



**samlex**power

**DC-AC  
Inverters**  
PST-15S-12E  
PST-15S-24E

**Owner's  
Manual**

Please read this  
manual before  
operating your  
inverter

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## SAFETY INSTRUCTIONS

Please read these instructions before installing or operating the inverter to prevent personal injury or damage to the inverter.

### GENERAL

#### Installation and wiring compliance

- Installation and wiring must comply with the local and national electrical codes and must be done by a certified electrician

#### Preventing electrical shock

- Always connect the grounding connection on the inverter to the appropriate grounding system
- Disassembly / repair should be carried out by qualified personnel only.
- Disconnect all AC and DC side connections before working on any circuits associated with the inverter. Turning the on/off switch on the inverter to off position may not entirely remove dangerous voltages
- Be careful when touching bare terminals of capacitors. The capacitors may retain high lethal voltages even after the power has been removed. Discharge the capacitors before working on the circuits

#### Installation environment

- The inverter should be installed indoor only in a well ventilated, cool, dry environment
- Do not expose to moisture, rain, snow or liquids of any type.
- To reduce the risk of overheating and fire, do not obstruct the suction and discharge openings of the cooling fans
- To ensure proper ventilation, do not install in a low clearance compartment

#### Preventing fire and explosion hazards

Working with the inverter may produce arcs or sparks. Thus, the inverter should not be used in areas where there are inflammable materials or gases requiring ignition protected equipment. These areas may include spaces containing gasoline powered machinery, fuel tanks, battery compartments

#### Precautions when working with batteries.

- Batteries contain very corrosive diluted sulphuric acid as electrolyte. Precautions should be taken to prevent contact with skin, eyes or clothing
- Batteries generate hydrogen and oxygen during charging resulting in evolution of explosive gas mixture. Care should be taken to ventilate the battery area and follow the battery manufacturer's recommendations.
- Never smoke or allow a spark or flame near the batteries.
- Use caution to reduce the risk of dropping a metal tool on the battery. It could spark or short circuit the battery or other electrical parts and could cause an explosion.
- Remove metal items like rings, bracelets and watches when working with batteries. The batteries can produce a short circuit current high enough to weld a ring or the like to metal and thus cause a severe burn.
- If you need to remove a battery, always remove the ground terminal from the battery first. Make sure that all the accessories are off so that you do not cause a spark

## **INVERTER RELATED**

### **Preventing paralleling of the AC output**

The AC output of this inverter cannot be synchronised with another AC source and hence, it is not suitable for paralleling. The AC output of the inverter should never be connected directly to an electrical breaker panel / load center which is also fed from the utility power / generator. Such a connection may result in parallel operation of the different power sources and AC power from the utility / generator will be fed back into the inverter which will instantly damage the output section of the inverter and may also pose a fire and safety hazard. If an electrical breaker panel / load center is fed from an inverter and this panel is also required to be powered from additional alternate AC sources, the AC power from all the AC sources like the utility / generator / inverter should first be fed to a manual selector switch and the output of the selector switch should be connected to the electrical breaker panel / load center.

To prevent possibility of paralleling and severe damage to the inverter, never use a simple jumper cable with a male plug on both ends to connect the AC output of the inverter to a handy wall receptacle in the home / RV.

### **Connecting to multi-wire branch circuits (Applicable to 120 VAC inverters only)**

Do not directly connect the hot side of the inverter to the two hot legs of the 120 / 240 VAC electrical breaker panel / load centre where multi-wire ( common neutral ) branch circuit wiring method is used for distribution of AC power. This may lead to overloading / overheating of the neutral conductor and is a risk of fire.

A split phase transformer ( isolated or auto-transformer ) of suitable wattage rating ( 25 % more than the wattage rating of the inverter ) with primary of 120 VAC and secondary of 120 / 240 VAC ( Two 120 VAC split phases 180 degrees apart) should be used. The hot and neutral of the 120 VAC output of the inverter should be fed to the primary of this transformer and the 2 hot outputs ( 120 VAC split phases ) and the neutral from the secondary of this transformer should be connected to the electrical breaker panel / load centre.

### **Preventing input over voltage**

It is to be ensured that the input voltage of the inverter does not exceed 16.5 VDC (PST-15S-12E) or 33 VDC (PST-15S-24E) to prevent permanent damage to the inverter. Please observe the following precautions:

- Ensure that the maximum charging voltage of the battery charger / alternator / solar charge controller is below 16.5 VDC (PST-15S-12E) or 33 VDC (PST-15S-24E)
- Do not use unregulated solar panels to charge a battery. Under cold ambient temperatures, the output of the solar panel may exceed 18 VDC for 12V battery system or 36VDC for 24V battery system. Always use a charge controller between the solar panel and the battery.
- Do not connect the inverter to a battery that has a voltage higher than the rated battery input voltage of the inverter.

### **Preventing reverse polarity on the input side**

When making battery connection on the input side, make sure that the polarity of battery connection is correct (Ensure that the centre contact of the cigarette lighter receptacle is connected to the positive of the battery. The centre pin (tip) of the cigarette lighter plug attached to the inverter is positive). If the input is connected in reverse polarity, DC fuse inside the inverter will blow and may also cause permanent damage to the inverter.

## INVERTERS - GENERAL INFORMATION

### **Why an inverter is needed**

The utility grid supplies you with alternating current (AC) electricity. AC is the standard form of electricity for anything that “plugs in” to the utility power. Direct current (DC) electricity flows in a single direction. Batteries provide DC electricity. AC alternates its direction many times per second. AC is used for grid service because it is more practical for long distance transmission. For more details read **“Characteristics of Sinusoidal AC Power” on page 7.**

An inverter converts DC to AC, and also changes the voltage. In other words, it is a power adapter. It allows a battery-based system to run conventional AC appliances directly or through conventional home wiring. There are ways to use DC directly, but for a modern lifestyle, you will need an inverter for the vast majority, if not all of your loads (**in electrical terms, “loads” are devices that use electrical energy**).

Incidentally, there is another type of inverter called grid-interactive. It is used to feed solar (or other renewable) energy into a grid-connected home and to feed excess energy back into the utility grid. This inverter is **NOT grid interactive**

### **Inverter should meet the application**

To choose an inverter; you should first define your needs. Where is the inverter to be used? Inverters are available for use in buildings (including homes), for recreational vehicles, boats, and portable applications. Will it be connected to the utility grid in some way? Electrical conventions and safety standards differ for various applications, so don't improvise.

### **Electrical Standards**

The DC input voltage must conform to that of the electrical system and battery bank. 12 volts is recommended for small, simple systems. 24 and 48 volts are the common standards for higher capacities. A higher voltage system carries less current, which makes the system wiring cheaper and easier.

The inverter's AC output must conform to the conventional power in the region in order to run locally available appliances. The standard for AC utility service in North America is 120 and 240 Volts at a frequency of 60 Hertz (cycles per second). In Europe, South America, and most other places, it is 220/230 volts at 50 Hertz.

### **Power capacity – “Continuous” and “Surge”**

How much load can an inverter handle? Its power output is rated in Watts. Read details under **“Characteristics of Sinusoidal AC Power” on page 7.** There are two levels of power rating -a **continuous rating** and a **surge rating**. Continuous means the amount of power the inverter can handle for an indefinite period of hours. When an inverter is rated at a certain number of Watts, that number generally refers to its continuous rating. The **“surge power”** indicates the power to handle instantaneous overload of a very short duration - usually less than 1 sec.

**Loads that require “surge power” to start**

Resistive types of loads (like incandescent lamps, toaster, coffee maker, electric range, iron etc) do not require extra power to start. Their starting power is the same as their running power.

Some loads like induction motors and high inertia motor driven devices will initially require a very large starting or “surge” power to start from rest. Once they have started moving and have attained their rated speed, their power requirement reduces to their normal running power. The surge may last up to 5 seconds.

TVs and microwave ovens also require surge power for starting. The manufacturers’ specification of the appliances and devices indicates only the running power required. The surge power required has to be guessed at best. See below under “Sizing of inverter for loads that require starting surge”

If an inverter cannot efficiently feed the surge power, it may simply shut down instead of starting the device. If the inverter’s surge capacity is marginal, its output voltage will dip during the surge. This can cause a dimming of the lights in the house, and will sometimes crash a computer.

