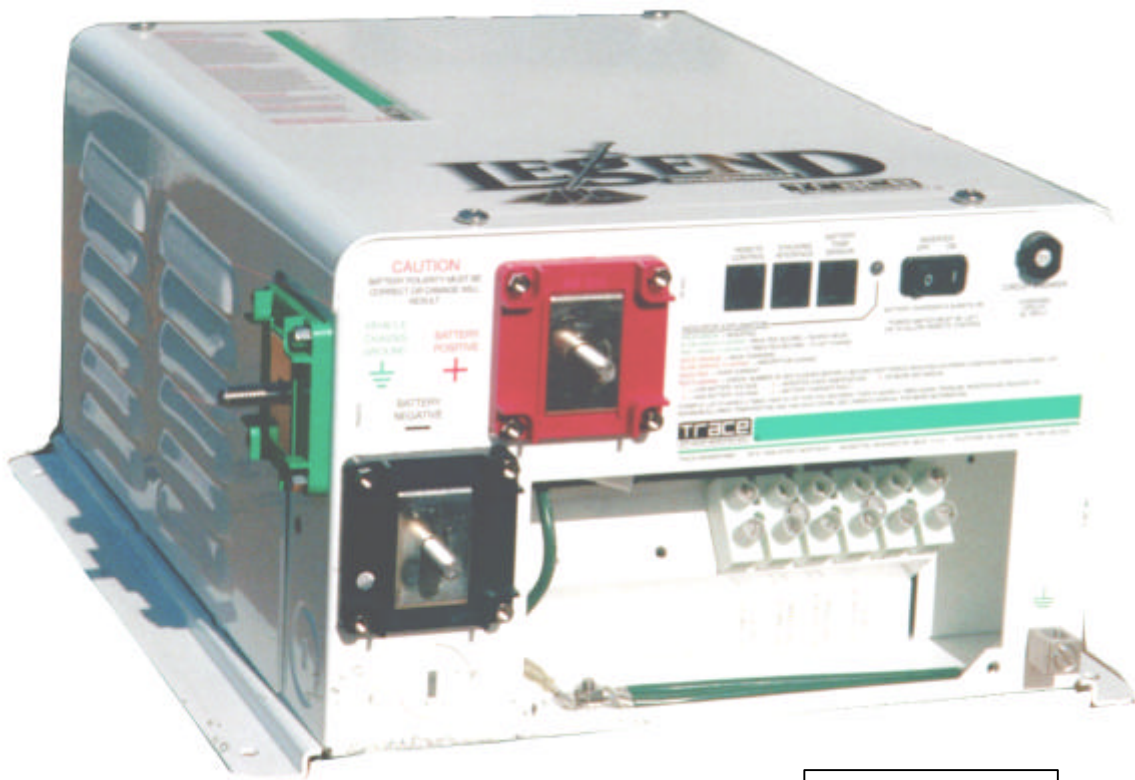




# Owner/Operator's Manual



Part Number 3179



# Packaging Materials

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

Owner's Manual;

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

AC terminal cover (with hardware);

Trace bumper sticker;

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

Model Number: \_\_\_\_\_

Serial Number: \_\_\_\_\_

Purchase Date: \_\_\_\_\_

Comments: \_\_\_\_\_

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



# Table of Contents

<b>INTRODUCING THE LEGEND SERIES II.....</b>	<b>1</b>
<b>IMPORTANT SAFETY INSTRUCTIONS.....</b>	<b>2</b>
GENERAL PRECAUTIONS.....	2
PERSONAL PRECAUTIONS.....	4
<b>FEATURES .....</b>	<b>7</b>
PROTECTION CIRCUITRY.....	7
<i>Automatic Low Battery Cut Out.....</i>	<i>7</i>
<i>Automatic High Battery Cut Out.....</i>	<i>7</i>
<i>High Temperature Cut Out.....</i>	<i>7</i>
<i>Over Current Cut Out.....</i>	<i>8</i>
<i>Battery Type Optimization.....</i>	<i>8</i>
<i>Charge Rate Regulation.....</i>	<i>8</i>
<i>Shore Power Amps Monitoring.....</i>	<i>9</i>
<i>VAC Dropout.....</i>	<i>9</i>
SEARCH MODE CIRCUITRY .....	9
IMPULSE PHASE CORRECTION .....	10
TRUE RMS VOLTAGE REGULATION.....	10
CRYSTAL CONTROLLED TIME BASE .....	11
STAND-BY BATTERY CHARGER .....	11
TRANSFER SWITCHING SPEED .....	11
AUTOMATIC INVERTER TO CHARGER TRANSITION.....	11
<b>UNIT IDENTIFICATION .....</b>	<b>12</b>
MODEL IDENTIFICATION .....	12
SERIAL NUMBER.....	13
<b>CONTROLS &amp; INDICATORS .....</b>	<b>15</b>
<b>QUICK INSTALL.....</b>	<b>19</b>
<b>INSTALLATION .....</b>	<b>23</b>
LOCATING THE INVERTER.....	23
VENTILATION.....	23
MOUNTING.....	24
DC WIRING.....	25
<i>Safety Instructions.....</i>	<i>25</i>
<i>DC Cabling Connections.....</i>	<i>25</i>
<i>Ground Cable Connection.....</i>	<i>27</i>
<i>Battery Cable Sizing.....</i>	<i>28</i>
<i>DC Over Current Protection .....</i>	<i>28</i>

AC WIRING .....	31
AC and DC Wiring Separation .....	31
AC Wire Connections.....	31
Ground Fault Interrupting Outlets (GFCI's).....	33
Neutral-to-Ground Switching.....	35
Disabling Neutral Ground Switching.....	37
<b>OPERATION.....</b>	<b>38</b>
<b>BATTERIES .....</b>	<b>41</b>
TERMINOLOGY .....	41
TYPES.....	42
Starting Batteries .....	42
Deep-Cycle Batteries .....	42
Sealed Gel Cell .....	42
ENVIRONMENT .....	43
Location.....	43
Enclosures .....	43
Temperature.....	43
BATTERY BANK SIZING .....	44
Estimating Battery Requirements .....	44
Battery Bank Sizing Example & Worksheet.....	45
MONTHLY MAINTENANCE.....	47
Preparation.....	47
Attire .....	47
Tools .....	47
Equipment.....	48
Supplies .....	48
Procedure.....	48
Battery Enclosure and Batteries .....	48
Terminals & Lugs .....	48
Cables .....	49
CABLING & HOOK-UP CONFIGURATIONS.....	49
Parallel Connection.....	50
Series Connection.....	50
Series – Parallel Connection.....	51
<b>THREE-STAGE BATTERY CHARGER .....</b>	<b>52</b>
CHARGING PROFILE .....	52
GENERATOR REQUIREMENTS .....	54
<b>THEORY OF INVERTER OPERATION.....</b>	<b>55</b>
WAVEFORM .....	55
REGULATION.....	56

<b>APPLICATIONS.....</b>	<b>57</b>
RESISTIVE LOADS.....	57
INDUCTIVE LOADS .....	57
PROBLEM LOADS.....	58
<b>OPTIONS.....</b>	<b>61</b>
THE RC6 REMOTE CONTROL .....	61
THE RC7 REMOTE CONTROL .....	62
BATTERY TEMPERATURE SENSOR (BTS) .....	63
BATTERY CABLES.....	63
<b>APPENDIX A: TROUBLESHOOTING.....</b>	<b>65</b>
<b>APPENDIX B: OTHER PRODUCTS FROM TRACE ENGINEERING .....</b>	<b>67</b>
<b>APPENDIX C: REFERENCE TABLES &amp; GRAPHS.....</b>	<b>69</b>
TYPICAL POWER CONSUMPTION OF COMMON APPLIANCES .....	69
ENGLISH TO METRIC WIRE CONVERSION CHART .....	70
MINIMUM RECOMMENDED BATTERY CABLE SIZE (IN FREE AIR) .....	70
RECOMMENDED MINIMUM AC WIRE SIZES .....	71
COMMON BATTERY CHARGING RATES.....	71
LEGEND SERIES II CHARGING GRAPH .....	72
LEGEND SERIES II EFFICIENCY CURVE .....	73
LEGEND PERFORMANCE GRAPH .....	74
<b>APPENDIX D: SPECIFICATIONS .....</b>	<b>75</b>
<b>APPENDIX E: DIMENSIONS.....</b>	<b>77</b>
<b>APPENDIX F: LIMITED WARRANTY .....</b>	<b>79</b>
<b>APPENDIX G: LIFE SUPPORT POLICY .....</b>	<b>82</b>
<b>INDEX.....</b>	<b>83</b>

## TABLE OF FIGURES

<i>Figure 1, Power Output Versus Temperature.....</i>	<i>24</i>
<i>Figure 2, Battery to Inverter Cable Connection .....</i>	<i>26</i>
<i>Figure 3, DC Wiring Diagram.....</i>	<i>30</i>
<i>Figure 4, AC Terminal Block.....</i>	<i>31</i>
<i>Figure 5, AC Wiring Diagram .....</i>	<i>32</i>
<i>Figure 6, Typical Mobile Installation Diagram.....</i>	<i>34</i>
<i>Figure 7, Neutral-to-Ground Switching without external AC source .....</i>	<i>35</i>
<i>Figure 8, Neutral-to-Ground Switching with External AC .....</i>	<i>36</i>
<i>Figure 9, Disabling Neutral-to-Ground Switching .....</i>	<i>37</i>
<i>Figure 10, Three-Stage Charging Profile .....</i>	<i>52</i>
<i>Figure 11, RC6 Remote Control Faceplate Display .....</i>	<i>61</i>
<i>Figure 12 , RC7 Remote Control .....</i>	<i>62</i>

## TABLE OF TABLES

<i>Table 1, Minimum Recommended Battery Cable Size (In free air).....</i>	<i>28</i>
<i>Table 2, Current Carrying Ability of Wire In Free Air at 75°C.....</i>	<i>29</i>
<i>Table 3, Recommended Minimum AC Wire Sizes .....</i>	<i>33</i>
<i>Table 4, Typical Appliance Watts .....</i>	<i>46</i>
<i>Table 5, Bulk and Float Setpoints .....</i>	<i>54</i>



## Introducing the Legend Series II

The Legend Series II inverter/chargers are specially designed for after market installation in recreational vehicles.

The Legend Series II inverter/chargers feature:

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

## Important Safety Instructions

### SAVE THESE INSTRUCTIONS

This manual contains important safety and operating instructions as prescribed by UL specifications for inverters used in land vehicle applications. This manual covers inverters and inverter/chargers models: L2012, L2512, and L3012 Legend Series II inverter/chargers.

The entire Legend series of inverters is UL listed to the general UL specification #458 covering power inverters for land vehicle applications.

### General Precautions

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

WORKING IN VICINITY OF A LEAD ACID BATTERY MAY BE DANGEROUS. BATTERIES GENERATE EXPLOSIVE GASES DURING NORMAL OPERATION. FOR THIS REASON, IT IS OF UTMOST IMPORTANCE THAT EACH TIME BEFORE SERVICING EQUIPMENT IN THE VICINITY OF THE BATTERY, YOU READ THIS MANUAL AND FOLLOW THE INSTRUCTIONS EXACTLY. Provide ventilation to outdoors from the battery compartment. The battery enclosure should be designed to prevent accumulation and concentration of hydrogen gas in "pockets" at the top of the compartment. Vent the battery compartment from the highest point. A sloped lid can also be used to direct the flow to the vent opening location.

To reduce the risk of battery explosion, follow these instructions and those published by battery manufacturer and any manufacturer of any equipment you intend to use in the

## IMPORTANT SAFETY INSTRUCTIONS

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vicinity of batteries. Review cautionary markings on these products and all other products being used.

