MARATHON

POWER

TRTC-2000-N1

User Manual

SAVE THESE INSTRUCTIONS

TABLE OF CONTENTS

IMPORTANT SAFETY INSTRUCTIONS ARE CONTAINED IN THIS MANUAL

CAUTION

RISK OF ELECTRICAL SHOCK

To reduce the risk of electrical shock and to ensure the safe operation, the important safety instructions are marked with the symbols as shown below. These symbols are used throughout this manual and wherever they appear, it indicates that the instructions should be carried out only by qualified personnel.

Indicates presence of **A DANGEROUS VOLTAGE** in the area.

Extreme caution should be used.

Indicates **ATTENTION** to Important operating instructions.

Follow them as indicated.

DANGER: Do not expose the unit to rain or moisture.

DANGER: Total Earth ground leakage current of loads connected to the unit should not exceed 2.4 mA.

The unit generates, uses and can radiate radio frequencies if not installed and tested in accordance with the instructions contained in this manual. It has been tested and found to comply with the limits established for a Class A computing device pursuant to part 15 of FCC rules when it is operated alone. It also complies with the radio interference regulations of DOC, which are designed to provide a reasonable protection against such interference when this type of equipment is used in a commercial environment. If there is interference to radio or TV reception, which is determined by switching the unit on and off, relocate the equipment or use an electrical circuit other than the one used by the unit.

IMPORTANT SAFETY PRECAUTIONS

Only qualified personnel should service or supervise the unit.

Danger: Sealed lead-acid batteries with high energy and chemical hazards are used. This manual contains important operation and safety instructions.

Safety System Checklist

- Carefully unpack the unit. Report any shipping damage **at once**.
- ***Read this manual.*** If you have any questions about safe installation, operations or maintenance of the system, contact Customer Service.
- ***Before installation***, confirm that the voltage and current requirements of the load(s) are compatible with the system's output. Confirm that the line voltage and current is compatible with the system's input requirements.
- The system should be installed on a dedicated power circuit.
- Place a warning label on the enclosure indicating that an Uninterruptible Power Supply (UPS) is located inside, in case of an Emergency.
- Use proper lifting techniques when moving system.
- The unit has more than one live circuit. It is fed from AC as well as Battery power. Power may be present at the output(s) even if the system is disconnected from line power.
- When installing the unit in a cabinet not provided with the system by the manufacturer, ensure that the environment meets the system specifications shown in Section 2.4.6, "Specifications" of this Manual.

SAVE THIS MANUAL

It contains important installation and operating instructions.

Keep it in a safe place

Battery Safety Checklist

- High & ***dangerous voltages*** are present inside the system. Only qualified personnel should perform installation and maintenance.
- Live battery wires ***must not*** touch the unit chassis or any other metal objects. ***This can cause a fire or explosion.***
- **Inspect** the batteries once a year for signs of cracks, leaks, or swelling. Replace as needed.
- When batteries are in storage, **charge** them at least once every three months for optimum performance and to extend their lifetime.
- **Always** replace batteries with the ones of identical type and rating. **Never** install old or untested batteries. **Never** mix old with new batteries. **Never** mix different types of batteries within one system.
- Use **insulated tools** during servicing.
- **Remove** all rings, watches, jewelry, or other conductive items before working inside the enclosure.
- **Follow** local regulations for the disposal of batteries. Recycling is the best method.
- ***Never*** burn batteries to dispose of them. ***They may explode.***
- Do not open the batteries. ***The contents are toxic.***
- Prior to handling suspect (damaged or discharged) batteries on a metal rack, insure the battery is not inadvertently grounded by measuring the voltage between the battery and the rack. The voltage should be zero.

Stand-By Generator

Note: If the unit constantly switches between Battery and Line modes because of line fluctuations, the input parameters should be ***broadened from Normal to Generator*** (see Section 2.2.12 “Sense Type”)

In Generator mode, the acceptable range of input frequency and voltage is expanded to accommodate the voltage and frequency fluctuations created by a generator or similar power source.

Use a generator with electronic speed and voltage controls which typically produces Total Harmonic Distortion in % (THD) to be less than 10%. Generators with Mechanical governors can force the system to run continuously in Battery mode.

Before installation, compare the generator’s output voltage to the unit’s input voltage requirements as listed on both nameplates. To insure the system’s smooth running, use a generator capable of supplying 2X or twice as much power as required by the total load.

Unpacking and Inspection Checklist

Purpose: Describes the unpacking and inspection procedures.

Carefully remove the unit from its box. Inspect the contents and make sure the following items are included:

- One UPS controller.
- One plastic bag containing following:
    - One temperature sensor cable with 3-pin connector.
    - Two sets of this manual.
    - One Warranty Card.

The Power Transfer Switch (PTS) and all the associated wiring & hardware required for installation are supplied in a separate box.

The set of four (4) batteries may be shipped separately if a large quantity of units is supplied.

Tip: If any items are missing or damaged, contact the manufacturer and the shipping company at once. Most shippers have a short claim period.

SAVE THE ORIGINAL SHIPPING BOX

When returning the unit for servicing, use the original shipping box with the supplied styrofoam protectors. Manufacturer is not responsible for damage caused by improper packaging of returned systems.

READ THE OPERATOR'S MANUAL

Before installation, become familiar with the unit by reviewing the procedures and drawings in this manual. If you have any questions about safe installation, operation, or maintenance, contact Customer Service.

Complete the following for records & future servicing

Model No._____

Serial No._____

Date of Manufacture_____

(Above items can be found on the nameplate label attached to the side of the unit)

Manufacturer Sales Order No._____

Manufacturer Part No._____

Your Purchase Order No._____

Purchased from _____

(Following details are for installation location)

Installation Date. _____

Installed by_____

City_____

State/Province _____

Zip/Postal Code _____

Country _____

Telephone #_____

Fax # _____

E-Mail_____

Street names of Location _____

Cabinet / Controller type _____

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Uninterruptible Power Supply Controller

1 Installation & Start-Up

1.1 Description

Purpose: *Describes the operation of the System (Figure 1, 2 & 3).*

1.1.1 System Description

The System provides backup power to traffic control signal equipment. It consists of the Uninterruptible Power Supply (UPS) Controller, the Manual Bypass Switch (MBS)/Power Transfer Switch (PTS), and Batteries. These three components are mounted inside an enclosure to provide protection from most weather conditions.

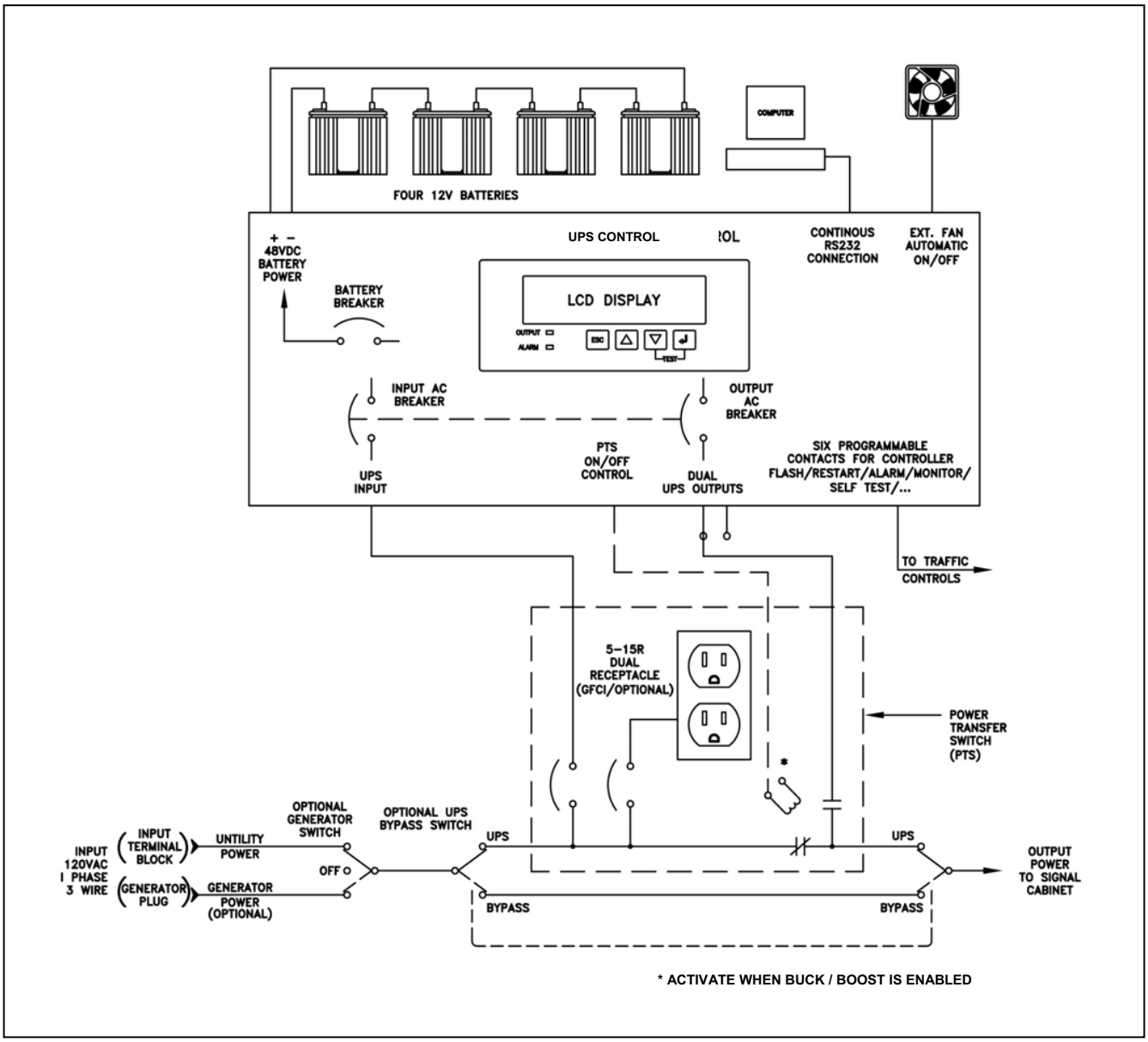


Figure 1
Simplified System Block Diagram

The traffic signal cabinet is powered continuously when the system is installed. The system allows connection for the normal utility power using standard terminal blocks or an optional generator power via standard 30 Amp generator plug. The Manual Bypass Switch allows the system to operate without the PTS or UPS if they need to be removed for service.

The PTS allows normal utility AC to flow out to the traffic cabinet when the utility line is qualified or is within the acceptable range as programmed. The UPS input is protected with one circuit breaker located on the PTS as well as another one located on the UPS module. When the UPS internal BOOST and BUCK is enabled, the PTS is activated normally allowing UPS transformer to continuously boost/increase the output voltage by a fixed 13.9% when input is lower, or buck/decrease the output voltage by a fixed 10.9% when input is higher. For even lower or higher input voltages, the UPS switches to run from batteries when input power is outside the specified acceptable range. The PTS has dual NEMA power receptacles for optional battery heating pads (switched off when On Battery) or connecting an external LED to indicate On Battery (switched on when On Battery).

The batteries are continuously maintained charged from a smart temperature-compensated internal charger. For the protection of the battery the charging of the battery is stopped when the battery temperature exceeds 50 °C. When the batteries are fully charged, the smart charger provides a continuously pulsating ON-OFF trickle charge to keep the batteries topped-off or fully charged. When input power is not qualified or is outside the acceptable range, the UPS draws DC power from the bank of four batteries connected in series and maintains AC output power until the batteries are depleted. The traffic intersection runs full phase and/or in flash mode as programmed by user. The programmable contacts allow user to put the intersection in flashing immediately as soon as the input power is lost, after batteries are depleted down to a certain capacity, or after a period of time. The amount of back-up time battery power can provide depends on the Amp-hour capacity of the batteries used, the load being supplied, and the environmental conditions (temperature).

1.1.2 UPS Controller

The UPS Controller shown below provides control functions and backup power as described above. For more information, please see Section 2 of this Manual.

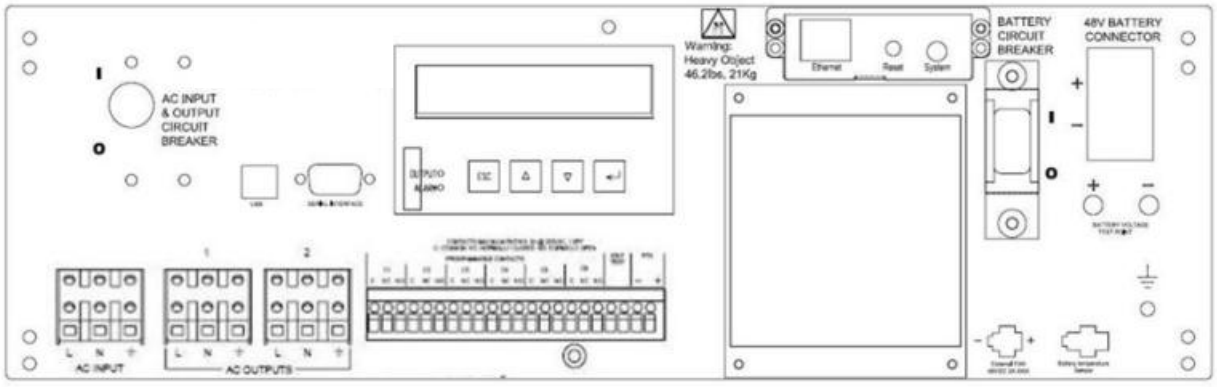


Figure 2
UPS Controller Front Panel

1.1.3 Manual Bypass and Power Transfer Switch

The Manual Bypass Switch (MBS) and Power Transfer Switch (PTS) may be one of several types but will be similar to that shown below. The manual bypass allows the UPS or PTS to be removed for service, replacement or maintenance without interrupting power to the traffic cabinet. The PTS provides automatic switching of the output from AC line to UPS while at the same time isolating and preventing backfeed of current into the AC line for electrical safety or personnel.

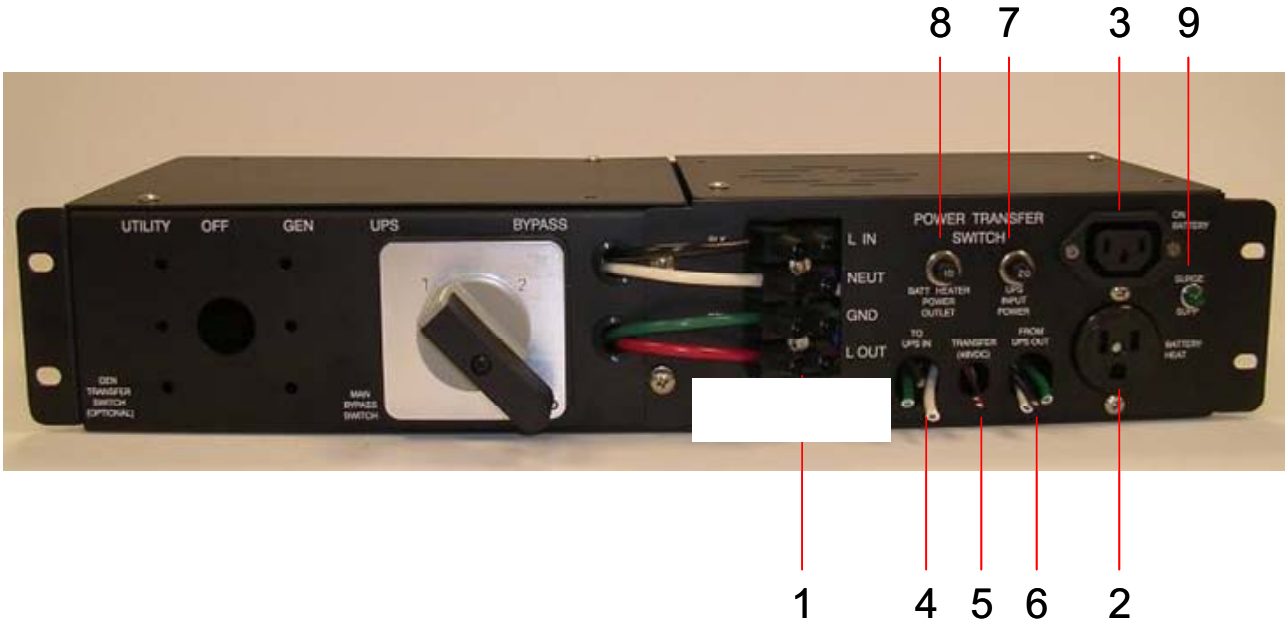


Figure 3
Manual Bypass and Power Transfer Switch

1. AC terminal block for connection of PTS to Manual Bypass Switch.
2. AC switched outlet Off when On Battery to power optional battery heater mats.
3. AC switched outlet On when On Battery to power LED on cabinet exterior for ON BATTERY indication.
4. “TO UPS IN” cable is connected to INPUT AC terminal blocks on the unit.
5. Red and Black PTS control wires are connected at terminals 21 & 22 of the green terminal block on the unit.
6. “FROM UPS OUT” cable is connected to one of the two OUTPUT AC terminal blocks on the unit.
7. “UPS INPUT POWER” circuit breaker provides input power protection for the UPS.
8. “BATT HEATER POWET OUTLET” circuit breaker protects AC outlet for battery heater mats.
9. “SURGE SUPP” green LED on to indicate surge suppression is active.

1.1.4 Batteries

Different Amp-hour capacities or sizes of batteries can be used in the UPS system to provide various backup times. Four batteries are connected in series for the required 48VDC. Contact customer service for information on the battery best suited for your application. The battery harness supplied with the system is polarized and equipped with Anderson type connectors. Each battery can be unplugged from the system for the hot swap as the battery harness provides heavy-duty connector for each battery. Each of the four batteries may be connected in any random order using the provided harness.

1.2 Mounting

Purpose: *Describes how to mount the System in an enclosure.*

The system components can be mounted in a single external cabinet or in the existing traffic cabinet.

EXTERNAL MOUNT:

The factory-supplied external cabinet can be bolted onto the existing or new traffic cabinet, pad-mounted on a concrete slab or be pole mounted. The separate base for the cabinet for installation in the concrete slab, bolts & hardware for bolting onto the side of the traffic cabinet, bushing for the wire ducts, brackets for pole mounting and all the required accessories including mechanical hardware and electrical wiring are supplied to make the installation easy for the contractor. External cabinets such as BC100, BC80, etc. are outdoor type, weather proofed provided with internal exhaust fan that is temperature controlled, an intake filter that can be cleaned or replaced, 3 point lock mechanism, lockable handle with dual keys and a unique internal keyed lock. The factory-supplied cabinet meets or exceeds the requirements of various NEMA classifications.

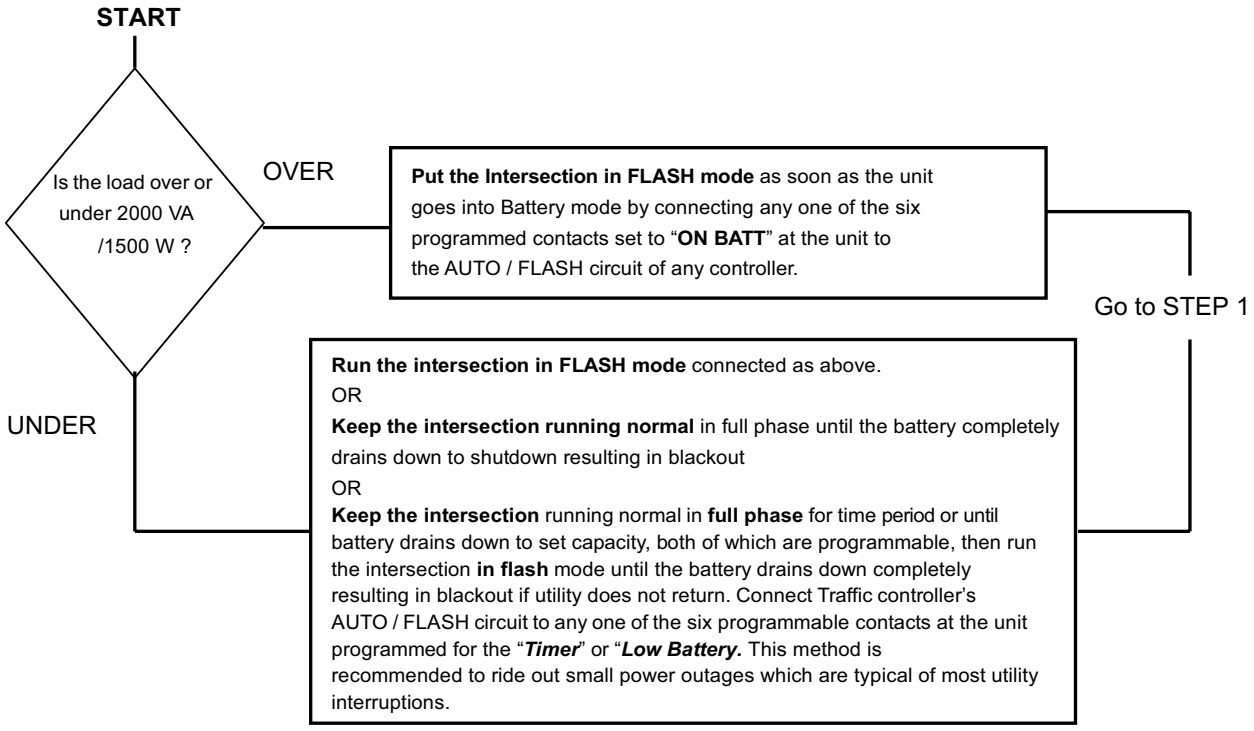
INTERNAL MOUNT:

The system components can also be mounted inside an existing NEMA, 332 or various other traffic cabinets. The special Swing Tray designed to hold the four batteries is easily mounted inside an existing 332 type or other equivalent cabinets using the hardware that is provided, or batteries can be shelf mounted in a NEMA or equivalent cabinets. The unit can be bolted into an industry standard 19" rack using the supplied brackets, or it can be shelf mounted in a NEMA type enclosure. The MBS/PTS supplied with or without optional Generator switch can be shelf mount or 19" rack mount.

1.3 Wiring

Purpose: *Describes how to wire the System (Figure 4 & 5).*

Before wiring the system, determine the size of the load:



TIP: Each of the six contacts are of form C type, meaning Normally Open (NO), common (C) and Normally Closed (NC) dry contact rated for 1A @ 240VAC. Each of these contacts can be individually programmed to energize and stay latched for ON BATTERY, LOW BATTERY, TIMER, ALARM, FAULT and many other conditions as described in subsequent chapters. The ON BATTERY contact(s) are activated as soon as the unit is transferred to Battery mode. LOW BATTERY contact(s) are activated only in the Battery mode, as soon as the discharged battery reaches the lower value battery capacity as set by user and remains latched as long as the system remains in Battery mode. The TIMER contact(s) are activated only in the Battery mode after the user-programmed time is attained, that can be set in 15 minute intervals from 15 minutes to 8 hours.

DANGER: *The utility input power line **must** have circuit breaker or fuse protection as per the local electrical code. It is referred as "Upstream Circuit Breaker" in this manual.*

STEP 1: Connect Power Cable to MBS/PTS Back Terminal

DANGER: If this is a new traffic signal installation with Utility AC power going directly to UPS, make sure the upstream circuit breaker feeding the Utility Power is **OFF** before beginning this step. If this is addition of a UPS to an existing traffic signal cabinet, DO NOT terminate the power cable from the signal cabinet to the UPS at the signal cabinet end until the final step after all other connections have been completed. This will minimize the length of time the traffic signals must be off for final power connection.

DANGER: There are many different ways that the Utility AC can be wired into the traffic signal cabinet. The intent of this manual is only to explain proper connection of utility AC at the UPS end of the cable. How the Utility AC is routed from the service entrance or through the traffic signal cabinet (hereafter referred to as the "power source") to the UPS shall be determined by a licensed electrician in accordance with local electrical codes.

***TIP:** The suggested method of wiring Utility AC to the UPS from the traffic signal cabinet is to connect the UPS at the traffic cabinet after the main cabinet breaker and surge suppressor so that the UPS is also protected by the cabinet surge suppressor.*

Make the following connections on the back of the MBS/PTS first before installing the MBS/PTS on the cabinet shelf or in the rack. The connections at the other end of these wires will be made in the last step. Use the 8-gauge wires that are supplied for connections between the AC power source and the MBS/PTS rear terminal block. Torque the MBS/PTS terminals to a maximum of 10.0 lb-in (1.1 Mm)

- Connect the external AC power (Black) wire that will be connected to the power source to "L IN" on the MBS/PTS rear terminal strip (see Figure 4).
- Connect the White wire that will be connected to the Neutral Bus Bar of the power source to the Neutral terminal "NEUT" on the MBS/PTS rear terminal strip.
- Connect the Green wire that will be connected to the Ground Bus Bar of the power source to the Ground terminal "GRN" on the MBS/PTS rear terminal strip.
- Connect the Red wire that will be connected to the traffic cabinet power input point to "L OUT" on the MBS/PTS rear terminal strip.

STEP 2: Connect the PTS to the UPS Controller

- Connect the Red and Black control wires from the PTS to the green relay terminal block 21 & 22 respectively.
- Connect the TO UPS IN cable on the PTS to the INPUT AC terminal block at the unit.
- Connect the FROM UPS OUT cable on the PTS to one of the two OUTPUT AC terminal blocks at the unit.

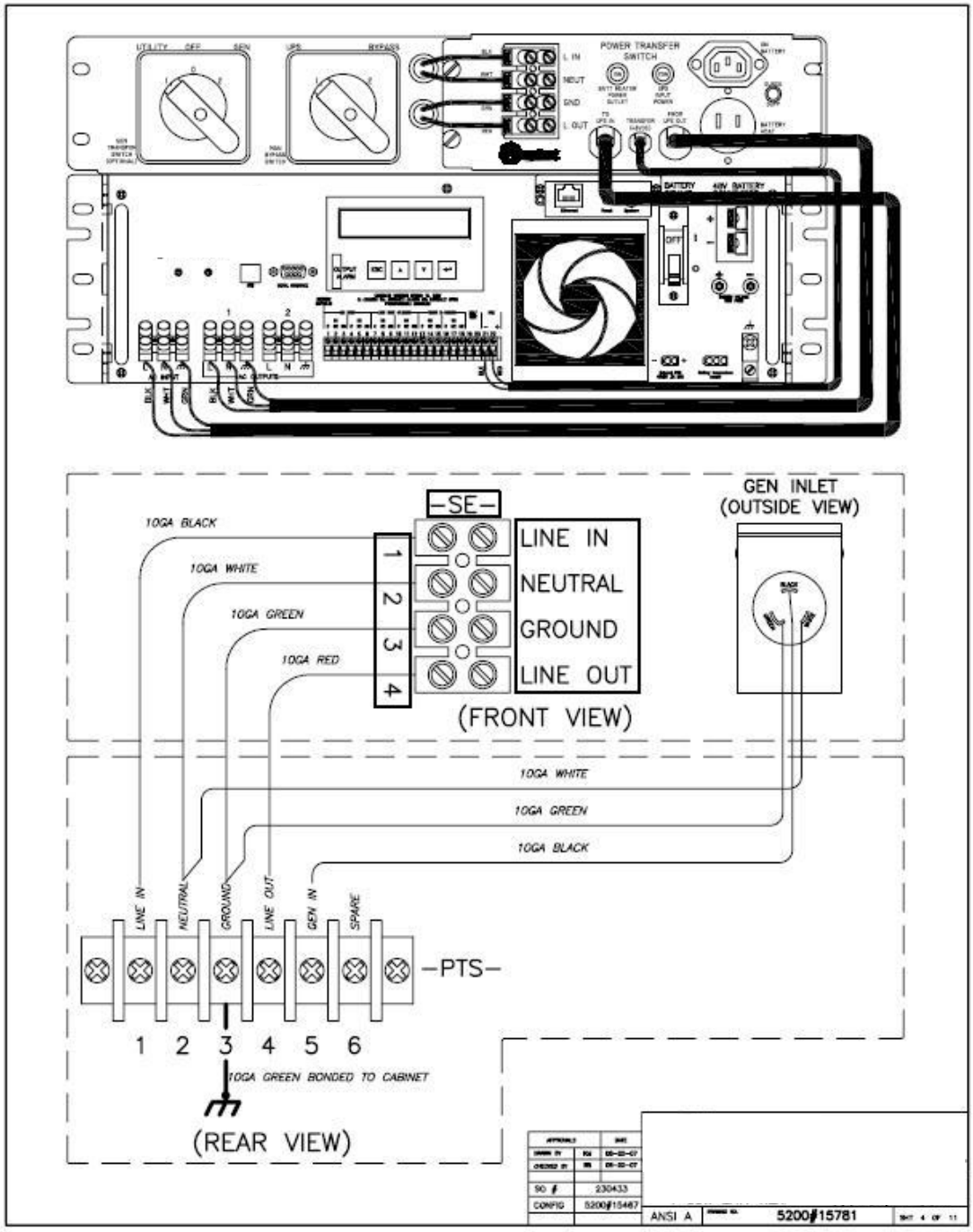


Figure 4
Wiring Diagram MBS/PTS (typical)

STEP 3: Install the Batteries

- Place battery heater mats (if used) on cabinet shelves and plug the heater mat power cable into the AC outlet on PTS.

- Since AGM batteries contain no free liquid, grease is not needed on battery terminals to prevent oxidation. A light coating of special antioxidant grease, such as NO-OX-ID or NCP-2, can be applied to prevent minor oxidation of lead terminals in air if desired.