Any weakness in the battery and cabling to the inverter will further limit its ability to start a motor. A battery bank that is undersized, in poor condition, or has corroded connections, can be a weak link in the power chain. The inverter cables and the battery interconnect cables must be sized properly. The spike of DC current through these cables is many hundreds of amps at the instant of motor starting. Please follow the instructions under "Installation - DC side connections" on pages 20 & 21.

**Sizing of inverter for loads that require starting surge**

Observe the following guideline to determine the continuous wattage of the inverter for powering loads that require starting surge. (Multiply the running watts of the device/appliance by the Surge Factor)

**\*NOTE: The surge power rating specified for this inverter is valid for duration of less than 1 second. This very short duration may not be sufficient to start motor based loads which may require up to 5 seconds to complete starting process. Hence, for purposes of sizing the inverter, use only the continuous power rating of this inverter.**

| <u>Type of Device or Appliance</u>     | <u>Surge Factor for Determining the Continuous *Wattage of the Inverter</u><br><u>(No. of times the running power rating of the device/appliance)</u> |
|--|---|
| Refrigerator / Freezer                 | 5   |
| Air Compressors                        | 4   |
| Dishwasher                             | 3   |
| Automatic Washer                       | 3   |
| Sump pump                              | 3   |
| Furnace fans                           | 3   |
| Industrial motors                      | 3   |
| Portable kerosene / diesel fuel heater | 2   |
| Circular saw                           | 3   |
| Bench Grinder                          | 3   |

### **Power rating of Microwaves**

The power rating of the microwave generally refers to the cooking power. The electrical power consumed by the microwave will be approximately 2 times the cooking power. The “surge power” of the inverter should be 2 times the electrical power (i.e., 4 times the cooking power). Please note that the surge power of the microwave is not as long as the motor load and hence, the surge power of the inverter can be considered to determine adequacy of meeting the starting surge power

### **Powering a water supply pump**

A water well or pressure pump often places the greatest demand on the inverter. It warrants special consideration. Most pumps draw a very high surge of current during start up. The inverter must have sufficient surge capacity to handle it while running any other loads that may be on. It is important to size an inverter sufficiently, especially to handle the starting surge (If the exact starting rating is not available, the starting surge can be taken as 3 times the normal running rating of the pump). Oversize it still further if you want it to start the pump without causing lights to dim or blink.

In North America, most pumps (especially submersibles) run on 240 VAC, while smaller appliances and lights use 120 VAC. To obtain 240 VAC from a 120 VAC inverter, use a 120 VAC to 240 VAC transformer. If you do not already have a pump installed, you can get a 120 volt pump if you don't need more than 1/2 HP.

### **Idle power**

Idle power is the consumption of the inverter when it is on, but no loads are running. It is “wasted” power, so if you expect the inverter to be on for many hours during which there is very little load (as in most residential situations), you want this to be as low as possible.

### **Phantom and idling loads**

Most of the modern gadgets draw some power whenever they are plugged in. Some of them use power to do nothing at all. An example is a TV with a remote control. Its electric eye system is on day and night, watching for your signal to turn the screen on. Every appliance with an external wall-plug transformer uses power even when the appliance is turned off. These little loads are called “phantom loads” because their power draw is unexpected, unseen, and easily forgotten.

A similar concern is “idling loads.” These are devices that must be on all the time in order to function when needed. These include smoke detectors, alarm systems, motion detector lights, fax machines, and answering machines. Central heating systems have a transformer in their thermostat circuit that stays on all the time. Cordless (rechargeable) appliances draw power even after their batteries reach a full charge. If in doubt, feel the device. If it's warm, that indicates wasted energy.

## CHARACTERISTICS OF SINUSOIDAL AC POWER

### **Voltage, current, power factor, types of loads**

The voltage waveform of 230 VAC, 50 Hz mains / utility power is like a sine wave. In a voltage with a sine wave-form, the instantaneous value and polarity of the voltage varies with respect to time and the wave-form is like a sine wave. For example, in one cycle in a 230V, 50Hz system, it slowly rises in the positive direction from 0 V to a peak positive value + **V<sub>peak</sub>** =325 V, slowly drops to 0 V, changes the polarity to negative direction and slowly increases in the negative direction to a peak negative value - **V<sub>peak</sub>** =325V and then slowly drops back to 0 V. There are 50 such cycles in 1 sec. Cycles per second is called the “**frequency**” and is also termed “**Hertz (Hz.)**”. If a linear load is connected to this type of voltage, the load will draw current which will also have the same sine wave-form. However, the peak value of the current will depend upon the impedance of the load. Also, the phase of the sine wave-form of the current drawn by the linear load may be the same or lead / lag the phase of sine wave-form of the voltage. This phase difference determines the “**Power Factor** (mathematically = the cosine of the phase difference)” of the load. In a **resistive type of load** (like incandescent lamps, heaters etc) the sine wave-form of the current drawn by the load has 0 phase difference with the sine wave-form of the voltage of the AC power source. The Power Factor of a resistive load is unity (1). **The rated output power (in Watts) of the inverters is normally specified for resistive type of loads that have unity (1) Power Factor.** In a **reactive type of load** (like electric motor driven loads, fluorescent lights, computers, audio / video equipment etc), the phase of the sine wave-form of the current drawn by the load may lead or lag the sine wave-form of the AC voltage source. In this case, the power factor of reactive loads is lower than unity (1) – generally between 0.8 and 0.6. **A reactive load reduces the effective wattage that can be delivered by an AC power source**

### **RMS and peak values**

As explained above, in a sine wave, the instantaneous values of AC voltage (**Volt, V**) and current (**Ampere, A**) vary with time. Two values are commonly used – Root Mean Square (**RMS**) value and peak value. For simplicity, RMS value can be considered as an average value. **Mathematically, Peak Value = 1.414 x RMS value.** For example, the 230 VAC, 50 Hz. mains / utility power is the RMS value. The peak value corresponding to this is = 1.414 x 230 = 325V.

### **The values of the rated output voltage and current of an AC power source are their RMS values**

#### **AC power – Watts / VA**

The power rating of an AC power source is designated in Volt Amperes (VA) or in Watts (W)

Power in Volt Amperes (VA) = RMS Volts (V) x RMS Amps (A)

Power in Watts = RMS Volts (V) x RMS Amps (A) x Power Factor

**NOTE :** The rated power of the inverter in Watts (W) is normally designated for a linear, resistive type of load that draws linear current at unity (1) power factor. If the load is linear and reactive type, the rated power of the inverter in watts will be limited to its normal rated power in watts (W) x Power Factor. For example, an inverter rated for 1000 W ( at unity power factor) will be able to deliver only 600 watts to a reactive type of load with a power factor of 0.6

## ADVANTAGES OF A PURE SINE-WAVE INVERTER OVER A MODIFIED SINE-WAVE INVERTER

The output voltage of a sine-wave inverter has a sine wave-form like the sine wave-form of the mains / utility voltage. In a sine wave, the voltage rises and falls smoothly with a smoothly changing phase angle and also changes its polarity instantly when it crosses 0 Volts. In a modified sine wave, the voltage rises and falls abruptly, the phase angle also changes abruptly and it sits at 0 Volts for some time before changing its polarity. Thus, any device that uses a control circuitry that senses the phase (for voltage / speed control) or instantaneous zero voltage crossing (for timing control) will not work properly from a voltage that has a modified sine wave-form.

Also, as the modified sine wave is a form of square wave, it is comprised of multiple sine waves of odd harmonics (multiples) of the fundamental frequency of the modified sine wave. For example, a 50 Hz. modified sine wave will consist of sine waves with odd harmonic frequencies of 3rd (150 Hz), 5<sup>th</sup> (225 Hz.), 7th (350 Hz.) and so on. The high frequency harmonic content in a modified sine wave produces enhanced radio interference, higher heating effect in motors / microwaves and produces overloading due to lowering of the impedance of low frequency filter capacitors / power factor improvement capacitors.