7. No terminals or lugs are required for hook-up of the AC wiring. AC wiring must be no less than 10 AWG (5.3 mm<sup>2</sup>) copper wire and rated for 75°C or higher. Battery cables must be rated for 75°C or higher and should be no less than the minimum wire size recommended by this manual. Crimped and sealed copper ring terminal lugs with a 5/16" hole should be used to connect the battery cables to the DC terminals of the inverter/charger. Soldered cable lugs are also acceptable. See section *Batteries and Chargers* for correct battery cable size and length for your application.
8. Torque all AC wiring connections to 15-20 inch-pounds. Torque all DC cable connections to 10-12 foot-pounds.
9. **CAUTION:** To reduce the risk of fire, use only input circuits provided with the correct ampere branch circuit protection in accordance with the National Electric Code, ANSI/ NFPA70
10. Use the correct tools to make AC/DC wiring connections: wire strippers, ½" (13mm) open-end wrench or socket, Phillips screw driver #2, and ¼" flat blade screwdriver (6mm).
11. This inverter/charger should be used with a battery supply of 12-volts DC nominal voltage.
12. Do not install this inverter/charger on or near flammable materials (plywood, chemicals, gasoline, etc.)
13. The unit is designed for mounting on a flat surface only. Do not mount on a wall or hang inverted.
14. No AC or DC disconnects are provided as an integral part of this inverter. Both AC and DC disconnects must be provided as part of the system installation. See *Installation* section on Page 23 of this manual.
15. No overcurrent protection for the battery supply is provided as an integral part of this inverter. Overcurrent protection of the battery cables must be provided as part of the system installation. See *Installation* section of this manual.
16. No overcurrent protection for the AC output wiring is provided as an integral part of this inverter. Over-current protection of the AC output wiring must be provided as part of the system installation. See the *Installation* section of this manual.
17. **GROUNDING INSTRUCTIONS** - This inverter/charger should be connected to a grounded, permanent wiring system. For most installations, the negative battery conductor should **not** be bonded to the vehicle chassis ground. Connection of the large green chassis ground terminal on the side of the inverter will create the battery negative to vehicle chassis ground. All installations should comply with all national and local codes and ordinances.
18. **AC Grounding Instructions** – The inverter/charger includes neutral to ground switching for the AC electrical system. The AC system in mobile installations must have the neutral physically isolated from the ground throughout the load distribution powered by the inverter.

## Personal Precautions

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

## IMPORTANT SAFETY INSTRUCTIONS

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15. Add ONLY distilled water in each cell until battery acid reaches level specified by battery manufacturer. This helps purge excessive gas from cells. Do not overfill. For a battery without cell caps, carefully follow manufacturer's recharging instructions.



## Features

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

### Protection Circuitry

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

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

### Automatic Low Battery Cut Out

The Legend inverter/charger protects your batteries from damage caused by over-discharging by automatically shutting itself off when battery voltage falls to a preset level. This feature is called the Low Battery Cut Out (*Auto LBCO*). Your Legend inverter/charger comes from the factory with the *Auto LBCO* enabled; LBCO voltage is set at 11.1 volts. You can adjust the cutoff voltage to 8.5 volts (*Auto LBCO* disabled) using the optional RC7 remote control. See The RC7 Remote Control section on Page 62 for more information about the configuring LBCO.

### Automatic High Battery Cut Out

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

### High Temperature Cut Out

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

## FEATURES

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### Over Current Cut Out

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

### Battery Type Optimization

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

### Charge Rate Regulation

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

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

<u>Battery Bank Capacity in Amp Hours</u>	<u>Recommended Charge Rate in Amps</u>	
	gel cell	liquid lead-acid
125	40	25
250	80	50
500	140	100

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

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

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



## Shore Power Amps Monitoring

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

## VAC Dropout

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

## Search Mode Circuitry

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

**Example:** With the threshold set to detect a 40 watt load, a 50 watt load will bring the unit to full output voltage. However, a 30-watt load will leave the inverter in its energy saving search mode 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 five-watt load will not.

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

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

**Example A:** If the threshold is set to detect a 40-watt load and a 30-watt incandescent light is turned on, the inverter will detect the light. The light is a bigger load than 40 watts when its filaments are cold. When the light gets hot it becomes a 30-watt load. Since this is below threshold of 40-watts, the inverter will not detect it and the light will go out. This will cause the light to cycle repeatedly.

## FEATURES

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

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

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

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

## Impulse Phase Correction

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

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

## True RMS Voltage Regulation

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

## Crystal Controlled Time Base

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

## Stand-by Battery Charger

The Stand-by feature includes an internal battery charger and automatic transfer relay. This allows the unit to operate as a battery charger or an inverter (but not at the same time). An external source of AC power (i.e. shore power or generator) must be supplied to the inverter's AC input to allow it to operate as a battery charger. When the unit is operating as a charger its AC output is powered by the external AC source. See the *Three-Stage Battery Charger* section beginning on Page 52 for an in-depth description of this charger.

## Transfer Switching Speed

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

## Automatic Inverter to Charger Transition

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

## Unit Identification

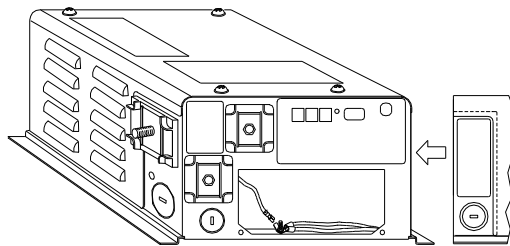
This section describes the marking and location of the model and serial number for Legend Series II inverter/chargers. Use this section to determine the type and model of your inverter/charger.

### Model Identification

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

Consider the following unit with a L2012 model number:

<b>L</b>	<b>20</b>	<b>12</b>
<i>Model</i>	<i>Power</i>	<i>Input Voltage</i>



**Model:** The first letter indicates the model, in this case the Legend Series. Legend Series II inverters are designed for after-market installations in recreational and other mobile vehicles. They are housed in a white enclosure and employ neutral-to-ground switching.

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

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

## Serial Number

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

The diagram shows a unit identification placard with the following fields and callouts:

- Model Number:** MODEL: 2012
- Inverter Continuous Duty Rating in Watts:** 3032-1
- Pass-Thru Current Capacity:** CONTINUOUS DUTY 2000 VA
- AC Input/Output Phase, Waveform, Frequency and Voltage:** PROVIDED WITH INTEGRAL PROTECTION AGAINST OVERLOADS  
PASS THRU 30 AMPS AT 120VAC.  
MAX IN 30 AMPS AC.  
POWER FACTOR .75 LAGGING.
- DC Input Voltage Operating Range:** AC INPUT: 1  $\phi$  T  
AC OUTPUT: 1  $\phi$  L  
120 VAC  $\pm$  5% / 60 HZ  
OPERATING RANGE: 10.2-15.5 VDC  
207 AMPS DC RATED
- Model Prefix:** L+
- Charger Continuous Duty Current Rating at DC Bulk/Float Charging Rates:** BATTERY CHARGER DC CONTINUOUS DUTY AT RATED INPUT LINE VAC  
12.9-13.9 / 90 AMPS  
14.0-14.4 / 70 AMPS
- Testing Laboratory Certification Number and Standards Identification:** TRACE ENGINEERING COMPANY, INC.  
5916 195TH ST. N.E.  
ARLINGTON, WA. 98223 USA  
UL POWER CONVERTERS/INVERTERS AND POWER CONVERTER/INVERTER SYSTEMS FOR LAND VEHICLES STANDARD UL458  
UL COMMERCIAL AND INDUSTRIAL POWER SUPPLIES CERTIFIED TO CAN/CSA-C22.2 No. 107.1-M91  
C LISTED 39FL
- Date of Manufacture:** DATE OF MANUFACTURE  
QUARTER YEAR  
1 2 3 4 98 99 00 01 02 03
- Serial Number and Product Code:** S/N AW  
Serial Number and Product Code: AV=3012, AW=2012, AX=2512



A detailed line drawing of the rear panel of the device. Numbered callouts point to the following components:

- 1: Power switch (I/O)
- 2: Power switch (ON/OFF)
- 3: Power switch (ON/OFF)
- 4: Power switch (ON/OFF)
- 5: Power switch (ON/OFF)
- 6: Grounding screw
- 7: Grounding screw
- 8: Grounding screw
- 9: Power cord
- 10: Grounding screw
- 11: Power switch (ON/OFF)
- 12: Power switch (ON/OFF)

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

### NOTE:

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

## 2. LED Indicator

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

### Green:

**Solid:** inverter is providing AC power from the batteries

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

**Fast Flashing:** (four times each second) charger is charging in Float mode at 13.5 volts, the factory setting for gel cell batteries. Float mode for liquid lead-acid batteries is 13.4 volts, configured using the RC7 remote control. See the *Three-Stage Battery Charger* section on Page 52 for a complete description of three-stage battery charging, and on Page 62, *The RC7 Remote Control* section.

### Orange

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

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

### Red

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



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

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

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

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

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

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

3. **BTS Port:** An optional battery temperature sensor (BTS) can be plugged in at the RJ-11 four-conductor connector. The BTS provides information that enables the three-stage standby battery charger to "fine tune" the battery charge rates for better charging performance, greater efficiency and longer life.
4. **Stacking Port (not used).** The Series II model is not a stackable unit.
5. **Remote Control Port:** The Legend Series II can be controlled up to 50 feet from the unit by plugging in a remote control (RC6 or RC7). See the *Options* section for a complete description of the RC6 and RC7 remote controls.
  - The RC6 reports DC voltage, charging or inverter current, and turns the inverter on and off..
  - The RC7 is a full function, programmable remote control with backlit LCD, battery capacity and other meters.
6. **Battery Positive Terminal**
7. **Vehicle Chassis Ground Terminal**
8. **Battery Negative Terminal**
9. **AC Safety Ground**
10. **External Chassis (equipment) Ground**
11. **AC Terminal Block**

## CONTROLS & INDICATORS

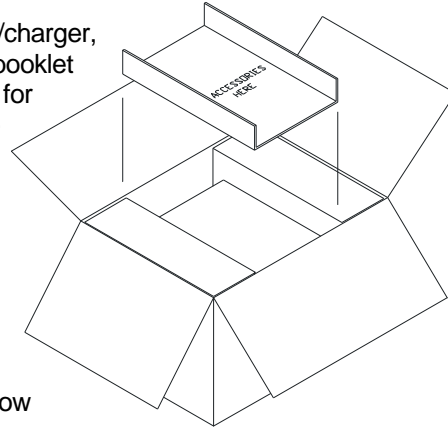
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12. **Charger Circuit Breaker:** 25 amps in the L2012 and L2512, 30 amps in the L3012. Press breaker to reset.

## Quick Install

Experienced installers, licensed electrical contractors, and knowledgeable laymen may follow the installation overview in this section. All others are urged to read the entire *Installation* section before installing the inverter/charger.

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



2. **Mounting** – Mount the unit securely in a horizontal position in a clean, dry, ventilated enclosure. Do not mount the unit in the same enclosure as vented or maintenance-free type vented batteries. Bolt the unit down securely. Allow adequate clearance to allow access to the front panel.

3. **DC Cabling**

- Ensure that the On/Off switch on the front panel of the inverter is in the Off position before you begin the installation.
- Connect a cable from the positive terminal of the battery or battery bank to the battery positive (red) terminal of the inverter. See *Minimum Recommended Battery Cable Size (In free air)* in Appendix C to determine the proper size cable to use for the inverter model and length of run needed for your specific application. The National Electric Code (NEC) requires the use of a DC fuse or disconnects in this cable within 18-inches of the batteries. See *Appendix C* to determine the correct size fuse or breaker to use.
- Connect an appropriate sized cable from the battery's negative terminal to the negative (black) terminal on the inverter. Torque all terminals to 12 foot-pounds.
- Connect a cable from the Vehicle Chassis Ground (green terminal) on the inverter to chassis ground (usually the frame of the vehicle).

4. **DC Loads**

- Connect a cable from the positive battery terminal to the positive buss of your DC load center.
- Ground all of your DC loads to your vehicle's chassis, or connect a cable from the ground bus of the DC load center to the vehicle chassis.