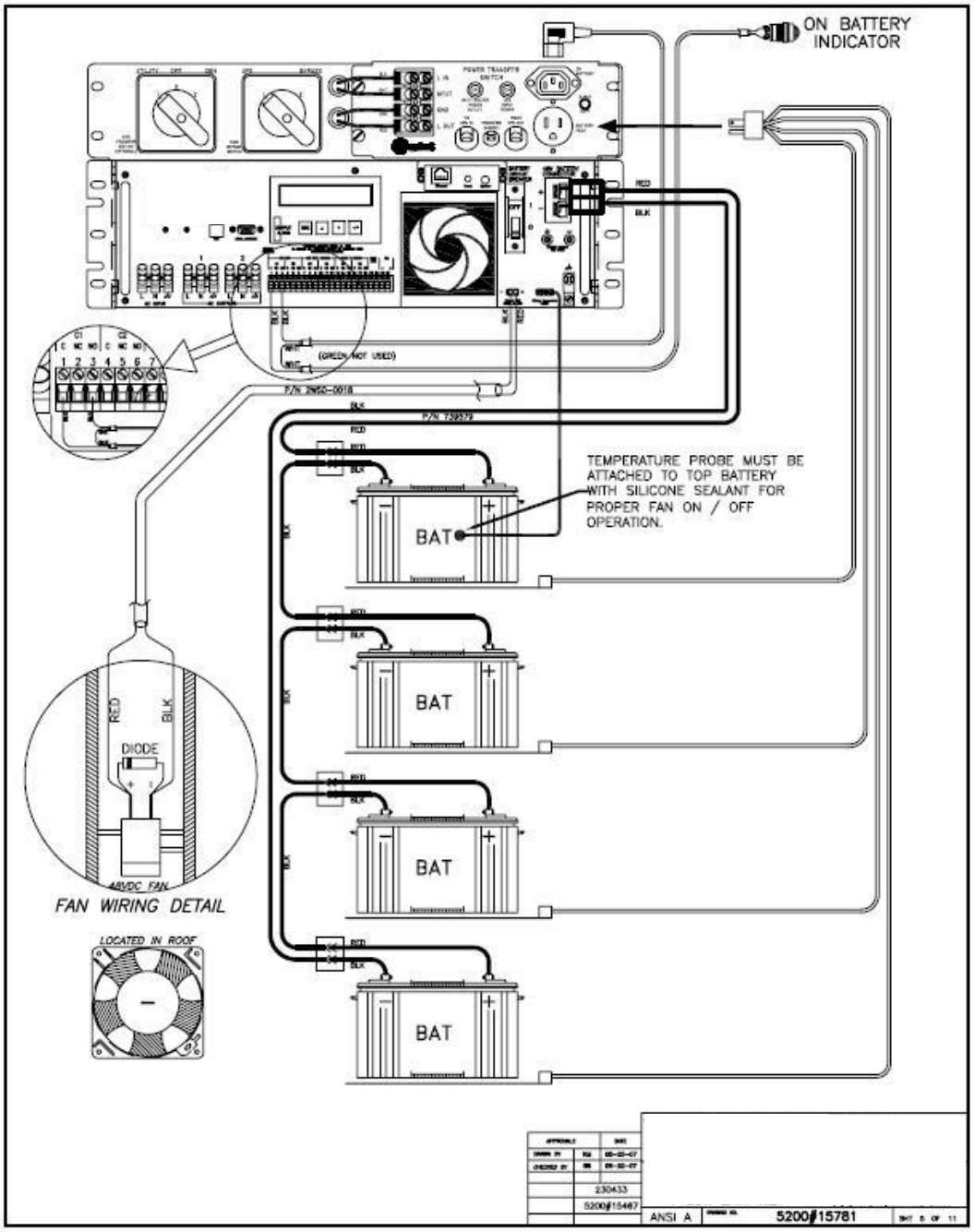


Figure 5
Wiring Diagram Batteries (typical)

- Place batteries on cabinet shelves with 0.5 inches of space between them to allow for convection cooling. NOTE: Batteries are sealed and can be placed on their side for easier connection if desired.

- Connect each battery to the battery harness. The harness is keyed to insure correct polarity connection between batteries. Batteries are connected in series (negative terminal of one battery to positive terminal of the next).

DANGER: Make certain that the BATTERY CIRCUIT BREAKER on the unit is OFF before performing the next step to prevent energizing any wiring.

- Plug the battery harness into the 48V BATTERY CONNECTOR on the unit.

TIP: *The 48V BATTERY CONNECTOR must 'click' when inserted for proper connection. A common source of problems is that the battery connector is not fully inserted. The unt will Alarm when turned on if the batteries are not properly connected.*

STEP 4: Connect Control Wires

- Tape or seal the ***Battery Temperature Sensor*** to the case of the top battery. Plug the connector on the other end into the unit at "Battery Temperature Sensor". Wrap a tie around the strain relief loop and the battery temperature sensor to prevent the connector from disconnecting during an earthquake or other severe vibrations.
- Connect the ***External Cabinet Fan*** and the ***RS-232/USB Cable*** (if used).
- Connect the cabinet external ON BATTERY LED cable (if used)
- Connect the programmable contacts: ***ON BATT, LOW BATT, TIMER*** or ***SELF TEST*** contacts from the unit to Traffic Cabinet for Flash mode (if used). Torque terminals to a maximum of 4.4 lb-in (0.5 Mm). Maximum wire size is 14 AWG. See Section 2.1.2 of this manual for details on the layout, operation, and specifications of the Control Terminal Block.

STEP 5: Make Final Connections at Power Source and Traffic Signal Cabinet

DANGER: If the installation is at an active intersection, have law enforcement begin directing traffic before the power to signals is turned off.

DANGER: Make sure the upstream circuit breaker for the power source is **OFF** before performing this step. Make sure both the BATTERY CIRCUIT BREAKER on the unit is also off.

- Connect the external AC power (Black) wire from "L IN" on the MBS/PTS rear terminal strip to the power source HOT.
- Connect the White wire from "NEUT" on the MBS/PTS rear terminal strip to the power source NEUTRAL bus bar. Leave the existing NEUTRAL wire connected on the power source side of the bus bar. Extend the NEUTRAL and GROUND wires from their corresponding Bus Bars in Traffic Cabinet to the Terminal block on the PTS.
- Connect the Green wire from "GRN" on the MBS/PTS rear terminal strip to the power source GROUND bus bar. Leave the existing GROUND wire connected on the power source side of the bus bar.
- Connect the Red wire from "L OUT" on the MBS/PTS rear terminal strip to the traffic signal cabinet HOT side.

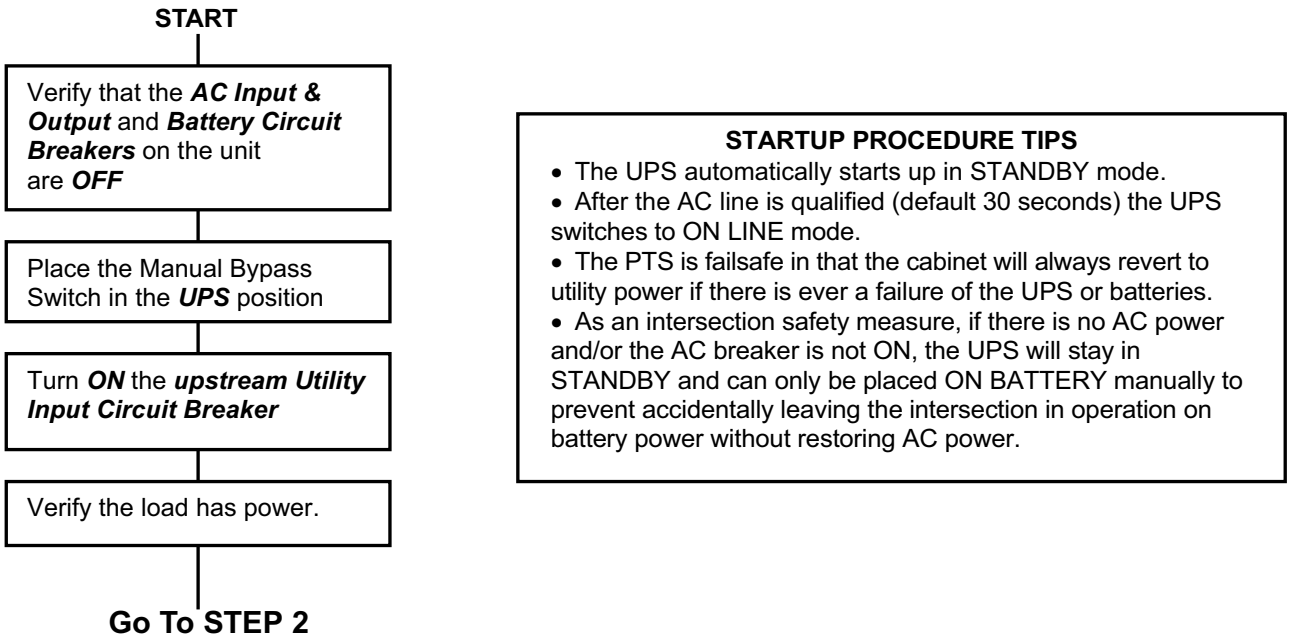
NOTE: The LCD Display and keypad on the unit are shipped with a protective plastic film over them. This film should be removed by peeling from one corner before first use of the system. The LCD display will be difficult to read if the film is left on.

1.4 Start-Up and Test

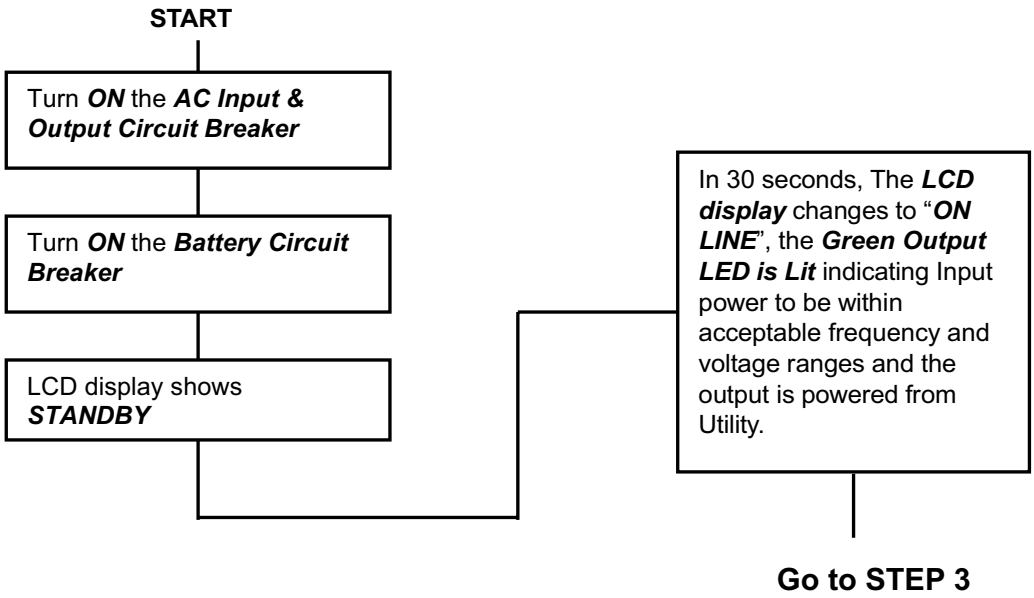
Purpose: *Describes how to Start-up and test the system.*

TIP: If the system does not perform as described below, see the troubleshooting table in Section 2.4.4 of this manual.

STEP 1: Turn on the Utility Input line Power



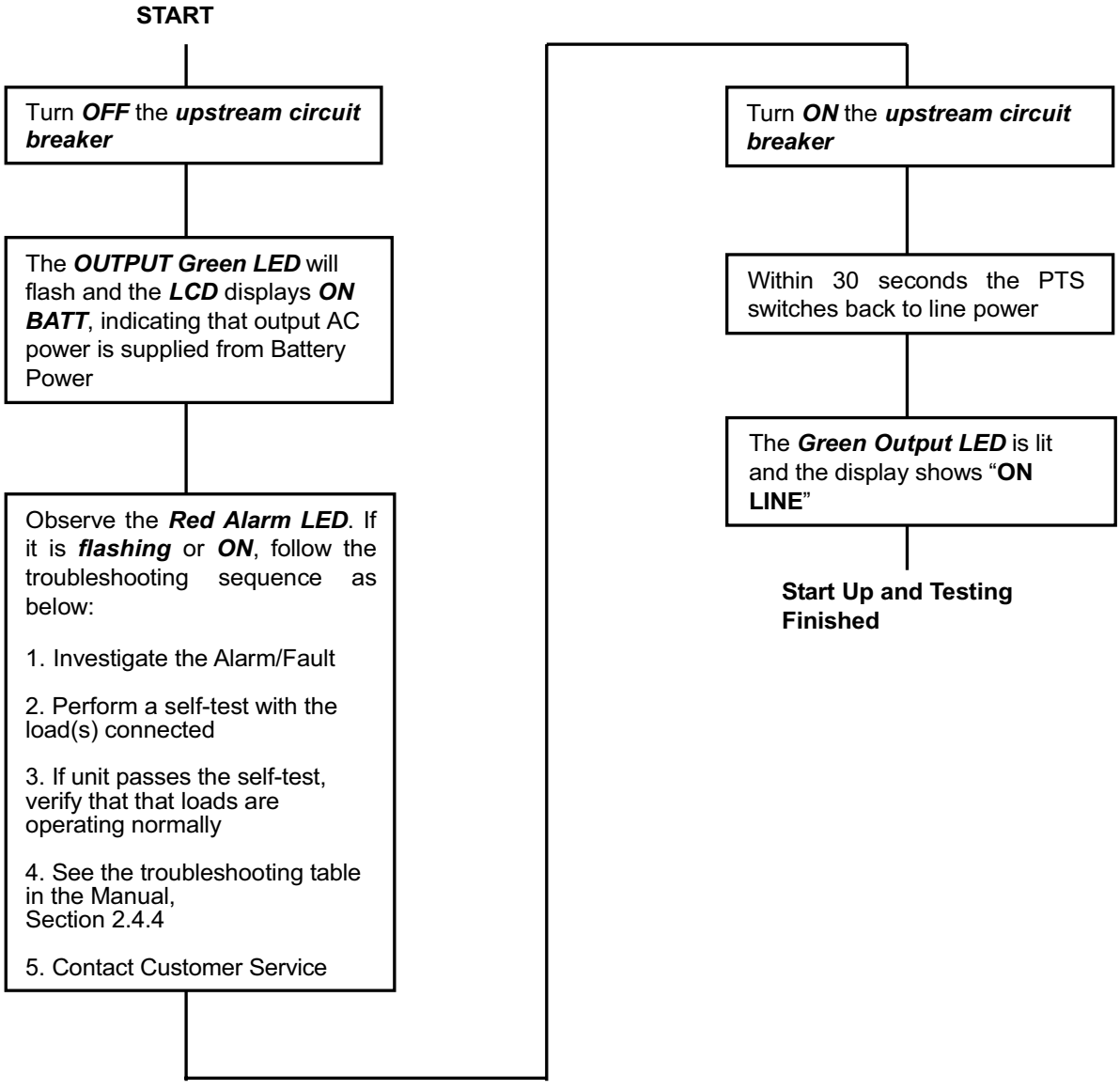
STEP 2: Turn on the UPS



STEP 3: Test the system.

TIP: Before turning off AC power to the intersection as a final test, verify proper installation and ability to go ON BATTERY by placing the MANAUL BYPASS SWITCH to BYPASS. The unit should immediately go On Battery. When the MANUAL BYPASS SWITCH is returned to UPS, the unit should go back On Line after AC Qualify time. Then to test the UPS further, perform the self-test feature via the CONTROL submenu (see this Manual, Section 2.2.3, “Self Test”.

DANGER: When performing the test below, if for any reason the unit fails to go ON BATTERY, immediately restore the AC power for the intersection at the upstream circuit breaker.



1.5 Shutdown

Purpose: *Describes how to shut down the system components for removal or maintenance.*

1.5.1 The UPS

DANGER: Shutting down the unit ***does not*** necessarily disconnect power to the loads.

START

Place Manual Bypass Switch in ***BYPASS***

Turn ***OFF*** the ***Battery Circuit Breaker***

Turn ***OFF*** the ***AC Input & Output Circuit Breaker***

Disconnect the ***AC Input & Output wires*** and insulate

Disconnect, mark and insulate wires at the green control terminal block, disconnect the plug for Ext. Fan, the plug for battery temperature sensor, and the RS232/USB connector.

Remove and perform maintenance on the unit

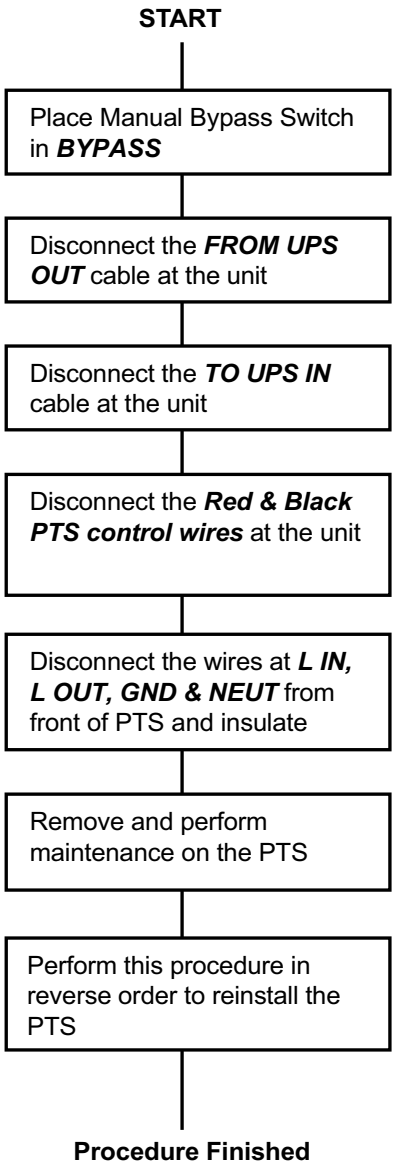
Perform this procedure in reverse order to reinstall the unit

Procedure Finished

IMPORTANT
Place the Manual Bypass Switch in BYPASS before doing any maintenance on the unit or PTS to prevent accidentally losing power to the traffic signals.

TIP: For additional information on how to operatethe unit, see Section 2.2.

1.5.2 PTS



IMPORTANT

Place the Manual Bypass Switch in BYPASS before doing any maintenance on the unit or PTS to prevent accidentally losing power to the traffic signals.

DANGER: Verify that both the AC and Battery Breakers are OFF at the unit to insure all circuits are de-energized.

1.6 Emergency Shutdown Procedure

The UPS is connected to more than one energy source. In an emergency, place the MANUAL BYPASS SWITCH in BYPASS, turn off all the unit breakers, then DISCONNECT Utility Input Power, Battery Power, as well as Optional Generator Power, if utilized. Disconnecting all the AC and DC power sources will ensure that the output circuit is not live.

START

Place the Manual Bypass Switch in **BYPASS**

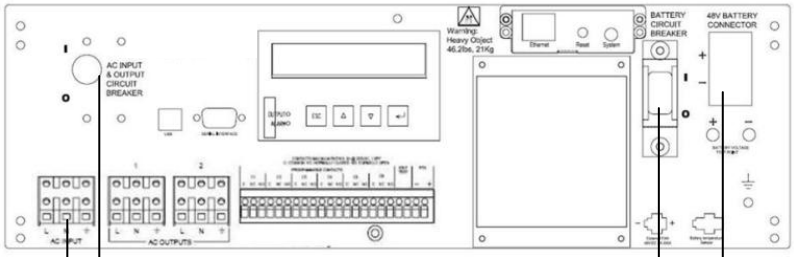
Turn ***OFF*** the AC Input & Output Circuit Breaker

Turn ***OFF*** the Battery Circuit Breaker

Disconnect **Battery Harness**

Disconnect and safety tape or cap **To UPS In Cable**

EMERGENCY SHUTDOWN COMPLETED



2 Operation

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2.1 Introduction

2.1.1 The Advantages

2.1.2 Front Panel

2.1.1 The Advantages

Advanced Power Protection Technology

The unit is an Uninterruptible Power Supply (UPS) controller designed for both indoor and outdoor applications. The UPS provides continuous power to traffic and signal equipment.

- **Advanced Communications**
  An RS-232 port, USB port, or optional Ethernet port allows for remote monitoring of the unit.

- **Smart Charging**
  Smart charge technology ensures the batteries are always at peak performance.

- **User Friendly Supervision**
  The LCD panel provides “At a Glance” monitoring and control.

- **Service Friendly**
  The batteries can be changed without shutting down the loads or the unit.

2.1.2 Front Panel

***Purpose**: Describes the connections, displays and switches on the front panel (Figure 6).*

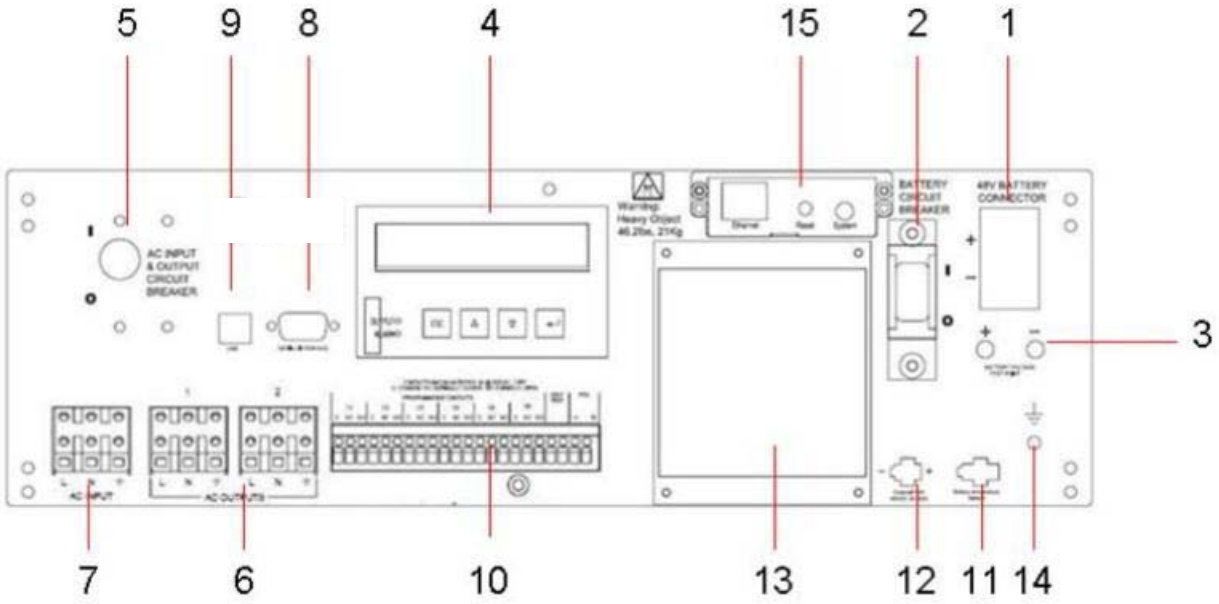


Figure 6
Front Panel

1. 48VDC Battery Connector

Connects the battery string to the unit. The battery string voltage is 48VDC.

2. Battery Circuit Breaker

Acts as an ON/OFF switch for battery power. It must be in the **ON** position for normal operation.

3. Battery Voltage Test Points

Battery Voltage can be measured at these test jacks only when the battery circuit breaker is turned **ON**.

TIP: Test jacks are not DC power outlet terminals and cannot provide any significant DC amps.

4. Liquid Crystal Display (LCD) and Touch Pad

The UPS can be controlled and monitored via this LCD Panel. See Section 2.2 for further information.

5. AC Input & Output Circuit Breaker

Acts as a line and output power ON/OFF switch to facilitate the unit's maintenance or replacement. It must be in the **ON** position for normal operation.

6. AC Output

Two sets of Terminal Blocks are provided for AC output at least one of which is the “FROM UPS OUT” cable to the Power Transfer Switch.

7. AC Input

Connection for line (utility) power input via the “TO UPS IN” cable from the Power Transfer Switch.

8. Serial Interface / RS-232 Connector

This DB-9 female connector is used to connect the unit to a computer for remote control, monitoring and calibration using Hyperterminal commands. Any straight-through RS-232 cable may be used (not included with the unit). See Section 2.3 for more details about connection and use.

Note: The interface is opto-isolated and shares a common ground with the grounding lug.

9. USB Interface

This USB connector is used to connect the unit to a computer for remote control, monitoring and calibration with Hyperterminal commands. Any standard USB cable may be used (not included with the unit) See Section 2.3 for more details about connection and use.

10. Green Control Terminal Block

This 22 position terminal block provides communication with the intersection controller, controls the Power Transfer Switch (PTS) and starts the self-test. Figure 7 shows its layout and operation.

Note: This terminal block is opto-isolated. Each of the six programmable contacts can be set for one of five functions listed below or be disabled. The relay contacts are Form C type*, i.e.,* each of the six programmable contacts have Common (C), Normally Closed (NC) and Normally Open (NO) contact positions.

• **On Batt:** Default setting for relay C1. Energizes when Utility Input line power is unqualified and the inverter turns on to provide AC power from the DC batteries.

• **Low Battery:** Default setting for relays C2 and C3. Energizes when the battery string drops below the programmed battery capacity. The default value is 47.5 volts which is approximately 40% Battery Capacity.

TIP: You can change the preprogrammed value to match the batteries used and the actual operating conditions. See Section 2.3.6.4, “Maintenance” # 35, “Battery Voltage Level % Capacity Remaining”.

• **Timer:** Default setting for relays C4 and C5. Energizes after the unit has been in Battery mode for programmed time. The factory default value is 2 hours.

TIP: The time can be programmed to be from 15 min. to 8 hours in 15 minute increments

• **Alarm:** Default setting for relay C6. Energizes on any alarm (default) or a specific alarm.

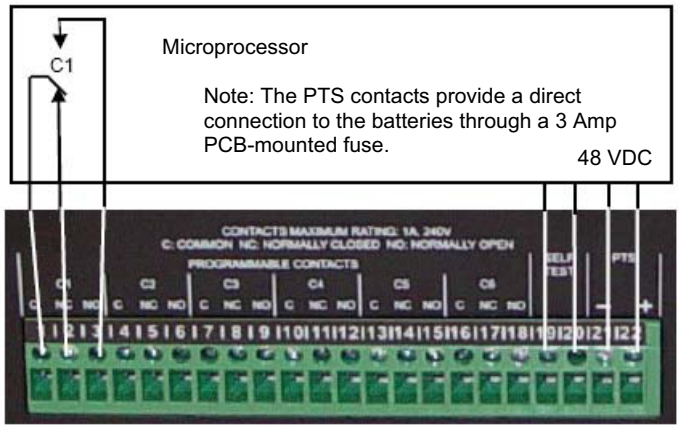
• **Fault:** Energizes on any fault or a specific fault.

• **Self-Test:** To initiate self test, jumper the TB 19 & 20 at the Green Control Terminal Block.

TIP: It is much easier to initiate a self-test from the Control submenu on the LCD display touch pad.

• **PTS:** The unit sends a 48VDC signal from battery to the PTS, which activates the PTS, resulting in transfer from Input Power to Battery Power. See Section 1.3, Wiring, of this Manual for connection instructions.

Note: These contacts have a maximum rating of 1 Amp at 240 V. Only the first (C1) contact is illustrated. The other 5 contacts are similar.



Note:
1. *Programmable contacts have the following factory default settings:*
   C1 = "On Batt"
   C2, C3 = "Low Batt @ 47.5VDC"
   C4, C5 = "Timer @ 2.00 Hours"
   C6 = "Any Alarm"

2. *User may program each of the 6 contacts for one or more functions. See Section 2.2.12 Setting Submenu for more detailed information.*

Note: Self Test can be performed by jumpering TB 19 & 20, however it is easier to start Self Test from LCD menus.

Figure 7
Green Control Terminal Block, Layout and Operation

11. Battery Temperature Sensor

The battery temperature probe attaches to the unit at this plug. The charging voltage is temperature dependent. The microprocessor of the smart charger adjusts the voltage for optimum charging. The probe connector **must** be plugged in for normal operation. The sensor end should be firmly attached to the case of the middle or top battery with high strength tape.

TIP: Older versions of the unit use a different temperature Probe. If the supplied temperature probe is not used, the charger may shut off and never charge the Batteries.

12. External Fan 48VDC

Provides DC Power (48VDC, 3 Amp Max), which could be used to power an optional 48VDC fan, mounted inside the enclosure for regulation of the interior temperature during power outages.

13. Internal Fan

Microprocessor-controlled fan regulates the unit's internal temperature. It must not be blocked. The filter in front of the fan is removable for cleaning.

TIP: Inspect the filter every 6 months, or as often as required. Clean by removing it, running water through the filter and air-drying before reinstallation.

14. Grounding Lug

Attach copper ground wire here to ground the UPS controller to the cabinet and electrical system.

15. Ethernet Slot (with optional TRL Ethernet Conversion Card)

This Ethernet connector is used to connect the unit to a computer or network for remote control, monitoring and calibration with Hyperterminal commands. See Section 2.3.3 for more details about connection and use. The Ethernet slot will be covered if the optional TRL Ethernet Conversion Card was not purchased.

2.2 Operation

2.2.1 LCD Panel

Purpose: Describes the LCD display (Figure 8) and navigation (Figure 9).