### Advantages of sine-wave inverters:

- The output wave-form is a sine-wave with very low harmonic distortion and clean power like utility supplied electricity.
- Inductive loads like microwaves and motors run faster, quieter and cooler
- Reduces audible and electrical noise in fans, fluorescent lights, audio amplifiers, TV, fax and answering machines
- Prevents crashes in computers, weird print outs and glitches in monitors

Some examples of devices that may not work properly with modified sine wave and may also get damaged are given below:

- Laser printers, photocopiers, magneto-optical hard drives
- The built-in clocks in devices such as clock radios, alarm clocks, coffee makers, bread-makers, VCR, microwave ovens etc may not keep time correctly.
- Output voltage control devices like dimmers, ceiling fan / motor speed control may not work properly (dimming / speed control may not function)
- Sewing machines with speed / microprocessor control
- Transformer-less capacitive input powered devices like (i) Razors, flashlights, night-lights, smoke detectors etc (ii) Re-chargers for battery packs used in hand power tools. **These may get damaged. Please check with the manufacturer of these types of devices for suitability**
- Devices that use radio frequency signals carried by the AC distribution wiring.
- Some new furnaces with microprocessor control / Oil burner primary controls
- High intensity discharge (HID) lamps like Metal Halide lamps. **These may get damaged. Please check with the manufacturer of these types of devices for suitability**
- Some fluorescent lamps / light fixtures that have power factor correction capacitors. **The inverter may shut down indicating overload**

## AC POWER DISTRIBUTION AND GROUNDING

**CAUTION!** PLEASE NOTE THAT THE AC OUTPUT CONNECTIONS AND THE DC INPUT CONNECTIONS ON THESE INVERTERS ARE NOT CONNECTED (BONDED) TO THE METAL CHASSIS OF THE INVERTER. BOTH THE INPUT AND OUTPUT CONNECTIONS ARE ISOLATED FROM THE METAL CHASSIS AND FROM EACH OTHER. SYSTEM GROUNDING, AS REQUIRED BY NATIONAL / LOCAL ELECTRICAL CODES / STANDARDS, IS THE RESPONSIBILITY OF THE USER / SYSTEM INSTALLER.

### **Conductors for electrical power distribution**

For single phase transmission of AC power or DC power, two conductors are required that will be carrying the current. These are called the “current-carrying” conductors. A third conductor is used for grounding to prevent the build up of voltages that may result in undue hazards to the connected equipment or persons. This is called the “non current-carrying” conductor (will carry current only under ground fault conditions)

### **Grounding terminology**

The term “grounded” indicates that one or more parts of the electrical system are connected to earth, which is considered to have zero voltage or potential. In some areas, the term “earthing” is used instead of grounding.

A “grounded conductor” is a “current-carrying” conductor that normally carries current and is also connected to earth. Examples are the “neutral” conductor in AC wiring and the negative conductor in many DC systems. A “grounded system” is a system in which one of the current-carrying conductors is grounded

An “equipment grounding conductor” is a conductor that does not normally carry current (except under fault conditions) and is also connected to earth. It is used to connect the exposed metal surfaces of electrical equipment together and then to ground. Examples are the bare copper conductor in non-metallic sheathed cable (Romex ®) and the green, insulated conductor in power cords in portable equipment. These equipment-grounding conductors help to prevent electric shock and allow over-current devices to operate properly when ground faults occur. The size of this conductor should be coordinated with the size of the over-current devices involved

A “grounding electrode” is the metallic device that is used to make actual contact with the earth. Other types of grounding electrodes include metal water pipes and metal building frames.

A “grounding electrode conductor” is the conductor between a common single grounding point in the system and the grounding electrode

“Bond” refers to the connection between the “grounded conductor”, the “equipment grounding” conductors and the “grounding electrode” conductor. Bonding is also used to describe connecting all of the exposed metal surfaces together to complete the equipment-grounding conductors.

### **Grounded Electrical Power Distribution System**

In a grounded electrical power distribution system, one of the two current-carrying conductors is required to be grounded. This grounded conductor is called the “Neutral / Cold / Return”. As this conductor is bonded to earth ground, it will be at near zero voltage or potential. There is no risk of electrical shock if this conductor is touched. The other current carrying conductor is called the “Line / Live / Hot”. The connection between the “Neutral” and the grounding electrode conductor is made **only at one point in the system**. This is known as the **system ground**. This single point connection (bond) is usually made in the service entrance or the load center. If this connection is inadvertently made in more than one place, then unwanted currents will flow in the equipment grounding conductors. These unwanted currents may cause inverters and charge controllers to be unreliable and may interfere with the operation of ground-fault detectors and over-current devices.

**NOTE: A current-carrying conductor that is not bonded to the earth ground cannot be called a “neutral”. This conductor will be at an elevated voltage with respect to the earth ground and may produce electrical shock when touched.**

### **Polarity and color codes for power cords, plugs and receptacles for 220 / 230 VAC devices and appliances**

Single phase 230 VAC, 50 Hz Class 1 AC devices and appliances use 2 pole, 3 wire grounding configuration for making AC side connections. For example, the European CEE 7/7 “Schuko” type of plug has two round male pins (also called poles) that are connected to the two current-carrying conductors and third round female slot and two contact surfaces which are connected to a non-current carrying grounding conductor (this will carry current only during ground fault conditions). Similarly, the European CEE 7/7 “Schuko” type of receptacle has two round female slots (also called poles) that are connected to the two current-carrying conductors and third round pin / two contact clips which are connected to a non-current carrying grounding conductor (this will carry current only during ground fault conditions). One of the current-carrying conductors / poles, also called “Line/Live/Hot”, uses brown wiring and the other current carrying conductor / pole, also called the “Neutral / Return / Cold”, uses blue wiring. The third non-current carrying grounding conductor also called “equipment grounding conductor”, uses wiring which is green or yellow with green stripes. This “equipment grounding conductor” is bonded to the metal chassis of the device or appliance.

### **AC output connections**

The inverter uses European CEE 7/7 (Schuko) receptacle for the AC output connection. The two round slots of CEE 7/7 are connected to the two current carrying conductors of the AC power source inside the inverter. The two clips of the CEE 7/7 are the “equipment grounding” connections and are internally connected to the metal chassis of the inverter

**Caution! : In the above AC output receptacle, both the current carrying conductors are isolated from the metal chassis. Do not touch the “Neutral” slot of the receptacles as it will be at an elevated voltage with respect to the metal chassis / earth ground and will produce an electrical shock if touched!**

(In some inverters, one of the two current carrying conductors is bonded to the metal chassis of the inverter and is called the “Neutral”. When the metal chassis of these inverters is bonded to the earth ground, the “Neutral” also gets connected to the earth ground and thus, the voltage on the “Neutral” will normally 0 V).

### **Grounding to earth or to other designated ground**

For safety, the metal chassis of the inverter is required to be grounded to the earth ground or to the other designated ground (For example, in a mobile RV, the metal frame of the RV is normally designated as the negative DC ground). An equipment grounding bolt with a wing nut has been provided for grounding the metal chassis of the inverter to the appropriate ground.

When using the inverter in a building, connect a # 8 AWG insulated stranded copper wire from the above equipment grounding bolt to the earth ground connection ( a connection that connects to the ground rod or to the water pipe or to another connection that is solidly bonded to the earth ground ). The connections must be tight against bare metal. Use star washers to penetrate paint and corrosion.

When using the inverter in a mobile RV, connect a # 8 AWG insulated stranded copper wire from the above equipment grounding bolt to the appropriate ground bus of the RV (usually the vehicle chassis or a dedicated DC ground bus ). The connections must be tight against bare metal. Use star washers to penetrate paint and corrosion.

## LIMITING ELECTRO-MAGNETIC INTERFERENCE (EMI)

The inverter contains internal switching devices which generate conducted and radiated electromagnetic interference (EMI).

The magnitude of EMI is limited to acceptable levels by circuit design but can not be entirely eliminated. The effects of EMI will also depend upon a number of factors external to the power supply like proximity of the inverter to the EMI receptors, types and quality of connecting wires and cables etc. EMI due to factors external to the inverter can be reduced as follows:

- Ensure that the inverter is firmly grounded to the ground system of the building or the vehicle
- Locate the inverter as far away from the EMI receptors like radio, audio and video devices as possible
- Keep the DC side cables between the battery and the inverter as short as possible.
- Twist the DC side cables. This will partially cancel out the radiated noise from the cables
- Shield the DC side cables with metal sheathing / copper foil / braiding
- Use co-axial shielded cable for all antenna inputs (instead of 300 ohm twin leads)
- Use high quality shielded cables to attach audio and video devices to one another
- Do not operate other high power loads when operating audio / video equipment

## POWERING DIRECT / EMBEDDED SWITCHED MODE POWER SUPPLY (SMPS)

### **Non-linear nature of current drawn by Switched Mode Power Supplies**

Power supplies are used to convert AC voltages like 120/230 VAC to various DC voltages like 3.3 V, 5 V, 12 V, 24 V, 48 V etc. Majority of modern day electronic devices use embedded general purpose Switch Mode type of Power Supplies (SMPS) to drive the electronic circuitry. General purpose Switch Mode Power Supplies (SMPS) ( **excepting those that have power factor correction** ) have one major disadvantage – the current drawn by them from the AC power source has a **non linear waveform** ( the waveform is not sinusoidal as the input voltage waveform but is in the form of short, larger value pulses around the area of + Vpeak and -Vpeak ). This is due to the charging of the input filter capacitor(s) mostly around the positive and negative peak portions of the sinusoidal input voltage. The degree of non-linearity is measured by the "**Crest Factor**":

$$\text{Crest Factor} = \text{Peak Current} / \text{RMS Current}$$

In a linear load, the Crest Factor is 1.414. However, in a general purpose SMPS, due to its non linear nature, this factor will be much higher - in the region of up to 4. This will mean that for a particular rated RMS current (applicable for a linear load), the general purpose SMPS will draw much larger peak currents – approx. up to 4 times more than its rated RMS current.

