGE TIMER* menu is set to the time the unit disconnects from grid. The beginning of the inverter run time. If the battery voltage falls to the *SET LOW BATTERY TRANSFER* value during inverter run time, a charge cycle will be initiated.
- Set the *BULK CHARGE TRIGGER TIMER* to a time at or near the beginning of the charge allowed window. This allows a delayed charge cycle with initial and final hold at float volts.

Active Strategy - Selling Battery Power to the Grid

Selling battery power to the grid involves creating a time window during which normal charging (no selling) occurs. Selling is then allow at all times outside the window. To do this:

- *GRID USAGE MODE* menu is set to *SELL*. This allows backflow to grid.
- *START CHARGE TIME* in the *GRID USAGE TIMER* menu is set to the beginning time the unit is allowed to charge. This is the end of the time that selling to the grid is allowed.
- *END CHARGE TIME* in the *GRID USAGE TIMER* menu is set to the time float volts ends and sell volts begins. This is the end of the charging period and the beginning of the selling period.
- Set the *BULK CHARGE TRIGGER TIMER* to a time at or near the beginning of the charge allowed window. This is necessary because without a power failure the charger will not automatically put the batteries thru a full charge cycle.
- The *SET SELL VOLTS DC* menu item in the *BATTERY* menu adjusts the voltage to which the unit is allowed to discharge the batteries.

  In order to discharge the batteries, their voltage must be driven down below the normal float voltage. The lower the DC setting, the deeper the discharge.

- *SET MAX SELL AMPS AC* - maximum current allowed to the grid.

Setting*END CHARGE TIME* and *START CHARGE TIME* the same, defeats the sell voltage set point. Batteries will be bulk charged at trigger time, then held at float voltage.

Here is another way to think of this scenario. One of three voltages is always determining the units operation. (1) The batteries voltage is raised to *bulk volts* after an AC failure or upon encountering the *bulk charge trigger timer* event. (2) The batteries are held at *float volts* at all other times that charging is allowed. (3) During the window when charging is not allowed, the battery voltage is slowly reduced to *sell volts* by delivering power from the batteries to the grid.

Auxiliary Relays

Three voltage controlled relays are provided to simplify installations that have battery voltage related tasks to perform. They are double pole pole single throw, five amp relays. Both the normally closed and normally open contacts are accessible.

The voltage trip point for each relay is set via the User Menu. The hysteresis (difference between opening and closing voltage) is also adjustable.

Menu Adjustable Auxilliary Relay Parameters

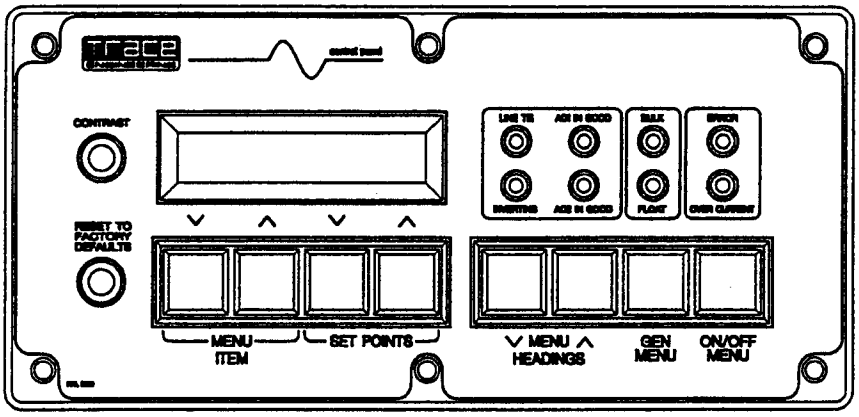
- *SET AUX RELAY 9 VOLTS DC* - set the trip voltage
- *R9 HYSTERESIS TENTHS VDC* - sets the difference between opening and closing voltages.
- *SET AUX RELAY 10 VOLTS DC* - set the trip voltage
- *R10 HYSTERESIS TENTHS VDC* - sets the difference between opening and closing voltages.
- *SET AUX RELAY 11 VOLTS DC* - set the trip voltage
- *R11 HYSTERESIS TENTHS VDC* - sets the difference between opening and closing voltages.

Control Panel

User Menu

Overview

All selectable features and adjustable parameters are controlled via the liquid crystal display (LCD) and the eight function buttons on the control panel. This includes turning the unit on or off. The menu is composed of 15 menu headings with related menu items under each heading. At the menu item level, either a parameter is changed, a feature is enable or or a value is read.



Figure, 2 - Control Panel

Navigating the User Menu

The two *Menu Heading* buttons are used to move either up or down thru the selection of menu headings. Once a menu heading is selected, the two *MENU ITEM* buttons are used to move up or down thru the list of menu items. The *two SET POINT* buttons change the value of a parameter or enable a feature. Two buttons are dedicated to automatically select commonly used menu headings. These are *ON/OFF MENU* and *GEN MENU* buttons.

Reset to Factory Defaults

A reset button is provided on the control panel that returns all settings to the factory default values.

ON/OFF MENU Button

Figure 4, On/Off Menu Display

Pressing the **ON/OFF MENU** button from any where in the user menu will will take you directly to the *SET INVERTER* menu item of the *INVERTER MODE* menu. There are four options available from this menu item.

- **OFF** - Inverter and charger are off.
- **SRCH** - Inverter and charger are enabled and search mode is activated.
- **ON** - Inverter and charger are enabled and search mode is off.
- **CHG** - Charger only operation. The inverter is defeated.

Use the **SET POINTS** buttons to make a selection. The second letter of the selected item will be underlined.

GEN MENU Button

Figure 3, Generator Menu Display

Pressing the **GEN MENU** button from anywhere in the user menu will display the *SET GENERATOR* menu item of the *GENERATOR MODE* menu. There are three options available from this menu.

- **OFF** - Turns off a generator if one has been started and is controlled by the unit. Defeats the automatic generator start features.
- **AUTO** - Enables the automatic generator start features.
- **ON** - Starts a generator that is wired to be controlled by the unit.

Use the *MENU ITEM* buttons to make a selection. The second letter of the selected item will be underlined.

GRID USAGE MODE Menu Item

Figure 5, Generator Menu Display

This is the second selection under the *INVERTER MODE* menu. It sets the basic mode in which the inverter will be operating, and therefore is being shown in detail.

- *FLT* - Float will charge batteries from grid and maintain the preset float voltage at all times that the charger is enabled.
- *SELL* - Enables the inverter to move excess power from the batteries to the grid (AC1 IN). **This mode must have the approval of the local power utility prior to its use.** In the U.S utility companies are required by law to purchase any excess power generated by their customers; however, they make the rules. Be advised: some utilities will be more receptive than others.
- *SLT* - The silent mode does not maintain a float voltage. Rather once a day at the time prescribed by the *BULK CHARGE TRIGGER TIMER*

the batteries are given a full charge cycle. The inverter will perform a bulk charge once per day from the grid. The inverter will then go totally silent and wait for AC to fail, or until the next day when it performs another bulk charge.

User Menu Headings and Menu Items

INVERTER MODE

SET INVERTER
OFF SRCH ON CHG

Turns the inverter on or off. Enables the search mode. Provides charger only operation. Move the single space cursor under the desired selection.

GRID USAGE MODE
FLT SELL SLT LBX

FLT (float) enables normal inverter charger operation. *SELL* allows power to be delivered to the grid. *SLT* (silent mode) turns the charger off while connected to grid. This setting expects to have a time set by the *BULK CHARGE TRIGGER TIMER* menu item that tells the unit at what time to charge the batteries each day. *LBX* (low battery transfer) instructs the unit to charge only if the batteries are low. Move the single space cursor under the desired selection.

GENERATOR MODE

GENERATOR SET
OFF AUTO ON

Off turns off a generator if one has been started and is controlled by the unit. Defeats the automatic generator start features. *AUTO* enables the automatic generator start features. *ON* starts a generator that is wired to be controlled by the unit. Move the single space cursor under the desired selection.