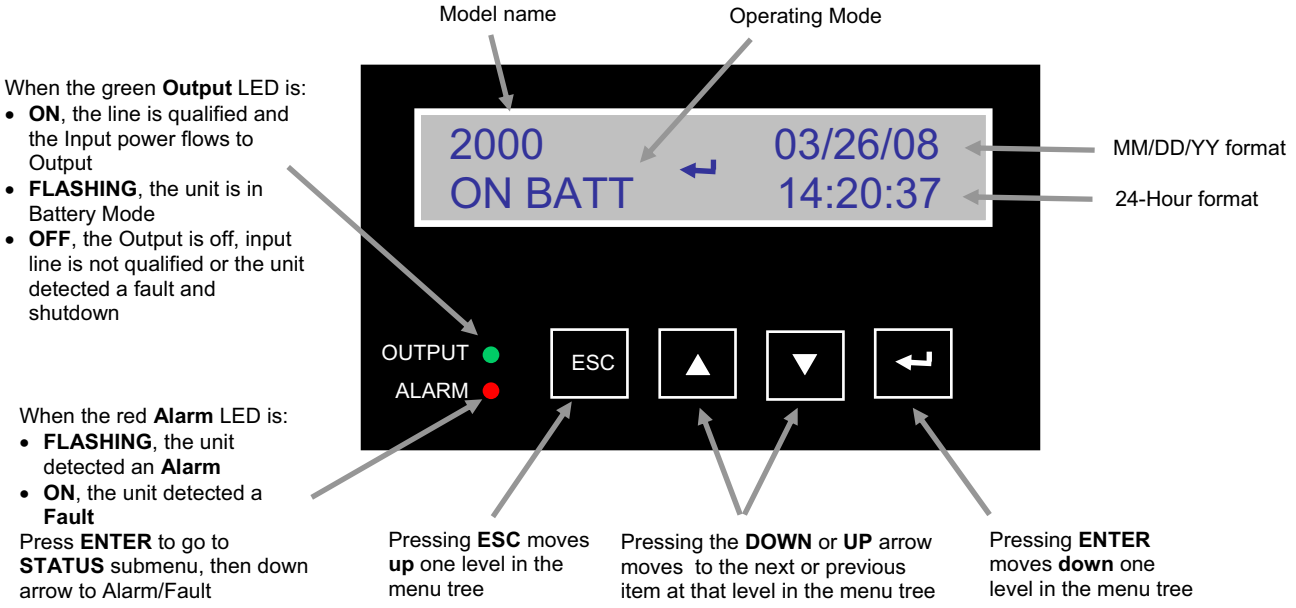


Figure 8
LCD Panel Key Functions

If both LEDs are OFF and the LCD is BLANK, the unit is shut off. If the ambient air temperature is below -20°C (-4°F), the LCD may darken until the temperature rises. However the unit will operate normally.

TIP: To adjust the contrast on the LCD display:

1) Press the ***ESC*** and ***ENTER*** buttons at the same time.
2) Use ***Up*** and ***Down*** arrows to increase or decrease contrast.
3) Press ***ENTER*** button when adjustment is complete.

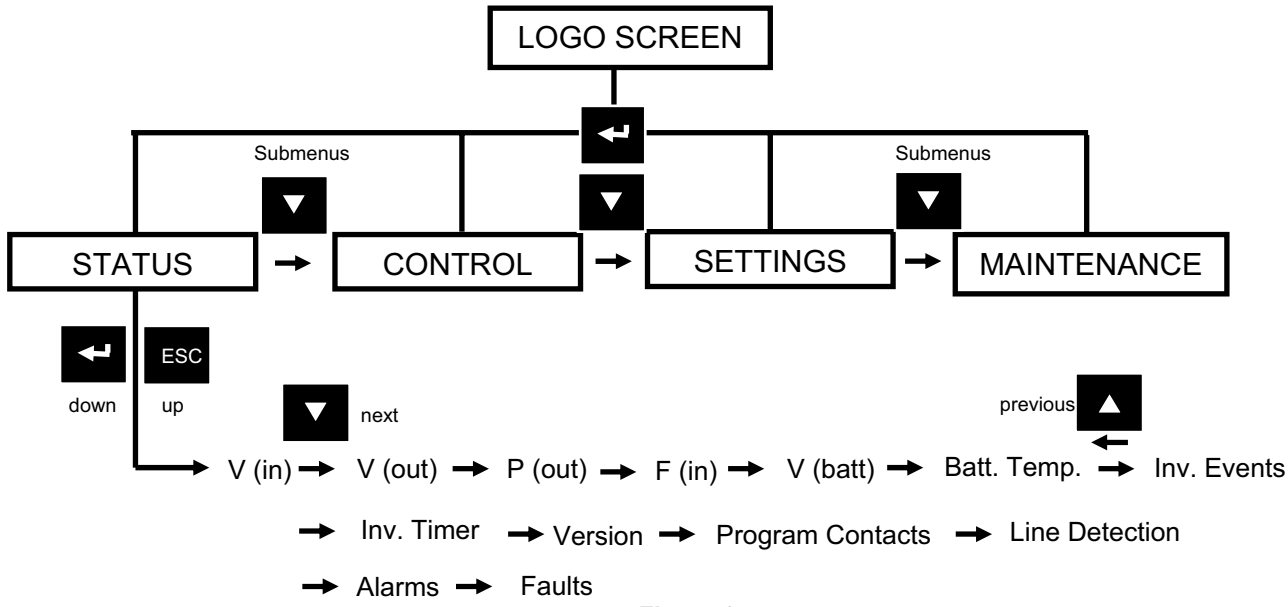


Figure 9
LCD Navigation

2.2.2 Operating Modes

Purpose: *Describes the Operating modes.*

TIP: The LCD automatically displays the following modes when they change.

LCD Shows	*Explanation*
STANDBY	Displayed when the unit is first turned on. The inverter remains off and the unit does not provide output power to the loads. If input line power is qualified, the unit automatically switches to ON LINE mode. If AC power is not available or the AC Input/Output breaker is OFF, the unit will stay in STANDBY to prevent accidentally leaving the intersection running on battery power. To provide battery power to the loads at startup without AC power, use the Manual On function (see Section 2.2.11)
ON LINE	Normal operating mode. Displayed when input line power is provided to the loads, the batteries are charging, and the unit is ready to provide backup power.
ON BATT	Displayed when batteries are supplying power to the loads. The unit automatically transfers to battery when the input power is unqualified (blackout, voltage is above or below programmed Hi/Lo limits, or frequency is out of tolerance)
BOOST (if enabled)	Displayed when the input line voltage has decreased to the programmed setpoint and it is being increased by a fixed percentage by the unit's transformer for output.
BUCK (if enabled)	Displayed when the input line voltage has increased to the programmed setpoint and it is being decreased by a fixed percentage by the unit's transformer for output.
SELF TEST	Displayed when “Self Test” is selected. The unit will enter ON BATT mode to check if output voltage and waveform are correct, then return to ON LINE mode after 1 minute. The self test time may be increased to longer than 1 minute using the Maintenance submenu.
LOW BATT	Displayed when the battery string voltage falls below the user programmed value (default is 47.5 VDC or approx. 40% battery capacity)

The following mode is not displayed by the LCD. It may be selected by the User (see Section 2.2.12)

Sense Type (Normal / Generator Mode)

This is used to broaden the tolerance on unit parameters to accommodate the voltage fluctuations created by a backup generator or a noisy line.

The factory default setting is Normal. Switching to Generator increases the allowed tolerance on parameters.

If the unit constantly switches between Line and Battery modes due to a noisy line, select Generator mode to prevent unnecessary transfers / returns.

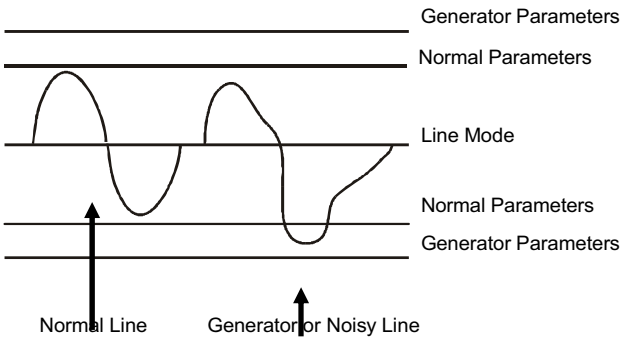
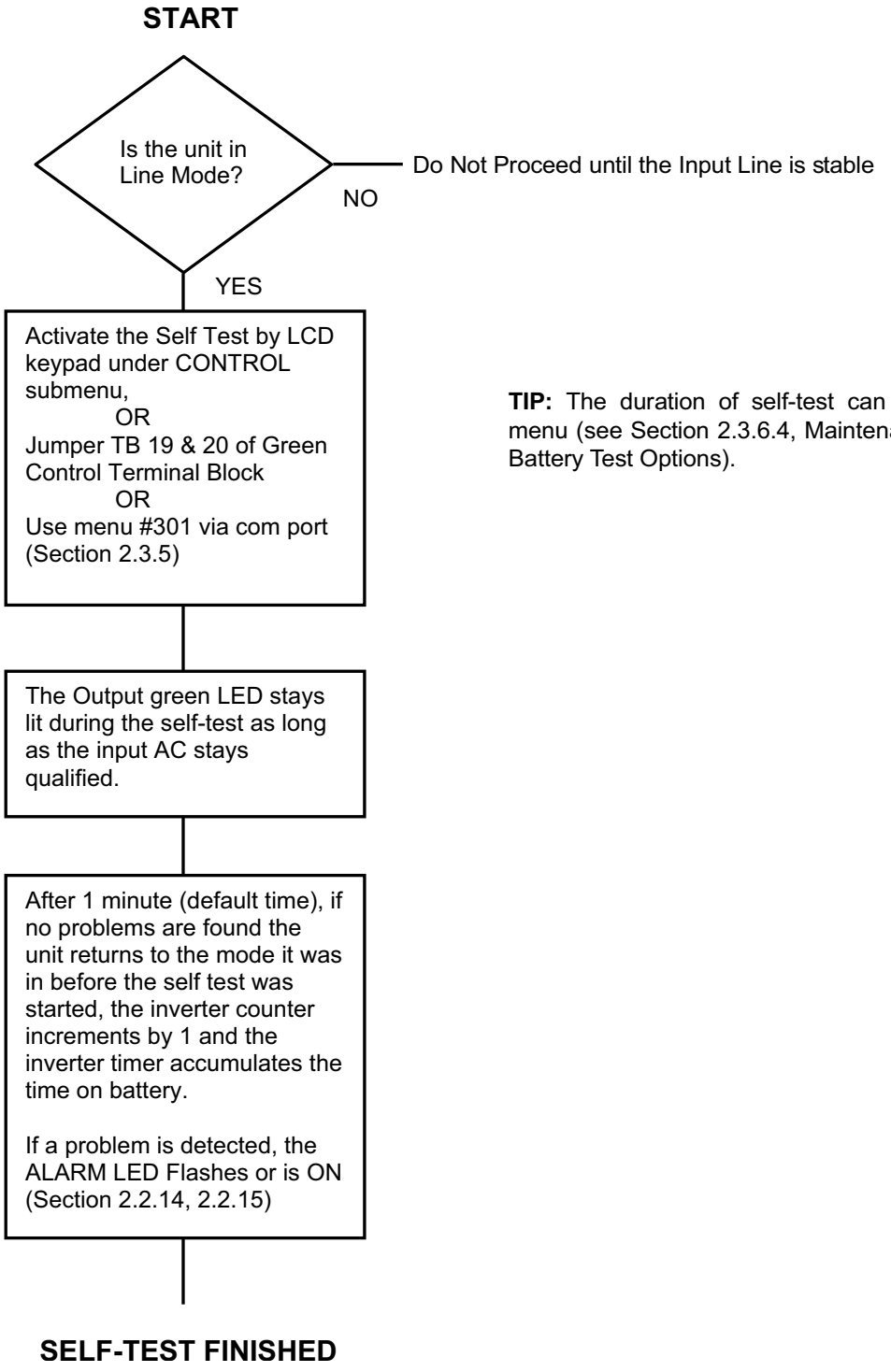


Figure 10
Normal and Generator Parameters

2.2.3 Self Test

Purpose: *Describes the Self-Test.*

The Self Test confirms that the unit can transfer into and out of Battery mode while supporting the output load at the same time.



TIP: The duration of self-test can be adjusted via menu (see Section 2.3.6.4, Maintenance Menu # 30, Battery Test Options).

2.2.4 Start Up

Purpose: *Describes the Start Up procedure.*

START

Verify that the ***AC Input & Output*** and ***Battery Circuit Breakers*** on the unit are ***OFF***

Place the Manual Bypass Switch in the ***UPS*** position

Turn ***ON*** the ***upstream Utility Input Circuit Breaker*** if not already on

Verify the load has power.

Turn ***ON*** the ***AC Input & Output Circuit Breaker***

Turn ***ON*** the ***Battery Circuit Breaker***

The ***LCD display*** shows ***STANDBY***

In 30 seconds or less depending on line qualify time setting, the ***LCD display*** changes to "***ON LINE***", the ***Green Output LED is Lit*** indicating Input power to be within acceptable frequency and voltage ranges and the output is powered from Utility.

Perform a self-test (see Section 2.2.3)

STARTUP PROCEDURE TIPS

- The UPS automatically starts up in STANDBY mode.
- After the AC line is qualified (default 30 seconds) the UPS switches to ON LINE mode.
- The PTS is failsafe in that the cabinet will always revert to utility power if there is ever a failure of the UPS or batteries.
- As an intersection safety measure, if there is no AC power and/or the AC breaker is not ON, the UPS will stay in STANDBY and can only be placed ON BATTERY manually to prevent accidentally leaving the intersection in operation on battery power without restoring AC power.

Warning: Never run the the unit when it is overloaded. Damage to the inverter, batteries or unexpected shutdowns may result. If the unit detects a load greater than 1650 watts, it automatically shuts down after 3 minutes.

Observe the ***Red Alarm LED***. If it is ***on*** or ***flashing***, follow the troubleshooting sequence as below:

1. Investigate the Alarm
2. Perform a self-test with the load(s) connected
3. If unit passes the self-test, verify that that loads are operating normally
4. See the troubleshooting table in the unit's User Manual, Section 2.4.4
5. Contact Customer Service

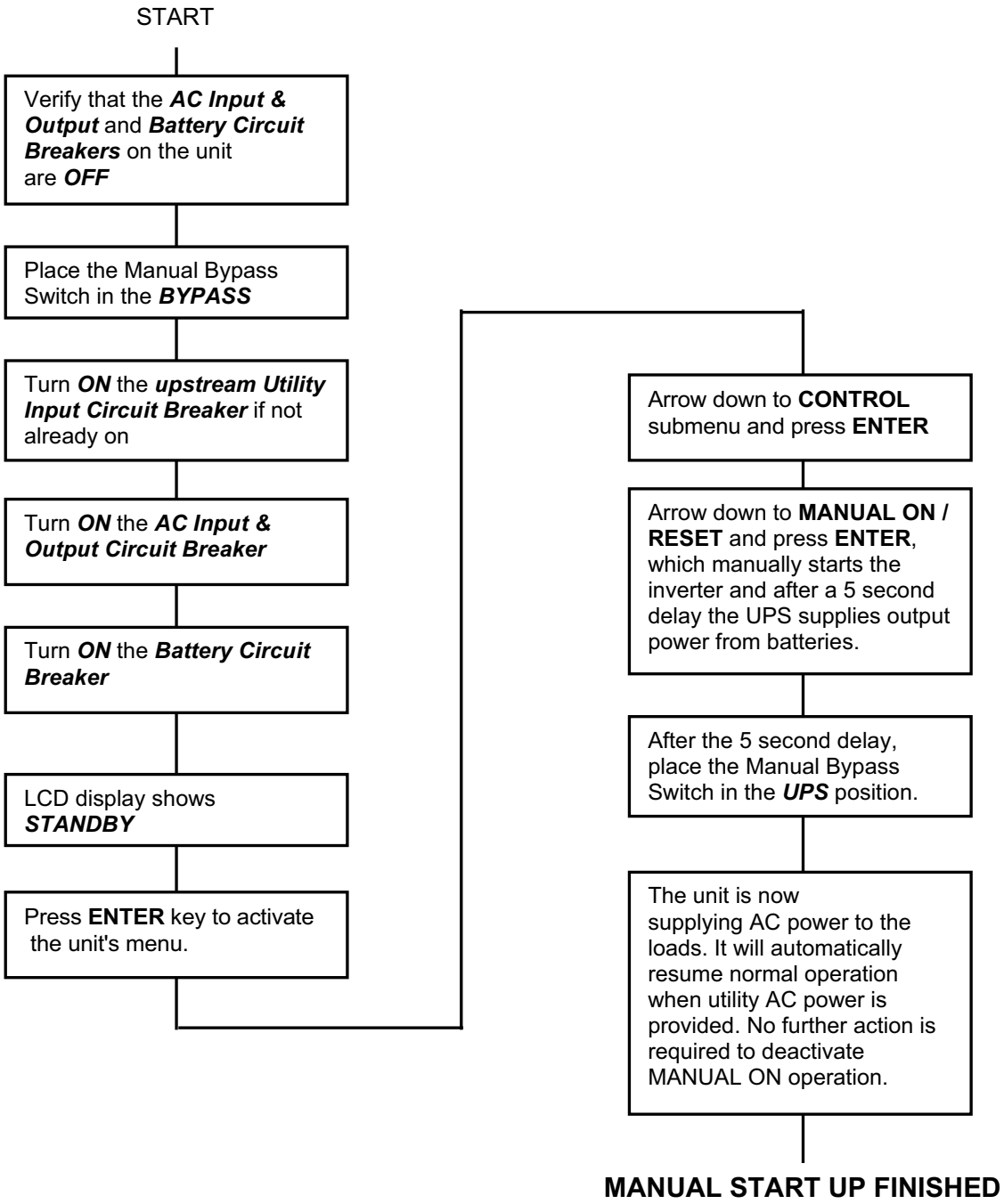
START UP FINISHED

2.2.5 Manual Start Up On Battery / Reset

Purpose: *Describes the Start Up procedure* ***when AC power is not available****.*

When AC power is not available, the unit can manually be turned on and function only ON BATTERY. When utility AC power returns, the unit will qualify the line for 30 seconds (default) and then resume normal operation in the ON LINE mode.

This function is available only when the unit is first turned on and the LCD shows STANDBY.
Verify that the ***AC Input & Output*** and ***Battery Circuit Breakers*** on the unit are ***OFF***



2.2.6 Shutdown

Purpose: *Describes the normal shutdown procedure.*

DANGER: Shutting down the unit ***does not*** necessarily disconnect power to the loads.

START

Place Manual Bypass Switch in ***BYPASS***

Turn ***OFF*** the ***Battery Circuit Breaker***

Turn ***OFF*** the ***AC Input & Output Circuit Breaker***

SHUTDOWN FINISHED

IMPORTANT
Although the Power Transfer Switch stays aligned to Utility if the unit is shut down so that the traffic signals continue to operate on AC, it is a good safety precaution to also place the Manual Bypass Switch in BYPASS to positively remove power from the PTS and the UPS AC input terminal block.

2.2.7 Generator Operation

Purpose: *Describes the procedure for supplying power from a backup generator.*

DANGER: Connecting an inexpensive generator with poor power quality to traffic signal controls can cause the traffic control conflict monitor to put the intersection in flash. The Generator Transfer Switch simply reroutes the incoming AC from Utility to Generator at the MBS/PTS. The unit does not change the AC sine wave (remove noise, etc) unless it goes ON BATTERY. Generators in the $200 to $500 price range at home improvement stores are not adequate. Generators such as the Yamaha 2800 that cost more than $1000 are needed for adequate power quality and reliability in industrial use.

START

Plug in Generator at Generator Inlet Plug

Set the unit's **SENSE TYPE** to **GENERATOR** in the SETTINGS Submenu

Place Generator Switch in ***GENERATOR*** position

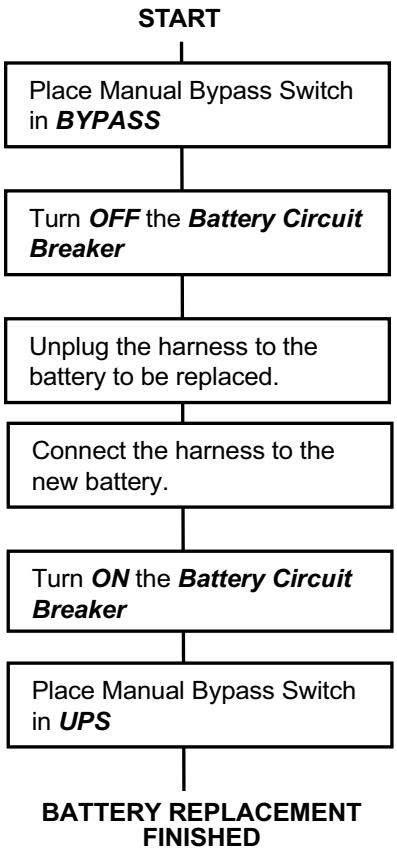
GENERATOR NOW SUPPLYING AC POWER

2.2.8 Battery Replacement

Purpose: *Describes how to change one or more batteries.*

Caution: Since the batteries are connected in series, disconnecting the battery harness to any one battery disconnects the entire string. Therefore, while a battery is being changed, the unit cannot provide backup power. This procedure should not be done while critical loads are running that depend upon the unit's backup power.

NOTE: If batteries are not properly connected or the harness is not fully plugged into the unit's controller, the Alarm LED will flash when the Bypass Switch is returned to UPS and the AC Input-Output breaker is ON.



IMPORTANT

Although it is not essential that the Manual Bypass Switch be placed in BYPASS since the Power Transfer Switch stays aligned to Utility if the unit is shut down or batteries are unavailable, it is a good safety practice to also place the Manual Bypass Switch in BYPASS to positively remove power from the PTS and the unit's input terminal block whenever any maintenance is performed.

2.2.9 LCD Menu Tree

Purpose: *Shows the Menu Tree (Figure 11) for the LCD display screen.*

TIP:

- The Alarm and Fault submenus alert the operator to a problem with the unit. When the **RED ALARM LED** is **FLASHING** or **ON**, press **ENTER** to go to the **STATUS** submenu, then use the down arrow key until the Alarm or Fault menu appears. Press **ENTER** and one of the Alarm or Fault conditions described in Section 2.2.14 or 2.2.15 appears on the LCD.
- The STATUS submenu provides measurements of important inputs, outputs, and other parameters via the LCD (Section 2.2.10).
- The CONTROL submenu allows the operator to manage the unit (Section 2.2.11).
- To start a command, when it appears on the LCD, press the **ENTER** button.

The complete LCD Menu Tree is shown on the next page.

NOTE: See Section 2.2.16 for details on Event Log View under the Maintenance submenu.

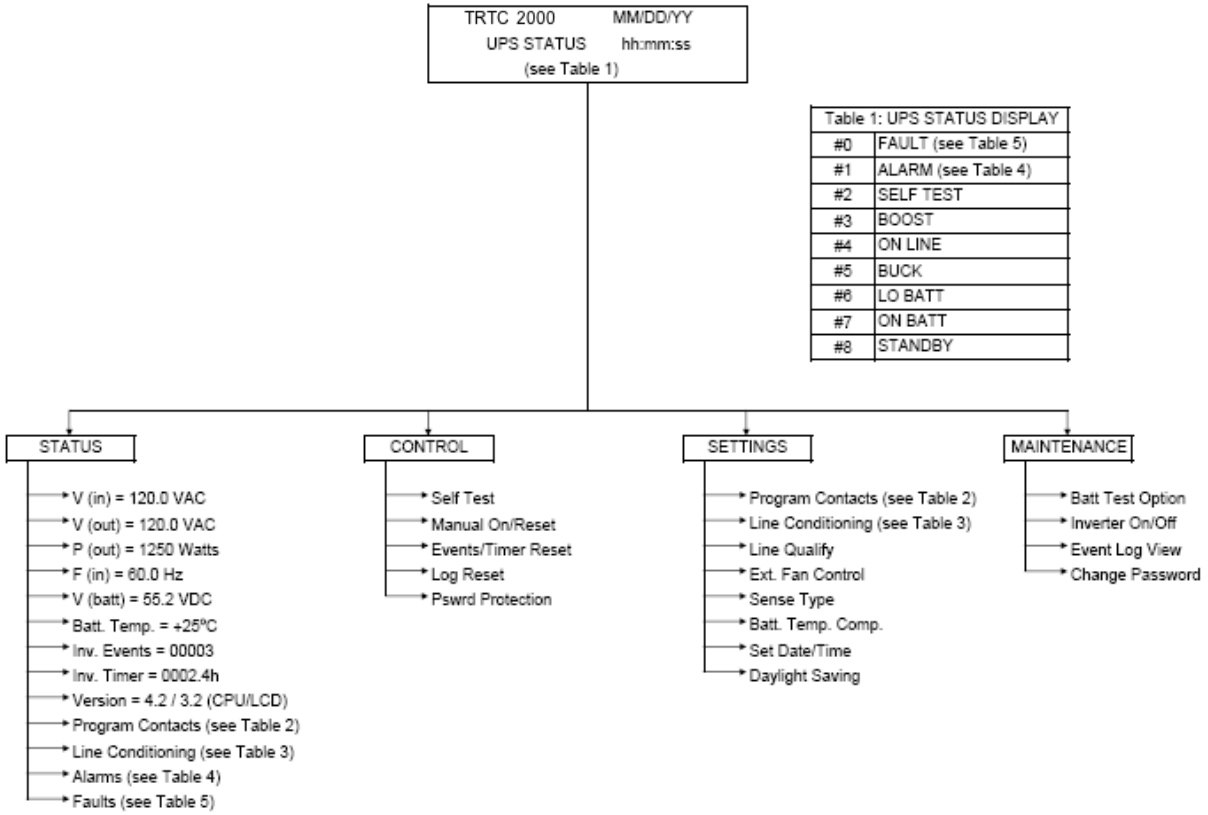


Table 1: UPS STATUS DISPLAY	
#0	FAULT (see Table 5)
#1	ALARM (see Table 4)
#2	SELF TEST
#3	BOOST
#4	ON LINE
#5	BUCK
#6	LO BATT
#7	ON BATT
#8	STANDBY

Table 2: CONTACT FUNCTIONS C1 to C6	
#1	ON BATT
#2	LO BATT (42.0-55.0V/0.5V increment)
#3	TIMER (0.25-8hr / 0.25 increment)
#4	ALARM (any alarm or #1-#7 Table 4)
#5	FAULT (any fault or #1-#5 Table 5)
#6	DISABLE

Table 3: LINE CONDITIONING	
#1	Hi Lmt = [120-150] VAC
#2	Hi Hyst = [117-147] VAC
#3	Hi Buck = [120-144] VAC
#4	Lo Buck = [117-141] VAC
#5	Hi Boost = [99-123] VAC
#6	Lo Boost = [96-120] VAC
#7	Lo Hyst = [93-123] VAC
#8	Lo Lmt = [90-120] VAC
#9	Buck Feature (Enable/Disable)
#10	Boost Feature (Enable/Disable)

Table 4: ALARMS	
#0	No Alarm
#1	Line Freq.
#2	Low Output Volt
#3	No Temp. Probe
#4	Overload (Alarm)
#5	Batt Not Conn
#6	High Temp
#7	Low Temp

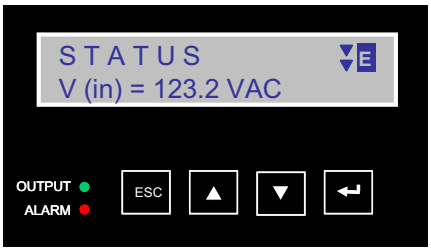
Table 5: FAULTS	
#0	No Fault
#1	Short Circuit
#2	Batt. Low Volt
#3	Batt. High Volt
#4	High Temp
#5	Overload (Fault)

Figure 11
LCD Menu Tree
Version 3.3

2.2.10 Status Submenu

Purpose: *Describes how to use the Status Submenu to measure the input and output parameters.*

Procedure: From Logo screen, press **ENTER** to go down to Main Menu. First submenu is STATUS. Press **ENTER** again to see first parameter under STATUS. Use Down arrow key to see more parameters, Up arrow key to go back to previous parameters, or ESC key to go back up to Main Menu and Logo screen.



PARAMETER	DESCRIPTION	LCD SHOWS
Input Voltage	Utility AC Input line voltage	STATUS V (in) = 123.2 VAC
Output Voltage	Output voltage (true RMS)	STATUS V (out) = 120.0 VAC
Output Power	Output Power (watts)	STATUS P (out) = 1200 Watts
Input Frequency	Utility AC Input line frequency	STATUS F (in) = 60.0 Hz
Battery Voltage	Average Battery String Voltage	STATUS V (batt) = 55.2 VDC
Battery Temperature	Temperature of battery case from probe	STATUS Batt. Temp. = +25 °C
Inverter Events	Number of times the unit has been in Battery Mode since the last reset.	STATUS Inv. Events = 00016
Inverter Timer	Amount of time unit has been in Battery Mode since last reset. Each decimal indicates 6 minutes (0.1 x 60 minutes). Example: 1.4 hours displayed = 1 hour and (0.4 x 60) min = 1 hour and 24 minutes On Battery since last reset.	STATUS Inv. Timer = 0005.7h
Version No.	Firmware versions in the unit. The CPU and LCD have separate firmware so the display is Control Board/LCD Board	STATUS Version = 4.2 / 3.2
Program Contacts	Programmed values of all 6 Contacts	STATUS Program Contacts
Line Conditioning	Programmed values of all Line Power conditioning setpoints	STATUS Line Conditioning
Alarms	Indicates any active Alarms (see Section 2.2.14)	STATUS Alarms
Faults	Indicates any Faults (see Section 2.2.15)	STATUS Faults

2.2.11 Control Submenu

Purpose: *Describes how to use the Control Submenu to operate the unit.*

Procedure: From Logo screen, press **ENTER** to go down to Main Menu. **Down arrow** once to CONTROL, then Press **ENTER** again to see first function under CONTROL. Use **Down arrow** key to see more functions, **Up arrow** key to go back to previous functions, or **ESC** key to go back up to Main Menu and Logo screen. When the desired function appears, press **ENTER** to call it up.

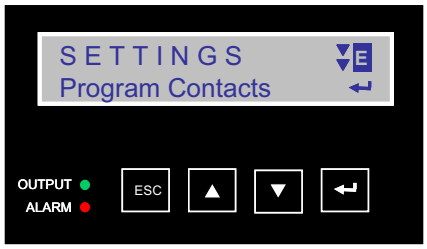
Many functions have more than one option available. Scroll through them by pressing the arrow keys. When the desired option appears, press **ENTER** to select the option.