Inverters are protected against over current ( also called overloading ) by either clipping the peaks of the output voltage ( this will result in a sine wave becoming a square wave, reduction in the RMS value of the output voltage and generation of harmonics and electrical noise ) or by shutting down the output voltage of the inverter completely. Thus, if an inverter / generator is used to power a general purpose SMPS, it will be forced to deliver higher peak currents resulting in premature triggering of the inverter's / generator's over current protection circuits. Thus, for safe operation, the continuous RMS current rating of the inverter / generator should be at least 2.8 times the continuous RMS current rating of the general purpose SMPS it is required to power:

$$\text{Peak current of inverter} = \text{Peak current of SMPS}$$

or

$$\text{RMS current of inverter} \times 1.414 = \text{RMS current of SMPS} \times 4$$

or

$$\text{RMS current of inverter} = 4/1.414 \times \text{RMS current of SMPS}$$

or

$$\text{RMS current of inverter} = 2.8 \times \text{RMS current of SMPS}$$

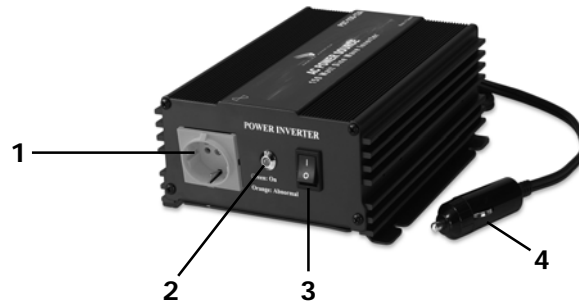
**Alternatively, the continuous power rating of the inverter / generator in Watts / VA should be at least 2.8 times the continuous power rating of the SMPS in Watts / VA**

## PRINCIPLE OF OPERATION

The inverter converts the DC voltage of the battery to 230 V, 60 Hz. AC voltage.

The voltage conversion takes place in two stages. In the first stage, the DC voltage of the battery is converted to a high voltage DC using high frequency switching and Pulse Width Modulation (PWM) technique. In the second stage, the high voltage DC is converted to 230 V, 50 Hz. sine-wave AC again using PWM technique. This is done by using a special wave shaping technique where the high voltage DC is switched at a high frequency and the pulse width of this switching is modulated with respect to a reference sine-wave.

## LAYOUT



- 1 230V AC output receptacle (Schuko/CEE 7/7)
- 2 L.E.D. indicator
- 3 On/Off Switch
- 4 Cigarette Lighter Plug
- 5 Cooling fan (back of the unit - not shown)
- 6 Grounding lug (back of the unit - not shown)

### **CAUTION!**

Reverse polarity of input connection will blow the fuse inside the inverter and may cause permanent damage. Ensure that the cigar lighter socket used for powering the inverter has the correct polarity with respect to the cigar lighter plug's, positive (+) & negative (-) contact points. The contact at the tip of the cigar lighter plug is positive (+) and the two spring loaded bow type contacts on the sides are negative (-). **Damage due to reverse polarity is not covered by warranty.**

## SPECIFYING BATTERIES, CHARGERS & ALTERNATORS

The inverter will require **Deep Cycle Lead Acid Batteries** of appropriate capacity.

Lead-acid batteries can be categorized by the type of application: automotive service - **Starting/Lighting/Ignition (SLI, a.k.a. cranking)** and **deep cycle** service

### **SLI Batteries**

Everybody is familiar with the SLI batteries that are used for automotive starting and powering vehicular accessories. SLI batteries are designed to produce high power in short bursts but must be constantly recharged (normally with an alternator while driving).

Vehicle starting typically discharges 1%-3% of a healthy SLI battery's capacity.

The automotive SLI battery is not designed for repeated deep discharge where up to 80 % of the battery capacity is discharged and then recharged. If an SLI battery is used for this type of application, its useful service life will be drastically reduced

### **Deep Cycle Batteries**

Deep cycle batteries are designed with thick-plate electrodes to serve as primary power sources, to have a constant discharge rate, to have the capability to be deeply discharged up to 80 % capacity and to repeatedly accept recharging. They are marketed for use in recreation vehicles (RV), boats and electric golf carts – so they may be referred to as RV batteries, marine batteries or golf cart batteries. There are two categories of deep cycle lead acid batteries – wet and sealed. A wet cell battery has a high tolerance to overcharging. However, it will release hydrogen gas when charging that must be properly vented and the water level must be checked frequently. Sealed batteries can either be Gel Cell or AGM (Absorbed Glass Mat). Both the Gel Cell and AGM are maintenance free, have no liquid to spill and gassing is minimal. The Gel Cell is the least affected by temperature extremes, storage at low state of charge and has a low rate of self discharge. An AGM battery will handle overcharging slightly better than the Gel Cell

### **Units of Battery capacity**

The battery capacity is the measure of the energy the battery can store and deliver to a load. It is determined by how much current any given battery can deliver over a stipulated period of time. The energy rating is expressed in **Ampere Hours (AH)**. As a bench mark, the battery industry rates batteries at 20 hour rate i.e. how many Amperes of current the battery can deliver for 20 hours at 80 ° F till the voltage drops to 10.5 Volts for 12 V battery and 21 V for 24 V battery. For example, a 100 AH battery will deliver 5 Amperes for 20 hours. Battery capacity is also expressed as **Reserve Capacity (RC)** in minutes. Reserve capacity is the time in minutes for which the battery can deliver 25 Amperes at 80 ° F till the voltage drops to 10.5 Volts for 12 V battery and 21 V for 24 V battery.

Approximate relationship between the two units is as follows:

**Capacity in AH = Reserve Capacity in RC minutes x 0.6**

**Typical battery sizes**

Below is a chart of some battery sizes applicable for powering inverters:

| <b>BCI * Group</b> | <b>Battery Voltage, V</b> | <b>Battery AH</b> |
|--------------------|---------------------------|-------------------|
| 27 / 31            | 12                        | 105               |
| 4 D                | 12                        | 160               |
| 8D                 | 12                        | 225               |
| GC2**              | 6                         | 220               |

\* Battery Council International

\*\* Golf Cart

**Reduction in usable capacity at higher discharge rates.**

As stated above, the rated capacity of the battery in AH is applicable at a discharge rate of 20 Hours. As the discharge rate is increased, the usable capacity reduces due to "Peukert Effect". This relationship is not linear but is more or less according to the table below:

**Table 1 Battery Capacity versus Rate of Discharge**

| <b>Hours of Discharge</b> | <b>Usable Capacity</b> |
|---------------------------|------------------------|
| 20                        | 100%                   |
| 10                        | 87%                    |
| 8                         | 83%                    |
| 6                         | 75%                    |
| 5                         | 70%                    |
| 3                         | 60%                    |
| 2                         | 50%                    |
| 1                         | 40%                    |

Using the above table will show that a 100 AH capacity battery will deliver 100% (i.e. full 100 AH) capacity if it is slowly discharged over 20 hours at the rate of 5 Amperes. However, if it is discharged at a rate of 50 Amperes then theoretically, it should provide  $100 \text{ AH} \div 50 = 2$  hours. However, the Table above shows that for 2 hours discharge rate, the capacity is reduced to 50% i.e. 50 AH. Therefore, at 50 Ampere discharge rate the battery will actually last for  $50 \text{ AH} \div 50 \text{ Amperes} = 1$  Hour

**Depth of discharge and battery life**

The more deeply a battery is discharged on each cycle, the shorter the battery life. Using more batteries than the minimum required will result in longer life for the battery bank. A typical cycle life chart is given at Table 2 below:

**TABLE 2. – TYPICAL CYCLE LIFE CHART**

| <b>Depth of Discharge<br/>% of AH Capacity</b> | <b>Cycle Life<br/>Group 27 / 31</b> | <b>Cycle Life<br/>Group 8D</b> | <b>Cycle Life<br/>Group GC2</b> |
|--|-------------------------------------|--------------------------------|---------------------------------|
| 10   | 1000                                | 1500                           | 3800                            |
| 50   | 320                                 | 480                            | 1100                            |
| 80   | 200                                 | 300                            | 675                             |
| 100  | 150                                 | 225                            | 550                             |

It is recommended that the depth of discharge should be limited to 50 %

**Loss of battery capacity at low temperatures.**

Batteries lose capacity in low temperatures. At 32 ° F, a battery will deliver about 70 to 80 % of its rated capacity at 80 ° F. If the air temperature near the battery bank is lower than 80 ° F, additional batteries will be needed to provide the same usable capacity. For very cold climates, an insulated / heated battery compartment is recommended.