AMP METERS

INVERTER
AMPS AC

Reads AC amperage. Plus (+) Amps indicates rate of charge. Negative (-) gives rate of discharge.
Range 0 to 64

INPUT
AMPS AC

Reads total AC input current from the grid or generator. The reading is positive if buying power and negative if selling.
Range 0 to 64

LOAD
AMPS AC

Reads the current that is going to the load. The reading is always positive.
Range 0 to 64

VOLT METERS		SW4024	SW4048
BATTERY ACTUAL VOLTS DC	Reads the average battery voltage. Similar to the voltage reading of a standard voltmeter.		
	Range	10 to 35.5	20 to 71
BATTERY TEMP COMP VOLTS DC	Reads the battery voltage after temperature compensation.		
	Range	10 to 35.5	20 to 71
INVERTER VOLTS AC	Reads the RMS value of the inverter's AC output voltage.		
	Range	0 to 255	0 to 255
GRID VOLTS AC	Reads the RMS value of the AC voltage at the inverter's AC HOT 1 input and NEUTRAL IN 1 terminals.		
	Range	0 to 255	0 to 255
GENERATOR VOLTS AC	Reads the RMS value of the AC voltage at the inverter's AC HOT 2 input and NEUTRAL IN 2 terminals.		
	Range	0 to 255	0 to 255
ERROR CAUSES			
OVER CURRENT	Safe operating limits of the power devices were reached. This can occur in inverter or charger mode.		
TRANSFORMER OVERTEMP	Transformer exceeded safe operating temperature.		
HEATSINK OVERTEMP	Power devices exceeded safe operating temperature.		
HIGH BATTERY	Battery voltage above safe limits.		
LOW BATTERY	Battery voltage below safe limits.		
EXTERNAL VOLTAGE EON OUTPUT	Reports that an AC voltage source was applied to the units AC input terminals.		
EXTERNAL ERROR (STACKED)	Something amiss with the series interface cable or the unit in series.		
MANUAL OFF	The unit was turned off.		
BATTERY		SW4024	SW4048
SET FLOAT VOLTS DC	Sets the voltage at which the batteries will be maintained upon completion of the charge cycle.		
	Factory setting	26.4	52.8
	Range	20.0 to 30.0	40.0 to 60.0
	Notes	.....	

		SW4024	SW4048
SET SELL VOLTS DC	Determines the level to which the batteries will be discharge when power is being sold from the batteries to the grid.		
	Factory setting	26.4	52.8
	Range	20.0 to 30.0	40.0 to 60.0
	Notes		
SET BULK VOLTS DC	Sets the maximum voltage at which the batteries will be charged.		
	Factory setting	28.8	57.6
	Range	20.0 to 31.0	40.0 to 62.0
	Notes		
SET MAX CHARGE AMPS AC	Sets the maximum charge rate in terms of AC current. Battery current is approximately 5 times this amount for a 24 volt model and 2.5 times for a 48 volt model. The available range is 0 to 33 amps.		
	Factory setting	30	same
	Range	+2 to +35	same
	Notes		
SET MAX SELL AMPS AC	Determines the maximum AC amps allowed to be delivered to the grid during utility inter-tie operation.		
	Factory setting	-30	same
	Range	-2 to -35	same
	Notes		
SET BULK DONE AMPS AC	Sets the current level at which the charger stops charging at the bulk voltage and begins charging at the float voltage.		
	Factory setting	3	same
	Range	0 to 20	same
	Notes		
SET MAX BULK TIME HM	This setting provides a limit to the amount of time that the batteries are held above float charge voltage. The charge current may not fall to a low enough level to trigger the change to float stage if DC loads are present.		
	Factory setting	5	same
	Range	0.0 to 23:50	same
	Notes		
SET LOW BATTERY CUT OUT VDC	The inverter turns off to protect the batteries when temperature compensated battery voltage is reached.		
	Factory setting	20.0	40.0
	Range	16.0 min	32.0 min
	Notes		

		SW4024	SW4048
SW 4024 **SW 4048**	SET LBCO AMP/VDC 100 200 400 800 50 100 200 400	Calibrates the current compensation of the low battery cut out feature. The numbers reprsent the amount of current required to create a 1 volt DC drop in the combination of batteries and wiring.	
		Factory setting	400	200
		Notes		
	SET LOW BATTERY CUT IN VDC	This is the battery voltage at which the inverter turns on after having shut off due to the low battery cut out.	
		Factory setting	25.0	50.0
		Range	10.0 to 35.0	20.0 to 70.0
		Notes		
	SET HIGH BATTERY CUT OUT VDC	This is the high battery voltage at which the inverter turns off. Hi battery cut-in occurs at 2 VDC under HBCO.	
		Factory setting	31.0	62.0
		Range	32.0 max	64.0 max
		Notes		
SW 4024 **SW 4048**	SET TEMP COMP -0.1V/8 DEG C -0.1V/4 DEG C	Battery temperature compensation rate. If the temperature compensation is set to 1, then battery voltage readings rise .1vdc for each 8 deg C (model SW4024) increase in temperature. This effectively reduces all battery charging set points. Temperature compensation is only employed with charge voltage set points.	
		Factory setting	4	same
		Range	0 to 6	same
		Notes		
	SET LOW BATTERY TRANSFER VDC	Used with the LBX fuction. Sets the battery voltage point used to transfer from inverterting to charging.	
		Factory setting	22.0	44.0
		Notes		
	INVERTER		**SW4024**	**SW4048**
	SET SEARCH WATTS	The threshold sensitivity of the search mode circuit is adjustable. The available settings are from 16 to 240 watts in 16 watt increments.	
		Factory setting	48	same
		Range	0 to 240	same
		Notes		
	SET SEARCH SPACING	The length of time between each search pulse is adjustable. The setting is in cycles. Therefore, a setting of 30 would generate search pulses that are 1/2 second apart. The range of settings is from 0 to 255 cycles.	
		Factory setting	59	same
		Range	4 to 255	same
		Notes		

		SW4024	SW4048
SET SEARCH OFF DELAY	When the inverter determines that the load size is below the search mode threshold setting, it waits before entering the search mode. The length of this wait is adjustable. The setting is in cycles. Therefore, a setting of 120 would cause the inverter to wait 2 seconds before entering the search mode. The range of settings is from 0 to 255 cycles.		
	Factory setting	60	same
	Range	0 to 255	same
	Notes		

AC INPUTS		SW4024	SW4048
SET GRID SIZE AMPS AC	This setting determines the level in AC amps at which the unit begins to support the line. Typically this is set to the size of the AC circuit breaker that feeds the *AC INPUT 1*.		
	Factory setting	60	same
	Range	0 to 63	same
	Notes		
SET GEN SIZE AMPS AC	This setting determines the level in AC amps at which the unit begins to support the generator. Typically this is set to the size of the generator's circuit breaker feeding the *AC INPUT 2*.		
	Factory setting	30	same
	Range	0 to 63	same
	Notes		
SET GRID LOWER LIMIT VAC	Sets the lowest voltage at which the unit will connect to the generator. This also sets the voltage at which the unit will begin supporting the grid. Grid support is maintained as long as there is power flowing from the grid to the load.		
	Factory setting	108	same
	Range	85 to 110	same
	Notes		
SET GRID UPPER LIMIT VAC	Sets the highest voltage at which the unit is allow to connect to the line. This is also the maximum voltage at which the inverter will *sell* back to the line if SELL BACK is enabled.		
	Factory setting	132	same
	Range	125 to 149	same
	Notes		

		SW4024	SW4048
SET GEN LOWER LIMIT VAC	Sets the lowest voltage at which the unit will connect to the generator.This also sets the voltage at which the unit will begin supporting the generator. Generator support is maintained as long as there is power flowing from the generator to the load.		
	Factory setting	105	same
	Range	85 to 110	same
	Notes		

Note: Typically SET GEN LOWER LIMIT VAC and SET GRID LOWER LIMIT AC will be based upon load requirements.