FUNCTION	ACTION	LCD SHOWS
Self Test	Pressing **ENTER** starts the self test (see Section 2.2.3) **CAUTION:** The unit cannot be placed in Self Test unless it is in Line Mode.	CONTROL Self Test
Manual On/Reset	This function is available only when the unit is first turned on and the LCD shows STANDBY because AC power is not available or the AC Input/Output breaker is OFF. Pressing **ENTER** manually places the unit ON BATTERY to supply output power.	CONTROL Manual On/Reset
Events/Timer Reset	Pressing **ENTER** resets the Inverter Events counter and Inverter Timer to zero. **CAUTION**: Resetting the Inverter Event counter and Timer may invalidate the battery warranty as it provides evidence of the duty cycle the batteries have been subjected to.	CONTROL Events/Timer Reset
Log Reset	Pressing **ENTER** clears all messages from the Event Log.	CONTROL Log Reset
Password Protection	This function allows the user to Enable or Disable password protection to the Maintenance Submenu. When Enabled, the Maintenance Submenu can only be accessed after the correct password is entered. When Disabled, the Maintenance Submenu can be accessed without a password. Enabling or Disabling password protection requires the password to be entered first.	CONTROL Pswrd Protection

2.2.12 Settings Submenu

Purpose: *Describes how to access and program various critical parameters.*

Procedure: From Logo screen, press **ENTER** to go down to Main Menu. **Down arrow** twice to SETTINGS, then Press **ENTER** again to see first function under SETTINGS. Use **Down arrow** key to see more functions, **Up arrow** key to go back to previous functions, or **ESC** key to go back up to Main Menu and Logo screen. When the desired function appears, press **ENTER** to call it up.



Many functions have more than one option available. Scroll through them by pressing the arrow keys. When the desired option appears, press **ENTER** to select the option.

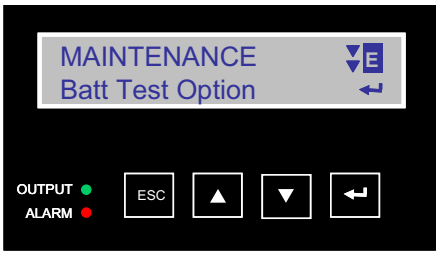
FUNCTION	ACTION	LCD SHOWS
Program Contacts	Indicates and sets programmed values of all 6 contacts	SETTINGS Program Contacts
Line Conditioning	Indicates and sets programmed values of all Line Power Conditioning setpoints.	SETTINGS Line Conditioning
Line Qualify	Indicates and sets AC recovery time. Selections are 3, 10 or 30 seconds. Default setting is 30 seconds.	SETTINGS Line Qualify
Ext. Fan Control	Indicates and sets the temperature at which an optional external fan turns on based on the battery temperature probe. Default setting is 25°C	SETTINGS Ext. Fan Control
Sense Type	Used to broaden the tolerance on unit parameters to accommodate the voltage fluctuations created by a backup generator or a noisy line. Toggle between Normal mode and Generator mode.	SETTINGS Normal Mode
Battery Temperature Compensation	Lowers the battery charging voltage as battery temperature increases by -2.5, -3.0, -4.0, or -5.0 mV/°C/cell. Consult battery manufacturer's specifications for best setting for batteries used. Default setting is -3.0 mV/°C/cell.	SETTINGS Batt Temp. Comp.
Set Date/Time	Sets the Date and Time	SETTINGS Set Date/Time
Daylight Saving	Enables or Disables automatic time adjustment for Daylight Saving Time	SETTINGS Daylight Saving

2.2.13 Maintenance Submenu

Purpose: *Describes how to access, view and modify various parameters used for unit maintenance.*

Procedure: From Logo screen, press **ENTER** to go down to Main Menu. **Down arrow** three times to MAINTENANCE, then Press **ENTER** again for password screen or to see first function under MAINTENANCE if password is Disabled. Use **Down arrow** key to see more functions, **Up arrow** key to go back to previous functions, or **ESC** key to go back up to Main Menu and Logo screen. When the desired function appears, press **ENTER** to call it up.

This Submenu is normally used only by qualified personnel, hence the password protection option is provided for access.



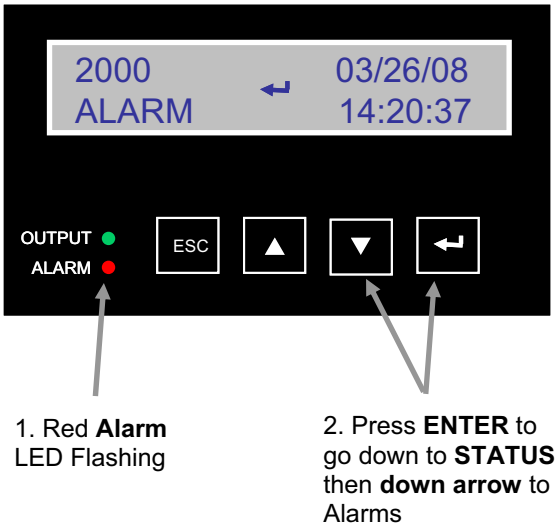
FUNCTION	ACTION	LCD SHOWS
Enter Password	If Password access is Enabled in the CONTROL Submenu, the password must be entered here before the Maintenance Submenu can be accessed. Use the UP and DOWN arrow keys to select the correct number in the first space then press ENTER to advance to the next space. Reentry is required if an error is made entering the Password. The factory default password is 1111. Consult the factory if the programmed password is lost or forgotten.	Enter Password Password : 0000
Battery Test Option	Indicates and sets programmed value of the Self Test period from 1 to 255 minutes in 1 minute increments. To run the Self Test go to the CONTROL Submenu.	MAINTENANCE Batt Test Option
Inverter On/Off	Inverter can be manually turned ON or OFF when the unit is in Battery or Standby mode.	MAINTENANCE Inverter On/Off
Event Log View	The Event Log with Date and Time is viewed in binary digital format. See Section 2.2.16 for details. NOTE: It is much easier to view the Event Log as ASCII text using the Com Port (see Section 2.3)	MAINTENANCE Event Log View
Change Password	The Password for access to the Maintenance Submenu is changed here. Use the UP and DOWN arrow keys to select a number in the first space then press ENTER to advance to the next space.	MAINTENANCE Change Password

2.2.14 Alarm Submenu

Purpose: *Describes the Alarm Submenu and how to use the LCD for troubleshooting. (Figures 12, 13 and 14)*

Procedure:

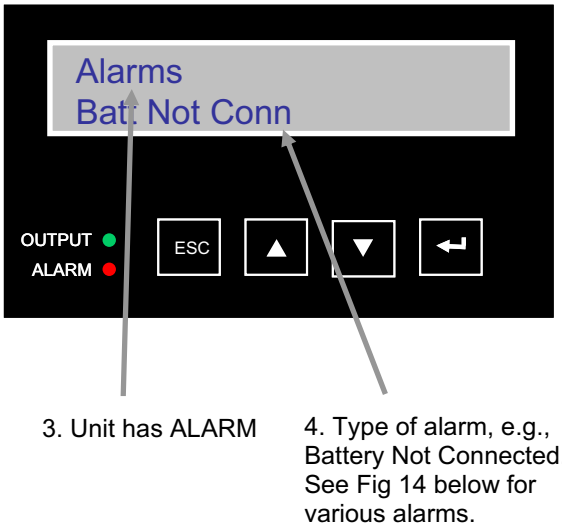
When the **red ALARM LED** is **FLASHING**, the unit has an alarm, a condition not serious enough to stop it from providing output power. To see what the alarm condition is, go to the **STATUS** submenu, then use the down arrow key until the **Alarm** menu appears. Press **ENTER** and one of the Alarm conditions described in Figure 14 appears on the LCD.



1. Red **Alarm** LED Flashing

2. Press **ENTER** to go down to **STATUS**, then **down arrow** to Alarms

Figure 12
LED Shows an Alarm



3. Unit has ALARM

4. Type of alarm, e.g., Battery Not Connected. See Fig 14 below for various alarms.

Figure 13
LCD Displays the Alarm

LCD SHOWS	ALARM	DESCRIPTION
Line Freq	Line Frequency	Input frequency is fluctuating & out of tolerance (<55 Hz or >65 Hz)
Low O/P Volt	Low Output Voltage	Output voltage is low but still usable
No Temp. Probe	Temperature Probe Unplugged	Battery temperature probe is unplugged or damaged. Unit will continue to operate but charger voltage is automatically set to value for 25°C
Overload	Overload	Loads are drawing more than 110% capacity. If continues for 3 minutes, Fault will occur and output will be shut off.
Batt Not Conn	Battery Not Connect	Battery is not connected
High Temp	High Temperature	Battery temperature is high (>40°C)
Low Temp	Low Temperature	Battery temperature is low (<-15°C)

* Alarms self-reset. After the alarm condition is removed, the unit automatically returns to Line mode if the line is qualified or Battery mode if it isn't.

Figure 14
Alarm Table

2.2.15 Fault Submenu

Purpose: *Describes the Fault Submenu and how to use the LCD for troubleshooting. (Figures 15, 16 and 17)*

Procedure:

When the red **ALARM LED is continuously ON**, the unit has a fault, a condition where backup power is unavailable. To see what the fault condition is, go to the **STATUS** submenu, then use the down arrow key until the **Fault** menu appears. Press **ENTER** and one of the Fault conditions described in Figure 17 appears on the LCD.

TIP: When the unit has a fault and Input line power is qualified and available, the output loads are directly connected to the Input line with no line conditioning or backup power provided.

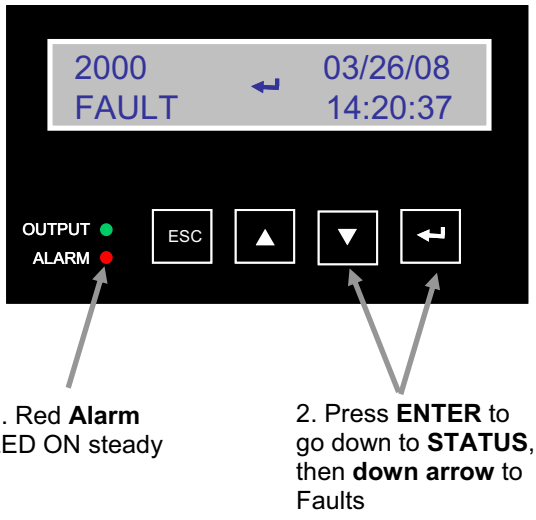


Figure 15
LED Shows a Fault

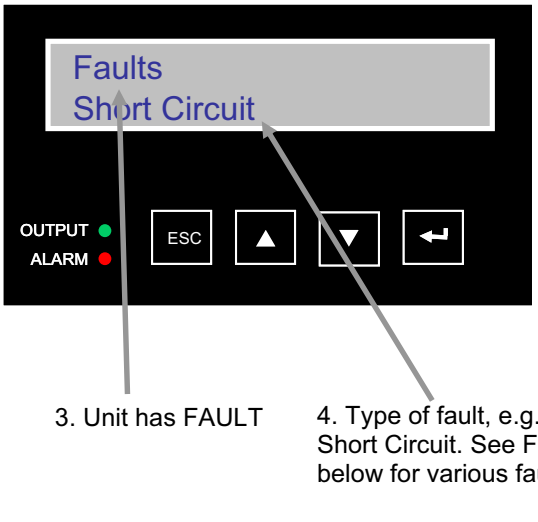


Figure 16
LCD Displays Fault

LCD SHOWS	FAULT	DESCRIPTION
Short Circuit	Short Circuit	Load is short-circuited or the inverter did not start
Batt Low Volt	Low Battery Voltage*	Battery output voltage is low (33 VDC) Not user programmable Not related to Low Battery Warning
Batt High Volt	High Battery Voltage	Battery output voltage is high (63 VDC) Not user programmable
Temp High	High Temperature*	Battery temperature (>80°C) Not related to the unit's internal temperature
Overload	Overload	Loads are drawing more than 110% capacity for 3 minutes

*These faults self-reset. After the fault condition is removed, the unit automatically returns to Line mode if the line is qualified or Battery mode if it isn't. For the other faults, the unit is reset by shutting it down and restarting, using AC & Battery Breakers. The faults can also be reset in the Control submenu of the LCD display.

Figure 17
Fault Table

2.2.16 Event Log View

Purpose: *Describes how to view and interpret the Event/Alarm Log.*

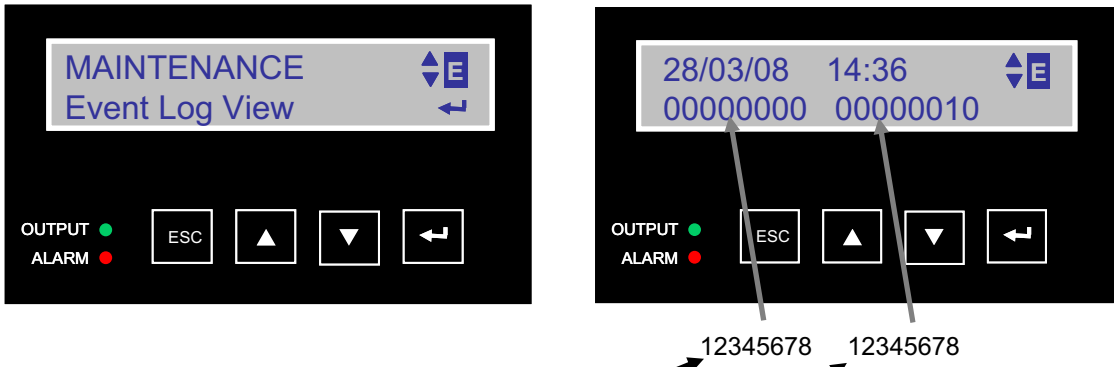
Procedure:

From the Logo screen on the LCD panel, press **ENTER** to go down to Main Menu. **Down arrow** three times to MAINTENANCE, then Press **ENTER** again for password screen or to see first function under MAINTENANCE if password is Disabled. Press **Down arrow** twice to get to the Event Log View screen. Press **ENTER** to see the first event. Press **Up arrow** to see next event.

EVENTS/ALARMS ARE DISPLAYED IN DIGITAL BINARY FORM

The first line of the Event Log screen indicates the date (DD/MM/YY) and time (HH:mm) of the event occurrence. Two blocks of numbers appear in the second line of the LCD screen. Each block has 8 digits, for a total of 16 digits. The position of each one of the 16 digits indicates a unique Event. Digit 1 indicates the presence of an event represented by the position of that digit, while 0 indicates an absence of that event. The assignment of events for each of these 16 digits is identified below. The example below shows an event log for "Alarm No Temp Probe."

TIP: It is much easier to view the Event Log as ASCII text via the com port, menu item 60 (see Section 2.3).



1st Block of 8 digits:

1	2	3	4	5	6	7	8
Event AC High (Hi Lmt)	Event AC Low (Low Lmt)	Event Blackout (No AC)	Alarm/Fault Overload	Fault Hi Temp (Battery)	Fault Batt Hi Volt	Fault Batt Low Volt	Fault Short Circuit

2nd Block of 8 digits:

9	10	11	12	13	14	15	16
Event Batt Low V (relay)	Alarm Freq Low	Alarm Freq High	Event AC Fail (No AC or over/under voltage)	Reserved	Alarm Batt Temp >40 or <-15C	Alarm No Temp Probe	Alarm Batt Not Connected

2.2.17 Low Battery Mode Status

Purpose: *Describes the various states of the Low Battery Mode (Figure 18).*

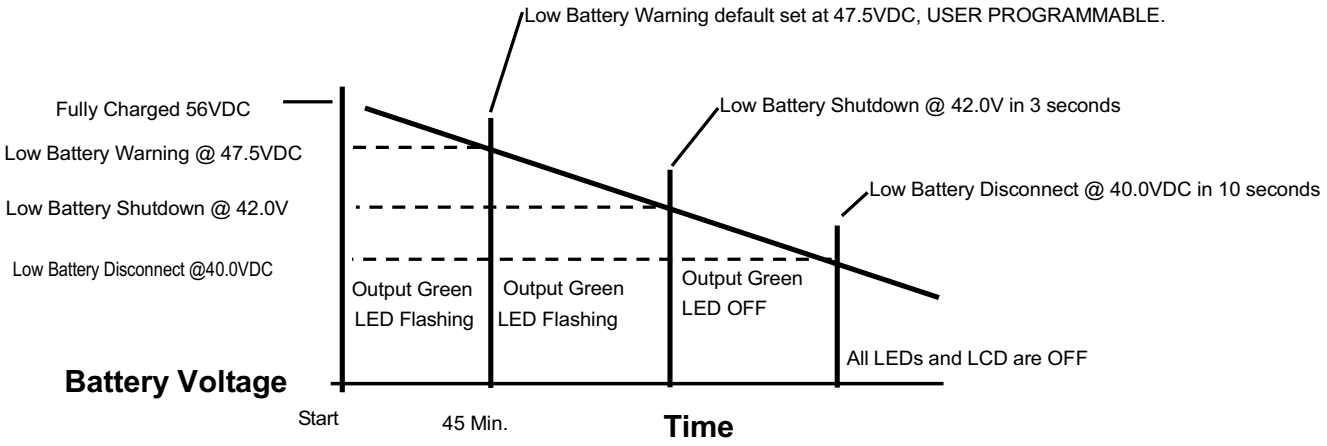


Figure 18
Low Battery Modes Status

Note: Not to scale. All values are shown for illustrative purpose ***only*** and will ***charge under different operating and battery conditions***. Actual times will be different. Perform a Battery Backup Time Test (Section 2.4.1) for your operating conditions.

Low Battery Warning

The Batteries still power the loads, but they are almost discharged and cannot power them much longer.

TIP: The operator should shut down unnecessary loads to extend battery backup time.

Low Battery Shutdown

When the battery decreases to 42.0 VDC for 3 seconds, the unit automatically shuts output OFF. The LCD display will show STANDBY and the output green LED will shut off. The batteries are considered fully discharged and can no longer power the load, but they have enough power to keep the unit's monitoring, control and communications (RS232/USB) circuits active. This housekeeping power supply is kept on. The unit will return to normal operation automatically and begin battery charging when AC power returns.

Low Battery Disconnect

When the housekeeping load further drains the battery to 40.0 VDC for 10 seconds, the unit automatically shuts down completely. It should take a week or more from low battery shutdown for the housekeeping loads to drain the batteries to this point unless the batteries are damaged or there is a short or other parasitic load on the DC circuits. The batteries are disconnected from the unit to protect them from damage via deep discharge. Both the LED and LCD shut OFF, showing the unit is shut off. The unit stays off until line power or a backup generator is available or fresh batteries are connected. The unit will restart automatically and begin battery charging when AC power returns. If the system is to remain off for more than a short period of time, to prevent battery damage, the AC Input/Output and battery circuit breakers **must be** switched OFF and the Manual Bypass switch **must be** switched to the Bypass position. For additional protection disconnect the Anderson battery connector from the BBS.

2.2.18 Parameter Changes

All parameter changes should be performed by authorized personnel as it will affect the performance of the traffic intersection.

2.3 Communication

2.3.1 RS-232 Set-up

Purpose: Describes how to set-up communication between any PC and the unit using a serial RS232 connection.

The unit has both an RS-232 and USB port for communications, or an optional Ethernet port can be used. Only one of these ports can be used to communicate with the unit at any given time as they share the same internal circuit board connections.

When the DB-9F connector at front panel is connected to a PC with Windows 3.1, 9X, or terminal emulation software, the unit can be remotely monitored, controlled and calibrated using RS-232 ASCII commands.

Beginning with the units with a date of manufacture of 2007 or later, a standard, straight-through RS232 DB9 cable is used that can be purchased from any computer supplier. Units manufactured prior to 2007 require an RS232 cable that has a special pin-out that can be ordered from the manufacturer.

Install the DB9 male connector at front panel of the unit and the DB9 female connector at the computer's COM port.

Configure the communications parameters to the values shown in the terminal set up table below.

TIP: In Windows 3.1, click the Terminal icon.
In Windows newer versions the path is Start/Programs/Accessories/Communication/HyperTerminal.

TERMINAL SET UP TABLE	
Emulation Type	VT 100 or Compatible
Duplex Mode	Half Duplex
Xon/Xoff Flow	NONE
RTS/CTS Flow Control	OFF
Line Wrap	ON
Screen Scroll	ON
CR Translation	CR
Back Space	N/A (See Note)
Break Length	N/A
Inquiry	N/A
COMMUNICATION PARAMETERS	
Handshaking	Software Handshaking
Baud Rate	2400 BPS
Data Format	8 Bit Data, No Parity, 1 Stop Bit

NOTE: The **Backspace** and **Delete** keys are ignored by the program.
If a command is wrong, press **Enter** and retype the command.

For a tutorial on how to connect the unit with Window's HyperTerminal, see Section 2.3.4, "HyperTerminal Set Up."

2.3.2 USB Set Up

Purpose: Describes how to set-up communication between any PC and the unit using a Universal Serial Bus (USB).

The unit has both an RS-232 and USB port for communications, or an optional Ethernet port can be used. Only one of these ports can be used to communicate with the unit at any given time as they share the same internal circuit board connections.

When a Universal Serial Bus (USB) cable is used to connect to the unit, the drivers for the USB port must first be loaded on the PC. The drivers can be downloaded from the Prolific Technology Inc. web site:

http://www.prolific.com.tw/eng/downloads.asp?ID=31

Install the drivers on the laptop computer that will be used to interface.

Note**:** Take notice of the installation order. First, run the InstallShield wizard, then plug in the USB cable from the unit to the laptop.

The following steps will show how to install the USB drivers under Windows XP. Basically, the procedures are also somewhat the same for other Windows operating systems.

1. Power on your computer and boot to Windows.

2. Run or double-click the InstallShield driver setup program “PL-2303 Driver Installer.exe”. The InstallShield Wizard will be displayed on your screen to inform you that the PL-2303 USB-to-Serial driver will be installed on your computer. Click **Next** to continue and start the installation.

3. Wait until the InstallShield Wizard informs you that driver installation is successfully installed. Click the **Finish** button to close the InstallShield program. If you have plugged the USB cable into the PC while running the setup installation, unplug and replug the cable for the system to detect the device.

4. Locate the USB port of your computer and plug in the USB cable. Windows should detect the driver as **Prolific USB-to-Serial Com Port**. Before Windows installs this, it may prompt you that this device driver has not yet passed Windows XP Logo compatibility. Click **Continue Anyway**. Windows will then start to install the driver for the USB-to-Serial Com Port.

Configure the communications parameters to the values shown in the terminal set up table in section 2.3.1.

TIP: In Windows 3.1, click the Terminal icon. In Windows newer versions, the path is Start/Programs/Accessories/Communication/HyperTerminal.

For a tutorial on how to connect the unit with Window’s HyperTerminal, see Section 2.3.4, “HyperTerminal Set Up.”

2.3.3 Ethernet Set Up

Purpose: Describes how to set-up communication between a network or PC and the unit using the optional Ethernet Card.

The unit has both an RS-232 and USB port for communications, or an optional Ethernet port can be used. Only one of these ports can be used to communicate with the unit at any given time as they share the same internal circuit board connections. If the optional Ethernet Card is installed in the unit and a network cable is connected, the RS-232 and USB ports are disabled. To enable the RS-232 or USB port for local communications, unplug the network cable.

If the optional Ethernet Card was not purchased, the Ethernet slot on the front panel of the unit will have a blank cover over it.

The optional Ethernet Card provides a method for connecting the unit to a Local Area Network (LAN) or Wide Area Network (WAN). It is designed to operate over 100M Ethernet networks. The data is transmitted via TCP/IP protocol. Therefore control is available via Ethernet, Intranet and Internet.

Features of the Ethernet Card include:

- **Dynamic IP Configuration:** Supports DHCP client mode, simplifying network address configuration and management.

- **Dual LAN Speed:** Supports 10/100 Mbps Ethernet, auto-detected.
- **Server / Client Dual Modes**: Can be configured as network server or network client. In the client mode, it can be installed in a network protected by NAT router or firewall, without the need of a real IP address.
- **Web-based Setup:** Parameters setup is based on HTTP protocol by using standard browsers (IE and Netscape). No special software required.
- **Built-in Security Control:** Protected by both setup password and access password to prevent intruders.
- **Firmware Remote Update:** Firmware can be updated directly via Ethernet network to keep up with latest network standards.

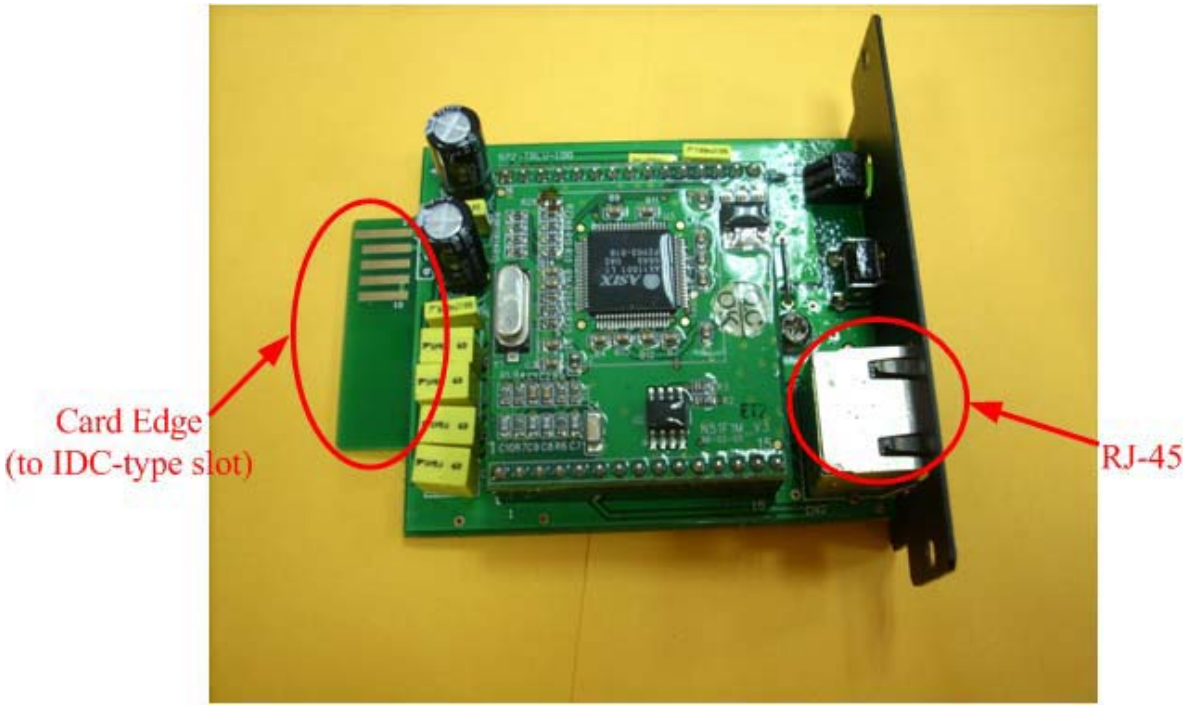


Figure 19
Optional Ethernet Card

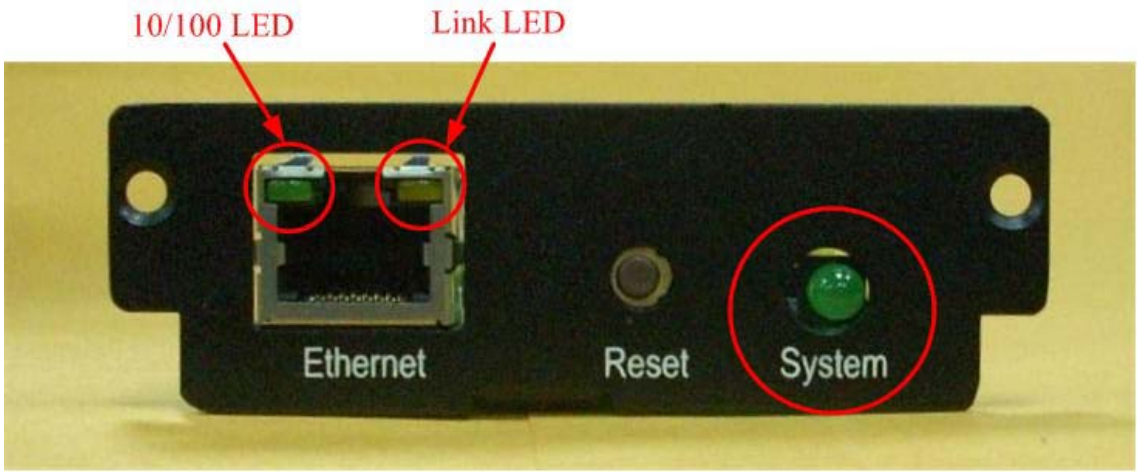


Figure 20
Ethernet Card Front View

LED Indicators

- LAN 10/100 Green LED: 10M/100M indicated (network speed 10M LED off, network speed 100M LED on).
- LAN Link LED: Network signal transmitting/receiving indicated (LED flashes when data transmitted or received from network).
- System LED: Power indicated (LED flashes when the Ethernet Card has power).

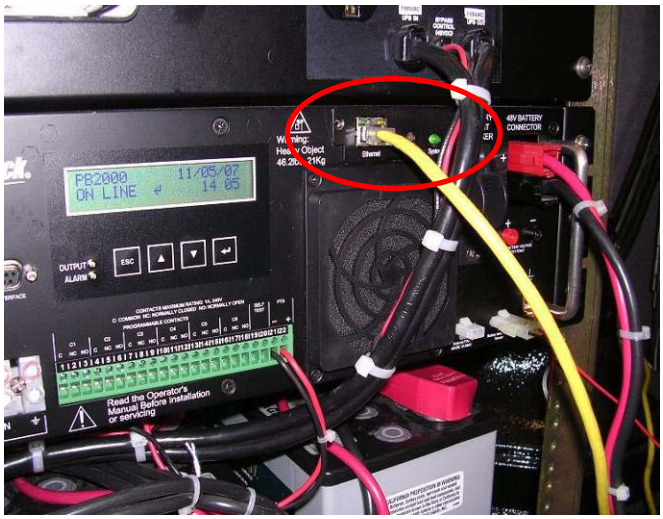


Figure 21
Ethernet Card Installed

2.3.3.1 Ethernet Card Initial IP Configuration

When setting up the Ethernet Card for the first time, the IP address must be configured. The default IP address is 192.168.0.10 and subnet mask is 255.255.255.0. A Device Management Utility called Ethernet Manager (ETM.exe) is provided to perform this task. ETM is used to detect and setup the installed Ethernet Card. It uses UDP broadcast packets to query and configure the Ethernet Card. The ETM.exe utility is available from the unit's supplier. ETM can only setup one Ethernet Card at a time and its broadcast packets can not pass thru routers..Thus it is best to perform this initial setup locally at the unit with a direct connection between laptop PC and the unit's Ethernet Card.