## QUICK INSTALL

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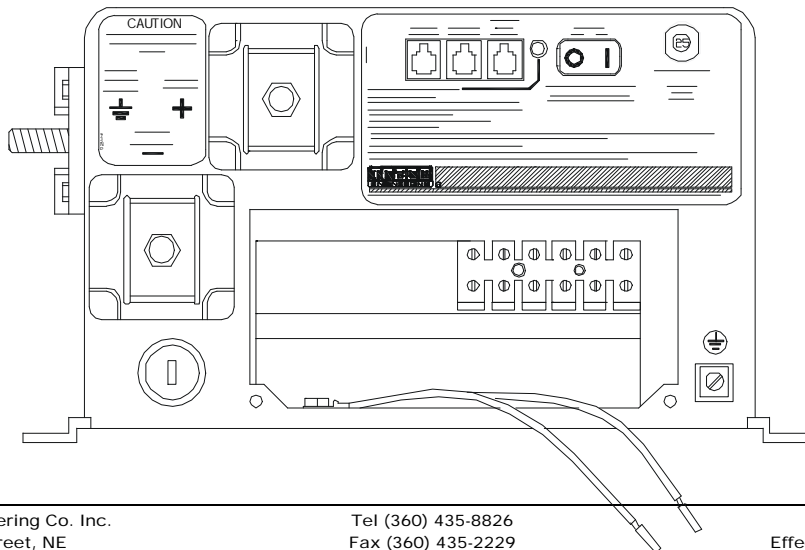
### 5. AC In Cabling

- See *Recommended Minimum AC Wire Sizes* in Appendix C to determine the appropriate AC wire size.

#### ! Caution:

**This inverter/charger includes neutral to ground switching for the AC electrical system. The AC system in mobile installations must have the neutral physically isolated from the ground throughout the load distribution powered by the inverter.**

- Disconnect any and all sources of AC power from the vehicle.
- Remove the knockout from the front or either side of the inverter chassis and install a strain relief or conduit in which to route the AC cabling in and out.
- Connect the black wire from an appropriately sized three-conductor AC cable from the hot side of the AC power supply (shore power connector) to the terminal labeled “AC Input Hot 1” on the inverter.
- Connect the white wire from the neutral side of the AC power source to the terminal labeled “AC Input Neutral” on the inverter.
- Connect the green wire from the ground of the AC power source to one of the two green wires (AC Safety Ground) bolted to the chassis of the inverter/charger.



## 6. AC Out Cabling

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

## 7. Wrap up

- Secure all wiring with wire ties or other non-conductive fasteners to prevent chafing or damage from movement and vibration. Use strain relief's, grommets, or conduit to prevent damage to the wiring where it passes through bulkheads or any apertures. Tighten all connections to 10-15 foot pounds.
- Check to see that the inverter front panel switch is in the “Off” position, then reconnect to the AC power source.
- Turn the inverter to the “On” position and check inverter operation (See *Operation* section)



## Installation

In this portion of the manual, we will look at requirements and recommendations for installing a Legend Series II inverter/charger. Keep in mind that these are only guidelines. Common sense, the National Electrical Code and local building codes are the final authority.

### Locating the Inverter

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 it works with, e.g. batteries, diesel generators, gas generators, washing machines etc. It is a highly complex microprocessor controlled device. Generically speaking, it is a cousin to stereo equipment, television sets, and 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 temperature change cause water to condense on components) all the ingredients for electrolysis are present — water, electricity, and dissimilar 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, potentially hazardous, and not covered by warranty.**

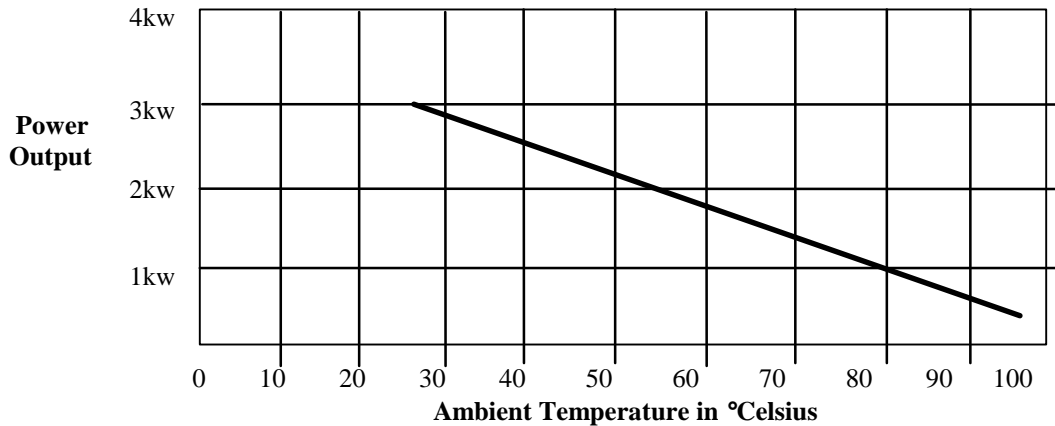
Locate the inverter as close to the batteries as possible in order to keep the battery cable length short. However, do not locate the inverter in the same compartment as vented batteries. Batteries generate hydrogen sulfide gas, which is very corrosive to electronic equipment and everything else. They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

### Ventilation

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

## INSTALLATION

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**Figure 1, Power Output Versus Temperature**

*Figure 1, Power Output Versus Temperature* is for the L3012. It outlines the ambient temperature needed in order for the inverter to perform to its published specifications.

The chart shows the output capabilities of the inverter, which is dependent on the ambient temperature in the enclosure where the inverter is located. The dark line represents the maximum power that may be expected from the inverter for a given ambient temperature. Testing has shown that the volume of the enclosure is not as important as the overall ventilation. As long as a minimum airspace of 1 ½- inches is maintained around the sides of the inverter, and three inches at the back of the inverter with the cooling fan, adequate ventilation should be maintained. Because the top of a Legend Series II inverter is not vented, clearance between the enclosure and the top of the inverter is not relevant.

The fan at the end of the inverter enclosure is for cooling. This fan pressurizes the inverter and ventilates through the side vents of the unit. A fresh air intake opening should be provided directly to the fan if possible, and an exhaust port directly opposite that will allow cool outside air to flow through the inverter and back out of the enclosure.

## Mounting

UL specification 458 (land vehicle installations) requires that the inverter be mounted on a flat surface. 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.



## DC Wiring

### Safety Instructions

The inverter's maximum peak current requirements and the charger's output current capabilities 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.

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

#### Caution!

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

Use the largest gauge wire and the shortest possible length when choosing battery cables. Tape the battery cables together every few inches with non-conductive electrician's tape or nylon tie-wraps. This reduces the inductance of the wire resulting in a better waveform and less current in the inverter's filter capacitors. This directly relates to output efficiency and inverter life span. High inductance in battery cabling is like placing a spring into the system between the battery bank and inverter. This spring absorbs, stores, and releases energy opposite to that flowing in the system. In this way efficiency and electrical characteristics are degraded.

#### Note

**Never disconnect the battery cables while the inverter is delivering power or battery charger is operating. The On/Off switch has no effect upon the charger. It turns Off only the inverter. To disconnect the batteries for service. a) turn off the power switch, b) disconnect all AC power, c) disconnect the battery cables.**

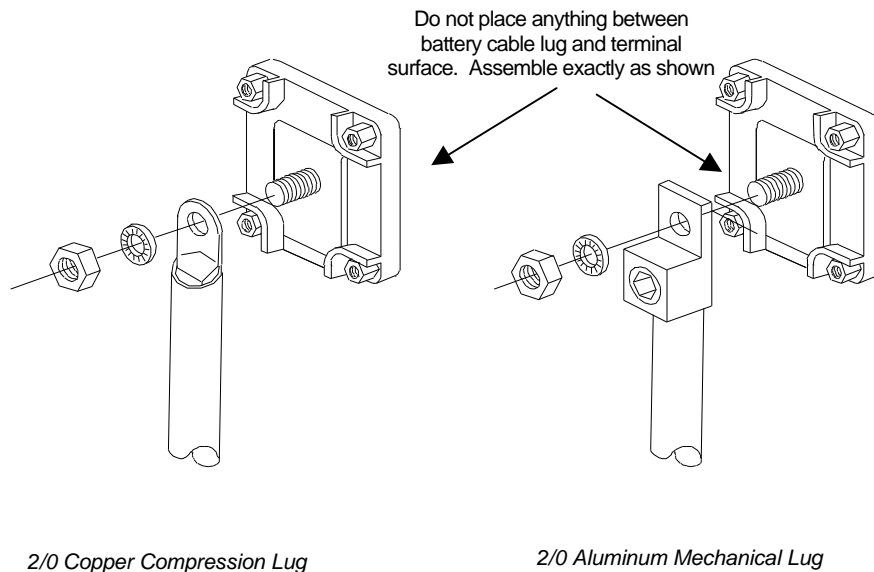
### DC Cabling Connections

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

## INSTALLATION

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Cables must have crimped and/or soldered copper compression lugs unless aluminum mechanical lugs are used. We suggest using high quality UL listed Trace Engineering battery cables. These cables are available in a specific assortment of sizes from 1 ½ to 10 feet, and in 2/0 or 4/0 AWG. They are color-coded and have pressure crimped, sealed ring terminals. Contact your Trace dealer to order.



**Figure 2, Battery to Inverter Cable Connection**

*Figure 2, Battery to Inverter Cable Connection* illustrates proper connections for the Legend Series II inverter/chargers. Points of caution are:

- ✓ **Do not** connect the battery negative (-) terminal to the vehicle chassis; connect it to the battery negative terminal of the inverter.
- ✓ **Do not** connect the DC load negatives to the battery negative (-), connect only to the chassis ground terminal on the inverter or to the vehicle chassis.

These connections are necessary in order for the RC7 remote control fuel gauge to work properly. All current into or out of the battery must pass through the internal shunt, which is between the chassis ground and battery negative terminals.

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

Hollingsworth, Pompano Beach, FL 305-979-2050	
Part #	Description
TL3061	2/0 Ring Terminal
TL3062	4/0 Ring Terminal
H40	8 AWG to 250MCM Air-Operated Crimping Tool
Thomas & Betts	
K973	2/0 Ring Terminal
M973	4/0 Ring Terminal
RJ737	2/0 Insulated Ring Terminal
RL737	4/0 Insulated Ring Terminal
TBM6	Hand Operated Crimping Tool (order dies separately)
Dies:	#11809 for crimping 2/0 non-insulated lugs
	#11811 4/0 non-insulated lugs
	#11826 2/0 insulated lugs
	#11828 4/0 insulated lugs

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

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

## Ground Cable Connection

You probably noticed that the Trace Legend Series II inverter/chargers have a third battery terminal labeled "Vehicle Chassis Ground" (the green terminal on the left side of the unit). The purpose of this third terminal is be sure that all DC load current into or out of the battery bank will flow through the internal shunt of the inverter. The internal shunt is connected between the black battery negative terminal and the green chassis ground terminal of the inverter (See *Figure 3, DC Wiring Diagram* on Page 30.)

Because all DC loads in a vehicle are generally connected to a common chassis ground and not directly to the battery negative (in a negative ground system), all DC current in the system will at some point pass through the chassis and then into the battery bank. If the inverter is in this loop the net current flow is easily monitored. Thus, the RC7 remote control's battery fuel gauge feature is

## INSTALLATION

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possible. You may connect the system without going through the chassis ground terminal, but the RC7's fuel gauge feature will not work properly.

### Battery Cable Sizing

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

**Table 1, Minimum Recommended Battery Cable Size (In free air)**

Inverter Model #	Typical DC Amps	Minimum Fuse Size	1 to 3 feet One Way	3 to 5 ft One Way	5 to 10 ft One Way
L2012	200 Amps	250A	00	00	0000
L2512	250 Amps	300A	00	0000	0000
L3012	300 Amps	400A	0000	0000	0000

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

The National Electric Code (NEC) requires that the cables be protected by a fuse or breaker rated to match the cables ampacity at 75 degrees Celsius. The NEC also allows rounding up to the next fuse size from the cable rating, i.e. 150-amp cable size rounds up to a 175-amp fuse size.