SET GEN UPPER LIMIT VAC	Sets the highest voltage at which the unit will connect to the generator.		
	Factory setting	140	same
	Range	125 to 149	same
	Notes		

GRID USAGE TIMER - used only in *FLT* and *SELL* modes

START CHARGINGTIME - Connects AC1 input to grid and starts charging.

Factory setting	21:00	same
Range	0 to 23:50	same
Notes		

END CHARGING TIME - Disconnects from the grid and runs the house from battery power.

Factory setting	21:00	same
Range	0 to 23:50	same
Notes		

Note: By setting the beginning time equal to the ending time, the grid usage timer feature is defeated.

GENERATOR TIMER		SW4024	SW4048
START RUN	time H:M - Will start generator daily at this time.		
	Factory setting	8:00	same
	Range	0 to 23:50	same
	Notes		
END RUN	time H:M - The generator is stopped daily at this time, unless, the bulk charge cycle has not been completed. In this case the generator is run untill completeion of bulk charge.		
	Factory setting	8:00	same
	Range	0 to 23:50	same
	Notes		

START QUIET

For auto starting based on battery voltage. Unit will not start during this period. Usually set during sleeping hours.

Factory setting	22:00	same
Range	0 to 23:00	same
Notes	.....	

END QUIET

This finishes the QUIET Timer, allowing the generator to start as required.

Factory setting	7:00	same
Range	0 to 23:00	same
Notes	.....	

GEN AUTO START SETUP **SW4024** **SW4048**

SET AUTO START LOAD AMPS

The automatic generator start feature can be triggered by the amount of inverter current that is being delivered to the loads. The available range is 0 to 255 amps. To defeat this feature, set the current trigger level to a high value.

Factory setting	-20	same
Range	-0 to -64	same
Notes	.....	

SET AUTO START BATT VOLTS

Sets a battery voltage that will initiate automatic generator start.

Factory setting	22.0	44.0
Range	10 to 35.5	10 to 71.0
Notes	.....	

SET AUTO START DELAY MIN

Sets the amount of time in minutes that an autostart condition must persist before generator start is initiated.

Factory setting	10	same
Range	0 to 255	same
Notes	.....	

SET MUST START BATT VOLTS

Sets a battery voltage that will initiate generator start regardless of generator QUIET timer settings.

Factory setting	21.0	42.0
Range	10 to 35.5	20 to 71.0
Notes	.....	

GEN STARTING DETAILS **SW4024** **SW4048**

SET GEN WARMUP SECONDS

Sets the number of seconds the generator is allowed to run before being connected to the loads. Factory default - 30 seconds.

Factory setting	30	same
Range	0 to 255	same
Notes	.....	

		SW4024	SW4048
SET MAX CRANKING SECONDS	Sets the maximum number of seconds the starter will be engaged during the starting sequence. Factory default - 5 seconds.		
	Factory setting	5	same
	Range	0 to 31	same
	Notes	.....	
SET MAX STARTING ATTEMPTS	Sets the maximum number of attempts that will be made to start the generator. The starting attempt counter is reset with the *GEN OFF* command.		
	Factory setting	8	same
	Range	0 to 30	same
	Notes	.....	

TIME OF DAY

SET SECOND	Sets the seconds of the unit's internal clock.
SET MINUTE	Sets the minutes of the unit's internal clock.
SET HOUR	Sets the hour. The setting is based on a 24 hour clock.
TIME OF DAY	Reads the time of day setting.

AUXILARY RELAYS R9,R10 AND R11

SET AUX RELAY 9 VOLTS DC	Sets the voltage trip point for the auxillary relay number 9.		
	Factory setting	29	58
	Range	10 10 35.5	20 to 71
	Notes	.....	
R9 HYSTERESIS TENTHS VDC	The hysteresis setting determines the voltage difference between when the relay is activated and when it returns to its normal condition. The relay closes at set point and opens on set point minus the hysteresis value.		
	Factory setting	.5	same
	Range	0 to 25.5	0 to 51
	Notes	.....	
SET AUX RELAY 10 VOLTS DC	Sets the voltage trip point for the auxillary relay number 10.		
	Factory setting	29.5	59
	Range	10 to 35.5	20 to 71
	Notes	.....	

		SW4024	SW4048
R10 HYSTERESIS TENTHS VDC	The hysteresis setting for relay number 10. The relay closes at set point and opens on set point minus the hysteresis value.		
	Factory setting	.5	same
	Range	0 to 25.5	0 to 51
	Notes		
SET AUX RELAY 11 VOLTS DC	Sets the voltage trip point for the auxillary relay number 12.		
	Factory setting	30	60
	Range	10 to 35.5	20 to 71
	Notes		
R11 HYSTERESIS TENTHS VDC	The hysteresis setting for relay number 11. The relay closes at set point and opens on set point minus the hysteresis value.		
	Factory setting	.5	same
	Range	0 to 25.5	0 to 51
	Notes		

LED Indicators

The Trace SW4000 Series inverters feature eight LED indicators which identify the various operating parameters of the sine wave unit. Unless otherwise indicated, LED's will be "solid" in appearance, when operational. Starting from left to right:

***LINE TIE* (Yellow)**

- *SELL* has been enabled.

***AC1 IN* (Green)**

- AC is available at input terminal, but not necessarily good.

***BULK* (Yellow)**

- The unit is charging at a constant current, causing battery voltage to rise until bulk volts is reached.

***ERROR* (Red)**

- A shutdown condition has occurred. (Refer to SHUTDOWN CAUSES in Control Panel section for a list of possible conditions.)

***INVERTING* (Yellow)**

- The inverter is providing primary power.

***AC2 IN GOOD* (Green)**

- Generator AC has been detected by the inverter, but is not necessarily good.

***FLOAT* (Green)**

- Battery voltage has reached "Float" voltage, where it will be maintained until another charge cycle is intiated.

***OVER CURRENT* (Red)**

- The output has reached 90 amps. A sustained over current condition will require a manual reset.

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.

Selection of Battery Type

Starting 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 often available at far below original cost. They are sometimes used in remote homes successfully. Typically, they are lead calcium in design. Therefore, they should not be cycled below 80% of their amp/hr rating. 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. The most common type is the non-sealed liquid electrolyte battery.

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

A popular and inexpensive battery of this type is the "golf cart" battery. It is a 6 volt design typically rated at 220 amp/hr, and costing 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.

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

NiCad and Nickel Iron (NiFe)

Trace inverters and battery chargers are optimized for use with lead acid batteries which have a nominal voltage of 2.0 volts per cell. NiCad/NiFe batteries have a nominal cell voltage of 1.2 volts per cell. The nominal voltage of a NiCad/NiFe battery bank can be made the same as a lead acid bank just by juggling the number of cells (20 cells for NiCad/NiFe vs 12 cells for lead acid both produce 24 volts nominal.) However, the NiCad/Nife battery bank will have a much higher operating voltage range.

The easiest and most effective way to use NiCad/NiFe batteries with Trace inverters is to use nineteen cells in the battery bank instead of twenty. This will reduce the battery bank operating voltage to about the same level as a lead-acid bank, so standard charger settings can be used.

A second option on either 12 or 24 volt systems is to adjust the Bulk Charge Voltage to its maximum setting (14.7 on a 12 volt system; 29.4 on a 24 volt system.) This will provide a complete charge, albeit at a slower rate than if a higher charge voltage (or lesser number of cells) were used.

Return Amps menu can be set higher than with lead acid batteries since NiCad/NiFe batteries do not require an Absorption stage.

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

Float Voltage settings for NiCad/NiFe batteries should be 1.32 to 1.35 volts per cell (26.4 - 27.0 volts).

Note: In alternative energy applications (solar, wind, hydro) DC charge controllers should be set to a level below the inverter high voltage cutoff point of 30.5 volts.

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 and type of your batteries. Standard vented lead acid batteries (with battery caps) can be charged at a high rate - equal to their capacity. Sealed and gel cel battery require a lower charge rate. Check with the battery manufacturer. 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. Gel cell batteries are usually set to the lower figure, while non-sealed batteries are set to the higher.
- **Float Voltage** - The batteries experience less gassing if they are maintained at a lower voltage than the voltage at which they are charged. Both sealed and non-sealed batteries can be set to a float charge of 2.2 VDC per cell.
- **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 received 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.