1. Connect an RJ-45 crossover cable from PC to the Ethernet Card.
2. On the PC under Network Connections, select Wired LAN and click on Properties.
3. On the GENERAL tab, select Internet Protocol (TCP/IP) in the window and click Properties.
4. Click on the ALTERNATE CONFIGURATION tab.
5. Set the User Configured IP address to 192.168.0.11 as shown in Figure 22 on next page.
6. Click OK and CLOSE
7. Click ETM.exe on the PC. It will detect the existence of the installed Ethernet Card and depict the Ethernet Card's status: IP address, Subnet Mask, MAC Address, and Device ID (see Figure 23).
8. To change the Ethernet Card IP address for the network it will be operated on, click Config on ETM screen Figure 24.
9. Enter the new IP address and click OK (Figure 25). The IP address will be refreshed in 2 to 3 seconds.

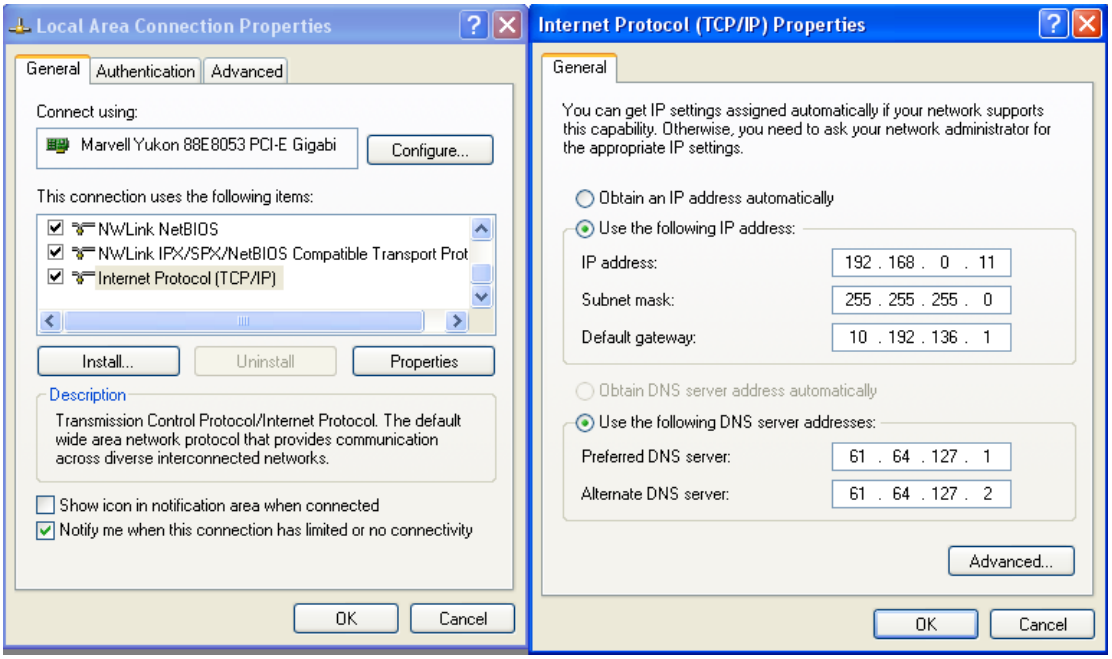


Figure 22
Setting PC to Communicate with Ethernet Card Default

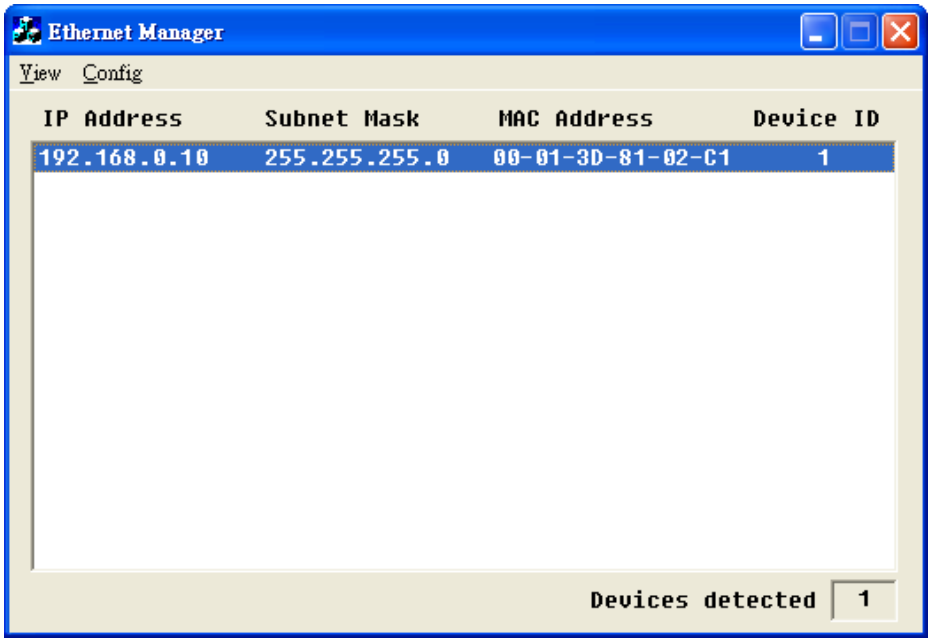


Figure 23
Ethernet Card Detected by ETM

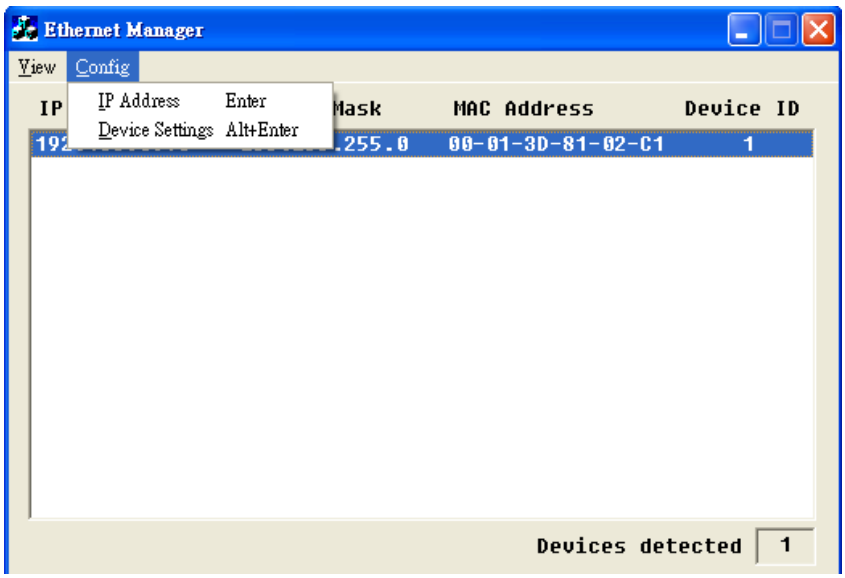


Figure 24
Config Ethernet Card ETM Screen

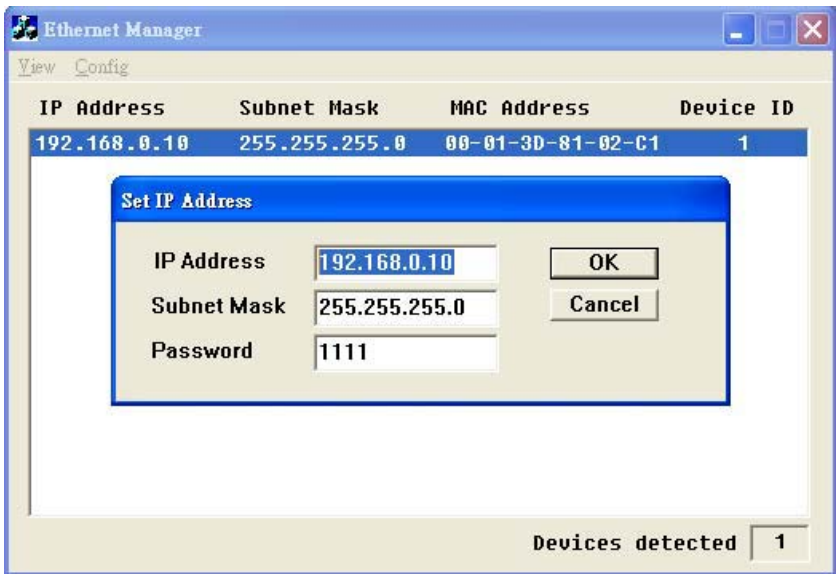


Figure 25
Change Ethernet Card IP Address Screen

2.3.3.2 Ethernet Card Settings Using Browser

In addition to basic IP address and subnet mask, specific device settings can be set through HTTP protocol with popular browsers, e.g. Internet Explorer, Netscape, etc. No special software is required. You can connect to the Ethernet Card directly by providing its IP address in the URL field of the browser. The “Controller Status” page will be shown (see Figure 26).

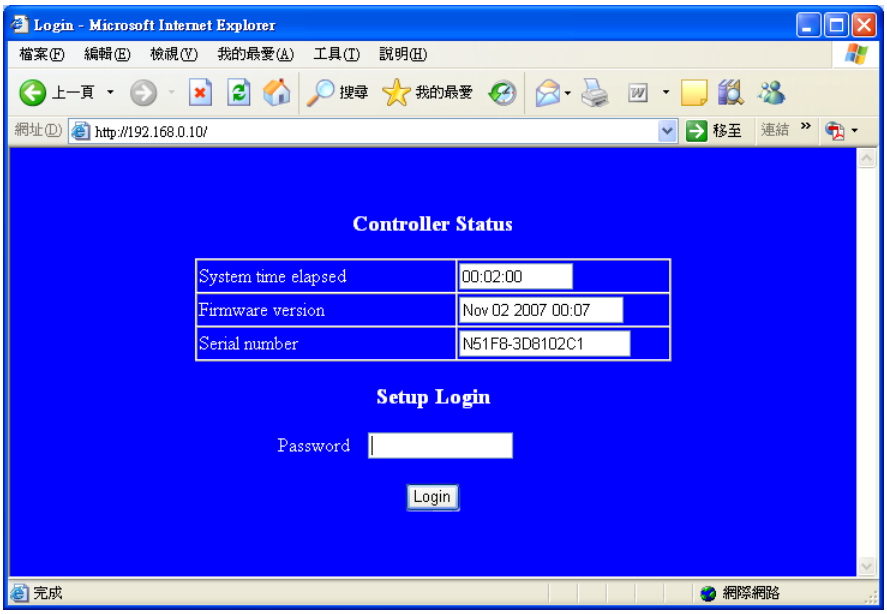


Figure 26
Ethernet Card Controller Status Screen

Click Login to proceed to the Setup Screen. If a password is requested, the factory default password is “1111”.

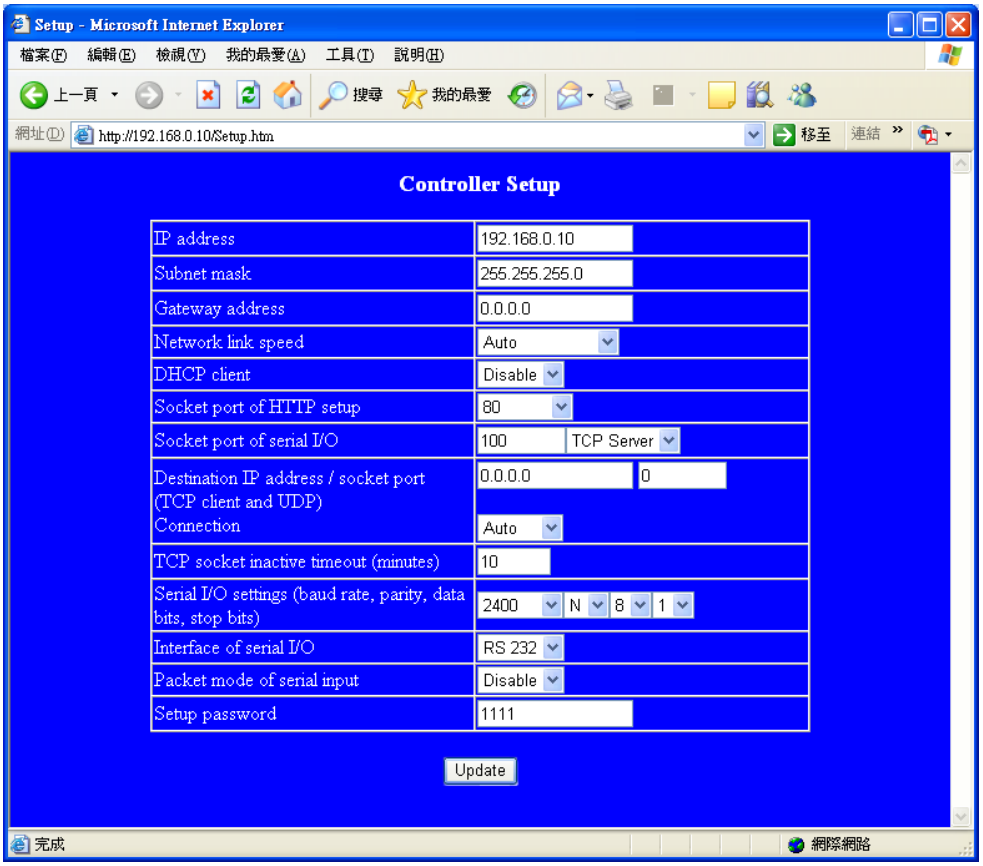


Figure 27
Ethernet Card Controller Setup Screen

Ethernet Card Controller Setup Screen Field Descriptions

IP Address

The IP address of TCP/IP Ethernet Card. If DHCP client mode is enabled and there is a DHCP server on the network, this field will be assigned by DHCP server automatically.

Subnet mask

Subnet mask of the network the TCP/IP Ethernet Card has connected to. “255.255.255.0” is usually used for a small network, “255.255.0.0” for a larger network. If DHCP client mode is enabled and there's a DHCP server on the network, this field will be assigned by DHCP server automatically.

Gateway address

Gateway or Router IP address. 'Gateway' is a device which connects a local network to an external network. If there is no gateway on the network, just leave it as “0.0.0.0”. If DHCP client mode is enabled and there's a DHCP server on the network, this field will be assigned by DHCP server automatically.

Network link speed

Ethernet physical link speed. “Auto” means the speed is automatically selected by the card. You can also specify “10Mbps” or “100Mbps” to match the speed of the HUB.

DHCP client

DHCP client mode can be enabled or disabled status. If DHCP is enabled, there should be a DHCP server on the network. If DHCP is disabled, IP address, Subnet mask, and Gateway address should be manually assigned.

Socket port of HTTP setup

The socket port used to conduct the browser setup. Normally, HTTP protocol uses TCP port “80” for communication. If the field is changed to “81”, the port “80” will be reserved for user's own Web. To enter the browser setup page, “http://x.x.x.x:81” should be typed for socket port “81” and “http://x.x.x.x” for socket port “80”, where “x.x.x.x” is the card’s IP address..

Socket type

- ☐ TCP Server: TCP protocol, passive open, to be connected from the TCP client**s**.
- ☐ TCP Client: TCP protocol, active open, connects to the TCP server.
- ☐ UDP: UDP protocol, connectionless

Destination setting

Destination IP address

The server IP address and socket port would be connected in TCP Client and UDP Client mode for a certain server IP address.

Destination socket port

The server socket port would be connected in TCP Client and UDP Client mode for a certain serial port.

Connection

The connection can be selected in 2 modes, “Auto” or “Manual”.

TCP socket inactive timeout (minutes)

Setup the timer of communication.

Serial I/O settings

Baud rate

The baud rate can be selected from 300bps to 115.2kbps.

Parity

The parity can be selected “None” or “Even” or” Odd”.

Data bits

The data bits can be selected “7” or “8” bits

Stop bits

The stop bits can be selected “1” or “2”bits

Packet mode of serial input

Packet mode can be in enabled or disabled mode. If packet mode is enabled, the data input from UART will be deferred until the input buffer is full, or the card detects a 10-character packet gap and no more characters arrived. The block waiting time is extended to avoid the splitting of the complete packet.

Setup password

Administration password used to login the "Controller Setup" page. It may be blank or up to 15 characters long.

After making any changes in settings, click the Update button. The Ethernet Card will save all parameters into internal non-volatile memory and reboot. This process takes about 5 seconds.

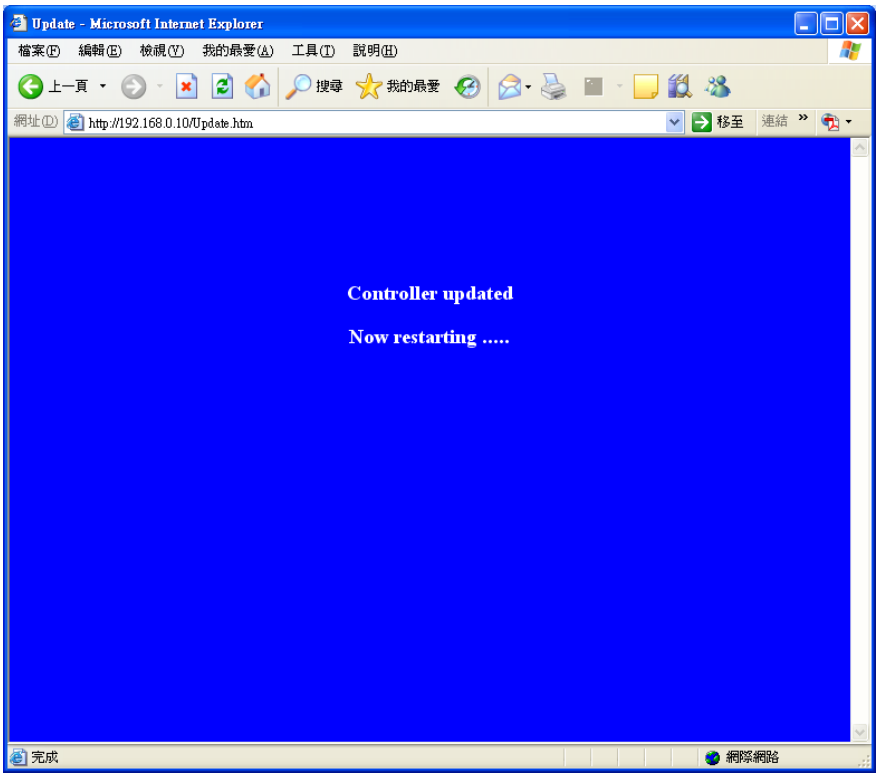


Figure 28
Ethernet Card Controller Updated Screen

You can re-login and check if all parameters have been correctly saved.

Note: If the domain of the Ethernet Card is different from that of the computer running the browser, the login page won't appear unless the Ethernet Card "Gateway Address" has been correctly set.

2.3.3.3 Using HyperTerminal to Communicate via the Ethernet Card

After completing the Ethernet Card setup, verify communications to the unit via the Ethernet Card using HyperTerminal for TCP/IP WinSock. Initiate HyperTerminal from the Start Menu in Windows (see Figure 29), enter a terminal name (e.g. UPS Ethernet), choose an icon, and click the "OK" button (see Figure 30).

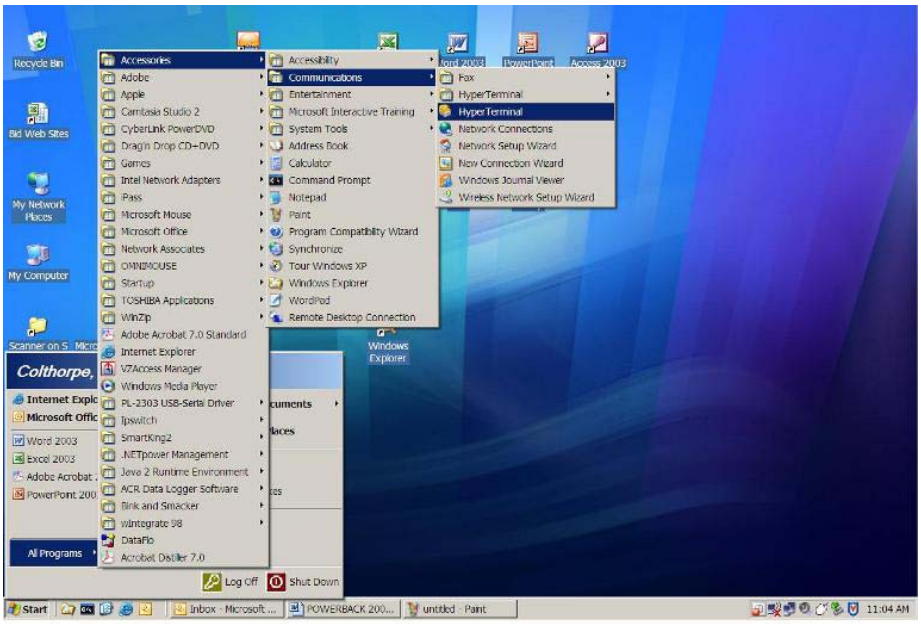


Figure 29
Starting HyperTerminal

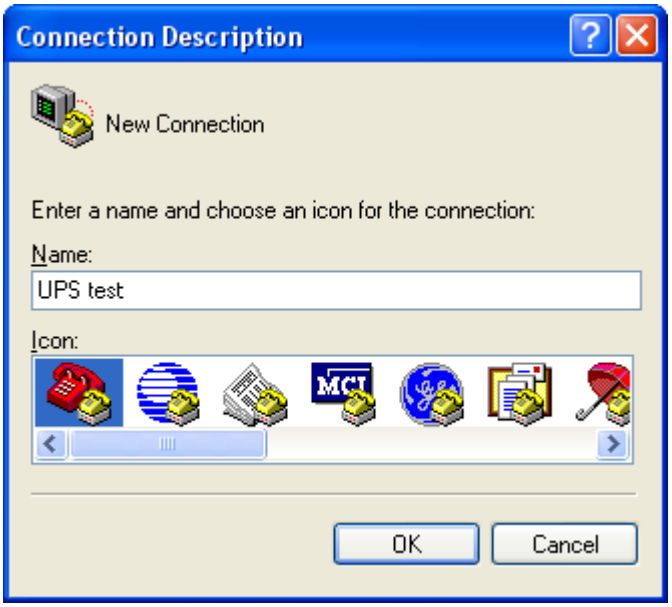


Figure 30
HyperTerminal New Connection

Select “TCP/IP (Winsock)” option at the “Connect using:” field (see Figure 31)

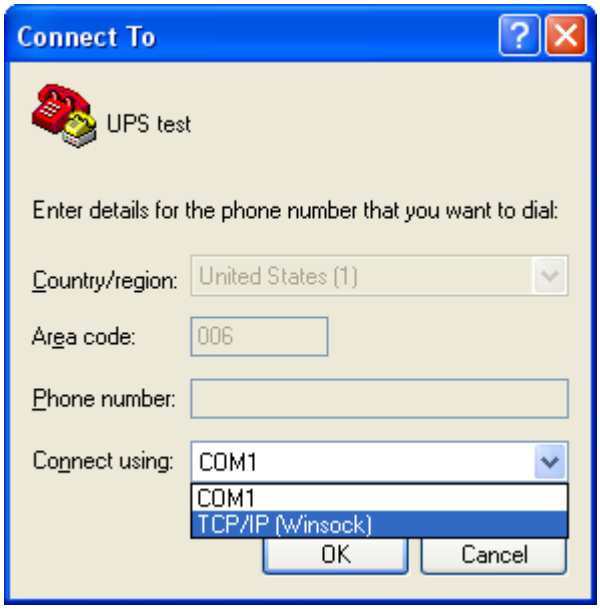


Figure 31
HyperTerminal Connect Using Field

After “OK” is clicked, the screen shown in Figure 32 appears. Enter the Ethernet Card IP address (e.g. 192.168.0.10) in the “Host address:” field, and the Socket port number set for Serial Port 1 at the “Port number:” field (e.g. 100). (The Socket type of the Serial Port 1 should be “TCP Server”.)

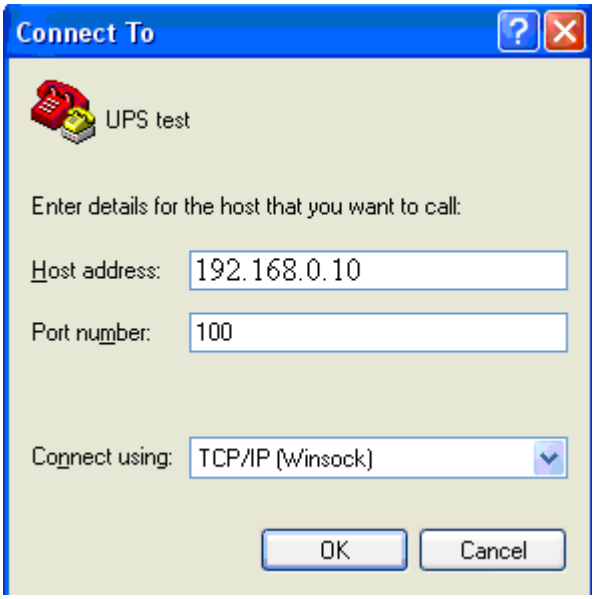


Figure 32
HyperTerminal Connect Host Address Field

After “OK” is clicked, Figure 33 appears. When HyperTerminal connects with the Ethernet Card successfully, the time clock at the lower left corner “Connected hh:mm:ss” will start counting. Click on File, Properties and under the Settings tab change Emulation to VT100.

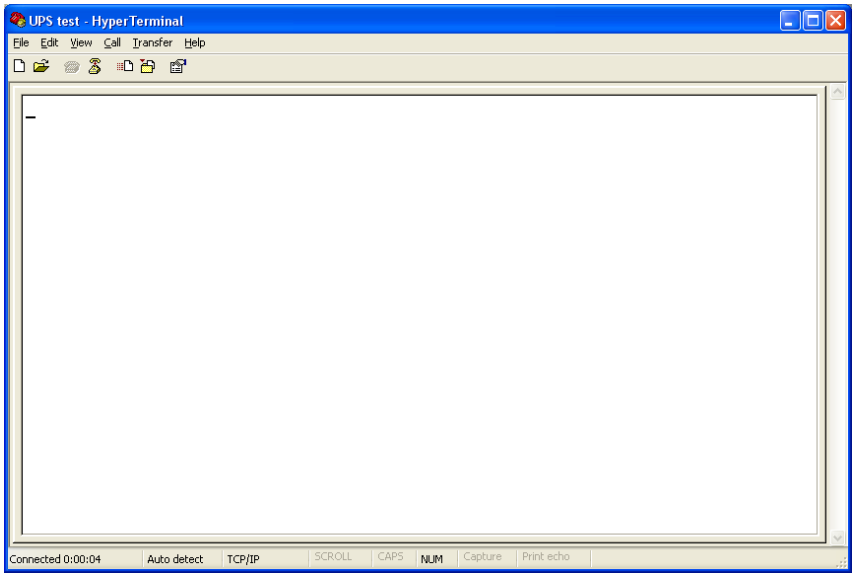


Figure 33
HyperTerminal Connected

When all steps described above are finished, press “Enter” and observe the UPS data displayed as shown in Figure 34.

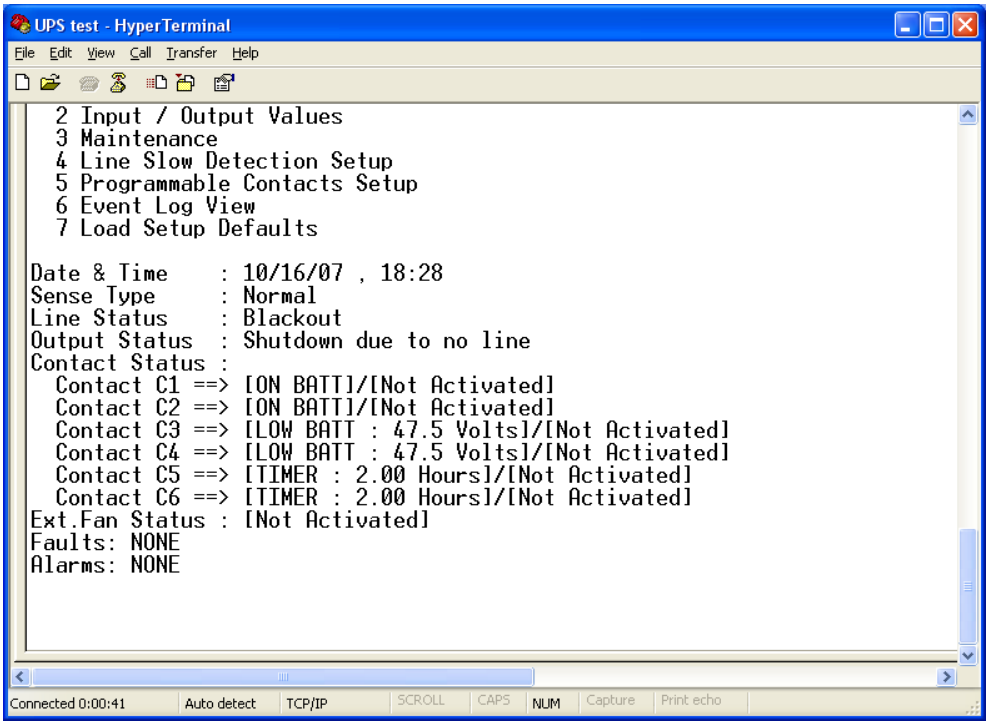


Figure 34
Display of UPS Data

2.3.4 HyperTerminal Set Up

Purpose: Describes how to set up the unit's RS-232 and USB Com ports using Windows© HyperTerminal program (see Figures 35 to 42)

The following HyperTerminal setting is recommended for local or remote communication between the unit & PC. For this tutorial, Com 1 is used. Verify the designation of COM port, where RS-232/USB cable to PC is connected such as COM1, COM2, etc.