#### Warning!

**Under-sized cables may melt or burn if the inverter is asked to produce high power.**

### DC Over Current Protection

In order to comply with the UL 458 safety standard (Land Vehicle Installations) a UL approved type of battery over-current protection is required. Fuses and disconnects must be sized to protect the wiring in the system. The fuse is required to blow before the wire reaches its maximum current carrying capability.

These installation parts are not supplied as part of the inverter. However, Trace Engineering offers a DC-rated class T fuse and safety-covered fuse block which are compatible with the Legend Series II

inverter. The fuses are available in 110, 200, 300, and 400 amp sizes. Contact your Trace dealer to order; see the *Options* section of this manual for more information.

Note

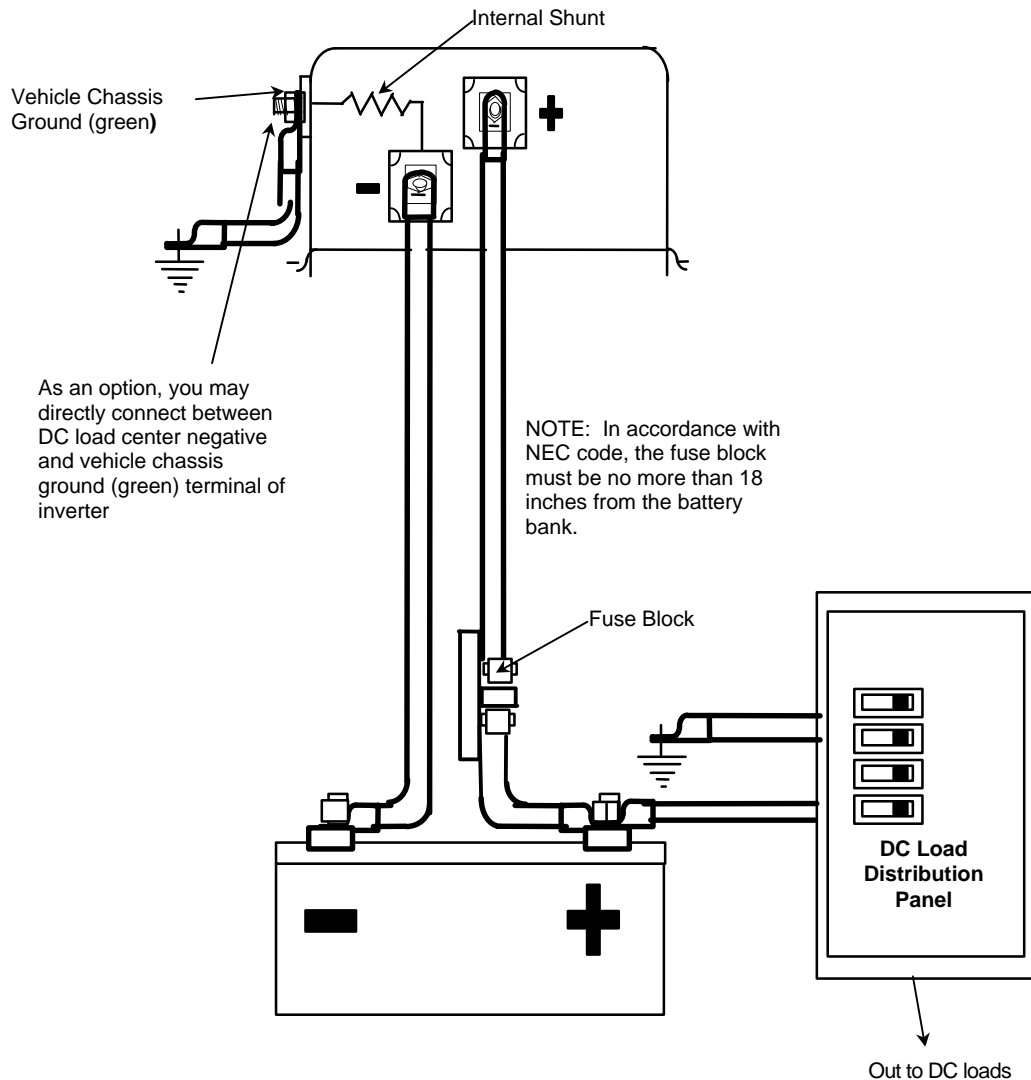
To order a fuse with fuse block from a Trace Dealer, order part number TFB followed by the desired fuse size in amps (i.e. TFB 400). When ordering replacement fuses, the part number is TF followed by the size in amps of the desired fuse (i.e. TF400).

**Table 2, Current Carrying Ability of Wire In Free Air at 75°C**

Cable Size	Maximum Rating in Free Air	Maximum Fuse Size
# 2 AWG	170 amps	175 Amp
00 AWG	265 amps	300 Amp
0000 AWG	360 amps	400 Amp

## INSTALLATION

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**Figure 3, DC Wiring Diagram**

## AC Wiring

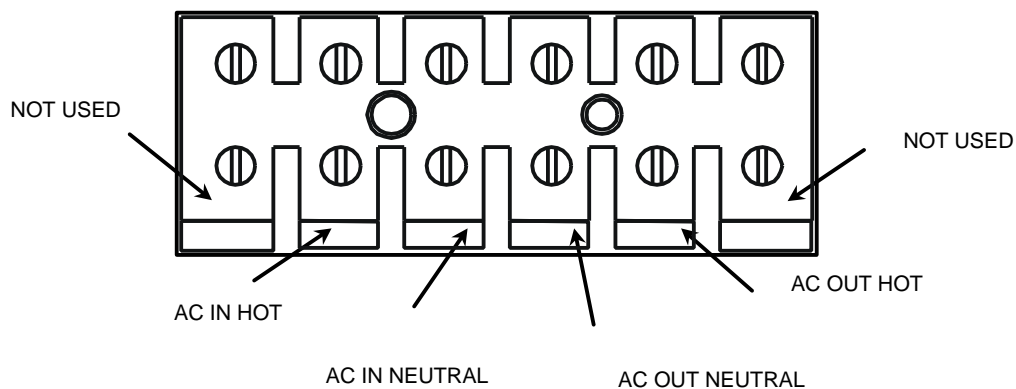
The National Electrical Code (NEC) defines the standards for AC installation wiring in vehicle applications, but there are still many installation variables; most are determined by the level of automatic switching desired and the amount of external AC power to be switched. A qualified electrician should do the installation.

## AC and DC Wiring Separation

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

## AC Wire Connections

The AC and DC terminals are located on the front panel of the chassis. A six-station terminal block is provided to make the AC connections. The terminal block is used to hardwire the AC input and AC output. All terminals are labeled on the inverter. Consult your local code for proper wire sizes, connectors, conduit, etc. Table 2, "*Current Carrying Ability of Wire in Free Air*" gives suggestions for wire sizing. 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.



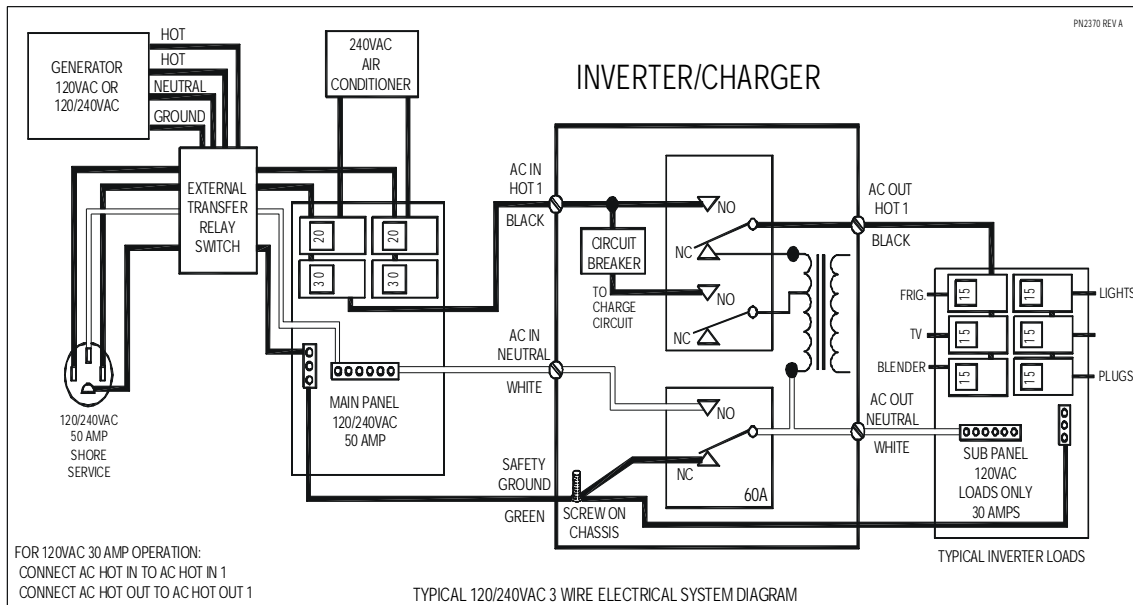
**Figure 4, AC Terminal Block**

When installing an inverter in a vehicle, do not use solid wires such as Romex™ because of the potential for shortened wire life due to vibration-induced breakage. Stranded copper wire is required. As a plus, stranded wire is generally much more flexible and thus easier to work with.

## INSTALLATION

The following steps are a basic guideline for installation and connection of the AC wiring into and out of the inverter.

1. Disconnect the inverter from the battery bank (if already connected), by either removing the DC side fuse, or opening the DC disconnect. Then remove the AC wiring compartment cover from the front of the inverter by removing the two screws at the bottom of the cover.
2. If conduit will be utilized (consult code, it may be required in your installation), determine which knockout(s) will be utilized and remove them from the inverter. Using appropriate conduit connectors, fasten the conduit to the inverter. Feed all AC wiring through the conduit and into the inverter AC terminal block (located on the front of the inverter). Be sure to leave yourself several extra inches of wire to work with. Remember that you need at least two sets of three conductor wiring, one for AC Hot, neutral, and ground into the inverter, and another for AC hot, neutral and ground out of the inverter to the loads. Torque all AC terminals to 10 to 15 inch-pounds.
3. Following the wiring guide shown below, connect the hot (black) and neutral (white) wires from the AC source (shore power or generator set) to the appropriately labeled terminals in the AC terminal block. The safety ground (green) should be connected to the terminal stud labeled "ground" bolted to the floor of the chassis. Repeat the procedure for the AC wiring going to the AC sub-panel which will power the loads, except connect these wires to the terminals labeled AC hot out.