**Series and parallel connection of batteries**

When two or more batteries are **connected in series**, their voltages add up but their AH capacity remains the same. For example, when two 12 V, 105 AH batteries are connected in series, it becomes a 24 V, 105 AH battery. (Positive of the first battery is the positive terminal of the series connection. The negative of the first battery is connected to the positive of the second battery. The negative of the second battery is the negative of the series connection)

When two or more batteries are **connected in parallel**, their voltages remain the same but their capacities add up. For example, if two 12 V, 105 AH batteries are connected in parallel, their voltage remains 12 V but their capacity becomes  $105 \times 2 = 210$  AH (Connect the positive terminal of the first battery to the positive terminal of the second battery. These paralleled common positive terminals become the positive terminal of the parallel combination. Connect the negative terminal of the first battery to the negative terminal of the second battery. These paralleled common negative terminals becomes the negative terminal of the parallel combination)

### **Sizing the Inverter Battery Bank**

One of the most frequently asked question is, “how long will the batteries last?”. This question cannot be answered without knowing the size of the battery system and the load on the inverter. Usually this question is turned around to ask “How long do you want your load to run?”, and then specific calculation can be done to determine the proper battery bank size.

There are a few basic formulae and estimation rules that are used:

|           |  |
|-----------|--|
| Formula 1 | Power in Watts (W) = Voltage in Volts (V) x Current in Amperes (A)   |
| Formula 2 | For an inverter running from a 12 V battery system, the DC current required from the 12 V batteries is the AC power delivered by the inverter to the load in Watts (W) divided by 10 |
| Formula 3 | Energy required from the battery = DC current to be delivered (A) x time in Hours (H)  |

The first step is to estimate the total AC watts (W) of load(s) and for how long the load(s) will operate in hours (H). The AC watts are normally indicated in the electrical nameplate for each appliance or equipment. In case AC watts (W) are not indicated, formula 1 given above may be used to calculate the AC watts by multiplying 230 VAC by the AC current in Amperes . The next step is to derive the DC current in Amperes (A) from the AC watts as per formulae 2 above. An example of this calculation for 12V inverter is given below:

Let us say that the total AC Watts delivered by the inverter = 1000 W

Then, using formula 2 above, the DC current to be delivered by the 12 V batteries =  $1000 \text{ W} \div 10 = 100 \text{ Amperes}$

Next, the energy required by the load in Ampere Hours (AH) is determined. For example, if the load is to operate for 3 hours then as per Formula 3 above:

Energy to be delivered by the 12 V batteries =  $100 \text{ Amperes} \times 3 \text{ Hours} = 300 \text{ Ampere Hours (AH)}$

Now, the capacity of the batteries is determined based on the run time and the usable capacity. From Table 1 above, the usable capacity at 3 Hour discharge rate is 60%. Hence, the actual capacity of the 12 V batteries to deliver 300 AH will be equal to  $300 \text{ AH} \div 0.6 = 500 \text{ AH}$

And finally, the actual desired rated capacity of the batteries is determined based on the fact that normally only 80% of the capacity will be available with respect to the rated capacity due to non availability of ideal and optimum operating and charging conditions. So the final requirements will be equal to:

$500 \text{ AH} \div 0.8 = 625 \text{ AH}$  (note that the actual energy required by the load was 300 AH)

It will be seen from the above that the final rated capacity of the batteries is almost 2 times the energy required by the load in AH

**Thus, as a thumb rule, the AH capacity of the batteries should be twice the energy required by the load in AH**

For the above example, the 12 V batteries may be selected as follows:

- Use 6 Group 27/31, 12 V, 105 AH batteries in parallel to make up 630 AH, **or**
- Use 3 Group 8D, 12 V, 225 AH batteries in parallel to make up 675 AH

### **Charging Batteries**

The batteries can be charged by using good quality AC powered battery charger or from alternative energy sources like solar panels, wind or hydro systems. Make sure an appropriate battery charge controller is used. It is recommended that the batteries may be charged at 10% to 13 % of the Ampere Hour capacity (20 hour discharge rate). Also, for complete charging (return of 100 % capacity ), it is recommended that a 3 stage charger may be used (Constant current bulk charging followed by constant voltage boost / absorption charging followed by constant voltage float charging )

### **Batteries, alternators and isolators on vehicles / RVs**

It is recommended that for powering the inverter, one or more auxiliary deep cycle batteries should be used that are separate from the SLI batteries. The inverter should be powered from the deep cycle batteries. For charging the SLI and the auxiliary deep cycle batteries, the output from the alternator should be fed to these two sets of batteries through a battery isolator of appropriate capacity. The battery isolator is a device that will allow the alternator to charge the two sets of batteries when the engine is running. The isolator will allow the inverter to be operated from the auxiliary batteries and also prevent the SLI batteries from charging the auxiliary deep cycle batteries when the engine is not running. Battery isolators are available from auto / RV / marine parts suppliers. A majority of smaller vehicles have 40 to 105 Ampere alternator and RVs have 100 to 130 Ampere alternator. When in use, the alternators heat up and their output current capacity can drop by up to 25%. When heated up, their charging voltage may also not reach the desired absorption voltage and will result in return of only about 80% of the battery capacity. In case the current output of the standard alternator is not adequate to charge the two sets of batteries rapidly and fully to 100% of their capacity, use heavy duty alternator that can produce higher current and voltage required to charge multiple battery systems. These alternators are available with auto / RV parts suppliers

# INSTALLATION

## GENERAL

### Installation and wiring compliance

- Installation and wiring must comply with the local and the national electrical codes and must be done by a certified electrician
- In building / residential applications, electrical codes do not allow permanent connection of AC distribution wiring to the inverter's AC output receptacles. The receptacles are intended for temporary (as needed) connection of cord connected loads only. **Read details under "AC Power Distribution and Grounding" on page 9.**
- The inverter does not have integral over current protection for the AC output side. Protection should be provided by the installer
- Over current protection of the cables from the battery to the inverter has to be provided by the installer
- The DC input positive and negative terminals are isolated from the chassis. Similarly, the neutral pole of the AC receptacles / the neutral wire is not bonded to the chassis. System grounding to suit the national / local electrical codes is to be undertaken by the installer. **Read details under "AC Power Distribution and Grounding" on page 9.**

### Preventing electrical shock

- Always connect the grounding connection on the inverter to the appropriate grounding system. **Read details under "AC Power Distribution and Grounding" on page 9.**

### Installation environment

- The inverter should be installed indoor only in a well ventilated, cool, dry environment
- Do not expose to moisture, rain, snow or liquids of any type.
- To reduce the risk of overheating and fire, do not obstruct the suction and discharge openings of the cooling fan.
- To ensure proper ventilation, do not install in a low clearance compartment
- Working with the inverter may produce arcs or sparks. Thus, the inverter should not be used in areas where there are inflammable materials or gases requiring ignition protected equipment. These areas may include spaces containing gasoline powered machinery, fuel tanks, battery compartments

### Mounting position of the inverter

- The inverter may be mounted horizontally on the top of a horizontal surface or under a horizontal surface. The inverter may be mounted on a vertical surface only horizontally **(the fan axis should always be horizontal i.e. the fan should not be pointing up or down)**

### Cooling by forced air fan ventilation

The inverters produce heat when operating. The amount of heat produced is proportional to the amount of power supplied by the inverter. DC fans are used to provide forced air cooling of these inverters. The fans are thermostatically controlled and will be switched on only if the temperature of certain hot spot inside the inverter rises above a certain temperature. **At lower loads and / or at lower ambient temperatures, the fan may not switch on at all. This is normal.** The units are protected against over-temperature due to failure of the fan / inadequate heat transfer. The AC output will be shut-down if the hot spot inside the inverter reaches a certain higher temperature.