Step 1: The path is **Programs/ Accessories/Communications/HyperTerminal** as shown on Figure 35.

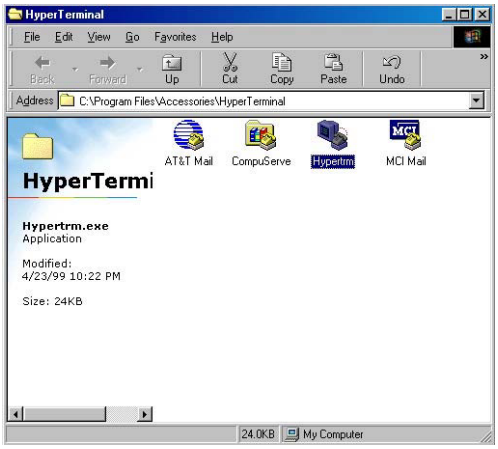


Figure 35
HyperTerminal Screen

Step 2: The Connection Description screen (Figure 36) appears as shown. Enter a name and icon for your unit and click **OK.**

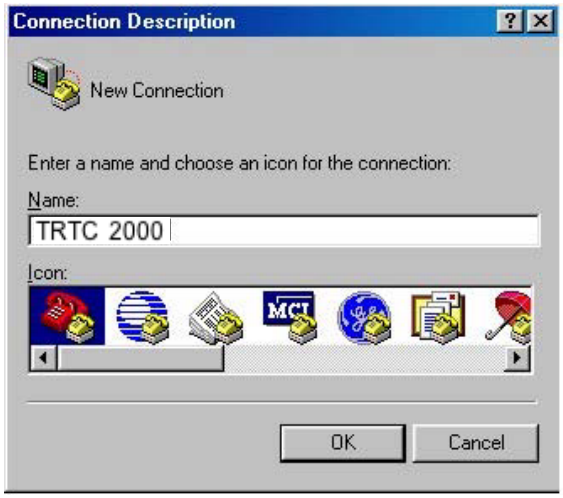


Figure 36
Connection Description Screen

Step 3:

The **Connect To** screen (Figure 37) appears. Select the COM port that will be used from the drop down menu as shown, Click OK.

Figure 37
Connect To Screen

Step 4: The ***COM Properties*** screen appears (Figure 38). Select the port settings as shown.

Step 5: Click the **Advanced** button.

*

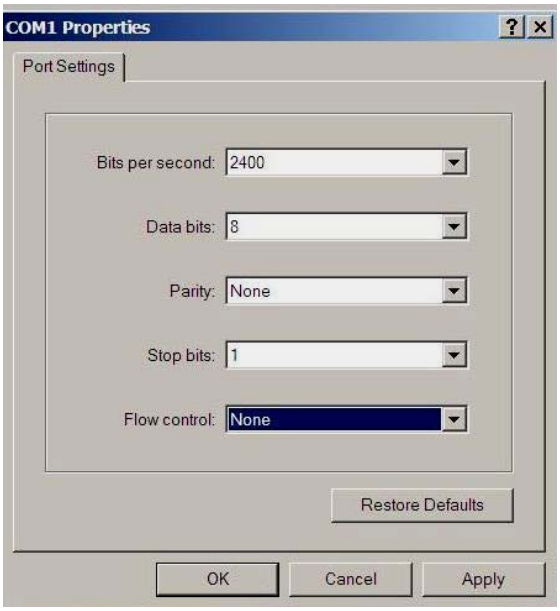


Figure 38
COM Properties Screen

Step 6: In the ***Advanced Port Settings*** screen (Figure 39) select the fields as shown.

NOTE: The Use FIFO buffers only applies to computers with 56Kbs modems or faster. For slower connections, leave it unchecked.

Click **OK**.

The **COM Properties** Screen reappears (Figure 38). Click **OK.**

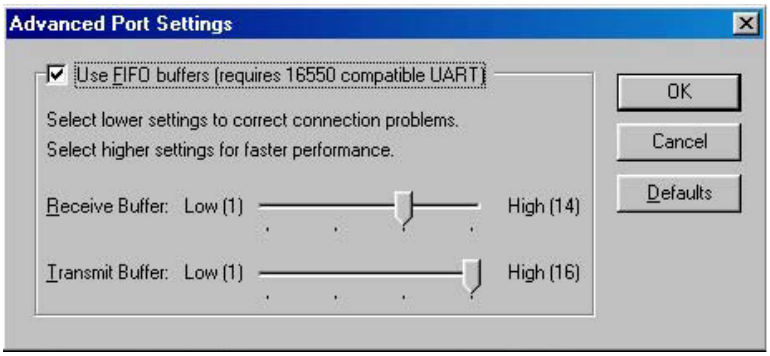


Figure 39
Advanced Port Settings Screen

Step 7: A blank window with the entered file name appears (Figure 40).

In the **File** menu, click **Properties.**

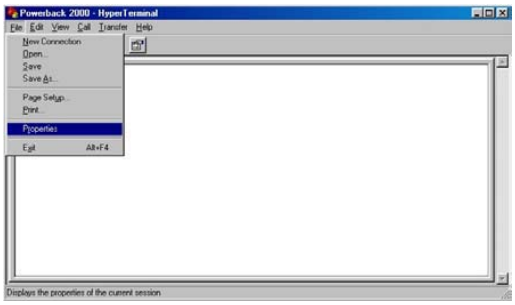


Figure 40
Unit Screen

Step 8: The Properties screen appears (Figure 41). Click on the ***Settings*** Tab. Select the fields as shown.

Step 9: Click the **ASCII Setup** button.

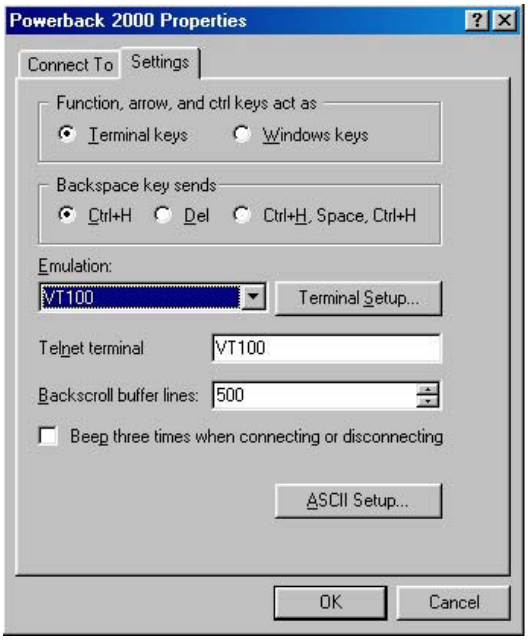


Figure 41
Properties Screen

Step 10: Select the fields in the ***ASCII Setup*** screen (Figure 42) as shown.

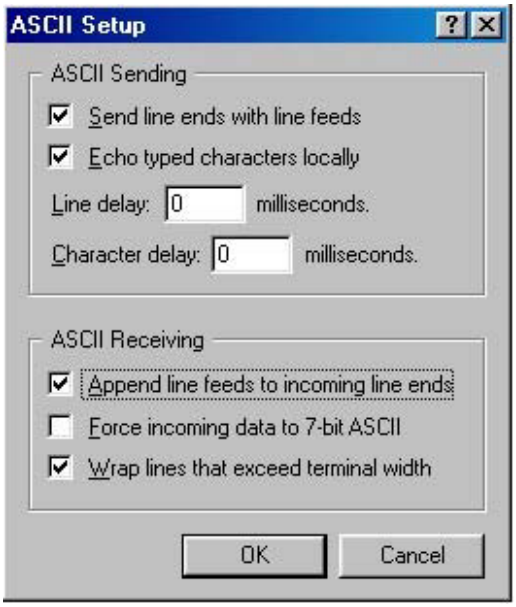


Figure 42
ASCII Setup Screen

Step 11: Click **OK**. The **P**roperties screen (Figure 41) reappears.

Step 12: Click **OK.**

HyperTerminal setup is completed.
Press **Enter** to go to unit's screen (Figure 40).
Press **Enter** to access the unit via com port communications.
The Com Port Main Menu (Figure 43) appears.

2.3.5 Com Port Main Menu

Purpose: *Describes the Main Menu seen via the com ports (Figures 43 to 46).*

The menus are hierarchical. The top-level menu, the main menu (Figure 43), is accessed by pressing **Enter**.

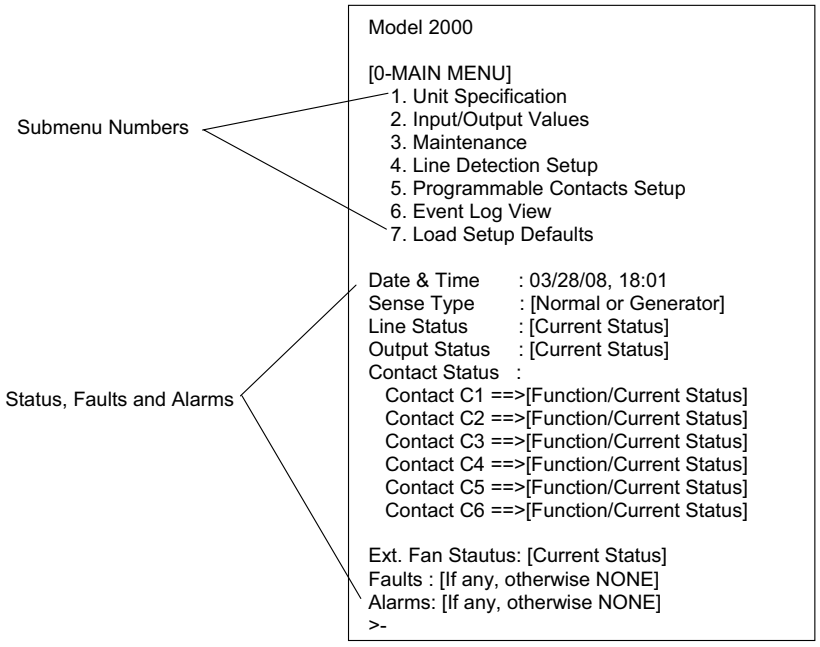
Figure 47 shows the entire menu tree accessible via the com ports.

The main menu displays the submenu numbers, the line status, the unit's output status and any faults or alarms that may be present.

TIP: The factory set default password **1111** is required to access and set many functions, such as in menu 34 & menu 35.

Procedure:

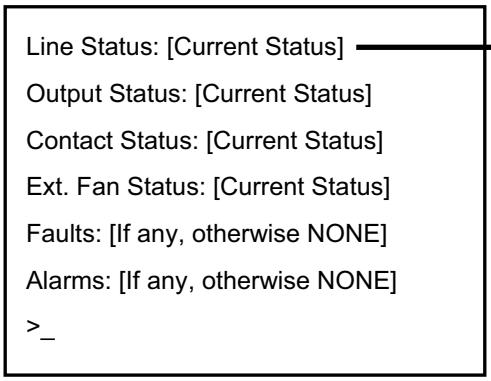
To access a particular submenu, type in the submenu number and press **Enter**.
To update the screen, press **Enter**.



TIP: The Status, Faults and Alarms are not automatically updated. Press ENTER to obtain current status.

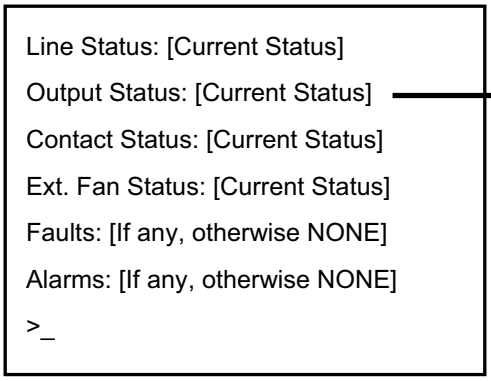
Figure 43
Com Port Main Menu Screen

Displayed text for Line Status, Output Status, Faults and Alarms are shown in Figures 44, 45, and 46.



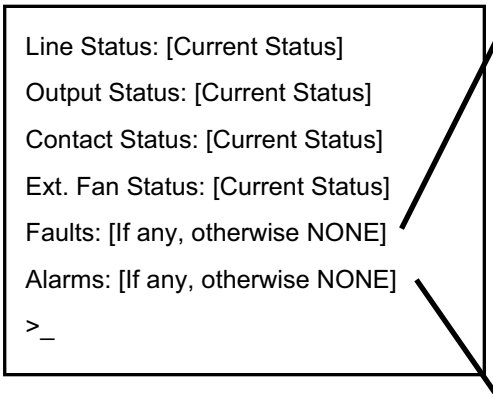
LINE STATUS	
Normal	Input power is normal
Boost	Input power is out of tolerance low. Boost mode is activated
Buck	Input power is out of tolerance high. Buck mode is activated
Blackout	Input voltage is not available
Low	Input voltage is lower than programmed low limit
High	Input voltage is higher than programmed high limit
Freq low	Input frequency is low (<55 Hz)
Freq high	Input frequency is high (>65 Hz)

Figure 44
Line Status Displays



OUTPUT STATUS
Line mode
Inverter mode
Inverter mode. Low Batt Warning
Inverter mode (testing battery)
Boost mode
Buck mode
Shutdown due to fault
Shutdown due to low battery
Shutdown due to no line

Figure 45
Output Status Displays



FAULT DISPLAYS	
Short-Circuit	Output Short Circuit
Vbat_Hi	Battery Voltage High
Temp_Hi	Ambient Battery Temperature High or Internal Temperature High
EEPROM_Flt	Error Reading EEPROM
Wout_Hi	Output Power High (Overload)
Bad Battery	Bad battery
ALARM DISPLAYS	
Overload	Output Overload
Temp_Lo	Ambient Battery Temperature Low
Line_Freq	AC Line Frequency High or Low
Tem_Probe_Disconnect	Temperature probe uninstalled or disconnected
Batt_Not_Connect	Battery breaker is off or batteries are disconnected

Figure 46
Fault and Alarm Displays

2.3.6 Com Port Menu Tree & Submenus

Purpose : *Describes the Menu Tree accessible via the com ports and the unit Specifications, Input/Output Values, Maintenance and Line Power Conditioning Setup Submenus (Figures 47 to 52)*

2.3.6.1 Com Port Menu Tree

The complete Com Port Menu Tree is shown on the next page with all default values. An enlarged version is also included as an insert to this manual for easier reading.

TIP: To access any item from the Main Menu, enter the function number and press ENTER. If the Main Menu reappears, the function is not allowed in the current UPS status (On Line, On Batt, or Standby).

TIP: To go back to the Main Menu press ENTER.

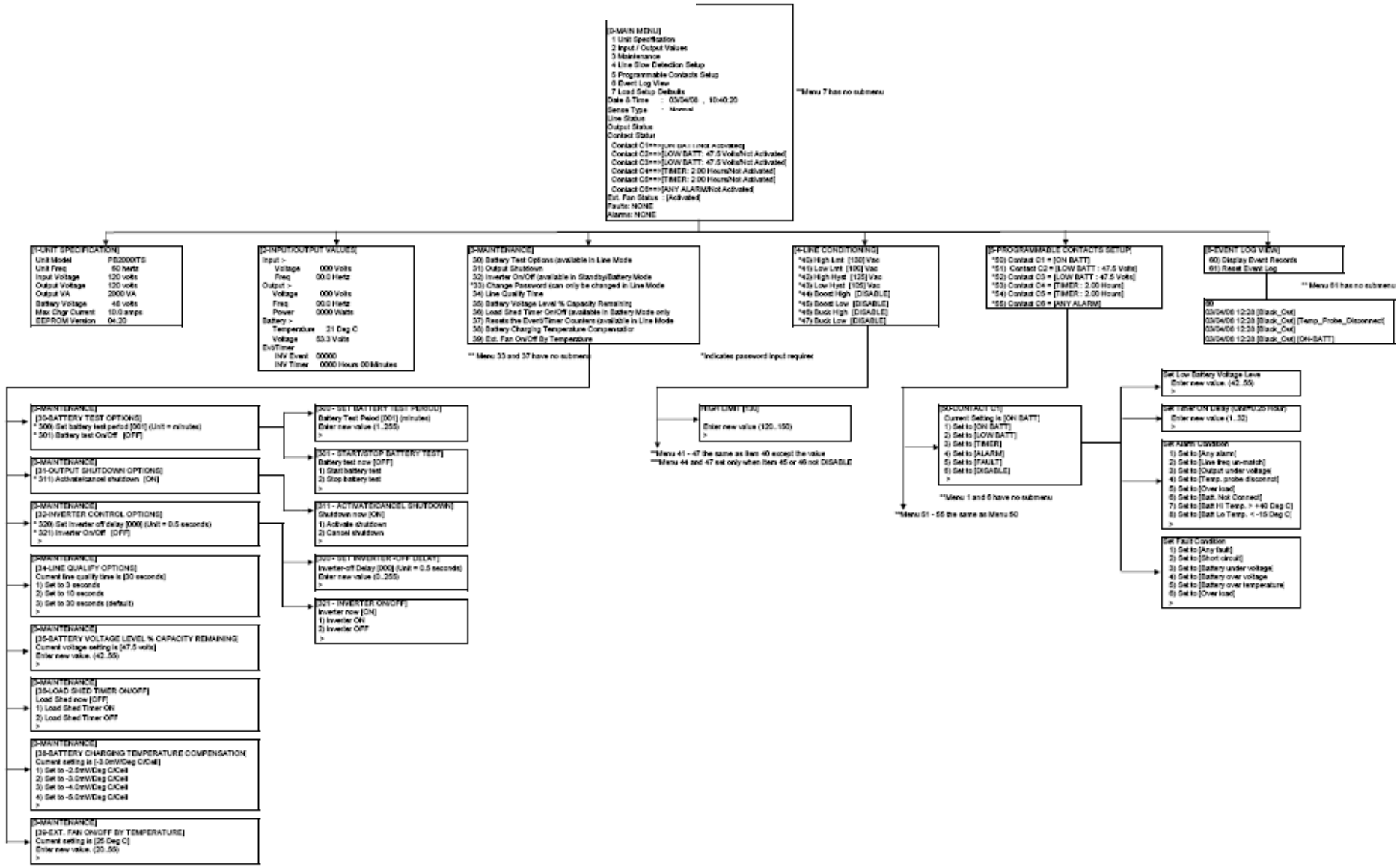


Figure 47
Com Port Menu Tree
Firmware 4.3/3.3

2.3.6.2 Unit Specifications Menu

Menu 1 below (Figure 48) lists the unit specifications as displayed by the com port.

Procedure: At the main menu, type **1** and press **Enter**. The screen displays the Unit Specifications as shown below. To return to the main menu, press **Enter**.

[1- Unit Specifications]		
Unit Model	2000	The model name
Unit Freq	60 Hertz	Nominal operating frequency
Input Voltage	120 Volts	Nominal input voltage
Output Voltage	120 Volts	Nominal output voltage
Output Power	2000 VA	Output capacity in VA
Battery Voltage	48 Volts	Nominal battery string voltage
Max Charger Current	10 amps	Maximum battery charger capacity
EEPROM Version	4.2	EEPROM firmware version of the unit

Figure 48
Unit Specifications Menu

2.3.6.3 Input / Output Values Menu

Menu 2 (Figure 49) lists actual measurements of various input/output parameters as displayed by the com port.

Procedure: At the main menu, type **2** and press **Enter**. The screen displays the values shown below. To return to the main menu, press **Enter**.

[2- Input/Output Values]		
INPUT		
Voltage	120 Volts	The input voltage
Freq	60.1 Hz	The input frequency
OUTPUT		
Voltage	120 Volts	The output voltage
Freq	60.1 Hz	The output frequency
Power	0000 Watts	The output Power in watts
BATTERY		
Temperature	25°C	Temperature of battery case as sensed by the temperature probe
Voltage	55.2 Volts	The battery string DC voltage
Evt/Timer		
Inv Event	00012	The number of input power failures (either blackout or above/below voltage hi/lo limits) = number of battery discharge cycles
Inv Timer	13 Hours 36 Minutes	Total time the inverter has operated since last reset =total battery discharge time

Figure 49
Input/Output Values Menu

2.3.6.4 Maintenance Menu

Menu 3 below (Figure 50) lists the various maintenance options available via the com port

Procedure

At the main menu, type 3 and press **ENTER**. The Maintenance Menu shown below is displayed. To return to the main menu, press **ENTER**.

[3- Maintenance]	
30 BATTERY TEST OPTIONS	The start – stop for the Battery Test / Self Test is initiated here. The test duration is user programmable in 1 minute intervals from1 to 255 minutes. The factor default setting is 1 minute. **Tip:** The time duration can be changed only in Line mode.
31 OUTPUT SHUTDOWN	Allows output to be switched OFF or Shutdown. The unit switches to STANDBY mode when this option is selected.
32 INVERTER ON/OFF	During ON BATTERY or STANDBY mode, this option allows the inverter to be switched OFF or turned ON after a user programmable delay time. The delay can be programmed in 0.5 second intervals from 0 to 255 (128 seconds). The delay is only available in Standby or Battery modes. When the unit returns to Line mode, the delay resets back to a default of 0 seconds. Thus during a battery discharge or ON BATTERY mode, the operator can select Inverter OFF and it will shut down after the programmed delay time of 0 to 128 seconds, making the intersection dark if AC power has not returned.
33 CHANGE PASSWORD*	This option allows the password to be changed. The factory set default password is 1111. **Tip:** Password can only be changed in Line mode.
34 LINE QUALIFY TIME	When input power returns and it is qualified, *i.e.,* it is within acceptable range, the retransfer from Battery mode to Line mode is delayed by user programmed 3, 10, or 30 seconds to insure the line AC is stable and prevent unit cycling. The factory set default value is 30 seconds.
35 BATTERY VOLTAGE LEVEL % CAPACITY REMAINING	The level for LOW BATTERY ALARM as well as the activation of Normally Open relay contact on com port connector is set here. The Voltage level is user programmable in 0.5VDC increments from 42VDC to 55VDC. The factory default setting is 47.5VDC or 40%. The relationship between remaining % capacity of battery and its DC Voltage depends on the characteristics of the batteries used.

Figure 50
Maintenance Menu
(continued next page)

[3- Maintenance Continued]	
36 LOAD SHED TIMER ON/OFF (available in Battery Mode only)	The programmable Timer contacts are Manually activated / deactivated ON DEMAND using this option. Certain Loads / Signals connected to this Timer can be shed or dropped earlier to extend the back-up time.
37 RESET EVENT/TIMER COUNTERS (available in Line Mode)	Resets Inverter Event counter to 0. Resets Inverter Timer to 0. **CAUTION**: Resetting the Inverter Event counter and Timer may invalidate the battery warranty as it provides evidence of the duty cycle the batteries have been subjected to.
38 BATTERY CHARGING TEMPERATURE COMPENSATION	A temperature-compensated smart charger is used in the unit. The rate of charging is adjusted based on the temperature measured by the battery temperature probe. The charging voltage is lowered as battery temperature increases. The factory default value is set at -3.0mv/°C/Cell. It can be set to –2.5, -3.0, -4.0, or -5.0 mv/°C/cell.
39 EXT. FAN ON/OFF BY TEMPERATURE	Set the temperature in °C above which 48VDC power will be provided for an optional external cooling fan. The temperature can be set in 1°C increments from 20 to 55 °C. The factory default temperature is set at 25°C.

Figure 50
Maintenance Menu
(continued)

***Password Changing Procedure**

1. Go to Menu 33.

2. Type the current password (the factory set password is 1111) and press **Enter**.

3. The words “Enter New Password” appears on the screen. Type the new password (any combination of 4 digits) and press **Enter**.

NOTE: The password can be four digits ONLY – NO LETTERS.

4. The words “Re-enter new Password” appear on the screen. Retype the new password and press **Enter**. If the wrong password is retyped, the screen displays “Error in entering data… please try again.” Type the correct password and press **Enter**.

If the retyped password is correct, the screen returns to the main menu.

For a tutorial on how to use the com port menu screens, see Section 2.3.7.

2.3.6.5 Line Power Conditioning Setpoints

This option allows the user to change setpoints for input AC voltages at which Activation and Release occurs for Boost/Buck from transformer and Boost/Buck from battery modes. The factory set default values are consistent with those specified by major DOTs (Department of Transportations). See Figure 52 for a description of each setpoint and allowable values. When Boost Low / Buck High are enabled, the PTS switches to UPS so that the UPS internal transformer can increase low line voltage by a fixed 13.9% or decrease high line voltage by a fixed10.9%. If the incoming line voltage goes even lower or higher, indicating a serious line fluctuation, the UPS automatically switches to stable battery power to isolate the load from damaging incoming voltage. Boost/buck to battery is always enabled (cannot be disabled) because a condition with incoming line voltage so far out of tolerance is no different than a blackout.

2.3.6.5.1 Setpoint Change Procedure

1. Go to the Menu 4.

2. "Enter Password" appears (the factory set password is 1111), Type the password and press **Enter**.

   If the wrong password is typed, the screen displays "Error in entering data… please try again." Type the correct password.

3. The Setpoint Change Screen appears (Figure 51). Type the new value that is within the range of acceptable parameter limits and press **Enter**.

The screen returns to the Line Detection Screen. For example:

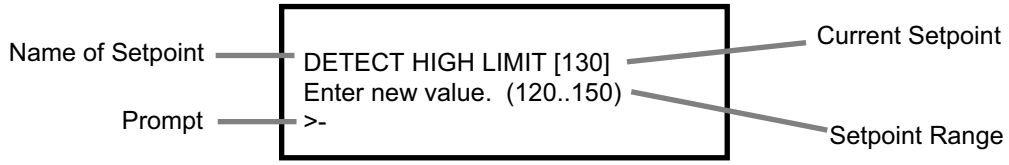


Figure 51
Setpoint Change Screen

(Detect High Limit Screen Shown)

For a tutorial on how to use the com port menu screen, see Section 2.3.7

2.3.6.5.2 Setpoint Descriptions (All setpoints are user programmable but acceptable range of release values depend on the activation value selected)

Setpoint	Description	Setting Range		Default Value [full range]	Remark
		lower	upper		
40 Hi Lmt	Transfer to Battery from either Buck (when enabled) or Line when line voltage exceeds setting	120	150	130 [120-150]	
42 Hi Hyst	Release from Battery to either Buck (when enabled) or Line when line voltage drops below setting	117	Hi Lmt-3	125 [117-147]	Setting range upper value depends on Hi Lmt setpoint so that Hi Hyst cannot be set above Hi Lmt
46 Buck Hi	Activate Buck (when enabled) when line voltage exceeds setting	120	144	126 [120-144]	
47 Buck Lo	Release Buck to Line when line voltage drops below setting	117	Buck Hi-3	123 [117-141]	Setting range upper value depends on Buck Hi setting so that Buck Lo cannot be set above Buck Hi. Cannot be set if 46 Buck Hi is Disabled.
NORMAL				**120 VAC**	
44 Boost Hi	Release Boost to Line when line voltage exceeds setting	Boost Lo+3	123	113 [99-123]	Setting range lower value depends on Boost Lo setting so that Boost Hi cannot be set below Boost Lo. Cannot be set if 45 Boost Lo is Disabled.
45 Boost Lo	Activate Boost (when enabled) when line voltage drops below setting	96	120	108 [96-120]	
43 Lo Hyst	Release from Battery to either Boost (when enabled) or Line when line voltage exceeds setting	Lo Lmt+3	123	105 [93-123]	Setting range lower value depends on Lo Lmt setpoint so that Lo Hyst cannot be set below Lo Lmt
41 Lo Lmt	Transfer to Battery from either Boost (when enabled) or Line when line voltage drops below setting	90	120	100 [90-120]	

Figure 52
Power Conditioning Setpoints

2.3.6.6 Changing Date & Time the Via Com Port

Units with firmware versions 4.2/3.2 (Control/LCD) or later allow the date and time of the unit to be changed remotely via the Com port.

Procedure: To read the current date/time, at the main menu, type **R** and press Enter. The UPS will respond with the current date/time in HyperTerminal textbox as follows:

mm/dd/yy, HH:MM:SS

mm = month dd = day yy = year HH = hour MM = minute SS = second

To change the date/time, place the UPS in time set mode by typing **pU** and pressing Enter. Then type **R** followed by the full date and time the unit is to be changed to as shown below, being sure to include a space after the R and between values:

R mm dd yy HH MM<enter>

mm: month [01-12] dd: day [01-31] yy: year [00-99]
HH: hour [00-23] MM: minute [00-59]

Once the new values are typed and <enter> is pressed, the UPS will respond with the new date/time in the HyperTerminal textbox and the LCD display will also show the new date/time information.

2.3.7 Com Port Menu Tutorial

Purpose: *shows how to use the menus accessible via the com ports (Figures 53 to 56)*

This tutorial shows how to change the Battery Test Options. The other menus work the same way.

1. At the main menu (Figure 43), type 3 and press **Enter**.

The Maintenance Menu 3 appears as below (Figure 53).