  Equalization is accomplished by charging batteries at a voltage of 2.5 to 2.6 VDC per cell.

CAUTION: Equalization should be done only with standard electrolyte batteries. If you have sealed or gel cell batteries, check first with the battery manufacturer before equalizing. 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 temperature probe automatically fine tunes these 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 and extends battery life.

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 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.

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.

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.

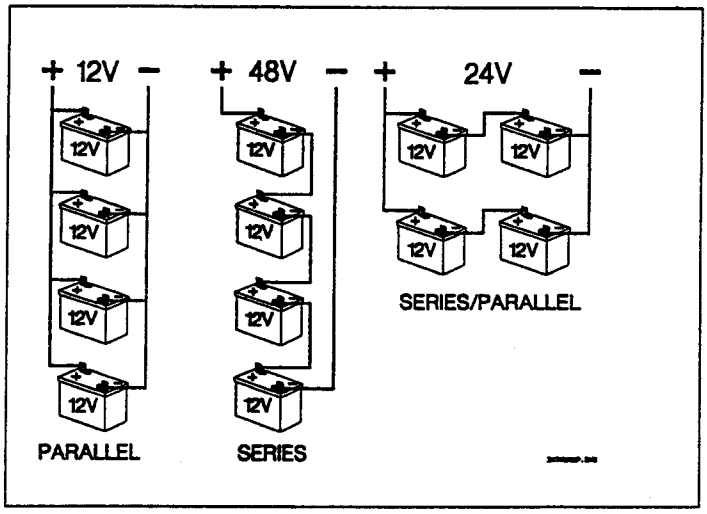


Figure 6, Multiple Battery Configurations

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 microprocessor 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 bus 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. 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.

UL specification 1741 (photovoltaic installations) requires that the inverter be mounted on a vertical surface (on a wall) and that the keyhole slots not be used for mounting. The purpose of this requirement is to orient the inverter so that its bottom cover has no holes that would allow burning material to be ejected in the event of an internal fire.

Use 1/4"minimum diameter bolts for mounting. The mounting must be capable of supporting twice the weight of the inverter in order to comply with UL 1741.

AC Wiring

Overview

The National Electrical Code (NEC) defines the standards for AC and DC installation wiring in residential, commercial 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 and the loads to be driven.

AC Connections

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

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.

A six station internal terminal block is provided to make the AC connections. The terminal block is located on the left-hand side of the inverter, enclosed under a cover plate. The terminal block is used to hardwire all AC connections. Consult your local code for proper wire sizes, connectors, conduit, etc. For 120 VAC units, we recommend 6 AWG (THHN) wire. 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.

Ensure the inverter is disconnected from the battery. Feed the wires thru conduit fittings located on the side of the inverter. (Note: Conduit fittings must be purchased separately and are required by code to comply with photovoltaic installations.) Following the wiring guide on the AC board inside the cover plate, connect AC wiring, as follows: (from top to bottom)

Wire	Color	Terminal Block
Public Power (Grid)	Black (Hot)	AC HOT IN 1
Generator	Black (Hot)	AC HOT IN 2
Public Power	White (Neutral)	NEUTRAL IN 1
Generator	White (Neutral)	NEUTRAL IN 2
AC Neutral Out	White (Neutral)	NEUTRAL OUT
AC Power Out	Black (Hot)	AC HOT OUT

Ground Fault Interrupt 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**

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.

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 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 UP 1741 safety standard (residential installations) 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

Battery Cable Connection

Observe Battery Polarity! 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. Undersized cables result in additional stress on the inverter, lower efficiency, reduced surge power and lower peak output voltage. Don't use cables that are too small 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

DC Volts	Under 5 ft	5 to 10 ft	10 to 20 ft
24	0000	0000	0000
48	0	0	00

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

Table of Load size vs. Time vs. Amp-Hours at 24 and 48VDC

		Time in Minutes					
Appliance	Watts	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 at 24 VDC					

		Time in Minutes					
Appliance	Watts	5	15	30	60	120	240
Single PL Light	10	.03	.1	.15	.35	.7	1.4
B & W TV	50	.1	.3	.5	1	2	4
Computer	100	.2	.5	1	2	4	8
Color TV	200	.5	1	2	4	8	17
Blender	400	1	2	4	8	17	33
Skil Saw	800	1.5	4	8	17	33	67
Toaster	1000	2	5	11	23	46	92
Microwave	1200	2.5	7	14	28	57	113
Hot Plate	1800	4	11	22	44	88	176
		Amp Hours at 48 VDC					

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 changes AC voltage polarity.

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, 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.

Technical Information

Theory of Operation

The SW4000 Series inverters employ a new patent pending design. They use three transformers in a topology that allows their individual voltages to be added or subtracted. Three transformers make twenty-seven possible voltages. The maximum number of steps available to create a sinewave is 52. One of the microprocessors uses the avaliable voltage steps to create waveforms of different voltages and frequencies.

The unit runs in two basic formats: as a standalone inverter, or with its output in parallel with and synchronized to an AC source. In inverter mode only 60 hz waveforms are created. As the battery voltage rises, waveforms with progressively fewer steps are generated. More steps are used with increased power and decreased battery voltage.

In synchronized mode the unit synchronizes with AC and then connects AC to the unit's output. The frequency of the AC source is tracked and the unit constantly adjusts its frequency to maintain a lock.

The power topology is bi-directional. If the waveform created by the unit is larger than the AC source, power flows from the batteries to the load. When the waveform generated is smaller than the AC source, power flows to the battery.

The various modes of operation use different algorithms for determining the size of the waveform to be created by the unit. In battery charger mode, for example, waveforms smaller than the AC source are created that cause current to flow into the batteries in accordance with the three stage charge cycle. However, if the AC source current approaches MAX AC INPUT, the unit will switch to the generator support algorithm and create waveforms that are larger than the AC source. This draws power from the batteries and prevents the AC input power from exceeding the MAX AC INPUT set point.

In utility inter-active mode, the unit acts as a bi-directional battery charger. Thus, if an external source such as solar panels attempts to raise the batteries above the float voltage setting, the unit will act to hold the battery voltage constant. The battery charger's output waveform will increase in amplitude. This moves power from the batteries to the grid.