**Figure 5, AC Wiring Diagram**



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

**Table 3, Recommended Minimum AC Wire Sizes**

Inverter Model	120 VAC Input	120 VAC Output
L2012	10 gauge	12 gauge
L2512	8 gauge	10 gauge
L3012	8 gauge	10 gauge

**! Important Precaution**

**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.**

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

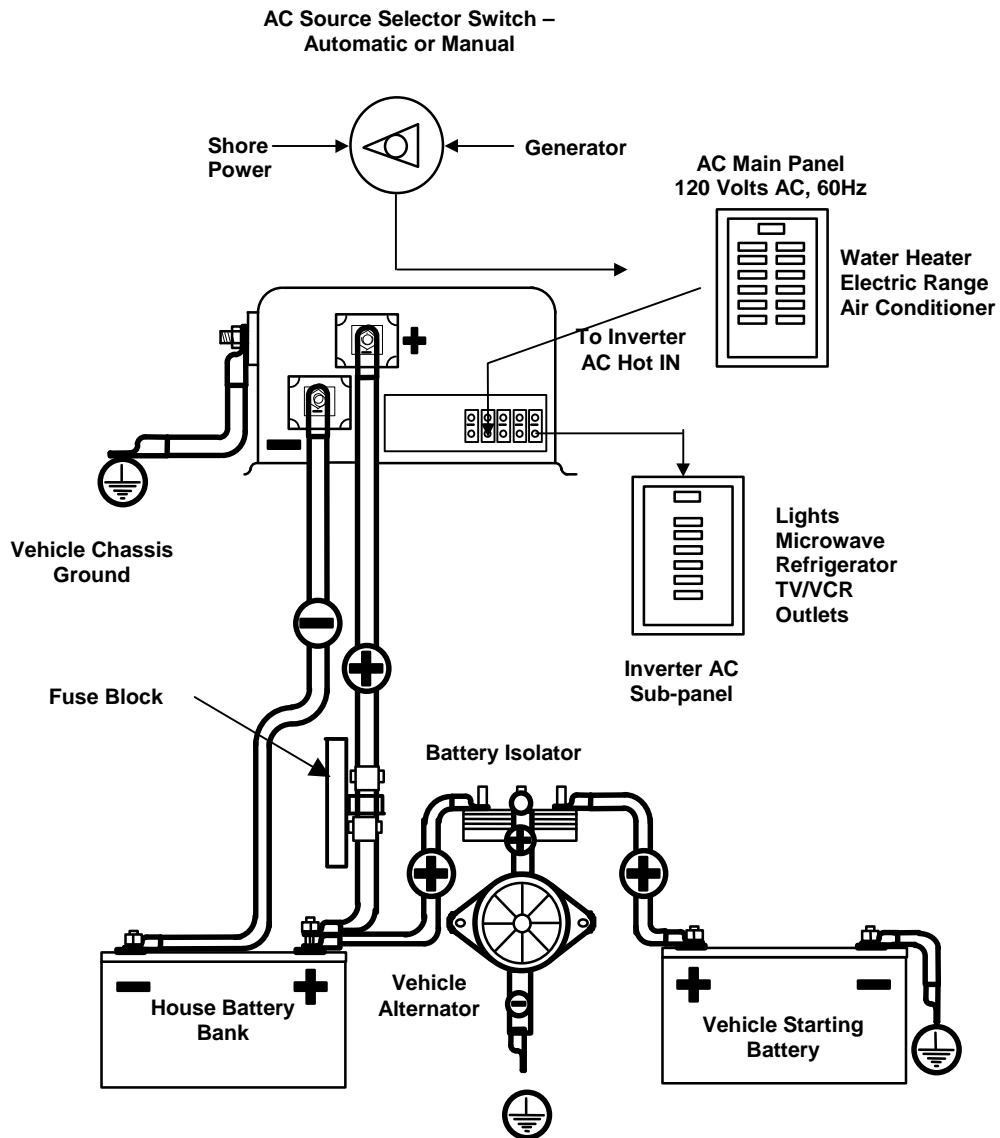
### Ground Fault Interrupting Outlets (GFCI's)

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

<b>LEVITON</b>	<b>6599</b>
<b>PASS &amp; SEYMOR</b>	<b>1591RI 4A957</b>
<b>ACE Hardware</b>	<b>ACE 33238</b>

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

## INSTALLATION



**Figure 6, Typical Mobile Installation Diagram**

## Neutral-to-Ground Switching

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

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

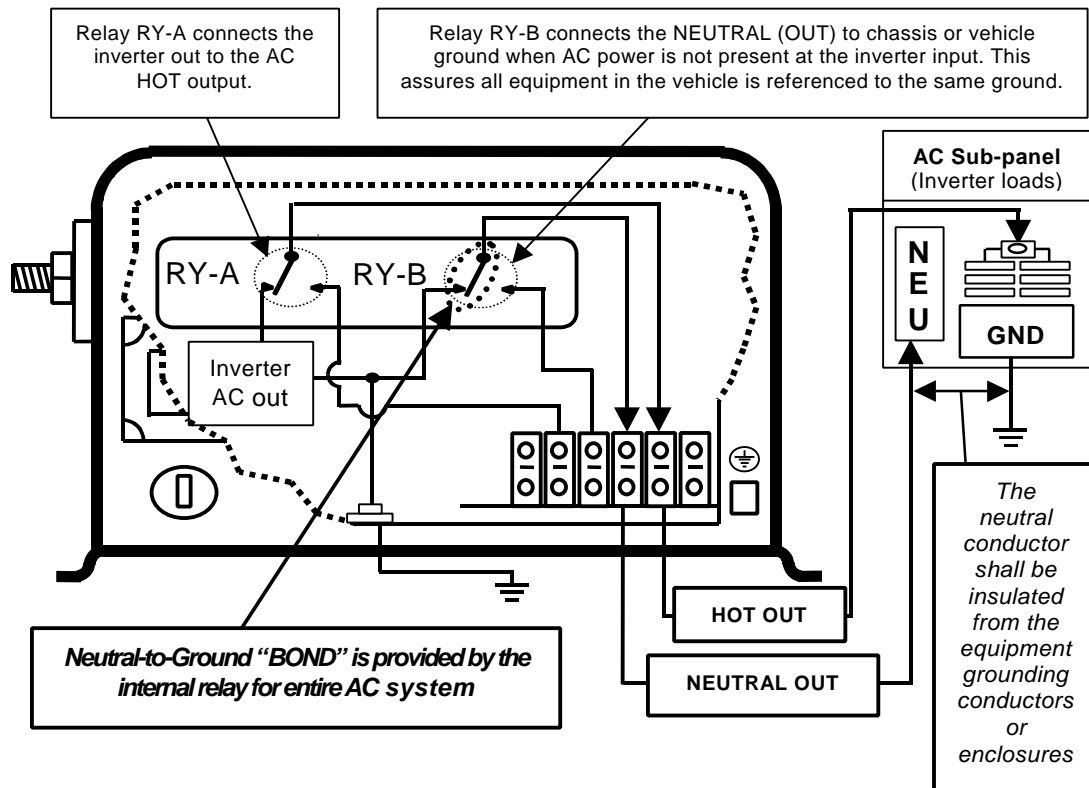
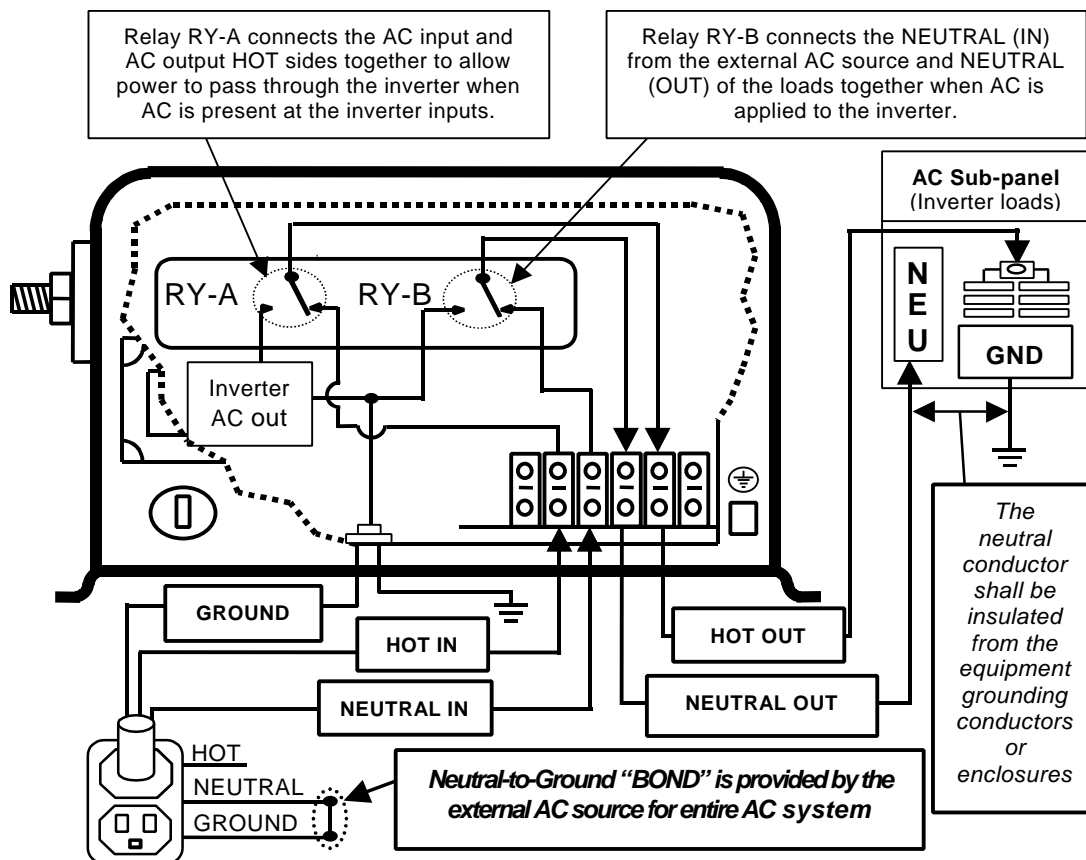


Figure 7, Neutral-to-Ground Switching without external AC source

## INSTALLATION

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

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



**Figure 8, Neutral-to-Ground Switching with External AC**

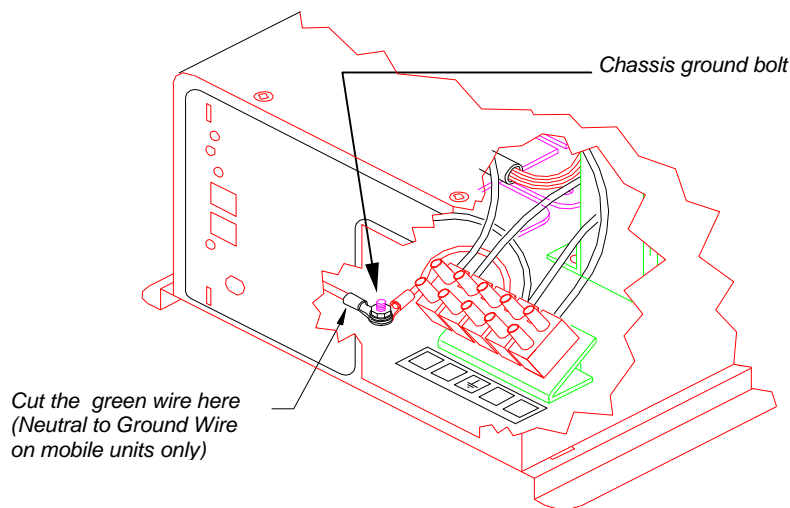
If no neutral to ground switching were employed in an inverter there would be one neutral tied to the AC sub-panel and the other neutral to the vehicle or chassis ground. The two different ground points would now form a current carrying conductor with the vehicle chassis acting as the “wire” between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

### Disabling Neutral Ground Switching

Legend inverters employ neutral-to-ground switching. In countries such as Canada this may be utilized, and therefore may need to be disabled before installation. Check local code if you are not sure whether you must disable the neutral ground switching feature.

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

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



**Figure 9, Disabling Neutral-to-Ground Switching**

## OPERATION

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

## Operation

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

Important! Before proceeding...

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

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

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

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

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

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





## Batteries

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

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

## Terminology

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

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

### Types

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

### Starting Batteries

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

### Deep-Cycle Batteries

Deep-cycle batteries are best suited for use with inverters. They are designed to have the majority of their capacity used before being recharged. Available in many sizes and types, the most common type is the non-sealed, liquid electrolyte battery. Non-sealed types have battery caps. The caps should be removed at least monthly to check the level of electrolyte. When a cell is low, only distilled water should be added. The electrolyte level should be checked monthly and topped up if needed after recharging.

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

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

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

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

### Sealed Gel Cell

Another type of battery construction is the sealed gel-cell. They don't use battery caps. The electrolyte is in the form of a gel rather than a liquid. This allows the batteries to be mounted in any position without spilling. The advantages are no maintenance (to the battery itself, the system will still

require routine maintenance), long life (800 cycles claimed) and low self-discharge. The disadvantage is high initial cost and the possibility of damage from overcharging.

While there are many manufacturers of quality non-sealed batteries, there are only a few manufacturers of suitable gel-cells. Don't confuse sealed batteries with maintenance free batteries. The latter is typically a standard liquid electrolyte type battery without caps for adding water, and when the electrolyte gets low, you replace the battery.

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

## Environment

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

### Location

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

The over-current protection device must be located per code within 18 inches of the battery installation, and must be covered to prevent possibility of discharging material in the event of a short circuit.