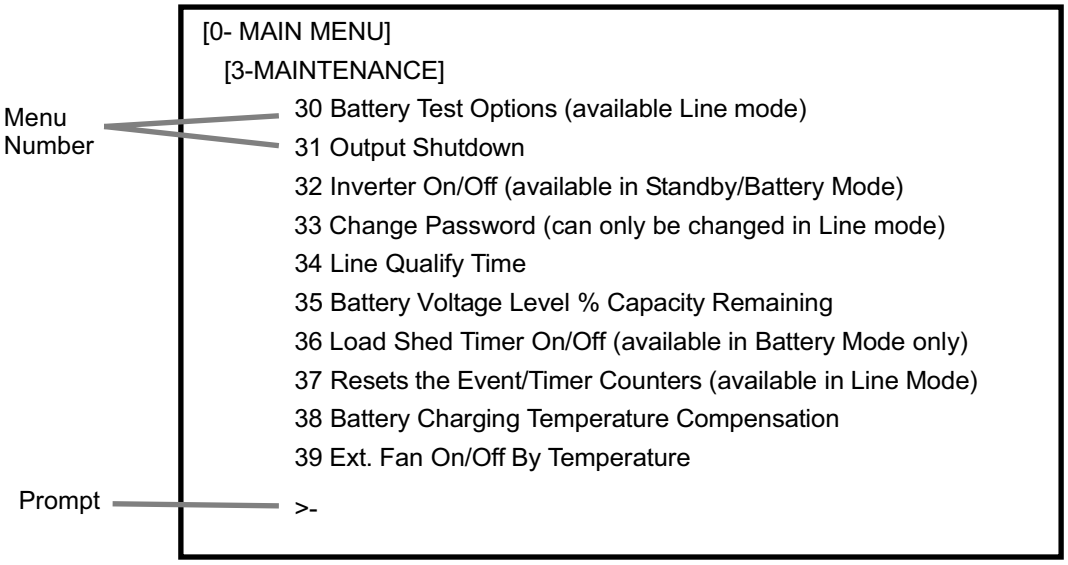
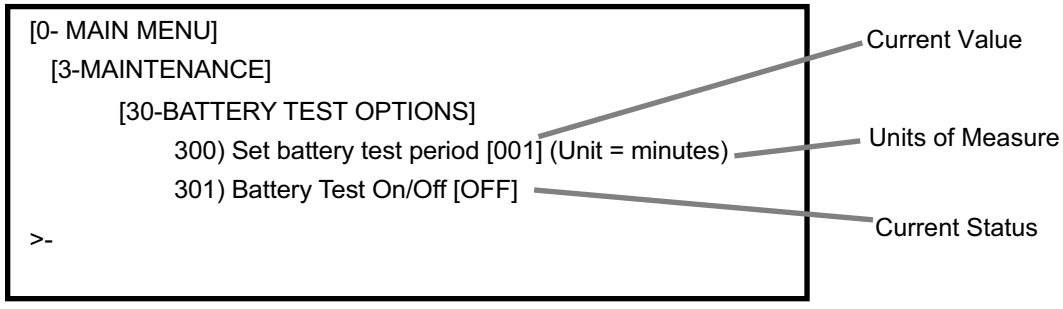


Figure 53
Maintenance Menu Screen

To the left of each maintenance option is a Menu number. Typing **30** and pressing **Enter** calls up the Battery Test Options screen (Figure 54).

2. Numbers or words inside square brackets show the present status value of that menu item.



To calculate the Test Period: Test Period = Current Value X Units

Example: Test Period = 001 x 1 Minute = 1 Minute

Figure 54
Battery Test Options Screen

3. To change the battery test period, type **300** and press **Enter**. The words “Enter password” appear on the screen. Type the password (the factory set password is 1111) and press **Enter**. If the wrong password is typed, the screen displays “Error in entering data… please try again.” Type the correct password and press **Enter**. The Set Battery Test Period screen appears as below (Figure 55).

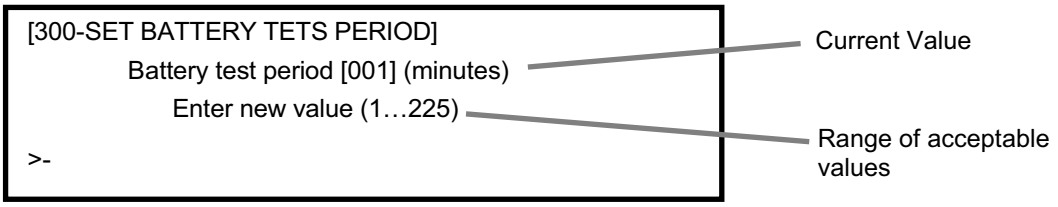


Figure 55
Set Battery Test Period Screen

Type in the new value within the acceptable range and press **Enter** to change the test period and go back to the Maintenance menu screen.

4. To change the Battery Test On/Off status, type **301** and press **Enter**.

The words “Enter password” appear on the screen. Type the password and press **Enter**.

The battery Test Screen appears (Figure 56).

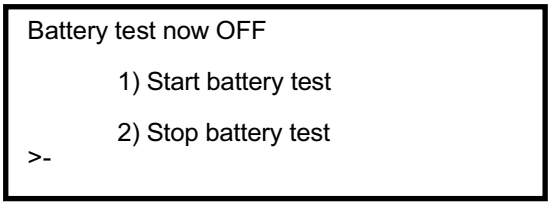


Figure 56
Battery Test Screen

Type **1** to start the battery test, or **2** to stop the battery test, and press **Enter**. This changes the battery test status and sends you back to the Maintenance menu screen.

2.3.8 Log File Capture

Purpose: *Shows how to capture and save the log file to a Laptop.*

1. Connect to the UPS with HyperTerminal as described in section 2.3.4.
2. On the HyperTerminal screen on the computer, click on Transfer in the top menu bar, then Capture Text in the drop down list.

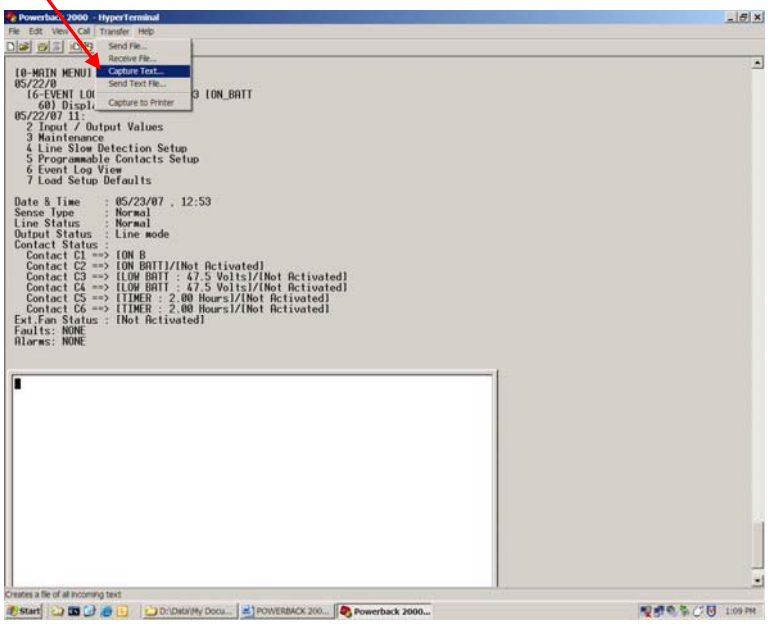


Figure 57
HyperTerminal Capture Text

3. Type in a file location and name in the Capture Text box that opens or click Browse to find an existing location on the computer. It is recommended that the filename take the form: location_logfile_mm-dd-yy, for example D:\Data\UPS\intersectionname_log file_5-23-07.TXT
4. Click the Start button
5. Type 60 and press Enter to scroll the log file on the screen.
6. Click on Transfer in the top menu bar, then Capture Text…and Stop in the drop down lists.
7. The log file has now been saved on your computer. Note that any information including a copy of all settings can be copied in a text file the same way.
8. Close the HyperTerminal window by clicking the X in upper right corner of screen.
9. To view the log file on the computer find the filename where it was saved and double click it to open. An example is shown.

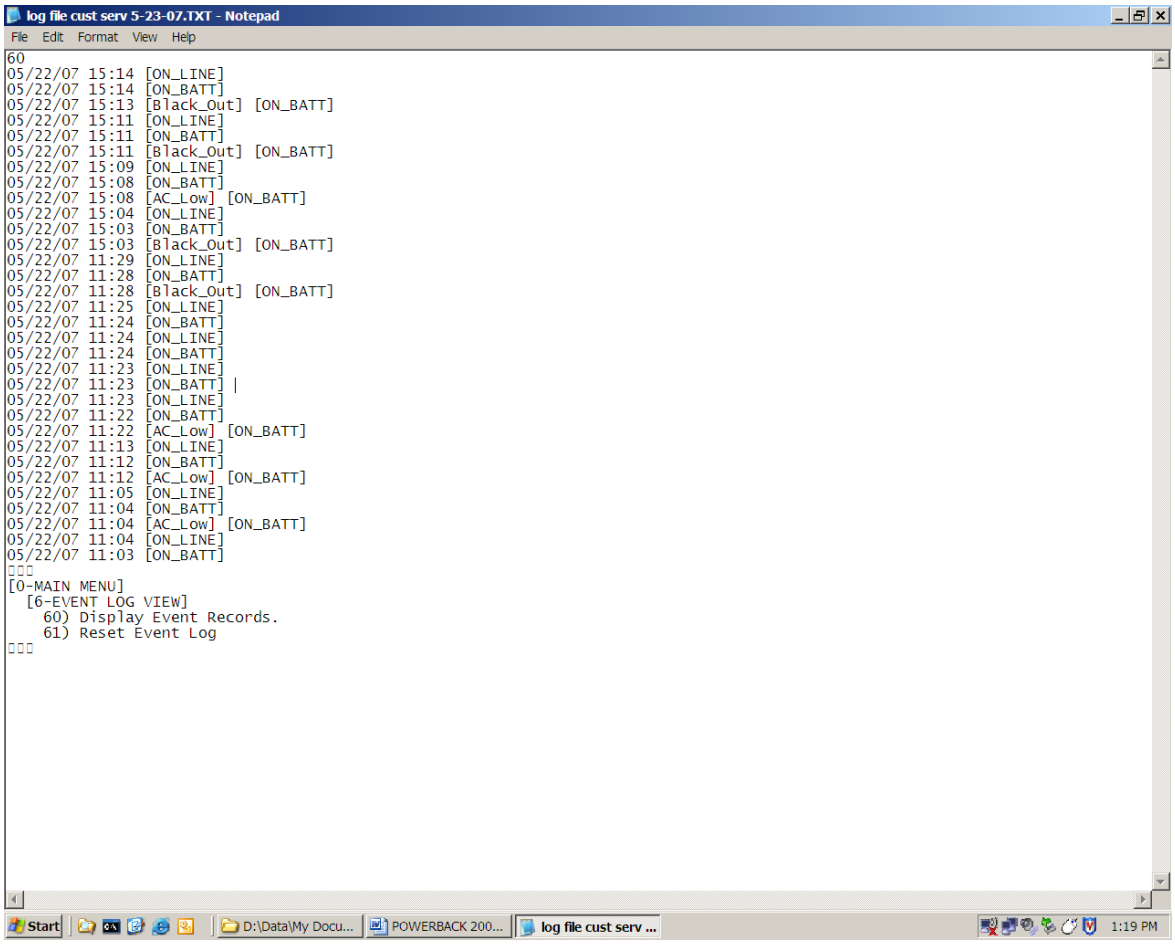


Figure 58
Example Captured Log File

2.3.9 Firmware Upgrade

Purpose: *shows how to upgrade the UPS CPU firmware from the communications ports.*

NOTE:

- This procedure can only be performed on units with a Date of Manufacture (DOM) of 2006-12-13 or later (DOM on side label of unit).
- Before executing this procedure, install SmartKing2 software first (available from manufacturer). This software will be used for UPS firmware upgrade.
- If any problems are encountered during firmware upgrade, the UPS will hold in firmware upgrade mode. If this situations occurs, download a correct firmware and repeat the procedure to upload it to the UPS.

1. Install UPS. Connect DC input (AC power is not needed). If already installed, place Manual Bypass Switch in Bypass. Connect RS-232/USB communication cable.
2. Turn on DC breaker. UPS will go into STANDBY mode.
3. Start SmartKing2 program.

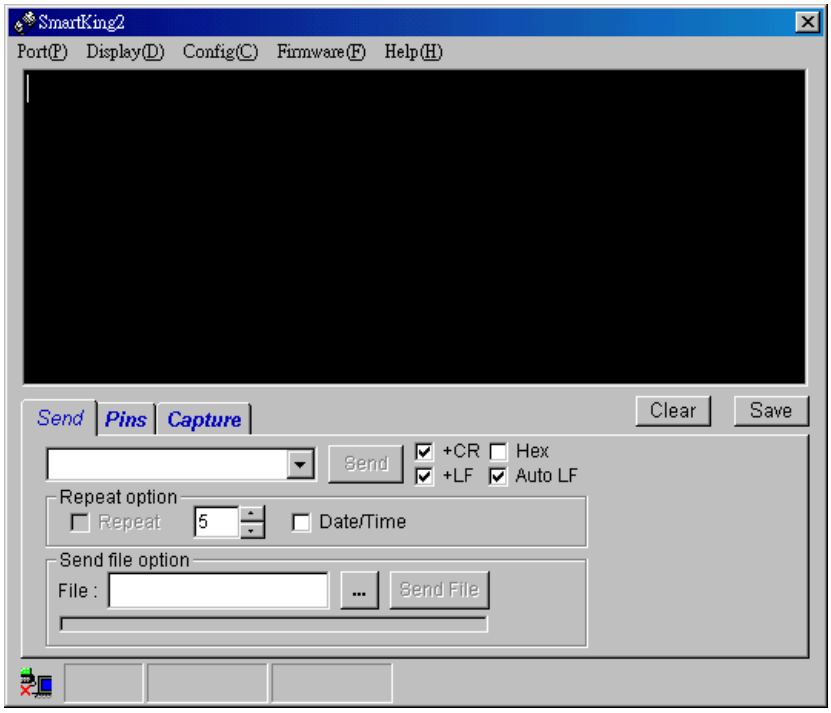


Figure 59
SmartKing2 Screen

4. Check communication port setting in SmartKing2 (Port menu).
   It should be 2400-8-n-1. If setting is correct, press F11 to enable COM port.
   Check communication function.
   Press “ENTER” key in Terminal text box (the black text box, it functions like HyperTerminal). PC must receive the unit's main menu. If not, check communication cable and that COM port shown at bottom of screen is the COM port used on the laptop. COM port can be changed under Port menu.
5. Record important setting values (only required if default values have been previously changed).
   Use “P’, “V” and “F” commands to read back setting values. NOTE: Commands are case sensitive. These commands are capital letters P, V, or F. Response should be similar to below:

   Command: P Returns: 55 55 55 55 (Line conditioning calibration values not user programmable)
   Command: V Returns:192 130 125 126 123 113 108 105 100 (Boost/Buck setpoints, ignore fist value)
   Command: F Returns: #120.0 030 048.0 60.0 (UPS rating: AC volt, AC current, DC volt, frequency)

6. Initiate firmware upgrade procedure.
   Enter “pU<enter>” and “UG<enter>” in Terminal text box. UPS will enter into firmware upgrade mode and wait to download new firmware. In this mode, LCD will be turned off and the text box will receive waiting signal repeatedly. Note: <enter> means “press ENTER”.
7. Press F9 in SmartKing2 firmware upgrade window, shown below. If it shows “Ready...” in blue, it means the UPS and SmartKing2 are ready to execute the upgrade procedure. If not, please go to step 1 and check everything again.

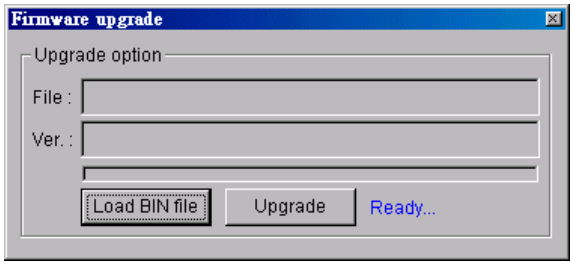


Figure 60
SmartKing2 Firmware Upgrade Window

8. Press “Load BIN file” button to load new firmware file. Browse your PC to locate the bin file to upload. The new firmware file must be in binary format, and its file length is 65536 bytes (file length can be checked by right clicking on the file name and selecting Properties). Incorrect file length may cause UPS fault. Nothing is entered in the Ver: box.
9. Press “Upgrade” button to start procedure. When the procedure finishes correctly, SmartKing2 will display a “Completed !! Press OK to restart CPU”. Press “OK” to restart UPS.
   Note: After the Completed box OK is clicked, com error!! will display in firmware upgrade window. Close this window, place cursor in HyperTerminal window, and press ENTER – normal communication response should occur.
10. Check important setting values. Settings should not change during firmware upgrade. Use “P”, “F” and “V” to read settings. Different settings being returned for P or F commands could indicate an incorrect version of firmware was loaded. Different settings being returned for V command indicates user-selected buck/boost setpoints have been lost. Use the menus to restore setpoints.

2.4 Maintenance

2.4.1 Battery Capacity Test

Purpose: *Describes how to measure the back up capacity of batteries.*

All batteries begin to lose capacity as soon as they are placed in service. Battery testing should be performed following general industry standards contained in IEEE 1188 “Recommended Practice for Maintenance, Testing, and Replacement of VRLA Batteries for Stationary Applications.” Run time is dependant on load, temperature, battery age, number of previous discharges and depth of discharges. More run time is available with less load or higher temperature and less time with more load or lower temperature.

There are three kinds of battery discharge tests:

(1) Acceptance test – performed at initial installation when the battery is new to verify capacity and to determine baseline battery voltage vs. time for comparison with future battery performance tests.

(2) Performance test - performed periodically to verify the battery is still within acceptable limits compared to when it was new.

(3) Service test – performed to verify the battery meets the design requirements (full run time) for the specific installation.

Acceptance and service tests may be full discharge, while performance tests are usually a partial discharge to save time and battery life. For traffic industry applications, the time-adjusted method of IEEE testing should be used since the intersection power draw cannot easily be changed to use the rate-adjusted method.

During the acceptance test for a new installation (which may last several hours to verify the system runs the intersection as long as required), or during the first performance test if no acceptance test is performed at installation, record the battery string voltage after at least 1 hour (or 2 hours for systems with an expected run time of more than 6 hours). This voltage will be the end-point voltage at which future performance tests are stopped and the time recorded to determine the change in battery capacity.

For example, in the first test, after 1 hour the battery string voltage has dropped from 52.2 V at test start to 49.0 V 1 hour later. In all succeeding performance tests, the time will be recorded for how long it takes the battery voltage to reach 49.0 V. The ratio of time for the second test to time for the first test gives the battery capacity as a percent of new capacity.

The general industry recommended practice is to replace batteries if the performance test capacity is below 80% of rating even if excess capacity is available because a capacity of 80% shows that the battery rate of consumption is increasing.

Tip: For traffic industry applications, it is recommended to test batteries yearly. If an acceptance test was not performed at initial installation, the first performance test should be performed within one year of installation. To avoid consuming batteries prematurely, performance tests should not discharge the batteries below the Lo Battery warning (47.5 VDC default setting) and need not be performed more than annually. The performance test must be at least an hour in length to use the time-adjustment method, otherwise battery efficiency can result in as much as a 50% error in indicated capacity. Partial discharge performance testing *is conservative* because it does not account for changes in battery efficiency with discharge time. Service testing (full battery discharge) should only be performed when performance testing indicates a battery has lost significant capacity such that it *may* no longer power the intersection as long as required.

Tip: Batteries are rated at 25°C (77°F). Operation at cooler temperatures will temporarily decrease the run time (less capacity). Operation at hotter temperatures will temporarily increase the run time but *permanently* decrease the overall battery life. If the initial battery temperature is significantly above or below 25°C (77°F), the run time determined in the test below should be adjusted by the Time Correction Factor in IEEE 1888 or provided by the battery manufacturer. The formula to correct battery capacity at other than room temperature to capacity at 25°C is

$$C = \frac{T[actual]}{(T[rated] \times TimeCorrectionFactor)} x100$$

C is temperature-corrected battery capacity in % of rating when new
T[actual] is the run time found in the test at other than room temperature
T[rated] is the run time for the same discharge when new
Time Correction Factor is a number from 0.684 for 5°C to 1.177 for 45 °C as found in IEEE 1188.

The graph below provides a simpler method to determine if actual run time is acceptable by showing what percent the rated or expected run time should be decreased or increased for battery temperature other than 25°C (77°F). This graph is generic as each battery design will have slightly different values. Also to be considered is that there is a 50% reduction in battery life for each 15°F the ***average*** operating temperature is above 77°F, meaning batteries that routinely operate in a hot environment will lose capacity faster.

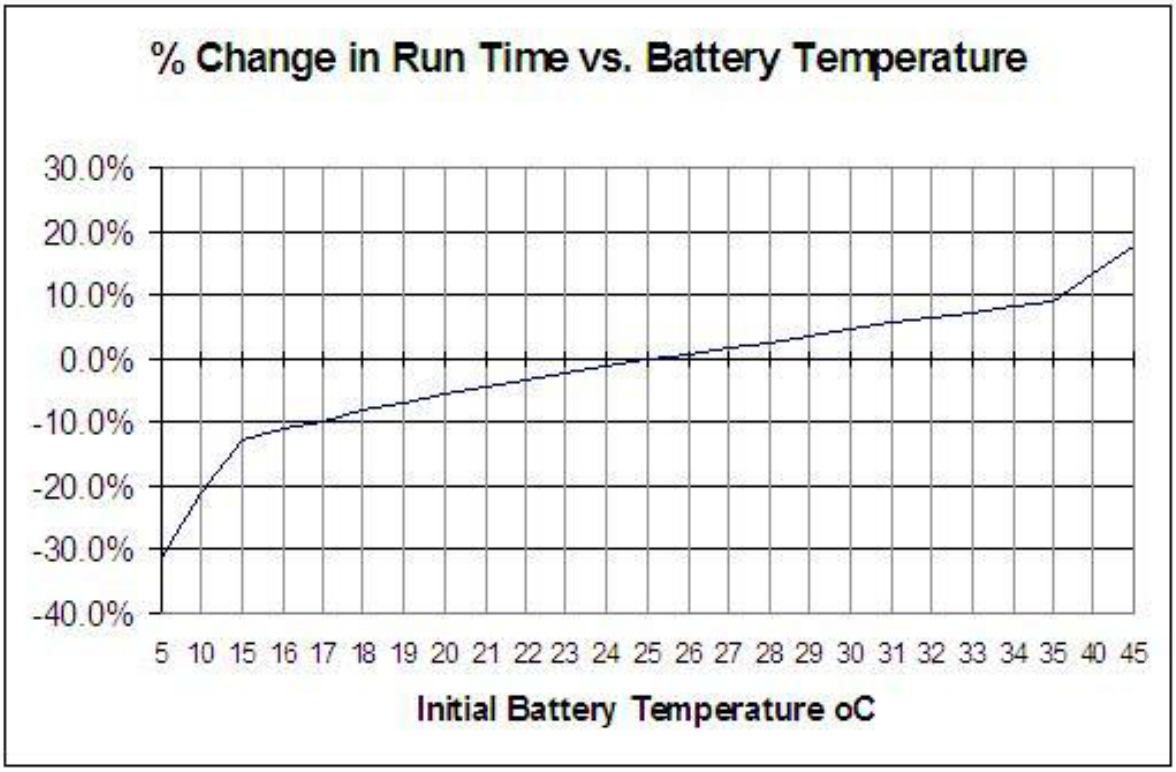


Figure 61
Battery Run Time Generic Correction for Temperature

Tip: Make sure the batteries are fully charged before starting this test. Batteries should have been on float charge for 3 to 7 days before load testing. (STATUS submenu shows V (batt) of approximately 55.2 VDC or greater at 25°C (77°F).

DANGER: If the actual intersection signals are used as the load for this test, and the load is left on the batteries beyond the low battery warning (AC line power is not restored), the batteries will continue to discharge down to the Low Battery Shutdown, at which point power output to the intersection from the UPS is automatically shut off to avoid damaging the batteries. The intersection will go DARK.

START

Verify that the **Manual Bypass Switch** is in the ***UPS*** position

Verify the unit's LCD display shows ***ON LINE*** with no alarms or faults

Record the battery initial temperature and voltage from the ***STATUS*** submenu

Turn ***OFF*** the upstream ***Utility Input Circuit Breaker*** (NOT the unit's AC Input/Output circuit breaker)

Verify the unit's LCD display shows ***ON BATT*** and the loads are being powered. Record the Start time and P (out) from the ***STATUS*** submenu.

When ***LO BATT*** displays on LCD, or the battery voltage in the ***STATUS*** submenu drops to the pre-determined test end point, record the Stop time.

Turn ***ON*** the upstream ***Utility Input Circuit Breaker***

Verify tthe unit returns to ***ON LINE*** after the line qualify time

Verify that the batteries are charging using the ***STATUS*** menu to show battery voltage increasing.

CAPACITY TEST COMPLETE

TIP: The event log can be used via the com port to record the battery initial voltage on float, the battery initial temperature, time the unit went On Batt and when the Lo Batt alarm occurred.

EXAMPLE:
Run time new = 140 min
Start time = 1 PM when display shows ***ON BATT.***
P (out) = 500 watts Temp = 21C

Stop time = 3:05 PM when ***LO BATT*** warning occurs or battery voltage drops to pre-determined test end point voltage for which the time was recorded in the initial test.

3:05 PM – 1 PM = 125 min run time

Compare this run time to the time obtained when the batteries were subjected to the same test at installation or within one year of installation, corrected for the actual battery temperature at test start. It will likely be less, but should not be significantly less than the previous test (more than 10% for the same P (out) value). >=80% capacity is acceptable.

Capacity:

$$C = \frac{125}{(140 \times 0.95)} = 0.94x100 = 94\%$$

2.4.2 Battery Maintenance

Batteries are the weak link in any UPS system. They cannot be simply installed and forgotten about as many people think. The batteries typically provided with the unit are Valve-Regulated Lead Acid/Absorbed Glass Mat (VRLA/AGM) and are often referred to as "maintenance-free", *which only refers to the fact that these are sealed batteries that do not require water to ever be added.* With no free liquid in them, they are ideal for side-of-road use where they could potentially be hit and broken open in a vehicle accident. AGM batteries are also ideal for high-rate design often used in UPS systems that must provide power immediately on loss of AC.

But all batteries, regardless of type, require some amount of preventive maintenance to prolong the life of the batteries, insure their reliability and to provide documentation of correct operation for warranty claims if defects occur. Regardless of warranty, battery service life can be affected by many factors such as: operating temperature, charging temperature, number of discharges during the battery's life, extent of discharge, and time left in discharged state. For example, if a battery has a 2-year warranty and is rated for 200 discharge cycles, but actually experiences 200 discharges in the *first* year of use, the 2-year warranty is no longer valid. The battery designer and manufacturer cannot control end user conditions that exceed the expectations for the battery selected. Customers may be asked to provide documentation of usage before warranty claims will be honored.

Industry-accepted guidelines for preventive maintenance for VRLA batteries can be found in IEEE Standard 1188 "Recommended Practice for Maintenance, Testing, and Replacement of VRLA Batteries for Stationary Applications." IEEE suggests monthly, quarterly and yearly maintenance which may not be practical in traffic industry applications, therefore batteries should be inspected any time the traffic signal cabinet is visited for other maintenance. Typical preventive maintenance consists of inspections and tests which should be performed at least annually at a minimum. The "UPS & Battery Preventive Maintenance Checklist" on the following pages should be printed and completed to document performance of preventive maintenance.

Industry-wide, VRLA batteries experience a failure rate of less than 0.5% due to manufacturing defects. Any battery failures that exceed this rate may indicate a problem with the UPS controller, cabinet ventilation & environment, or AC and DC breakers. In traffic industry use, the expected service life of VRLA/AGM batteries is approximately 3 years. A high number of discharge cycles or high operating temperatures will reduce this lifespan. For a better understanding of VRLA/AGM batteries see section 2.4.3 of this manual immediately following the preventive maintenance checklist.

UPS & BATTERY PREVENTIVE MAINTENANCE CHECKLIST

Date:_____ **Name:**_____ **Agency:**_____

Intersection:_____

Part Number:_____ **Serial #**_____ **DOM** _____
(Above information is on label on left side of the unit)

Battery Manufacturer:_____ **Model/Part No.**_____ **In-Service Date**_____

- ❑ Download the unit's log file to verify the number of discharge cycles and battery temperature are not excessive. The log file may be required for warranty claims. Review the file for alarms and faults.
- ❑ Record the number of Inverter Events and Inverter Timer from the Status submenu:
  Inverter Events:_____ Inverter Timer:_____
  CAUTION: RESETTING OF INVERTER EVENT COUNTER AND TIMER INVALIDATES BATTERY WARRANTY.
- ❑ Verify charger float voltage (batteries fully charged) corrected for battery temperature compensation setting (Status submenu, Battery Voltage & Battery Temperature; Settings submenu, Batt. Temp. Comp): 55.2 V +/- .5V at 25°C (subtract 0.060 V, 0.072 V, 0.096 V, or 0.120 V per °C for -2.5/ -3 /-4 / or –5 mV/°C/Cell respectively) Actual: _____
- ❑ Measure voltage of each individual battery while on float charge. Individual battery voltages may vary by ±0.30 volts of the average battery float voltage above. Because float readings are affected by discharge and recharges, these readings should be taken when batteries have been on continuous, uninterrupted float for at least 3 days. A significantly different voltage on one battery may indicate a bad battery which degrades the entire battery string and string capacity since they are connected in series.
  Batt 1:_____ Batt 2:_____ Batt 3:_____ Batt 4:_____
- ❑ Verify the charger float current with batteries fully charged is approximately 50 mA per 100 Ah of battery capacity. If more than 3 times this value an internal problem such as a cell internal short may exist, or the charger float voltage is too high or the ambient temperature is too high.
- ❑ Verify individual battery temperatures are within approximately 3 °C (1.7 °F) of each other at the negative post.
  Batt 1:_____ Batt 2:_____ Batt 3:_____ Batt 4:_____
- ❑ Verify the battery temperature probe is firmly connected at the battery and the unit (remove the probe at the unit's front panel, verify the unit's alarm LED flashes, reinstall the probe, verify the alarm LED goes out.) If indicated battery temperature is suspect compared to individual readings above or the unit's “No Temp Probe” alarm is indicated even with probe plugged in, verify that temperature probe resistance is approximately 12,000 Ohms.
- ❑ Observe or Record the following values from Status submenu during On Line, Self Test (Control submenu, Self Test, then press Enter twice to access Status submenu) and On Batt (Manual Bypass Switch to Bypass). Expected values are in ( ).