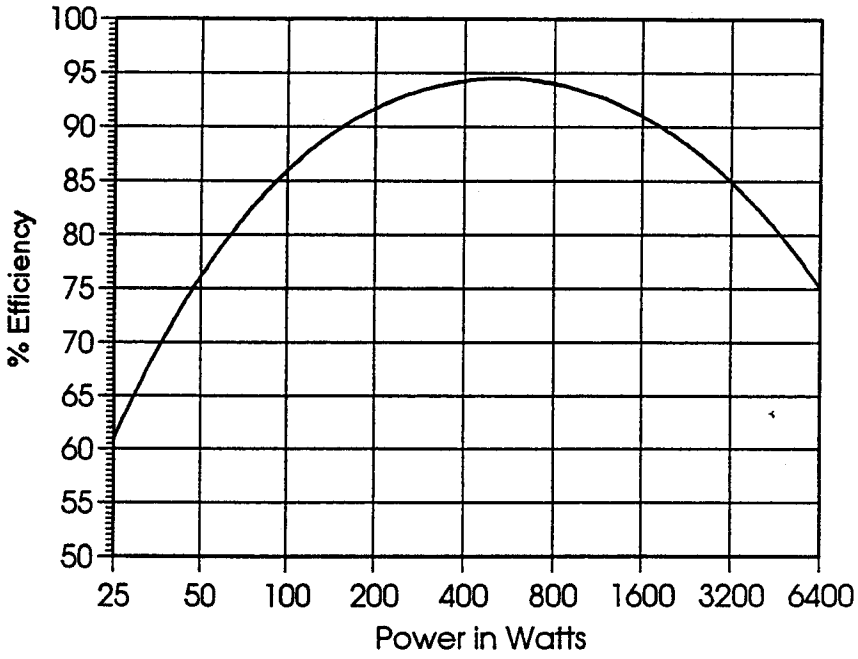
Specifications

MODEL	SW4024	SW4048	SW4024W
Continuous Power @ 20° C	4000 watts	4000 watts	4000 watts
Maximum AC Output	78 amps RMS	78 amps RMS	78 amps RMS
Efficiency	94% maximum	95% maximum	94% maximum
Input Current			
Search Mode (lowest setting)	.04 amps	.025 amps	.040 amps
Full Voltage	.70 amps	.35 amps	.70 amps
Rated Power	200 amps	100 amps	200 amps
Short Circuit	360 amps	180 amps	360 amps
Nominal Input Voltage	24 vdc	48 vdc	24 vdc
Input Voltage Range	20 to 31.5 vdc	40 to 63 vdc	20 to 31.5 vdc
Voltage Regulation	+/- 2%	+/- 2%	+/-2%
Waveform	sine wave	sine wave	sine wave
Distortion	3 to 5%	3 to5%	3 to 5%
Power Factor Allowed	-1 to 1	-1 to 1	-1 to 1
Frequency Regulation	60 Hz +/- .04%	60 Hz +/- .04%	60 Hz+/- .04%
Output Voltage	120 vac	120 vac	220 vac
Adjustable Load Sensing	16 watts to defeated	16 watts to defeated	16 watts to defeated
Series Operation (with optional cable)	yes (240 vac)	yes (240 vac)	no
Automatic Low Battery Protection	adjustable	adjustable	adjustable
Forced Air Cooling - 4 Speed	thermally activated	thermally activated	thermally activated
Automatic Transfer Relay	60 amp	60 amp	50 amp
Adjustable Charge Rate	0 to 120 amps DC	0 to 60 amps DC	0 to 120 amps DC
Three Stage Charging	yes	yes	yes
Temperature Compensation Probe	yes	yes	yes
Remote Control	optional	optional	optional
Environmental Characteristics			
Operating Ambient Temperature	0°C to +60°C	0°C to +60°C	0°C to +60°C
Non-operating Ambient Temp	-55°C to +75°C	-55°C to +75°C	-55°C to +75°C
Altitude Operating	15,000 ft	15,000 ft	15,000 ft
Altitude Non-operating	50,000 ft	50,000 ft	50,000 ft
Weight	105 lbs	105 lbs	105 lbs
Dimensions	depth 8" height 15.1" width 21"		
Mounting	Wall with 16" mounting centers or shelf		

Performance Graphs

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.

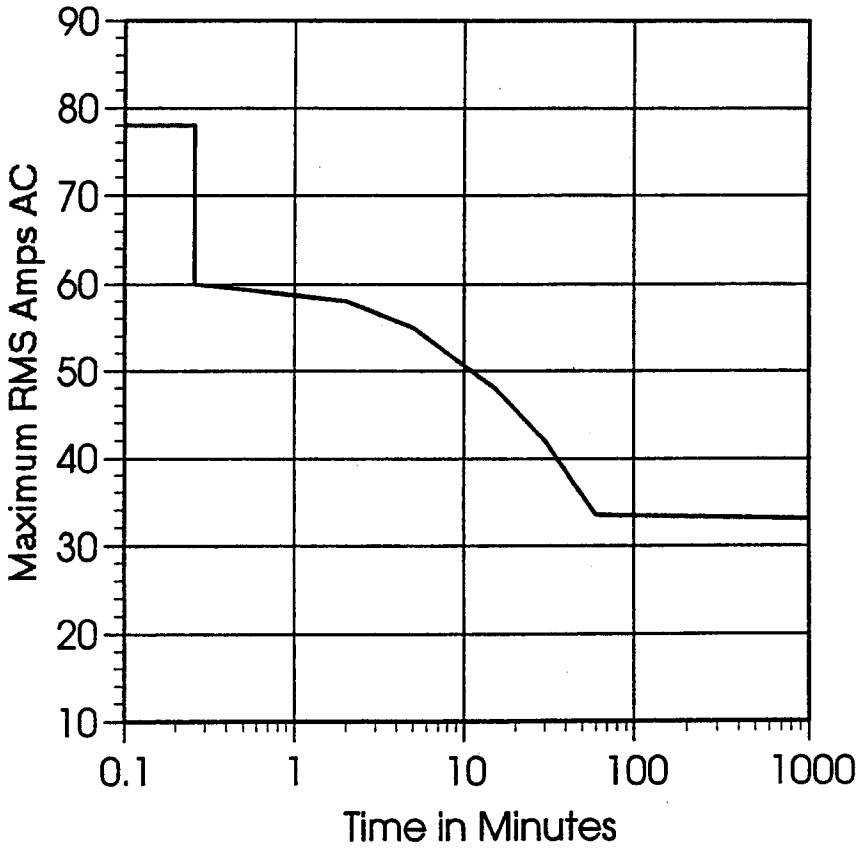


The second and largest source of loss is a result of the resistance in the transformer and power devices. The power lost here is proportional to the square of the output power. For Example, losses at 2000 watts will be four times higher than losses at 1000 watts.

This graph above represents a typical 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 RMS Amps AC 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 AC currents that are larger than the inverter can sustain continuously can be operated for useful periods of time.

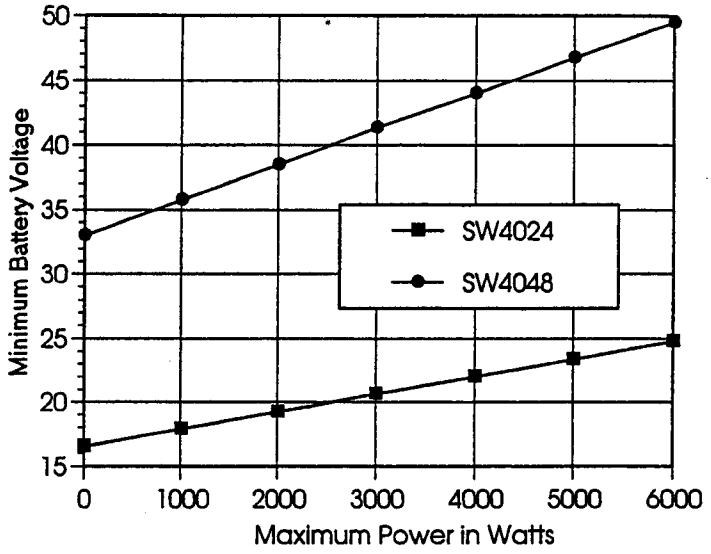


The length of time that the inverter can operate at high power is limited by temperature. When large loads are run, the inverter's temperature increases. At the point where more heat is created in the inverter than can be dissipated, its ability to operate becomes time limited. The accompanying graph shows the relationship between AC output current and the length of timethe indicated current can be sustained. If the combination of battery voltage and load size are within the inverter's regulation capability, then power will be AMPS X 120. Typically, most battery bank's voltage will drop under heavey loads, limiting maximum regulation to a range of 40 to 50 amps.

This graph assumes an ambient operating temperature of 20^0 C.