### Enclosures

Batteries must be protected inside a ventilated enclosure. The enclosure should be ventilated to the outdoors from the highest point to prevent accumulation of hydrogen gasses released in the charging process. An air intake should also be provided at a low point in the enclosure to allow air to enter the enclosure to promote good ventilation. For most systems, a one-inch diameter vent pipe from the top of the enclosure is adequate to prevent accumulation of hydrogen.

### Temperature

The effective capacity of a battery is reduced when cold. This phenomenon is more significant with lead-acid type batteries compared to alkaline types. When the internal temperature of a lead-acid battery is 32°F (0°C) the capacity can be reduced by as much as 50%. This effectively reduces the size of the system's "gas tank", requiring more frequent "refueling" by the back-up source (usually a generator). This should be considered when designing the system. If extremely cold temperatures are expected at the location of a system, either a heated equipment room or alkaline batteries should be considered.

If the system is located in an unheated space, an insulated enclosure is highly recommended for the batteries. During the charging process, the batteries release heat due to the internal resistance of

## BATTERIES

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the battery. If the batteries are insulated, the heat can be kept in the batteries to keep them warmer. This will substantially increase the performance of the system.

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

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

### Battery Bank Sizing

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

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

### Estimating Battery Requirements

In order to determine the proper battery bank size, it is necessary to compute the number of amp-hours that will be used between charging cycles. When the required amp-hours are known, size the batteries at approximately twice this amount. Doubling the expected amp-hour usage ensures that the batteries will not be overly discharged and extends battery life. To compute total amp-hours usage, the amp-hour requirements of each appliance that is to be used are determined and then added together.

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

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

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

Motors are normally marked with their running current rather than their starting current. Starting current may be three to six times running current. Manufacturer literature may provide more accurate information compared to the motor nameplate. If large motors will be started, increase the battery size to allow for the high demand start-ups require.

## Battery Bank Sizing Example & Worksheet

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

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

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

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

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

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

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

## BATTERIES

### Worksheet

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

**Table 4, Typical Appliance Watts**

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

## Monthly Maintenance

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

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

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

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

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

## Preparation

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

### Attire

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

### Tools

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

## BATTERIES

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- Inexpensive ½ inch chip brush or soldering brush

### Equipment

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

### Supplies

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

### Procedure

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

### Battery Enclosure and Batteries

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

### Terminals & Lugs

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

The most common cause of battery system failure is loose or corroded battery terminals and cable lugs. If any white powdery residue forms between the battery cable lug and the battery terminal, the cable must be removed for cleaning. When it is necessary to detach a battery cable from the battery,



turn the DC disconnect switches to the 'Off' position. Using the appropriate tool, remove the Negative battery cable first and install it last.

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

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

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

## **Cables**

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

## **Cabling & Hook-up Configurations**

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

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

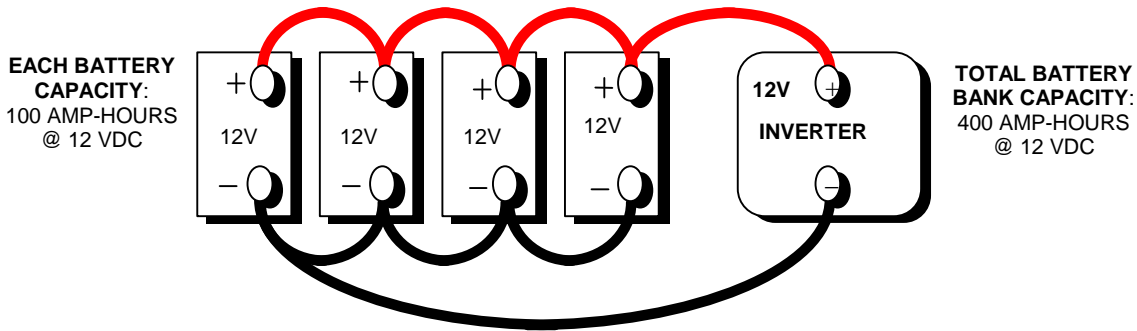
Connect several smaller batteries together when creating a battery bank of substantial size. There are three ways to do this. Batteries can be connected in parallel, series, or series - parallel.

## BATTERIES

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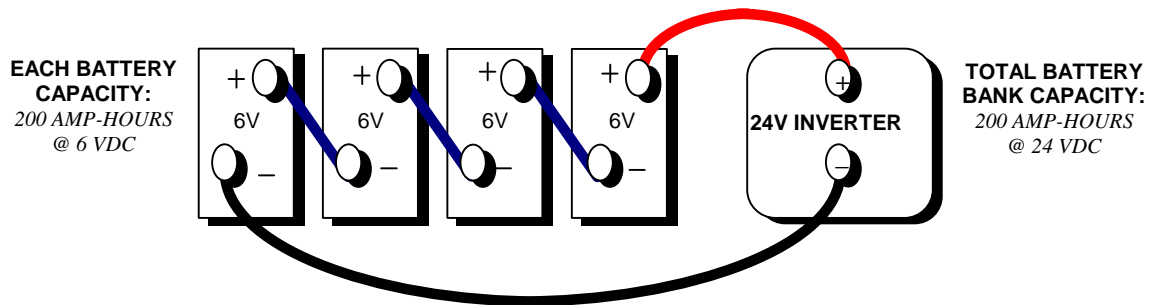
### Parallel Connection

Batteries are connected in parallel when all the positive terminals of a group of batteries are connected and then, separately, all the negative terminals are connected. In a parallel configuration, the battery bank have the same voltage as a single battery, but an amp/hour rating equal to the sum of the individual batteries. This is usually only done with 12-volt battery-inverter systems.



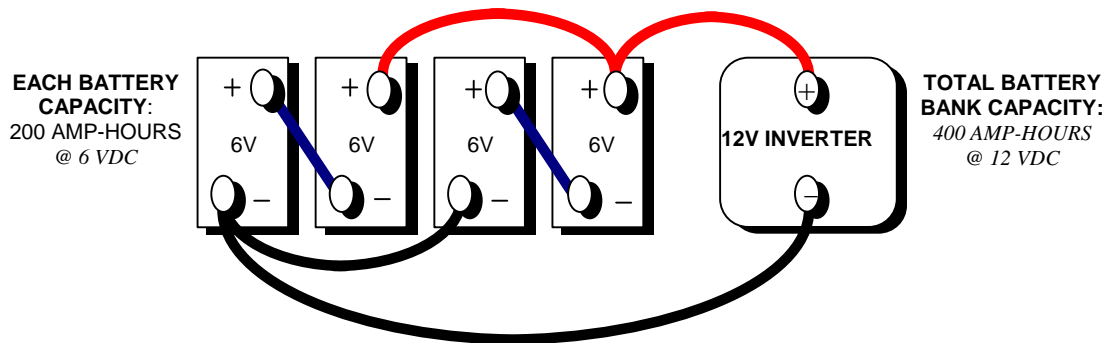
### Series Connection

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



### Series – Parallel Connection

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



#### ! CAUTION:

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

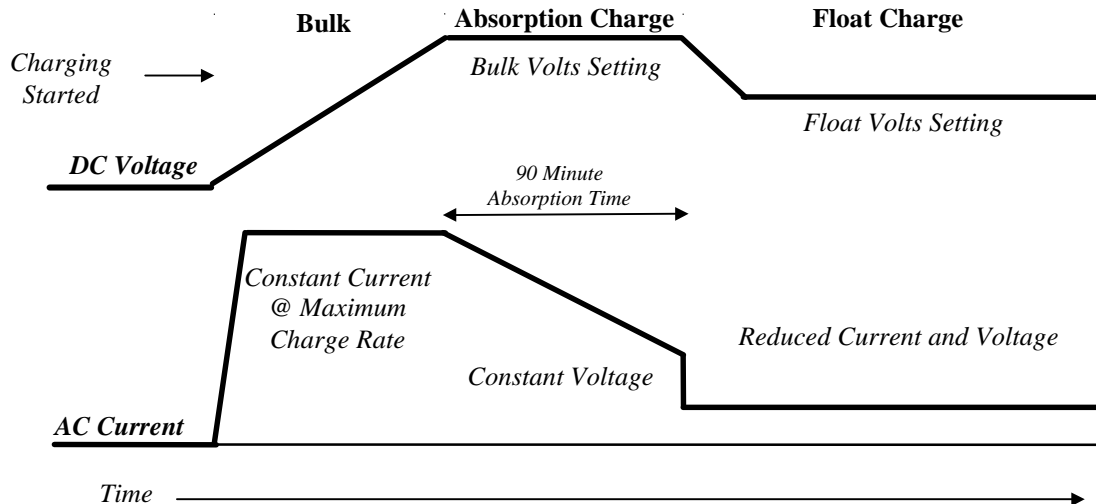
## Three-Stage Battery Charger

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

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

### Charging Profile

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



**Figure 10, Three-Stage Charging Profile**

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

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

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

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

Note

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

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

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

Note

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

**Table 5, Bulk and Float Setpoints**

Typical BULK and FLOAT Setpoints for Common Battery Types (12V System)		
Battery Type	Bulk Volts	Float Volts
Gelled Lead-Acid (sealed)	14.1 volts	13.5 volts
Liquid Lead-Acid (non-sealed)	14.5 volts	13.4 volts

## Generator Requirements

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

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

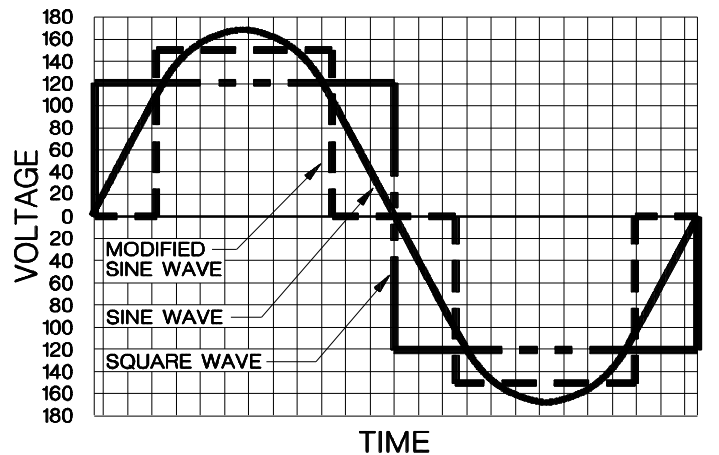
## Theory of Inverter Operation

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

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

## Waveform

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



**Figure 12, Comparison of Output Waveforms**

## Regulation

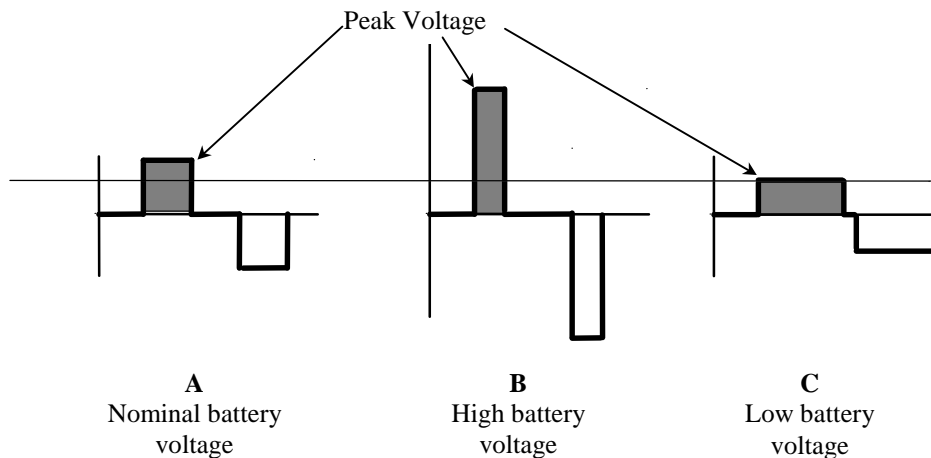
An advantage of a modified square wave compared to a square wave is the ability to regulate Root Mean Square (RMS) voltage by means of varying the pulse width, and off time periods. The pulse width variation method of regulation is referred to as pulse width modulation or PWM.