	On Line	Self-Test	On Batt (Bypass)
PTS transfers (if buck/boost is disabled; NA if enabled as it is already transferred)	NA	(audible “clunk”)	(audible “clunk”)
V (in)	(~120)	(~120)	(0)
V (out)	(~120)	(~120)	(~120)
P (out)	(0)	(<1500)	(0)
F (in)	(~60)	(~60)	(0)
V (batt)	(~55.2)	(~50)*	(~55.2)*
Batt. Temp.	(~25C)	(~25C)	(~25C)
Output LED	(steady on)	(steady on)	(flashing)
Alarm LED	(not on)	(not on)	(not on)
Current out - optional (clamp-on ammeter at AC Output terminal block)	NA	(<12)	(0)

*Observe that battery voltage holds steady after initial drop. Any rapid continuing decrease indicates one or more weak batteries or a DC drain somewhere on the system.

UPS & BATTERY PREVENTIVE MAINTENANCE CHECKLIST
(Page 2)

- ❑ Verify the power being drawn from the system during Self-Test above is the same as when the system was initially installed and does not exceed 1500 watts.

  Original power at installation: _____watts Power as of test date: _____watts

- ❑ If the power being drawn as observed above has changed, note any new hardware that has been installed at the intersection that increases power requirements.

  _____

- ❑ Verify no alarms or faults are indicated before or during above self-test. Record any indicated alarms or faults:_____

- ❑ Perform a run-time test (see 2.4.1 of this manual) and correct for actual battery temperature at start of test if ambient temperatures have been less than 77°F.

- ❑ Verify the cabinet fan is operating correctly. Heat is the main problem for batteries. Even though batteries will operate (discharge) at 165°F, their life is severely shortened. The unit's charger shuts off at 122°F (50°C) to protect batteries.

- ❑ Verify batteries have at least ½ inch of space between them and between batteries and cabinet wall to provide adequate heat dissipation. VRLA batteries on float charge convert almost all energy into heat. If this heat is not removed, the battery temperature increases and more current will be required to maintain float voltage, resulting in still more heat. If not prevented this "thermal runaway" can result in AGM battery melting. The unit's charger shuts off at 122°F (50°C) as a safety measure and to prevent battery damage from overheating.

- ❑ Verify battery terminals and connections are tight, clean and free of corrosion. The battery cable connector on the front of the unit must be firmly seated. There should be a "double click" when properly connected.

- ❑ Verify battery cases are clean to allow maximum heat dissipation and in particular are free of excessive dirt or moisture between terminals that could allow "tracking" of current. DO NOT use hydro-carbon (oil-based) or strong alkaline cleaning solutions as they can cause battery case to crack or craze.

- ❑ Batteries are not bulging excessively. **A certain amount of bulge is normal.** To prevent the permanent loss of gases so that recombination has time to take place, each battery can hold up to about 1.5 psi without venting. Batteries with very large cells will bulge somewhat as this normal pressure builds. This is especially true in higher temperatures, because the polypropylene case is pliable. If a battery bulges severely on charge, it is not normal. It is an indication of a blocked valve or an overcharge situation. Such a battery should be removed from service.

- ❑ Batteries are not "sucked-in" excessively indicating deeply discharged batteries. **A slightly sucked-in appearance can be normal.** The valve on a sealed battery only lets gas out, never in, so a partial vacuum can form under various circumstances. Battery temperature and ambient pressure play a role, but predominantly the recombination and discharge reactions are responsible. After charging ends, the recombination reaction continues until most of the oxygen in the battery headspace is consumed. The total volume of the battery components decreases slightly during a discharge. Batteries with large cells may display this appearance even when fully charged. A sucked-in battery should be charged. If it remains sucked-in after charging, or if only a single battery in a string displays or lacks this appearance a load test would be prudent.

COMMENTS:_____

CORRECTIVE ACTIONS TAKEN:_____

2.4.3 Understanding VRLA/AGM Batteries

2.4.3.1 Introduction

Batteries are not as simple as many people think them to be. Before declaring a battery *defective* under warranty, the following should be understood **(see details in sections below):**

1. **Effect of design on service life:** high rate vs. long duration vs. general purpose design have different plate thickness and specific gravity which determines how long a battery will last
2. **Effect of Battery selection and installation on service life:** load profile, capacity margin and installation geometry (effects operating temperature)
3. **Effect of operating conditions on service life**: temperature, number of cycles, and maintenance practices
4. **Relationship between warranty and service life:** marketing vs. actual conditions, warranty covers premature loss of capacity due to defects, not conditions beyond the control of the designer or manufacturer.

Misconceptions about lead-acid battery life:

1. Battery design life is equal to warranty life. FALSE
2. Battery warranty life is equal to service life. FALSE
3. Battery selection and installation have little impact on service life. FALSE
4. Installation, operation and maintenance practices have little impact on service life. FALSE

Definitions:

Design Life = Expected (calculated) life of a battery based on the design at assumed manufacturer-established ideal operating conditions.

Service Life = Actual life of a battery based on the actual installation, operating conditions, and maintenance practices.

Warranty Life = The life of a battery over which the manufacturer amortizes the cost, often unrelated to the design and has no relationship to the service life of the battery where, for example, duty cycle alone can result in a service life shorter than warranty through no defect of the battery or fault of the battery supplier. For some battery suppliers this is nothing more than a marketing tool or an insurance policy – customers pay up front for battery replacement later when an unreasonable warranty has been offered or required.

2.4.3.2 Effect of Design on Service Life

There are three basic battery types based on purpose and they have different service lives:

- High Rate (often called UPS)
- Long Duration (often called Telecom)
- General Purpose

The aging mechanism of a lead-acid battery is positive plate growth. As the grid grows, active material can shed and electrical contact between the grid and the active material is lost resulting in a loss of capacity.

Factors that influence the rate of positive plate growth:

- Physical strength of the grid
- Acid concentration
- Operating temperature

The battery designer cannot control operating practices, and design life is based on operating the battery within the parameters established by the designer.

The amount of current a battery can produce depends on the amount of active material in contact with the electrolyte and the acid concentration in the electrolyte.

In a high rate design, the goal is to have the maximum amount of active material in contact with the electrolyte at all times. This is done by reducing the thickness of the plates, thus allowing more plates in the same volume, increasing the surface area in contact with the electrolyte. It is also not uncommon for manufacturers to increase the specific gravity to 1.250 or 1.300 to improve the high rate.

In a long duration battery *the opposite is true*. Thick grids are used and specific gravity is typically 1.215. This results in a battery with a low 1 minute current but excellent long term power production capabilities.

A general purpose battery falls in between these two extremes. Plates are thicker than high rate designs, but less thick than long duration designs. Specific gravity is typically 1.215 to 1.250. This results in a battery with moderate high rate capabilities and good long term power production capabilities.

High rate designs with thin grids have the least amount of strength, while long duration designs have the highest grid strength. Thick grids have the strength to resist the growth caused by corrosion. Thin grids do not. Higher specific gravity gains short term capabilities but sacrifices life due to the increase in corrosion rate. So as you go from high rate to general purpose batteries you gain 25% to 30% life expectancy.

Not all batteries are designed to deliver the same service life, even if they have the same warranty life.

2.4.3.3 Effect of Selection and Installation on Service Life

Lead-calcium batteries are excellent for float operation, but they have a relatively short cycle life (typically 80 to 100 cycles).

2.4.3.3.1 Battery selection depends on load profile. The load profile that a battery must supply is usually the deciding factor. A high rate design has a shorter expected service life than a general purpose or long duration. In some cases, high rate designs are selected for applications that can be served by a general purpose design, such as when a high initial rate is required and the physical space for the battery is relatively small. It is not uncommon to find a high rate battery installed with a relatively long load profile of several hours. The other advantage is that the high rate battery will have a lower cost than the general purpose battery. However use of high rate batteries for frequent long duration service is not recommended.

2.4.3.3.2 Lack of aging margin in battery sizing is becoming more common as an issue. Unless the purchase specification explicitly details aging factors, competitive pressures force vendors to leave them out. This keeps the initial cost down but results in a battery without any aging margin that will have to be replaced when capacity falls below 100%. Specifications should always require at least 20% aging margin unless run time only has to be guaranteed when the battery is new. A battery has not failed simply because it no longer meets a required run time if aging margin was not specified or purchased for the battery.

2.4.3.3.3 Battery installation effects on operating temperature.
In the US, batteries are rated at 25°C or 77°F. Operation at cooler temperatures will decrease the operating time. Operation at higher temperatures will decrease the overall service life of the battery.

Operating temperature is one of the most misunderstood battery parameters. In reality, the operating temperature is *the internal cell temperature*. While ambient temperature influences battery temperature, it is not the only determinant. Battery temperature in a well ventilated space normally runs 1 to 2°F above ambient temperature. In a space with localized temperature gradients caused by such things as direct sunlight or a heat source, the battery can be exposed to *very large extremes in cell temperature resulting in uneven aging of the cells.*

For Valve Regulated Lead-Acid (VRLA) batteries, air flow is of great importance. In VRLA designs, the recombination reaction at the negative plate produces heat that must be dissipated to the environment. If adequate air flow around the cells is not provided, or if the air flow is restricted, localized hot spots can develop within the battery. *At the least, these*

hot cells will age at a more rapid rate. At the worst, they can pull the battery into thermal runaway and in the worst case scenario result in a fire.

2.4.3.4 Effect of Operating Conditions on Service Life

2.4.3.4.1 It's a fundamental fact: heat is bad for batteries and has the greatest effect on battery life. IEEE 450 contains a graph that shows for every 15°F rise above 77°F *continuous average operating temperature*, a flooded battery loses half of its available life. This holds true for VRLA high rate designs also, except the life is much shorter to start with. For a 10 year expected service life, the life drops to 5 years at 92°F and 2.5 years at 107°F. *Unfortunately, battery manufacturers have not developed a way to accurately predict the effects of the more normal frequent hot and cold cycles.*

2.4.3.4.2 Temperature gradients can cause a battery string to have a shorter life. Temperature can be unequal across the battery string to the point that batteries in a string age at significantly different rates. Because heat rises, typical causes are racks with more than 2 tiers and uneven temperature gradients from bottom to top. *The aged batteries in the string become the limiting factor in ability of the string to produce energy, resulting in reduced run times.*

2.4.3.4.3 Number of discharge cycles effects battery life and is not well understood. It is easier to quantify the effect of temperature on battery life than it is to quantify the effect of discharge cycles. The impact of cycles on battery life is highly dependent on the frequency of the discharges, the depth of the discharge, and how quickly the battery is recharged following the discharge. Most lead-calcium batteries are rated for 80 to 100 cycles (a cycle is defined as a discharge of greater than 80% of available battery capacity followed by a recharge.) While a battery can withstand a higher number of shallow discharges, frequent shallow discharges still accelerate the aging of the battery and result in loss of service life. While a lead-calcium battery may be initially selected for a particular location, if the site is subjected to frequent power disturbances (hence battery discharge / recharge cycles), then the battery should be replaced with a battery more suited to cycling operation such as a lead-antimony or lead-selenium design.

2.4.3.4.4 Maintenance practices affect battery life. A continuous over-charge of .01 volts per cell has a similar impact as operating the battery at 80°F. For a typical 48 volt battery string with 24 cells, this results in a 0.24 volt increase in overall string voltage. In the opposite case, failure to maintain individual battery voltages above critical voltage can cause batteries to self-discharge and sulfate. In extreme cases, this can lead to the plates expanding until the case ruptures**,** creating an open circuit in the battery string. Even if the case does not rupture, a failed battery creates a high resistance condition that significantly reduces the battery string's ability to produce power. High resistance terminal connections can also fail and cause battery fires.

2.4.3.4.5 Air quality is a potential issue. The build up of dust on the battery cover in the presence of humidity can result in tracking. An even worse impact is if the battery is exposed to an environment where the dust is conductive. Tracking creates external shorts and can cause individual batteries in a string to fail. Ability to use horizontal arrangement of posts in VRLA designs (batteries on their side) does not make them immune to tracking because the vent is normally located with the posts and can release small amounts of acid, which does not dry and attracts moisture and dust.

2.4.3.5 Relationship Between Warranty and Service Life

FACT: Conditions beyond the control of the manufacturer affect the service life of a battery.

EXAMPLE: In the United States, many industrial *flooded* lead-acid batteries are sold with a twenty-year warranty whether or not there is a reasonable expectation that the battery will last twenty years. This is because industrial consumers have come to expect the twenty-year warranty. In Europe, the opposite is true. Almost no batteries are sold with twenty-year warranties. The difference is that some U.S. manufacturers use longer battery warranties as a marketing tool to increase sales. It has little to do with the actual design life of the battery.

2.4.3.5.1 Long warranties for high rate products or VRLA designs are not reasonable compared to the actual service life. Manufacturers must charge extra money for the longer warranty, knowing they will be giving some of it back. This is like an insurance policy. A reasonable warranty provides the necessary coverage against manufacturing

defects as intended without excessive coverage and its associated cost based on battery capacity over time with all its variables.

2.4.3.5.2 Warranty claims must be reasonable and documented. The warranty is specific about the operating conditions and maintenance requirements. When the end user fails to meet these requirements, they must shoulder the burden for short battery life. End users should keep the necessary records to support warranty claims. With the price of lead doubling in 6 months, battery suppliers are not going to accept warranty returns without proof of proper operation, and that may mean more frequent PM checks or diligently recording UPS system log files every month to prove the number of cycles or temperature have not been excessive.

2.4.3.5.3 Battery selection, installation, operating conditions, and maintenance affect the service life of the battery. If battery strings in one or more locations fail while others from the same purchase and supplier do not, there is usually a reason other than defective batteries. End users must be able to tell the difference between what is a warranty claim due to manufacturing defects or errors and what is shortened service life based on operating conditions and maintenance practices.

2.4.3.5.4 Provide capacity margin for aging. Batteries begin consuming themselves as soon as they enter service. A design that has no margin sacrifices battery life to keep the initial cost down. This may result in a 10-year battery having only a 3 to 5 year service life before capacity falls below the value needed for the battery to perform its design function. *This is not a warranty issue*. This is a failure on the part of the purchaser to understand that the lowest price up front can have a significant impact on the overall life cycle maintenance cost of the installation. Aging margin of 20 to 25% capacity should be included on top of the needed operating capacity.

2.4.4 Troubleshooting

Purpose: *Describes the most common problems with the unit.*

There are NO user maintainable items inside the unit. The unit should be opened or serviced only by factory authorized personnel in order not to void the WARRANTY. If the unit fails to perform a specific function, the table below lists typical symptoms, causes and solutions. If you cannot resolve a problem, contact Customer Service (see 2.4.5 below).

SYMPTOM	CAUSE	REMEDY
No Output	AC Input & Output Circuit Breaker is OFF	Turn on breaker.
	No incoming Utility line power	Close upstream utility input circuit breaker. If still no output, check with AC voltmeter at utility line input to cabinet. If no voltage contact utility.
	Red LED is lit solid on front indicating FAULT	Determine the FAULT under STATUS submenu of LCD display. See 2.2.15. Clear the FAULT. Shut off both the AC and DC breakers on the front panel. Restart. Contact Customer Service if the FAULT persists.
	Wiring error at PTS terminal block	Check and correct wiring at PTS (see Figures 3 and 4).
	Faulty PTS	If 120 VAC is present at L IN and NEUTRAL at the PTS terminal block, replace the PTS.
Output LED OFF	Incoming Utility power or Battery Power not available	Apply qualified input power and verify battery breaker is closed
	Faulty unit	Contact Customer Service
Backup time is less than rated	Batteries are not fully charged	Fully recharge the battery string (float voltage of at least 55.2 VDC @ 25°C) then test backup time (see 2.4.1)
	Back-up time test was not corrected for initial battery temperature less than 25°C	Correct back-up time for temperature less than 25°C as described in 2.4.1
	One or more weak batteries in string	Check voltage and temperature of individual batteries at battery posts (battery voltages may vary by ±0.30 volts of the average battery float voltage; battery temperatures should be within about 3 °C (1.7 °F) of each other)
	One or more bad battery terminal connections in string	Clean and tighten battery connections.
	Additional hardware has been added to intersection increasing amount of power drawn	Recalculate back-up time for increased power. Increase battery size if necessary.
	Batteries nearing end of service life due to number and depth of discharge cycles or operating temperature	Check inverter events & timer for number and length of discharges, check cabinet fan for proper operation (see 2.4.2 & 2.4.3)

SYMPTOM	CAUSE	REMEDY
Unit does not transfer to Battery mode during a power failure	Battery not connected	Connect batteries (48 VDC nominal)
	Battery Circuit Breaker is OFF	Turn ON the battery breaker
	Battery string is discharged to Low Battery Shutdown (42.0 V)	With AC power qualified, verify battery temperature is less than 50°C and charger is operating (up to 10 A current on battery cable indicated by clamp-on ammeter)
	One or more dead batteries in string	Replace with good battery
	One or more battery failures in string	Check voltage and temperature of individual batteries at battery posts (battery voltages may vary by ±0.30 volts of the average battery float voltage; battery temperatures should be within about 3 °C (1.7 °F) of each other)
	One or more bad battery terminal connections in string	Clean and tighten battery connections.
	The unit's output power not connected to PTS	Verify “FROM UPS OUT” cable at PTS is properly connected to the AC OUTPUT terminal block at the unit
	“UPS INPUT POWER” circuit breaker at PTS is OPEN	Reset the breaker & clear the fault that tripped it
	PTS control wires are not connected at the unit	Connect red and black control wires from PTS to Green Control Terminal Block TB21 & 22 at the unit
	48VDC signal missing at TB21 & 22 of Green Control Terminal Block of the unit	The unit is preventing transfer because backup power is not available or a fault exists. (see 2.2.15)
	Faulty PTS	Replace PTS
	Faulty unit	Contact Customer Service
Alarm LED is flashing or lit	Red LED flashing indicates ALARM (a problem exists but backup power is still provided)	Correct the Alarm (see 2.2.14) Contact Customer Service if Alarm persists.
	Red LED steady ON indicates FAULT (backup power is not available)	Correct the Fault (see 2.2.15) Contact Customer Service if Fault persists.
The unit does not return to ON LINE mode	Utility input line power is missing or unstable	Verify that “TO UPS IN” cable from PTS is properly connected to the AC INPUT terminal block at the unit
		Verify that the “UPS INPUT POWER” circuit breaker at PTS is CLOSED
		Verify upstream utility input circuit breaker is CLOSED. If still no output, check with AC voltmeter at utility line input to cabinet. If no voltage contact utility.
		Utility input line power voltage is above or below HI/Low setpoints keeping system ON BATT

SYMPTOM	CAUSE	REMEDY
Batteries will NOT charge	Battery Circuit OPEN	Check battery connections clean and tight. Check battery cable harness for connection error, loose / open connections. Check 46 to 56 VDC present at the battery connector to the unit. Check if Battery Breaker is ON. Replace bad battery, if any.
	Wrong or bad temperature probe connected at front panel	Use factory-supplied temperature probe reading approximately 12,000 Ohms. Older units used a probe with 2,000 Ohm value.
	Battery string voltage too low (< approx. 38 VDC)	As a safety precaution to prevent continuously pushing 10 amps into batteries and overheating them, charger will not operate if low battery string voltage indicates an abnormal condition, such as loose battery connection, shorted battery, or short/drain on DC system. Check battery connections and individual battery voltages. If no problems are found use an external charger to bring batteries up to 10.5 VDC each then turn on the unit.
	Battery Temperature too high	Charger shuts off if battery temperature is 50°C. Check cabinet fan for proper operation. Check for ½" space between batteries to allow for proper ventilation. Check battery cases are clean to allow heat dissipation.
LCD screen NOT readable	Adjust the contrast for LCD screen	Press the ***ESC*** and ***ENTER*** buttons at the same time. Use ***Up*** and ***Down*** arrows to increase or decrease contrast. Press ***ENTER*** button when adjustment is complete.
	User wearing polarized sun glasses	LCD's work by polarizing light, so images from LCD displays can become difficult to read when wearing polarized sun glasses at certain viewing angles.
	Protective film still over display	Remove the protective plastic film that covers the LCD display and keypad.
	Faulty unit	Contact Customer Service
	Ambient air temperature is below - 20°C (-4°F)	The LCD may darken until the temperature rises. However the unit will operate normally.
Password Access NOT available	Entered Password is LOST or forgotten	Contact Customer Service for instructions on resetting password

2.4.5 Return Instructions

Purpose: Describes how to return the unit for repairs.

Note: Manufacturer does not assume responsibility for damage caused by improper packaging of returned units. The unit weighs approximately 46 lbs and should only be shipped in a box or carton of sufficient thickness to withstand handling.

Before returning a unit or any system component for repair or replacement, including batteries, a Return Material Authorization (RMA) number must be obtained from Customer service at the following Telephone / Address. Clearly write the RMA number on the original shipping container. If you do not have the original container, pack the unit with at least three inches of shock absorbing material, but do ***not*** use popcorn type material. Returns should be prepaid and insured (COD and freight collect cannot be accepted).

Contact Customer Service for ordering any parts or service.

BATTERY WARRANTY RETURN

Before contacting us to request a Return Material Authorization (RMA) for batteries supplied as part of the UPS system, verify the batteries were supplied by us and not by the local distributor.

An RMA for batteries will require that the preventive maintenance checklist in section 2.4.2 of this manual be completed and faxed to us before an RMA will be issued, including the signature of the person that performed the checks and the date they were performed at the top of the checklist.

2.4.6 Specifications

ELECTRICAL	
INPUT	
Voltage Range, VAC	90 to 150 programmable Default 100 to 130 +/- 2VAC
Frequency, Hz	60 +/- 3 Hz
Maximum Input Current, A	30 A (resistive)
Inrush Current	Load Dependent
Over current Protection	Double pole single throw circuit breaker rated 30 A for input and output DC bus 60 A breaker
Transient Suppression	MOV transient suppression elements (>150 V)
Step Load Response (50% Load Change)	½ Cycle Full Recovery' (Full resistive load)
Short Circuit Protection	15 A Circuit Breaker
Battery String Voltage, VDC	48 (Four 12VDC Batteries)
OUTPUT	
Apparent Power, VA	2000VA (Inverter Mode) 2000VA (Line Mode)
Active Power, W	1500 (Inverter Mode) 1500 (Line Mode)
Power Factor	0.75
Output Voltage, VAC Line and Buck/Boost Mode Inverter Mode	120 nominal 100-130 +/- 2 VAC (follows input voltage) 120 VAC+/- 5%
Frequency, Hz	60 +/- 0.4 Hz
Transformer	Linear (non-isolated)
Output Waveform	Sine Wave
Output Waveform THD	<3% (Resistive Load)
Load Crest Factor	3:1 (Max)
Overload Capacity	110% for 3 min.
PERFORMANCE	
Transfer Time Controller PTS TOTAL	 4 to 10 ms <30 ms <65 ms
Efficiency, Line Mode	>95% (Resistive Load)
Efficiency, Inverter Mode	>80% (Resistive Load)

Note: Specifications subject to change without notice.

ENVIRONMENTAL	
Operating Temp °C	-37 to +74°C (See Notes 1 & 2)
Storage Temp °C	-50 to +75°C
Humidity	<95% non-condensing
Altitude, ft (m)	10,000 (3000) (See Note 2)
MECHANICAL	
Dimensions (WxDxH) inch/mm	W 17.5/444 19/483 w/flange D 10.5/267 H 5.25/133 3U
Weight (lb/kg) 46.2/21	
Mounting	19" (483mm) rack or shelf mount
Input Connection	3 Position Terminal Block
Output Connection to Loads	Two 3 Position Terminal Blocks
Cooling	Microprocessor controlled, 12 VDC, 3.6" (92mm) fan
Audible Noise Level, dBA	<40
MBS/PTS Dimensions (WxDxH) inch/mm	W 17.5/444 19/483 w/flange D 8 .5/216 H 3.5/89 2U
MBS/PTS Weight (lb/kg)	7.0/3.2
MBS/PTS Mounting	Shelf or 19" rack mount
MBS/PTS Input Connection	Terminal Block
MBS/PTS Output Connection to Loads	Terminal Block
MBS/PTS Output Connection to UPS	6 foot cable ready for hard wire to UPS terminal block
MBS/PTS Cooling	Convection (approx 7 W contactor coil dissipation)
DESIGNED TO CONFORM TO	
Electrical Safety	UL-1778, CSA-107.1, UL-1950
EMI	FCC Class A
Surge Immunity	Tested to: IEC 1000-4-5, IEEE C62.41

NOTES:

1. Between 55° and 74°C, the unit is de-rated to a maximum rectified-capacitive load of 1500VA / 1200W.
2. De-rate operating temperature above 4900 ft (1500m) by 2°C per each additional 1000 ft (300m).

FUNCTIONS	
Brownout Protection	Unit boosts output voltage (or transfers to battery) during brownout or low input line conditions and returns to normal when input power stabilizes over user-selected time period. Setpoints for Transfer / Retransfer, To / From Battery / Boost are users programmable
Generator Compatibility	Generator mode allows wider variation in input voltage and frequency for use with an AC generator
Battery Charger 10 A	PFC switch-mode, two-stage charger, temperature compensated (-2.5 to -5 mV/°C/cell, auto shutoff above 50°C
Inverter Mode	Capable of running continuously in inverter mode
Inverter Mode Current Limit	Continuous electronic current limit is provided
Remote monitoring	-Input and output voltages -Input line frequency -Output power -Battery voltage -Battery temperature
CONTROL TERMINAL BLOCK	
Functions	A. Provides 6 sets of programmable contacts at pin 1 thru pin 18 for intersection flash control, Remote Alarms, Pagers or other user interface. 1. “Low Batt”: batteries have reached approximately 40% capacity remaining 2. “On Batt”: unit is in inverter mode 3. “Timer”: unit has been in inverter mode for 2 hours (programmable) 4. “Alarm”: any of the following conditions occur: a. Line Frequency error b. Low Output voltage c. No Temperature Probe d. Overload e. No battery connected f. High temperature g. Low temperature 5. “Fault”: any of the following conditions occur: a. Short circuit b. Batt low voltage c. Batt high voltage d. High temperature e. Overload B. Provides 48 VDC signal to PTS on pins 21 & 22 C. Triggers self-test by momentarily shorting pin 19 & 20 with less than 100 ohm
Contact Type	Form C. Dry contacts rated 1 Amp at 240V
Wiring	Uses 14-26 AWG
COMMUNICATIONS	
RS-232/USB/Ethernet ports	Monitors, controls with terminal emulation software
RS-232	DB-9, Female, Opto-Isolated, straight-thru cable
USB	B-Type receptacle
Ethernet (optional)	10/100 Mbps Ethernet, auto-detected
Display Panel	2-line LCD

2.4.7 WARRANTY

LIMITED TWO YEAR WARRANTY

Manufacturer warrants its equipment to be free of manufacturing defects in material and workmanship for a period of 24 months from the date of shipment. The liability of Manufacturer under this warranty is solely limited to repairing, replacing, or issuing credit for such equipment (at the discretion of Manufacturer) provided that: Manufacturer's Customer Service Department is promptly notified, by facsimile or telephone, that a failure or defect has occurred.

Manufacturer's Customer Service Department issues a Return Materials Authorization (RMA) number, and designates the service location. The RMA must be clearly marked on the outside of the shipping container.

Purchaser is responsible for all in-bound shipping and handing charges (COD and freight collect will not be accepted without prior approval from Manufacturer). Manufacturer will pay out-bound surface shipping charges for return of repaired equipment.

A satisfactory examination of the returned unit by Manufacturer's Customer Service personnel shall disclose that defects have not been caused by misuse, neglect, improper installation, repair, alteration, or accident, or failure to follow instructions furnished by Manufacturer. If Manufacturer's Customer Service personnel determine that the unit has been damaged due to one of these causes, or if the unit is free of defects, a handing or repair fee may be assessed prior to returning the unit.

BATTERIES, PERIPHERAL DEVICES, ATTACHMENTS OR APPARATUS MANUFACTURED BY THIRD PARTIES: MANUFACTURER WILL ASSIGN TO THE PURCHASER, ITS RIGHTS UNDER THE THIRD PARTY MANUFACTURER'S WARRANTY OF SUCH BATTERIES, PERIPHERAL DEVICES, ATTACHMENTS OR APPARATUS, BUT OFFERS NO ADDITIONAL WARRANTIES IN CONNECTION THEREWITH. BATTERIES SHALL NOT BE CONSIDERED FOR WARRANTY REPLACEMENT UNLESS THEY HAVE DROPPED TO LESS THAN 80% OF ORIGINAL NEW CAPACITY DURING THE WARRANTY PERIOD AS DEMONSTRATED BY CAPACITY TESTING THAT MEETS IEEE STANDARD 1188-2005 PRACTICES. THE WARRANTY PERIOD MAY BE REDUCED BASED ON OPERATING TEMPERATURES, FREQUENCY AND DEPTH OF DISCHARGE. RESETTING OF INVERTER EVENT COUNTER AND TIMER INVALIDATES BATTERY WARRANTY.

THIS LIMITED 24-MONTH WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, IMPLIED WARRANTIES OF MERCHANT ABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

IN NO CASE SHALL MANUFACTURER BE LIABLE FOR ANY INCIDENTAL, SPECIAL OR CONSEQUENTIAL DAMAGES WTHATSOEVER, INCLUDING WITHOUT LIMITATION ANY CLAIM FOR LOST PROFITS OR REVENUES, EVEN IF MANUFACTURER HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH, FOR BREACH OR THIS OR ANY OTHER WARRANTY, EXPRESS OR IMPLIED.

Any action for breach of this limited 24-month warranty must be brought within a period of 24 months from date of shipment.

This limited 24-month warranty does not extend to any unit that has been repaired or altered by any party other than Manufacturer, or its Authorized Customer Service Center.

Manufacturer reserves the right to discontinue particular models and to make modifications in design and/or function at any time, without notice and without incurring obligations to modify previously purchased units.