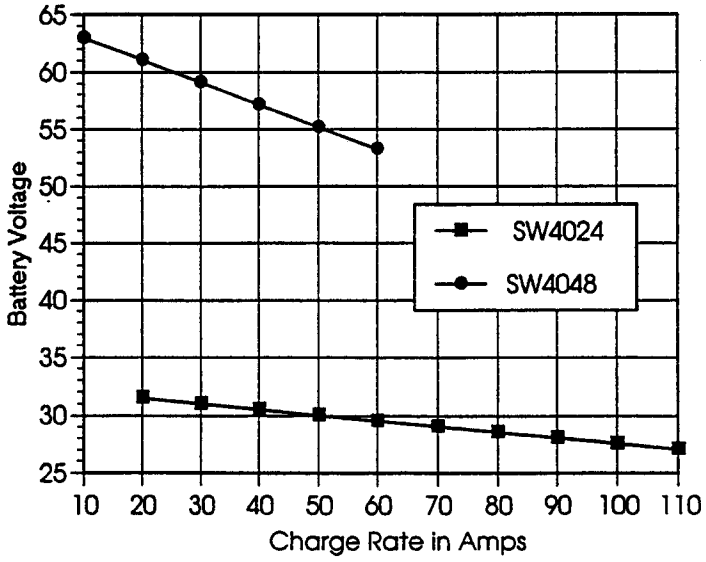
Maximum Regulated Power vs. Battery Voltage

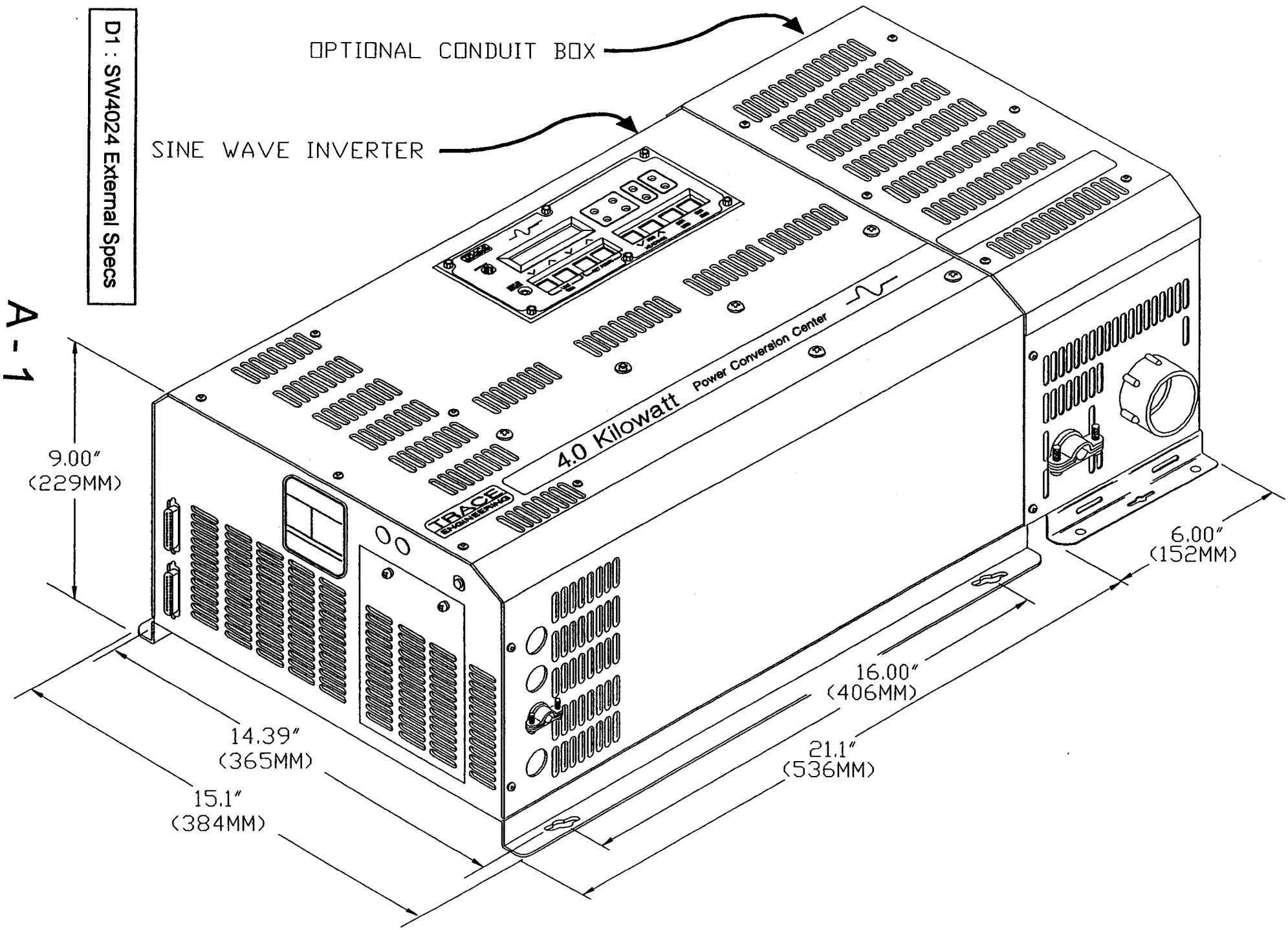
The inverter's ability to regulate its output voltage is affected by battery voltage. As the battery voltage is reduced, the maximum regulated power the inverter can produce decreases. The area below the line defines the region inwhich there is insufficient battery voltage to acheive the related power level and still provide regulated output.



Charger Performance at 108 VAC (Low Line Voltage)

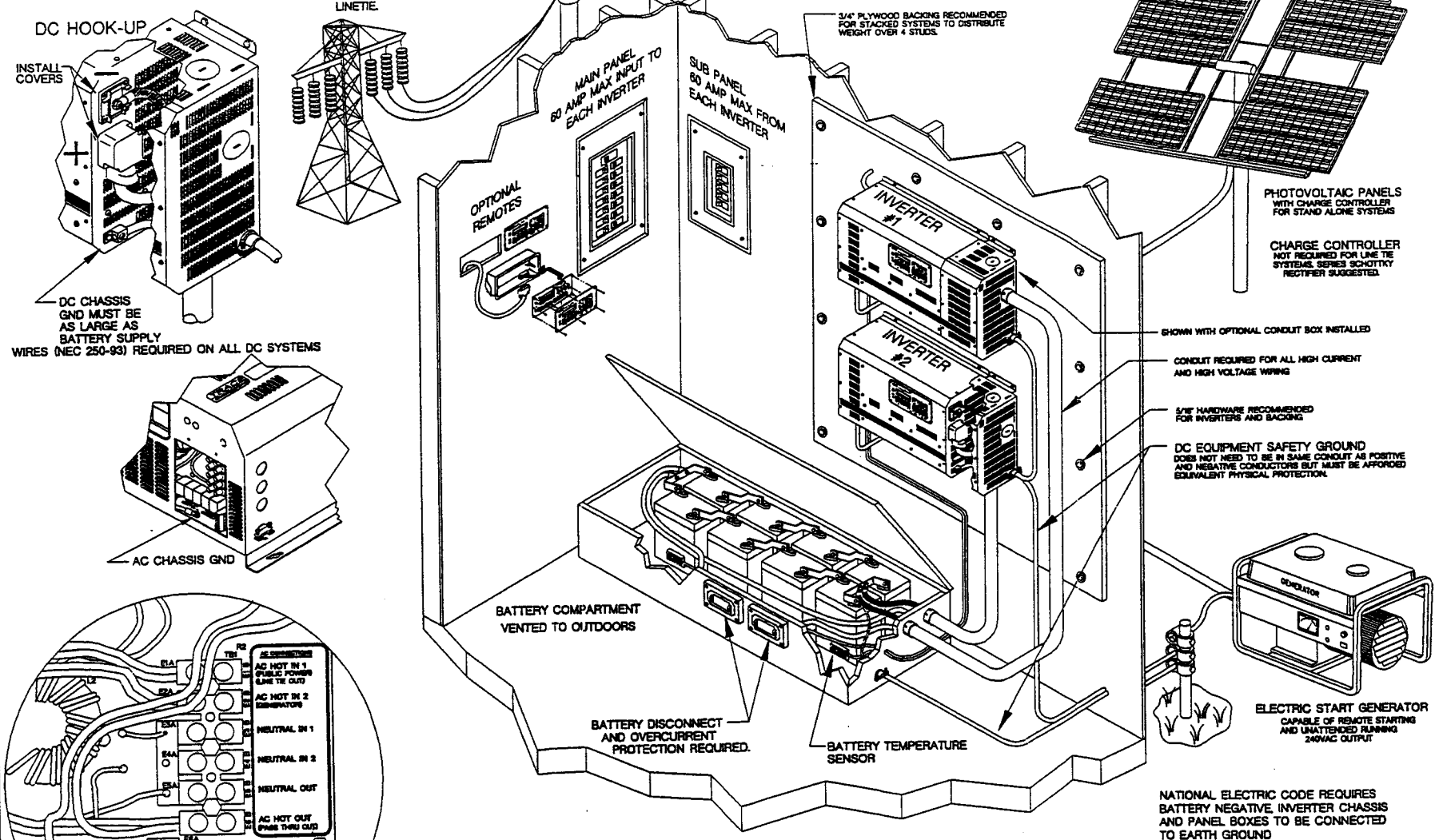
With Low AC line voltage the charging capability of the unit is reduced. The combination of low line and high battery voltage reduces maximum charge rate still further. The graph below shows the maximum charge rate for various battery voltages when the line voltage is 108 VAC.