## DC SIDE CONNECTIONS

The DC input power to the inverter is derived from deep cycle batteries of the required capacity. Read under “**Specifying Batteries, Chargers and Alternators**” on page 14 for details on sizing and charging of batteries.

### Preventing input over voltage

It is to be ensured that the input voltage of the inverter does not exceed 16.5 VDC for PST-15S-12E or 33 VDC for PST-15S-24E to prevent permanent damage to the inverter. Please observe the following precautions:

- Ensure that the maximum charging voltage of the battery charger / alternator / solar charge controller is below 16.5 VDC for PST-15S-12E or 33 VDC for PST-15S-24E
- Do not use unregulated solar panels to charge a battery. Under cold ambient temperatures, the output of the solar panel may exceed 18 V for 12V system or 36 V for 24V system. Always use a charge controller between the solar panel and the battery.
- When using Diversion Charge Control Mode in a charge controller, the solar / wind / hydro source is directly connected to the battery bank. In this case, the controller will divert excess current to an external load. As the battery charges, the diversion duty cycle will increase. When the battery is fully charged, all the source energy will flow into the diversion load if there are no other loads. The charge controller will disconnect the diversion load if the current rating of the controller is exceeded. **Disconnection of the diversion load may damage the battery as well as the inverter connected to the battery due to high voltages generated during conditions of high winds (for wind generators), high water flow rates (for hydro generators) or cold temperatures (for solar panels). It is, therefore, to be ensured that the diversion load is sized correctly to prevent the above over voltage conditions.**
- A series type of charge controller connects the solar / wind / hydro charging source directly to the battery through the series connected switching MOSFET(s). The battery is a capacitive type of load and will thus, dampen the input voltages of the charging source due to its capacitive loading effect. As the inverter is connected to the battery bus, it will see the voltages of the charging source as conditioned by the battery. **Please ensure that the inverter is connected to the battery bus only after the battery is connected to the battery bus or the inverter is disconnected from the battery bus first before removing the battery from the battery bus. If the inverter is connected to the battery bus without the battery connected to the battery bus, the inverter will be fed with the high open circuit voltages from the solar / wind / hydro and will damage the inverter permanently**
- Do not connect the inverter to a battery system with a voltage higher than the rated battery input voltage.

### Preventing reverse polarity on the input side

When making battery connection on the input side, make sure that the polarity of battery connection is correct (Connect the positive of the battery to the positive terminal of the inverter and the negative of the battery to the negative terminal of the inverter). If the input is connected in reverse polarity, DC fuse(s) inside the inverter will blow and may also cause permanent damage to the inverter

### Connection from the batteries to the DC input side of the inverter – cable and fuse sizes

The flow of electric current in a conductor is opposed by the resistance of the conductor. The resistance of the conductor is directly proportional to the length of the conductor and inversely proportional to its cross-section (thickness). The resistance in the conductor produces undesirable effects of voltage drop and heating. **Thus, thicker and shorter conductors are desirable.** The size (thickness / cross-section) of the conductors is designated by AWG (American Wire Gauge). **Please note that a smaller AWG # denotes a thicker size of the conductor up to AWG #1.**

The DC input circuit is required to handle very large DC currents and hence, the size of the cables and connectors should be selected to ensure minimum voltage drop between the battery and the inverter. Thinner cables and loose connections will result in poor inverter performance and will produce abnormal heating leading to risk of insulation melt down and fire.

Use oil resistant, multi-stranded copper wire cables rated at 90 ° C minimum. Do not use aluminium cable as it has higher resistance per unit length. Cables can be bought at a marine / welding supply store

The cables from the battery to the inverter should be protected by a suitable, very fast acting DC fuse. Use a DC fuse of the appropriate capacity in line with the positive cable. The fuse should be within 18” from the battery. **Type ANN fuses with Fuse Block 4164 made by Bussmann are recommended.**

The following size of cables and fuse are recommended. The distance shown is the distance between the battery and the inverter. The recommended size of the cables will limit the voltage drop to approximately 2% ( The length of the cable for calculating the voltage drop has been taken as 2 times the distance between the inverter and the battery assuming that two ( one positive and one negative)cables are used for the connection )

|             | Distance up to 2' | Distance up to 6' | Ampere rating of fuse |
|-------------|-------------------|-------------------|-----------------------|
| PST-15S-12E | # 12 AWG          | #10 AWG           | 20 A (ANN20)          |
| PST-15S-24E | # 14 AWG          | #12 AWG           | 10 A (ANN10)          |

**CAUTION!** The input section of the inverter has large value capacitors connected across the input terminals. As soon as the DC input connection loop ( Battery + ⇔ fuse⇔ inverter +⇔ inverter - ⇔ battery negative) is completed, these capacitors will start charging and will momentarily draw very heavy current that will produce sparking on the last contact in the input loop even when the on / off switch on the inverter is in the off position. Ensure that the fuse is inserted only after all the connections in the loop have been completed so that the sparking is limited to the fuse area.

**DC Input Connection**

For connecting the DC input, an attached 2' cable with a cigarette lighter plug has been provided. The cable size is AWG #14.

**NOTE: The centre pin of the cigarette lighter plug is positive.**

**NOTE: When using cigarette lighter receptacle in a 12V vehicle, limit the power to less than 100 watts as the cigarette lighter receptacle wiring in a 12V vehicle is normally fused for 8 to 10A**

#### **Reducing RF interference**

To reduce the effect of radiated interference, twist the DC side cables. To further reduce RF interference, shield the cables with sheathing /copper foil / braiding..

#### **Taping battery cables together to reduce inductance.**

Do not keep the battery cables far apart. In case it is not convenient to twist the cables, keep them taped together to reduce their inductance. Reduced inductance of the battery cables helps to reduce induced voltages. This reduces ripple in the battery cables and improves performance and efficiency.

### **AC SIDE CONNECTIONS**

#### **Preventing paralleling of the AC output**

The AC output of the inverter cannot be synchronised with another AC source and hence, it is not suitable for paralleling. The AC output of the inverter should never be connected directly to an electrical breaker panel / load center which is also fed from the utility power / generator. Such a connection may result in parallel operation of the different power sources and AC power from the utility / generator will be fed back into the inverter which will instantly damage the output section of the inverter and may also pose a fire and safety hazard. If an electrical breaker panel / load center is fed from an inverter and this panel is also required to be powered from additional alternate AC sources, the AC power from all the AC sources like the utility / generator / inverter should first be fed to a manual selector switch and the output of the selector switch should be connected to the electrical breaker panel / load center.

To prevent possibility of paralleling and severe damage to the inverter, never use a simple jumper cable with a male plug on both ends to connect the AC output of the inverter to a handy wall receptacle in the home / RV.

#### **Connecting to multi-wire branch circuits (Applicable to 120 VAC inverters)**

Do not directly connect the hot side of the 120 VAC of the inverter to the two hot legs of the 120 / 240 VAC electrical breaker panel / load centre where multi-wire ( common neutral ) branch circuit wiring method is used for distribution of AC power. This may lead to overloading / overheating of the neutral conductor and is a risk of fire.

A split phase transformer ( isolated or autotransformer ) of suitable wattage rating ( 25 % more than the wattage rating of the inverter ) with primary of 120 VAC and secondary of 120 / 240 VAC ( Two 120 VAC split phases 180 degrees apart) should be used. The hot and neutral of the 120 VAC output of the inverter should be fed to the primary of this transformer and the 2 hot outputs ( 120 VAC split phases ) and the neutral from the secondary of this transformer should be connected to the electrical breaker panel / load centre.

### **AC output connections**

The inverter uses European CEE 7/7 (Schuko) receptacle for the AC output connection. The two round slots of CEE 7/7 are connected to the two current carrying conductors of the AC power source inside the inverter. The two clips of the CEE 7/7 are the “equipment grounding” connections and are internally connected to the metal chassis of the inverter. A CEE 7/7 (Schuko) to universal adapter has been provided for ease of connection for different plug configurations.