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

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

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

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



**Figure 13, RMS Voltage Regulation**



## Applications

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

### Resistive Loads

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

### Inductive Loads

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

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

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

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

### Problem Loads

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

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

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

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

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

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

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

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

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

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

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

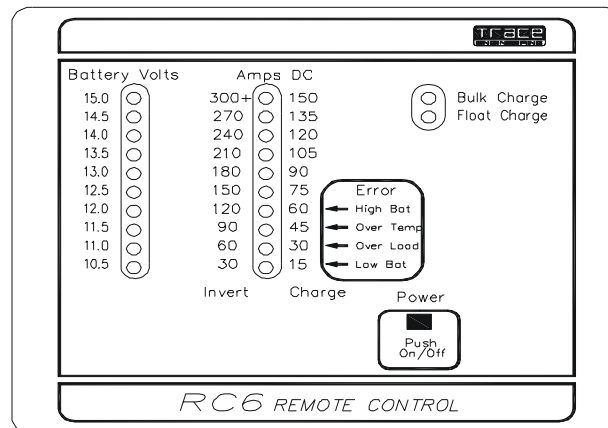


## Options

*Options available for the Legend Series II inverter/charger include a choice of remote controls, and a battery temperature control.*

### The RC6 Remote Control

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



**Figure 11, RC6 Remote Control Faceplate Display**

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

## OPTIONS

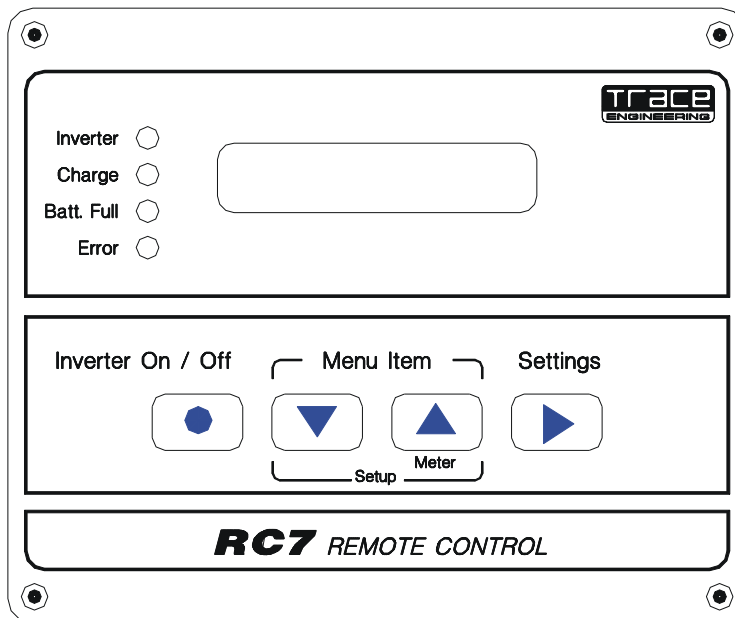
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four lights will blink when an error condition occurs. The Bulk Charge or Float Charge lights will light to indicate the inverter is in either the bulk or float stage of the charging process.

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

## The RC7 Remote Control

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



**Figure 12 , RC7 Remote Control**

The RC7 displays its information on a LCD screen and has multiple modes. A menu tree accompanies the RC7 to help navigate the RC7's many features. The RC7 is the only way to change the setpoints of the inverter. Once the desired changes have been made, the RC7 may be unplugged and these changes will be retained, even if the inverter is completely powered down.

When the RC7 is connected to the inverter, the inverter's status LED still operates normally. Installation and operating instructions are included with the RC7.

## Battery Temperature Sensor (BTS)

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



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

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

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

## Battery Cables

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





## Appendix A: Troubleshooting

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



## Appendix B: Other Products from Trace Engineering

### SW SERIES SINEWAVE INVERTER

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

### C40 MULTI-PURPOSE CONTROLLER

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

### C12 CHARGE CONTROLLER

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

### SW AND DR SERIES POWER PANEL SYSTEMS

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

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



## Appendix C: Reference Tables & Graphs

### Typical Power Consumption of Common Appliances

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

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

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

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

## English to Metric Wire Conversion Chart

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

## Minimum Recommended Battery Cable Size (In free air)

Inverter Model #	Typical DC Amps	Minimum Fuse Size	1 to 3 feet One Way	3 to 5 ft One Way	5 to 10 ft One Way
L2012	200 Amps	250A	00	00	0000
L2512	250 Amps	300A	00	0000	0000
L3012	300 Amps	400A	0000	0000	0000

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

## Maximum Fuse Rating in Free Air

Cable Size	Rating in Free Air	Maximum Fuse Size
# 2 AWG	170 amps maximum	175 Amp
00 AWG	265 amps maximum	300 Amp
0000 AWG	360 amps maximum	400 Amp

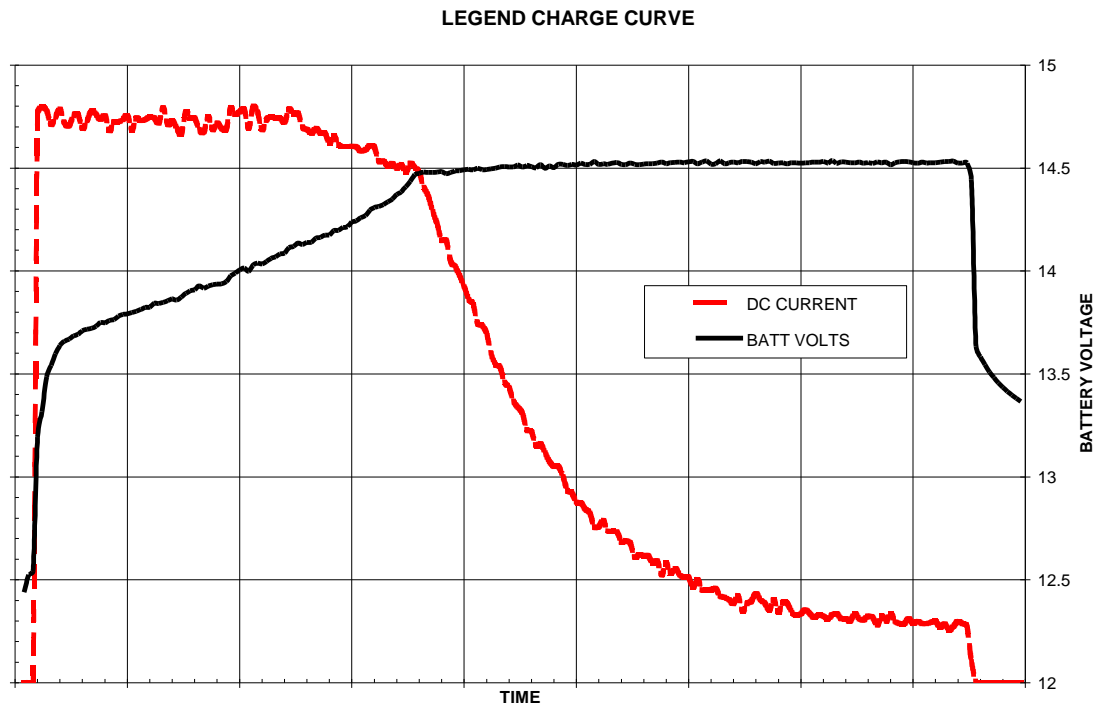
## Recommended Minimum AC Wire Sizes

Inverter Model	120 VAC Input	120 VAC Output
L2012	10 gauge	12 gauge
L2512	8 gauge	10 gauge
L3012	8 gauge	10 gauge

## Common Battery Charging Rates

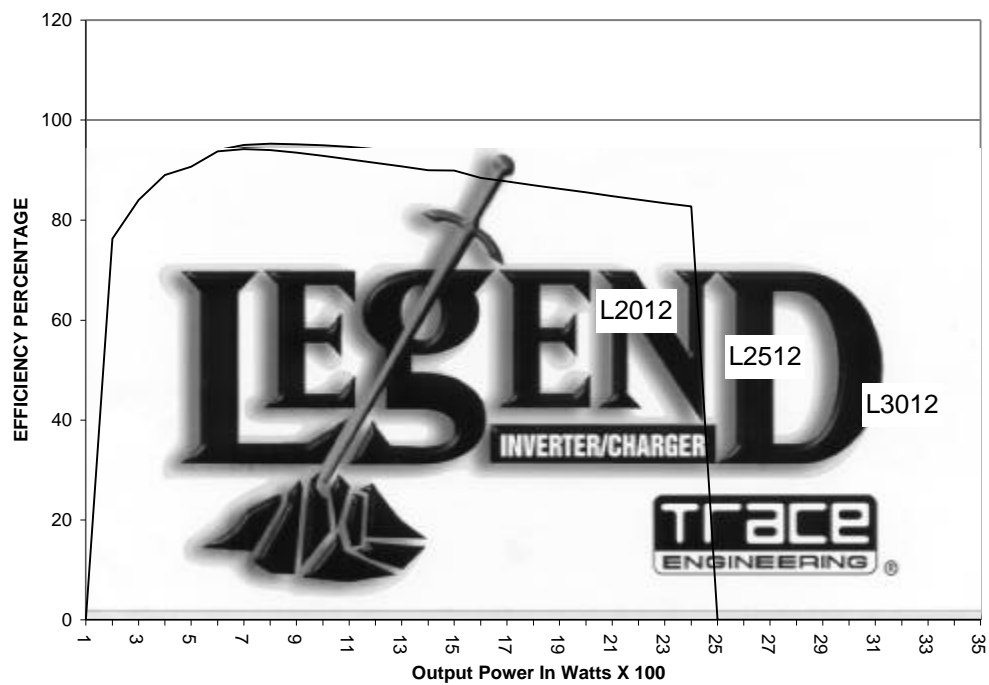
Typical BULK and FLOAT Setpoints for Common Battery Types (12VDC System)		
Battery Type	Bulk Volts	Float Volts
Gelled Lead-Acid (sealed )	14.1 volts	13.5 volts
Liquid Lead-Acid (not-sealed)	14.5 volts	13.4 volts

## Legend Series II Charging Graph

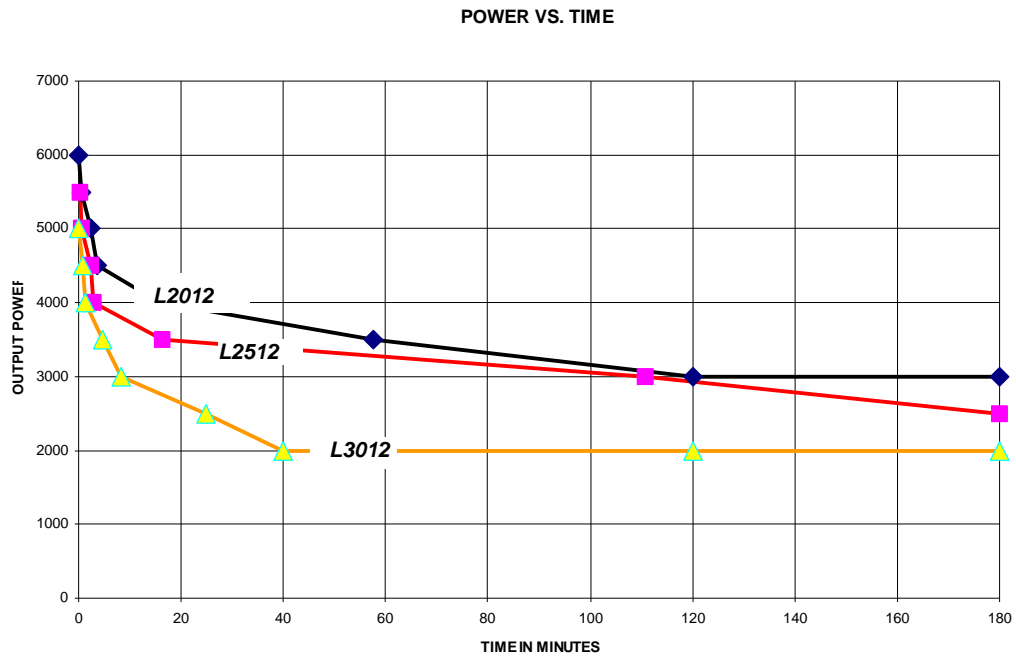




## Legend Series II Efficiency Curve



## Legend Performance Graph



## Appendix D: Specifications

MODEL	L2012	L2512	L3012
Continuous Power @ 25°C	2000 Watts	2500 Watts	3000 Watts
Continuous AC Current	16.6 amps	20.8 amps	28 amps
Efficiency (Maximum)	94%	94%	94%
Adjustable Charge Rate	10-100 amps	12-120 amps	14-140 amps
Unit Weight	45lbs(20.5kg)	50lbs(22.7kg)	60lbs(27.2kg)