OPTIONAL CONDUIT BOX
SINE WAVE INVERTER
4.0 Kilowatt
Power Conversion Center
TRACE ENGINEERING
9.00"
(229MM)
6.00"
(152MM)
16.00"
(406MM)
14.39"
(365MM)
21.1"
(536MM)
15.1"
(384MM)

D2 : Series Stacked Installation

ZONE	LTR	REVISION DESCRIPTION	DATE	APPROVED



A-2

ASSOCIATED PARTS LIST—NONE

RELEASE STATUS	PRODUCTION
NEXT ASSY / FINAL ASSY	NEXT ASSY
QTY REQUIRED	APPLICATION

UNLESS OTHERWISE SPECIFIED
ALL DIMENSIONS ARE IN INCHES
TOLERANCES ARE:
LINEAR XX = ± .02
XXX = ± .010
ANGULAR ± 2°
DIMENSIONS APPLY PRIOR TO FINISH
BREAK ALL SHARP EDGES
ALL ANGLES AND BENDS 90°
ALL DIMENSIONS PER ANSI Y14.5
125 ALL MACHINED SURFACES

DRAWN	ROBIN GUDGEL	DATE 3-24-94
MECH		DATE
ELEC		DATE
MFG		DATE
PURCH		DATE
APPRVD		DATE

TRACE ENGINEERING
5916 195TH ST NE
ARLINGTON, WA.98223
206 435-8826/FAX 206 435-2229

TITLE
SW4024 INSTALLATION

SIZE	DRAWING NO.	REV
C	SW4024IN	—
SCALE NONE	SHEET 1 OF 1	

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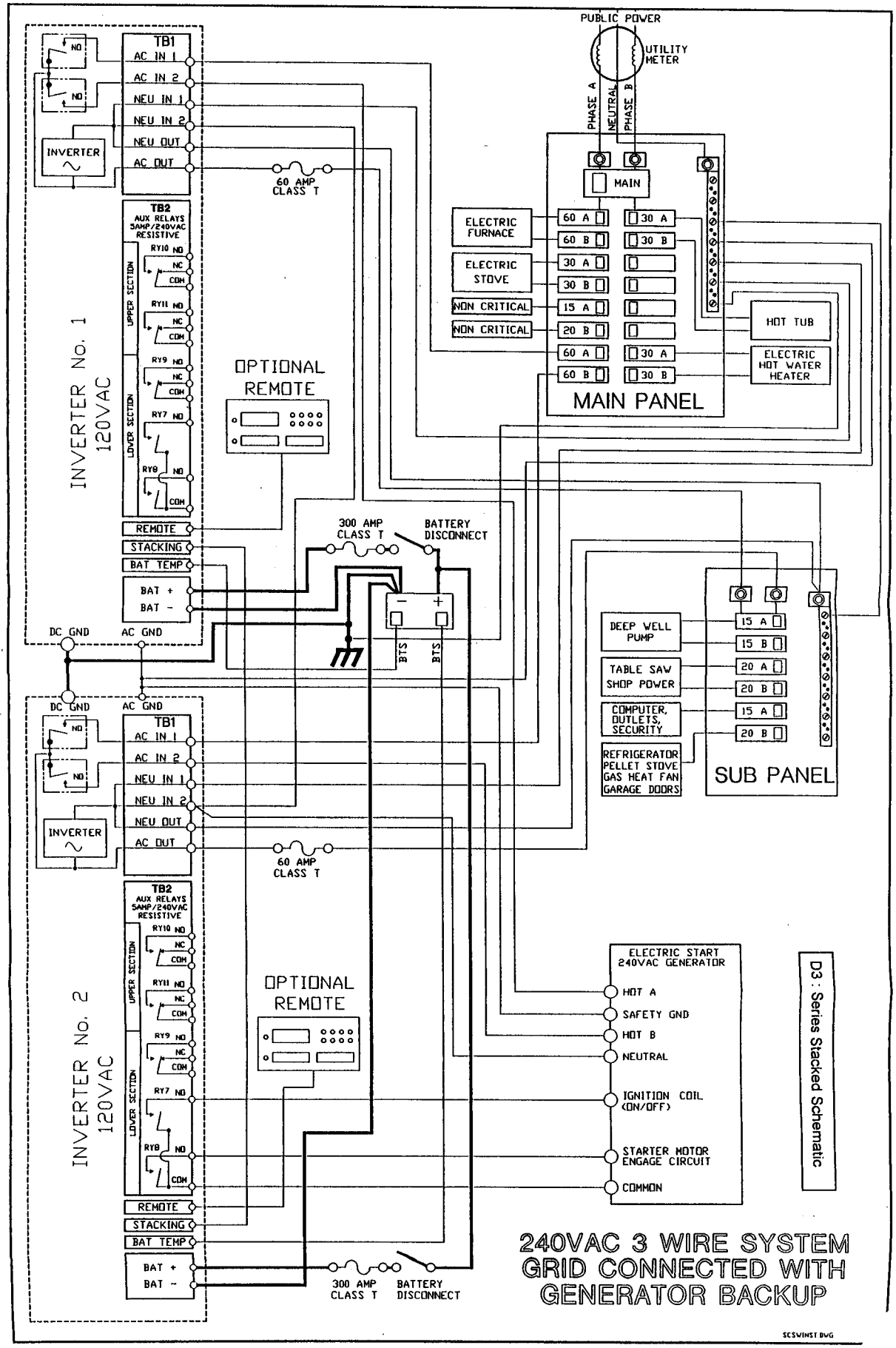
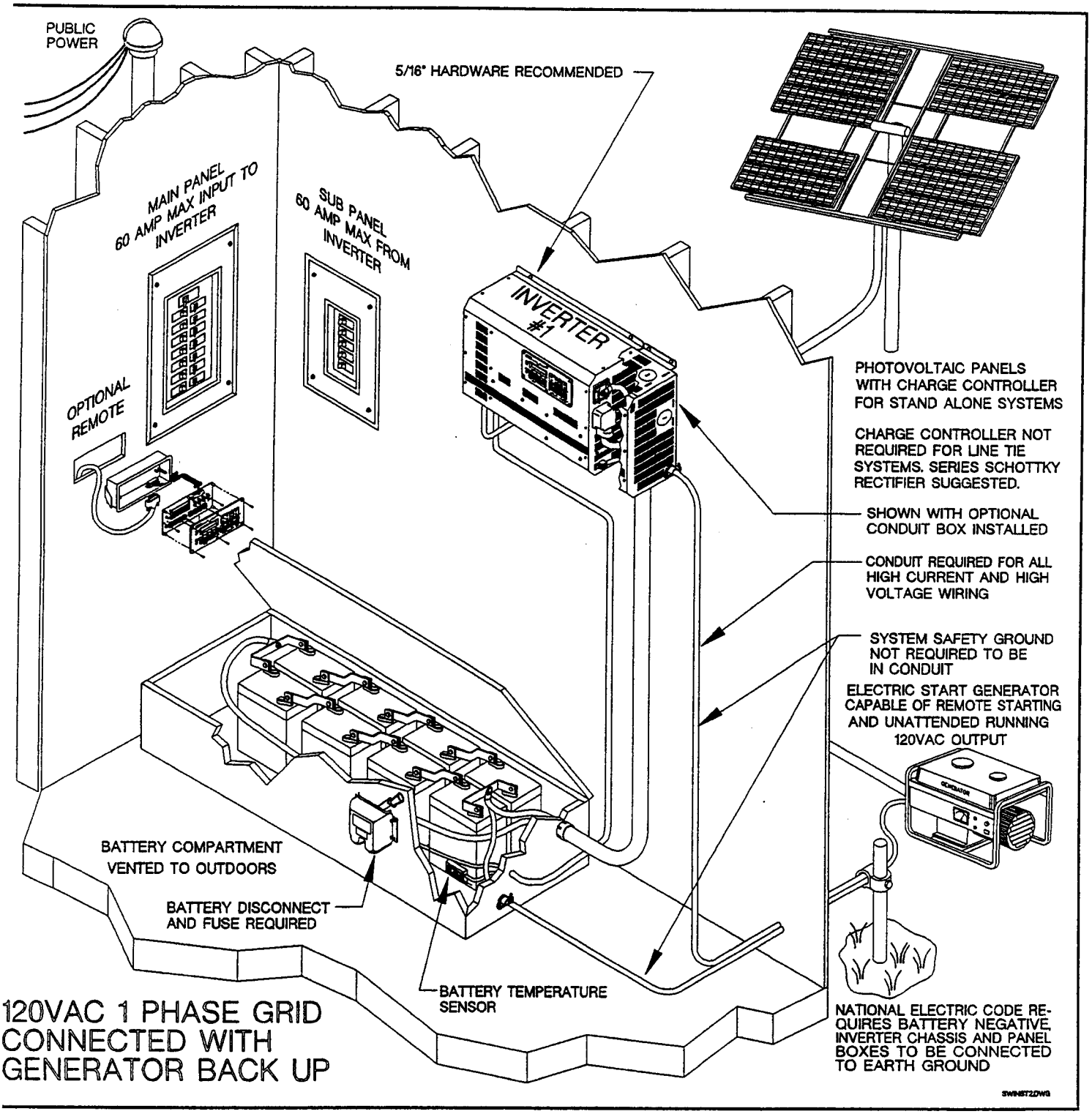
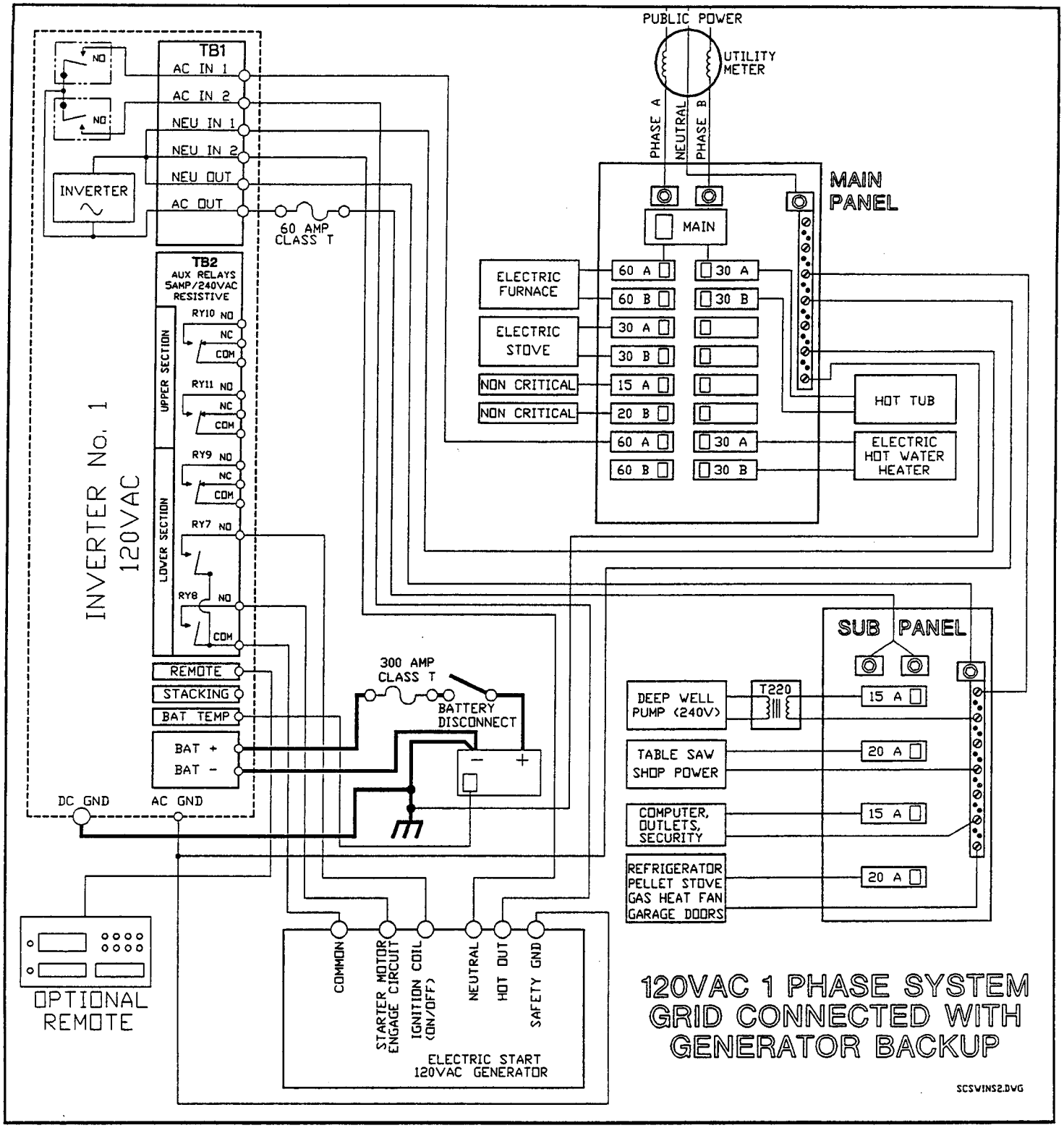

PUBLIC POWER
UTILITY METER
PHASE A
NEUTRAL
PHASE B
MAIN
ELECTRIC FURNACE
ELECTRIC STOVE
NON CRITICAL
NON CRITICAL
HOT TUB
ELECTRIC HOT WATER HEATER
MAIN PANEL
INVERTER No. 1
120VAC
TB1
AC IN 1
AC IN 2
NEU IN 1
NEU IN 2
NEU OUT
AC OUT
INVERTER
60 AMP CLASS T
TB2
AUX RELAYS 5AMP/240VAC RESISTIVE
UPPER SECTION
LOWER SECTION
RY10 NO
RY11 NO
RY9 NO
RY7 NO
RY8 NO