**CAUTION!** : In the above AC output receptacle, **both the current carrying conductors are isolated from the metal chassis. Do not touch the “Neutral” slot of the receptacles as it will be at an elevated voltage with respect to the metal chassis / earth ground and will produce an electrical shock if touched!**

(In some inverters, one of the two current carrying conductors is bonded to the metal chassis of the inverter and is called the “Neutral”. When the metal chassis of these inverters is bonded to the earth ground, the “Neutral” also gets connected to the earth ground and thus, the voltage on the “Neutral” will normally 0 V).

### **Ground Fault Circuit Interrupter (GFCI)**

An un-intentional electric path between a source of current and a grounded surface is referred to as a "ground fault". Ground faults occur when current is leaking somewhere. In effect, electricity is escaping to the ground. How it leaks is very important. If your body provides a path to the ground for this leakage you could be injured, burned, severely shocked or electrocuted. A GFCI protects people from electric shock by detecting leakage and cutting off the AC source.

Installation in recreation vehicles (RV) may require GFCI protection on the AC output. In addition, electrical codes may require GFCI protection for certain residential applications. There is no internal GFCI protection in these inverters. If required, this protection may be provided externally by the user / installer.

### **Grounding to earth or to other designated ground**

Please see details regarding grounding under “**AC Power Distribution and Grounding**” on page 9.

For safety, the metal chassis of the inverter is required to be grounded to the earth ground or to the other designated ground (For example, in a mobile RV, the metal frame of the RV is normally designated as the negative DC ground). An equipment grounding bolt with a wing nut has been provided for grounding the metal chassis of the inverter to the appropriate ground.

When using the inverter in a building, connect a # 8 AWG insulated stranded copper wire from the above equipment grounding bolt to the earth ground connection ( a connection that connects to the ground rod or to the water pipe or to another connection that is solidly bonded to the earth ground ). The connections must be tight against bare metal. Use star washers to penetrate paint and corrosion.

When using the inverter in a mobile RV, connect a # 8 AWG insulated stranded copper wire from the above equipment grounding bolt to the appropriate ground bus of the RV ( usually the vehicle chassis or a dedicated DC ground bus ). The connections must be tight against bare metal. Use star washers to penetrate paint and corrosion.

## OPERATION

### Powering on the loads

After the inverter is switched on, it takes a finite time for it to become ready to deliver full power. Hence, always switch on the load(s) after a few seconds of switching on the inverter. Avoid switching on the inverter with the load already switched on. This may prematurely trigger the overload protection.

When a load is switched on, it may require initial higher power surge to start. Hence, if multiple loads are being powered, they should be switched on one by one so that the inverter is not overloaded by the higher starting surge if all the loads are switched on at once.

### Switching the inverter on / off

Before switching on the inverter, check that all the AC loads have been switched off.

The on / off switch (3) on the front panel of the inverter is used to switch on and switch off the inverter. This switch operates a low power control circuitry which in turn controls all the high power circuitry.

**CAUTION!** Please note that this switch is not switching the high power battery input circuit. Parts of the DC side circuit will still be alive even when the switch is in the off position. Hence, disconnect the DC and AC sides before working on any circuits connected to the inverter

When the inverter is switched on, the LED indicator (2) will turn green. This LED indicates that the inverter is operating normally. Under normal operating conditions, AC output voltage will now be available at the output receptacles.

Switch on the AC load(s). The green LED should remain lighted for normal operation of the load.

### Temperature controlled cooling fan

The cooling fan is thermostatically controlled. Temperature of a critical hot spot inside the inverter is monitored to activate the fan and the over temperature shut-down. When the temperature of this hot spot reaches 48°C, the fan is switched on. The fan will be automatically switched off once the hot spot cools down to 42°C. **Please note that the fan may not come on at low loads or if the ambient temperature is cooler. This is normal.**

### Indications for normal operation.

When the inverter is operating normally and supplying AC load(s), the LED (2) will be green. In case of abnormal operation, other displays and alarms will be activated. Please see under “**Protections Against Abnormal Conditions**” on page 25.

**No load draw (idle current)**

When the on / off switch is turned on, all the circuitry inside the inverter becomes alive and the AC output is made available. In this condition, even when no load is being supplied (or, if a load is connected but has been switched off), the inverter draws a small amount of current from the batteries to keep the circuitry alive and ready to deliver the required power on demand. This is called the idle current or the no load draw. Hence, when the load is not required to be operated, turn off the on / off switch on the inverter to prevent unnecessary current drain from the battery.

## PROTECTIONS AGAINST ABNORMAL CONDITIONS

The inverter has been provided with protections detailed below.

**Low DC input voltage warning alarm.** The voltage at the DC input terminals will be lower than the voltage at the battery terminals due to the voltage drop in the battery cables and connectors. The drop in the voltage at the DC input terminals of the inverter could be due to lower battery voltage or due to abnormally high drop in the cables if the cables are not thick enough (Please read under “**Installation – Connection from the batteries to the DC input side of the inverter – cable and fuse sizes**” on page 20) If the voltage at the DC input terminals falls below 10.5 V for PST-15S-12E or 21 V for PST-15S-24E, a buzzer alarm will be sounded. The LED (2) will continue to be green and the AC output voltage will continue to be available. This warning buzzer alarm indicates that the battery is running low and that the inverter will be shut down after sometime if the voltage at the inverter terminals further drops to 10 V for PST-15S-12E or 20 V for PST-15S-24E.

**Shut-down due to low DC input voltage.** If the inverter continues to power the load after the low DC input voltage buzzer alarm is sounded, it will shut down temporarily when the DC input voltage further drops below 10 V for PST-15S-12E or 20 V for PST-15S-24E. The LED (2) will turn orange and there will be no AC output voltage. The buzzer alarm will continue to sound. **The unit will reset automatically when the voltage of the battery rises to 11.5 V for PST-15S-12E or 23 V for PST-15S-24E.**

**Shut-down due to high DC input voltage.** If the voltage at the DC input terminals exceeds 16.5 V for PST-15S-12E or 33 V for PST-15S-24E, the inverter will be shut down temporarily. The LED (2) will turn orange and there will be no AC output. **The buzzer will be sounded. The unit will be reset automatically when the voltage drops down to 16.7 +/- 0.2 V for PST-15S-12E or 33.5 V +/- 0.2 for PST-15S-24E.**

**Shut-down due to reversal of polarity at the DC input terminals.** The positive of the battery should be connected to the positive DC input terminal of the inverter, (the tip of the cigarette lighter plug), and the negative of the battery should be connected to the negative DC input terminal of the inverter (The spring loaded bow type contacts of the cigarette lighter plug). A reversal of polarity (the positive of the battery **wrongly connected** to the negative DC input terminal of the inverter and the negative of the battery **wrongly connected** to the positive DC input terminal of the inverter) will blow the DC side fuses inside the inverter. If the DC side fuse is blown, the inverter will be dead. The LED (2) will be switched off and there will be no AC output. The internal fuse should be replaced with the correct size of fuse shown under specifications. If the unit does not work after replacing the fuse, it has been permanently damaged. Please call Technical Support for assistance.

**Shut-down due to over-temperature.** In case of failure of the cooling fan or in the case of inadequate heat removal due to higher ambient temperatures / insufficient air exchange, the temperature inside the unit will increase. The temperature of a critical hot spot inside the inverter is monitored and at 95° C, the AC output of the inverter is shut down temporarily. The LED (2) turns orange and a buzzer is sounded. The unit will automatically reset after the hot spot has cooled down to 70° C.

**Shut down due to overload.** The inverter can provide a higher than normal instantaneous (< 1 second) power limited to the surge power rating of the inverter. Also, the inverter can provide continuous power limited to the continuous power rating of the inverter. If there is an overload beyond the specified limits, the AC output of the unit will be shut down permanently. LED (2) will turn orange and buzzer alarm will be sounded. The unit will be required to be reset manually by switching the unit off and on again. Before switching on the unit, please remove the cause of the overload.