### **DC Input Current Consumption**

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

### **The following specifications apply to all models:**

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

### **Environmental Characteristics**

Operating Ambient Temp	0°C to +50°C
Non-operating Temp	-55°C to +75°C
Altitude Operating	15,000 feet
Altitude Non-operating	50,000 feet
Dimensions	13.15" x 7.25" x 14.3" 33.3cm x 18cm x 35.2cm
Mounting	Shelf mount only

## APPENDIX D: SPECIFICATIONS

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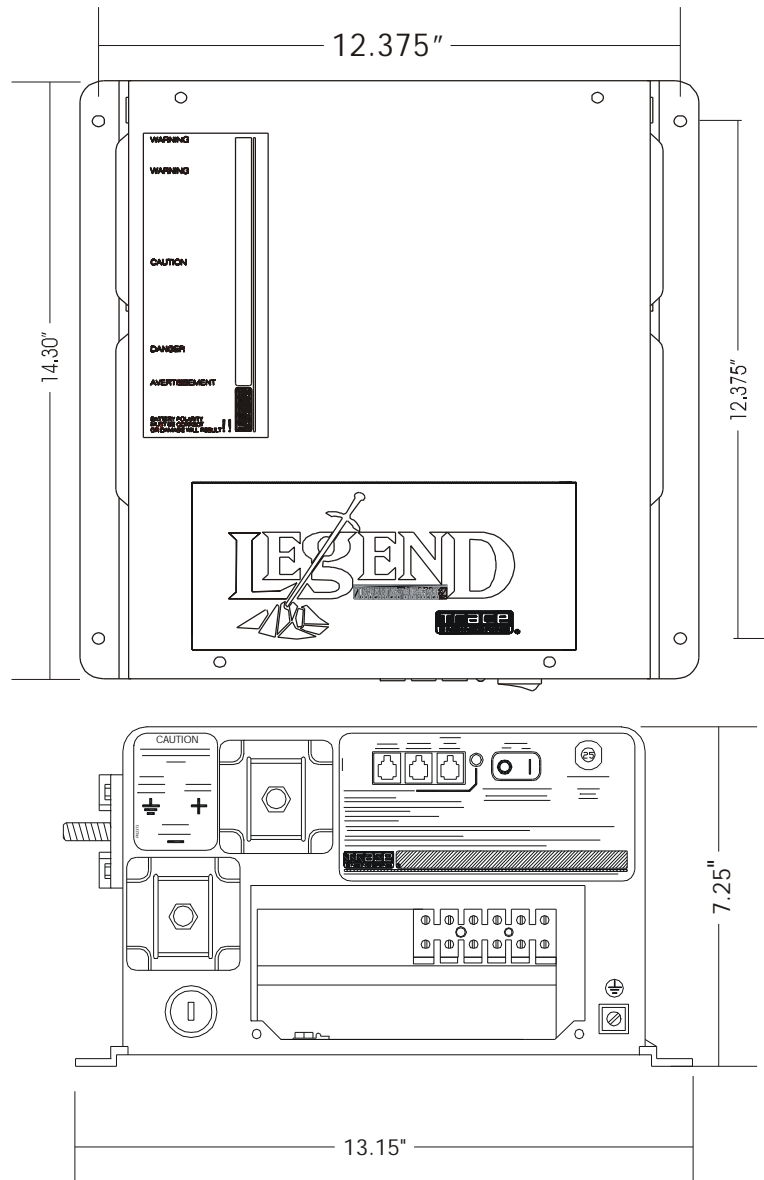
### **Factory Default Settings**

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

**All Specifications Subject to Change Without Notice**

## APPENDIX E: DIMENSIONS

### Appendix E: Dimensions



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



## Appendix F: Limited Warranty

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

This warranty period is extended to five (5) years to the original purchaser only, when the following conditions are met: (a) the unit is installed in a recreational vehicle (RV) only, and (b) the warranty is registered (warranty card is returned to Trace Engineering) by the original purchaser.

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

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

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

ALL REMEDIES AND THE MEASURE OF DAMAGES ARE LIMITED TO THE ABOVE. TRACE ENGINEERING SHALL IN NO EVENT BE LIABLE FOR CONSEQUENTIAL, INCIDENTAL, CONTINGENT OR SPECIAL DAMAGES, EVEN IF TRACE ENGINEERING HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. ANY AND ALL OTHER WARRANTIES EXPRESSED OR IMPLIED ARISING BY LAW, COURSE OF DEALING, COURSE OF PERFORMANCE, USAGE OF TRADE, OR OTHERWISE, INCLUDING BUT NOT LIMITED TO IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN DURATION TO A PERIOD OF FIVE (5) YEARS FROM THE DATE OF PURCHASE.

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

---

## Warranty Procedure

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

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

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

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

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

### Ship To:

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

Be sure to include in the package:

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



## APPENDIX F: LIMITED WARRANTY

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3. A copy of your proof of purchase (purchase receipt).

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

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

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

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## Appendix G: Life Support Policy

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

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

# Index

## A

absorption	
charging .....	53
AC Connections .....	31
AC input neutral .....	36
AC output neutral .....	35, 36
AC safety ground .....	17
AC Terminal Block .....	17
AC Wiring .....	30
ACE Hardware .....	33
alkaline	
batteries .....	43
AM radios .....	59
ambient temperature .....	24
autotransfusion devices .....	82
AWG .....	26, 49

## B

Baking Soda	
neutralizer .....	4
bar graph	
RC6 remote control .....	61
battery cable	
length .....	25
Battery Cable Sizing .....	28
battery cables .....	63
Battery Enclosures .....	43
Battery Location .....	43
Battery negative terminal .....	17
Battery plates .....	41
Battery Polarity .....	25
Battery Positive Terminal .....	17
Battery Temperature .....	43
Battery Temperature Sensor (BTS) .....	63
battery terminal .....	41
breakers .....	31
BTS Port .....	17
bulk voltage	
charge .....	53

## C

Cable ends .....	26
Charge Rate .....	75
Charger Circuit Breaker .....	18

chassis ground .....	26, 27, 35, 37
clock accuracy .....	58
clocks .....	58
compressors .....	57
computers - use with inverter .....	11
conduit .....	31, 32
conduit connectors .....	32
Controls & Indicators .....	15
Copper Compression Lugs	
described .....	27
copper wire .....	31

## D

deep cycle .....	41
deep cycle battery .....	42
dimmer switches .....	59
Disabling Neutral Ground Switching .....	37
disconnect switch .....	31
distilled water	
and batteries .....	47

## E

efficiency .....	57, 69
electrolyte .....	41, 42, 47, 53
defined .....	41
Environmental Characteristics .....	75
equipment ground .....	17
error condition	
LED indication .....	17
estimating battery requirements .....	44
external chassis ground .....	17

## F

Factory Default Settings .....	76
fan, cooling .....	24
FET .....	See field effect transistor
field effect transistor switches .....	55
float voltage .....	53
Fluorescent lights .....	58
Free Air .....	28
Fuse Block	
part number .....	29
fuse size .....	28, 29

---

## G

generator .....	43, 44, 53, 57
spin up .....	38
Generator Requirements .....	54
GFCI's .....	33
ground .....	
equipment .....	17
Ground Cable Connection .....	27
Ground Fault Interrupting Outlets .....	33
ground switching .....	35, 37

## H

Hand Crimping Tool .....	27
hemodialysis .....	82
Hollingsworth .....	27
hydrogen .....	43
hydrogen sulfide gas .....	23

## I

identification placard .....	
defined .....	13
Impulse Phase Correction .....	10
incubators .....	82
Induced current .....	31
induction motors .....	10, 57
Inductive Loads .....	57
infusion pump .....	82
Input Voltage .....	12
Inverter Operation .....	
theory .....	55
Inverter to Charger Transition .....	11

## K

knockout(s) .....	32
-------------------	----

## L

Laser Printers .....	59
lead acid .....	8
lead acid batteries .....	8, 43, 53, 75
lead acid, neutralizer .....	4
LED Indicator .....	16
LEVITON .....	33
life support devices .....	82
Life Support Policy .....	82

## M

Maintenance .....	
batteries .....	47
maintenance free .....	
batteries .....	43
Mechanical Lugs .....	27
microwave ovens .....	10
Model Identification .....	12
Model Type .....	12
modified sine wave .....	55, 56
motors .....	
capacitor start .....	57
Mounting .....	24
Murphy's Law .....	9

## N

National Electric Code .....	35
National Electric Code (NEC) .....	28, 31
neonatal ventilator .....	82
neoprene .....	
liquid .....	47
nerve stimulators .....	82
neutral ground switching .....	35, 37
neutral wire .....	32
neutral-ground switching .....	
error .....	33
Neutral-to-Ground Switching .....	35
nuisance trip .....	33

## O

On/Off Switch .....	
operation .....	15
operating environment .....	23
Operation .....	38
output capabilities .....	24
Over Current Protection .....	28
overcurrent .....	7
over-current .....	
LED indication .....	16
overload .....	7
overtemp .....	7
oxygen analyzers .....	82

## P

parallel .....	49, 50
parallel connection .....	50
PASS & SEYMOR .....	33

## INDEX

---

pass through ..... 15  
peak output voltage..... 28, 58  
peritoneal dialysis ..... 82  
Plates ..... 41  
Power LED..... 9  
Power levels ..... 12  
power supplies ..... 58  
Precautions ..... 2, 4  
Problem Loads..... 58  
pulse width modulated square wave See  
    waveforms  
pumps ..... 57, 82  
PWM ..... see waveforms. see

## R

RC6 Remote Control..... 61  
RC7 Remote Control..... 62  
Rechargeable Devices..... 59  
Regulation..... 56  
Remote Control Port ..... 17  
repair procedure..... 80  
Resistive Loads..... 57  
reverse polarity ..... 25  
RMS..... 56  
RMS- Root Mean Square..... 65  
Romex™ ..... 31  
root mean square..... 56  
running current..... 44, 57

## S

Sealed Gel Cell Battery..... 42  
search mode  
    nightlite ..... 9  
Search Mode..... 9  
self test ..... 38  
    described ..... 38  
Serial Number..... 13  
series ..... 26, 49, 50, 61  
Series – Parallel Connection  
    described ..... 51  
Series Connection  
    described ..... 50  
sine wave ..... See waveforms  
Specifications..... 75  
square wave..... See waveforms  
Stacking Port ..... 17

Starting Batteries ..... 42  
starting current..... 42, 44  
status LED ..... 7, 63  
Stratification ..... 41  
Sulfating ..... 41  
surge power ..... 28, 57

## T

T fuse  
    DC rated ..... 28  
Temperature Compensation ..... 41  
terminal block..... 31  
Thomas & Betts ..... 27  
Torque  
    wire connections ..... 32  
Transfer Switching Speed..... 11  
transfer time..... 11  
Troubleshooting ..... 65  
True RMS Voltage Regulation ..... 10

## U

UL 458 ..... 2, 24, 28  
uninterruptable power supply  
    UPS ..... 9  
UPS  
    uninterruptable power supply ..... 11

## V

vehicle chassis..... 26  
Vehicle Chassis Ground Terminal..... 17  
Ventilation ..... 23  
Vinegar  
    electrolyte, neutralizer..... 4  
voltage  
    bulk ..... 53

## W

Warranty ..... 79  
Warranty Procedure..... 80  
waveform(s) ..... 55  
wire  
    stranded copper ..... 31  
Wiring Separation ..... 31