NC
COM
OPTIONAL REMOTE
REMOTE
STACKING
BAT TEMP
BAT +
BAT -
DC GND
AC GND
300 AMP CLASS T
BATTERY DISCONNECT
BTS
DEEP WELL PUMP
TABLE SAW SHOP POWER
COMPUTER, OUTLETS, SECURITY
REFRIGERATOR PELLET STOVE GAS HEAT FAN GARAGE DOORS
SUB PANEL
INVERTER No. 2
120VAC
ELECTRIC START 240VAC GENERATOR
HOT A
SAFETY GND
HOT B
NEUTRAL
IGNITION COIL (ON/OFF)
STARTER MOTOR ENGAGE CIRCUIT
COMMON
D3 : Series Stacked Schematic
240VAC 3 WIRE SYSTEM
GRID CONNECTED WITH
GENERATOR BACKUP
SCSWINST.DWG



D4 : Series Unit Installation



D5 : Single Unit Schematic

Other Products available from Trace Engineering

Sine Wave Series Options

Remote control (SWRC)

Remote control panel with On/Off switch, LED indicator, full panel readout. Available March '94.

Series Operation Interface Cable (SWI)

Allows two SW4024 model inverters to be connected in series for three wire operation at double the rated AC output voltage.

C30A 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

Battery cables are available from Trace in various lengths to ensure maximum power from the inverter and batteries.

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 warranty to 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, 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.

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 you 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 _____

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