## TROUBLESHOOTING GUIDE

| <b><u>SYMPTOM</u></b>   | <b><u>POSSIBLE CAUSE</u></b>  | <b><u>REMEDY</u></b>  |
|---|---|---|
| On switching on, LED (2) does not light.<br>Buzzer is off. There is no AC voltage   | There is no voltage at the DC input terminals   | <ol style="list-style-type: none"> <li>1. Check the continuity of the battery input circuit.</li> <li>2. Check that the battery fuse is intact. Replace if blown</li> <li>3. Check that all connections in the battery input circuit are tight</li> </ol>   |
|   | Polarity of the input voltage has been reversed that has blown the internal DC side fuse        | <p>Correct the polarity of the input connections and replace the internal fuse ( <b>Note: Reverse polarity may cause permanent damage</b>)</p> <p>If the unit does not work after replacing the fuse, the unit has been permanently damaged. Call Technical Support.</p>  |
| Buzzer alarm is sounded when load is switched on. Voltage at DC input terminals reads between 10 and 10.5 V for PST-15S-12E or between 20 & 21 V for PST-15S-24E.<br>LED (2) is green.<br>AC output voltage is available. | DC input voltage is less than 10.5 V for PST-15S-12E or less than 21 V for PST-15S-24E.         | <ol style="list-style-type: none"> <li>1. Check that the battery is fully charged. Recharge, if low</li> <li>2. Check that the battery cables are thick enough to carry the required current over the required length. Use thicker cables, if required.</li> <li>3. Tighten connections of the battery input circuit</li> </ol>   |
| Buzzer alarm is sounded when load is switched on. Voltage at the DC input terminals reads below 10 V for PST-15S-12E or 20 V for PST-15S-24E.<br>LED (2) turns orange.<br>There is no AC output.                          | Shut-down due to low input DC voltage (Less than 10 V for PST-15S-12E or 20 V for PST-15S-24E). | <ol style="list-style-type: none"> <li>1. Check that the battery is fully charged. Recharge, if low</li> <li>2. Check that the battery cables are thick enough to carry the required current over the required length. Use thicker cables, if required.</li> <li>3. Tighten connections of the battery input circuit</li> </ol>   |
| There is no AC output.<br>LED (2) turns orange.<br>Buzzer is on.  | Shut-down due to high input DC voltage (> 16.5 V for PST-15S-12E or 33 V for PST-15S-24E).      | <ol style="list-style-type: none"> <li>1. Check that the voltage at the DC input terminals is less than 16.5 V for PST-15S-12E or 33 V for PST-15S-24E.</li> <li>2. Ensure that the maximum charging voltage of the battery charger / alternator / solar charge controller is below 16.5 V for PST-15S-12E or 33 V for PST-15S-24E.</li> <li>3. Ensure that an un-regulated solar panel is not used to charge a battery. Under cold ambient temperatures, the output of the solar panel may exceed 18 V for a 12 V battery system or 36V for a 24V battery system. Ensure that a charge controller is used between the solar panel and the battery</li> </ol> |

| <b><u>SYMPTOM</u></b>  | <b><u>POSSIBLE CAUSE</u></b>   | <b><u>REMEDY</u></b>  |
|--|--|---|
|  | Shut-down due to over temperature because of fan failure or inadequate cooling as a result of high ambient temperature or insufficient air exchange                    | <ol style="list-style-type: none"> <li>1. Check that the fan is working. If not, the fan / fan control circuit may be defective. Call Technical Support.</li> <li>2. If the fan is working, check that the ventilation slots on the suction side and the openings on the discharge side of the fan are not obstructed.</li> <li>3. If the fan is working and the openings are not obstructed, check that enough cool replacement air is available. Also check that the ambient air temperature is less than 40° C</li> <li>4. Reduce the load to reduce the heating effect.</li> <li>5. After the cause of over heating is removed and the unit cools down, it will reset automatically.</li> </ol> |
|  | Shut down due to overload or short circuit on the output side.   | <ol style="list-style-type: none"> <li>1. Disconnect the load.</li> <li>2. Manually reset the unit by switching off and then on again. The unit should power on normally. (If not, the unit may have been damaged permanently). Call Tech Support</li> <li>3. Reduce the load or remove the short circuit before powering on again.</li> </ol>  |
| AC output voltage shuts down when vehicles engine is cranked | The inverter has been powered from the starting battery. When the engine is cranked, the battery voltage drops below 10V for PST-15S-12E or below 20V for PST-15S-24E. | Use a separate deep cycle battery for powering the inverter. (see page 18)  |

# SPECIFICATIONS

|  | <u>PST-15S-12E</u>              | <u>PST-15S-24E</u> |
|--|---------------------------------|--------------------|
| Input Voltage .....  | 10.5 to 16.5 VDC.....           | 21 to 33 V DC      |
| Input Current at No Load .....   | < 500 mA.....                   | < 300 mA           |
| Output Voltage .....   | 230 V AC +/- 3%.....            | 230V AC +/- 3%     |
| Output Frequency.....  | 50 Hz.....                      | 50 Hz              |
| Output Voltage Waveform .....  | Sine Wave.....                  | Sine Wave          |
| Total Harmonic distortion .....  | < 3%.....                       | < 3%               |
| Output Power   |                                 |                    |
| -Continuous .....  | 150 Watts*.....                 | 150 Watts*         |
| -Surge (for <1 second) .....   | 300 Watts*.....                 | 300 Watts*         |
| * The power specified is for a resistive type of load which has power factor = 1. Reactive type of loads may have power factor of 0.8 to 0.6. The power that can be delivered to such type of loads will reduce by this factor. <b>See page 7 for details.</b> |                                 |                    |
| Low Input Voltage Warning Alarm .....  | 10.5 V .....                    | 21 V               |
| Low Input Voltage Shut-down .....  | 10 V.....                       | 20 V               |
| High Input Voltage Shut-down .....   | 16.5 V.....                     | 33 V               |
| Operating Ambient Temp. ....   | 0 to 40°C +/- 5°C.....          | 0 to 40°C +/- 5°C  |
| Peak Efficiency .....  | 85%.....                        | 85%                |
| Cooling .....  | Temperature Controlled Fan..... |                    |
| Connections:   |                                 |                    |
| -Input .....   | Cigarette Lighter Plug .....    |                    |
| -Output .....  | European CEE 7/7 (Schuko).....  |                    |
| DC Side Input Fuse .....   | 20 A.....                       | 10 A               |
| (Automotive Type ATC, 32V)   |                                 |                    |
| Dimensions(L x W x H) .....  | 210 x 146 x 65 mm.....          |                    |
| Weight .....   | 1.3 kg / 2.9 lbs.....           |                    |

**Note:** Specifications are subject to change without notice.

## **2 YEAR Limited Warranty**

The PST-15S-12E/ PST-15S-24E manufactured by Samlex America, Inc. ( the “ Warrantor “ ) is warranted to be free from defects in workmanship and materials under normal use and service. This warranty is in effect for 2 years from the date of purchase by the user ( the “ Purchaser “ )

For a warranty claim, the Purchaser should contact the place of purchase to obtain a Return Authorization Number.

The defective part or unit should be returned at the Purchaser’s expense to the authorized location. A written statement describing the nature of the defect, the date of purchase, the place of purchase, and the Purchaser’s name, address and telephone number should also be included.

If upon the Warrantor’s examination, the defect proves to be the result of defective material or workmanship, the equipment will be repaired or replaced at the Warrantor’s option without charge, and returned to the Purchaser at the Warrantor’s expense.

No refund of the purchase price will be granted to the Purchaser, unless the Warrantor is unable to remedy the defect after having a reasonable number of opportunities to do so.

Warranty service shall be performed only by the Warrantor. Any attempt to remedy the defect by anyone other than the Warrantor shall render this warranty void.

There shall be no warranty for defects or damages caused by faulty installation or hook-up, abuse or misuse of the equipment including exposure to excessive heat, salt or fresh water spray, or water immersion.

No other express warranty is hereby given and there are no warranties which extend beyond those described herein. This warranty is expressly in lieu of any other expressed or implied warranties, including any implied warranty of merchantability, fitness for the ordinary purposes for which such goods are used, or fitness for a particular purpose, or any other obligations on the part of the Warrantor or its employees and representatives.

There shall be no responsibility or liability whatsoever on the part of the Warrantor or its employees and representatives for injury to any persons, or damage to person or persons, or damage to property, or loss of income or profit, or any other consequential or resulting damage which may be claimed to have been incurred through the use or sale of the equipment, including any possible failure of malfunction of the equipment, or part thereof.

The Warrantor assumes no liability for incidental or consequential damages of any kind.

Samlex America Inc. (the “Warrantor”)  
110-17 Fawcett Road  
Coquitlam BC V3K6V2 Canada  
(604) 525-3836



**samlex**power

110-17 Fawcett Rd  
Coquitlam, B.C.  
Canada  
V3K 6V2

T: 604 525 3836  
F: 604 525 5221

e-mail: [samlex@samlexamerica.com](mailto:samlex@samlexamerica.com)  
website: [www.samlexamerica.com](http://www.samlexamerica.com)