PS1 Sinewave Interactive Inverter Charger

Technical Manual

Document: PC0009
Revision 05

About This Manual

This manual (PC0009) contains information for installation, maintenance and troubleshooting of the PS1 Sinewave Interactive Inverter Charger family. These activities should be performed by suitably qualified and trained personnel only.

The indicated values are for a PS1 10/48. Refer to C.1 for a list of applicable models and to C.2 for document and software revision information.

This manual must be read in conjunction with the user manual. The User Manual (PC0004) describing the operation is available. Refer to Appendix C for document and software revision information.

A PDF copy of this manual may be downloaded from the Selectronic web site www.selectronic.com.au PDF copy includes many cross-reference hotlinks (underlined) to facilitate moving around within the document. (If you have clicked one of these links and wish to return to the place where you were previously reading, click on the "Go to Previous View" symbol on the Acrobat Reader toolbar at the top of the document.)

Contact your supplier or the manufacturer (see below) to order a printed copy of this manual (see manual details in page footer below).

In this manual, the symbol  indicates important information such as hazards and warnings.

If you have any suggestions for improvements to either this manual or any Selectronic Australia product please contact us (see Manufacturers Details below).

Warning

The equipment described in this manual may be hazardous. Before operating the equipment please see 1 Precautions and Safety and ensure that you understand the relevant information in the manual. Procedures in this manual require the PS1 front door to be opened, only suitably qualified and trained installation, commissioning and maintenance personnel should open the PS1 door or disturb the PS1 wiring.

Selectronic Australia shall have no obligation as to any equipment which has been improperly installed, stored, or handled, or which has not been operated or maintained according to this manual, nor for any operating mistakes and consequences arising therefrom.

This product is not to be used for Life Support equipment.

Manufacturers Details

Selectronic Australia Pty Ltd
Suite 5, 20 Fletcher Rd
Mooroolbark VIC 3138
Australia
Ph +61 3 9727 6600
Fax +61 3 9727 6601
sales@selectronic.com.au
www.selectronic.com.au/

Contents

1 Precautions and Safety

1.1 Multiple Hazardous Energy Sources

Hazardous voltages and energy are generated by the PS1, are fed into the PS1 by external wiring from multiple sources, and may be stored in capacitors after the PS1 is switched off and disconnected from external wiring.

Do not operate with the door open. No operating procedures in this manual require the PS1 door to be opened. All PS1 operations are performed with the door closed. This includes the front panel operation of all PS1 pushbuttons, displays and circuit breakers.

Only suitably qualified and trained personnel should open the PS1 front door.

Installation procedures in this Technical Manual require the PS1 front door to be opened to access internal wiring terminals and connectors. All commissioning and test procedures are performed with the door closed except where explicitly stated in this manual.

1.2 Heavy

The PS1 is heavy (up to 98kg). Take care when lifting and moving the PS1. Use appropriate mechanical lifting aids to move the PS1. Four eye bolts (provided) can be screwed into the top of the PS1 cabinet for attaching a lifting harness.

1.3 Installation

The PS1 requires adequate ventilation, away from hot equipment. Do not obstruct the airflow through the ventilation holes in the PS1 case (sides, rear and door top). Ensure when installed in an enclosed space that there is adequate ventilation.

The PS1 must be located in a dry place away from water, electrolyte and corrosive aerosols.

The PS1 contains arcing contacts so must not be located where explosive gas mixtures could occur, such as hydrogen from batteries or diesel fuel fumes. The PS1 must never be installed above the battery bank.

1.4 Maintenance

Ensure that all energy sources are isolated before working on connected wiring. The generator may start or power may be restored by the inverter at any time

Never work on equipment or investigate a problem without following appropriate safety isolation procedures. Procedures are defined in the PS1 Technical Manual.

1.5 Inverter or Generator may Start Automatically

The PS1 automatically starts and/or restarts and may restore power or start the generator at any time.

If a fault or overload is detected the PS1 will shutdown and automatically attempt to restart at varying intervals of up to several hours.

1.6 Battery

Batteries are very dangerous. Please read the safety information provided by the battery supplier.

Battery acid is dangerous.

Batteries can emit hydrogen gas, which is explosive.

Batteries connected in series can produce hazardous voltages.

Disconnecting a DC power connection (even on one battery cell) can cause dangerous high-energy DC arcs, which can cause serious burns and eject hot particles, and can be difficult to extinguish.

Disconnecting a DC power connection (even on one battery cell) can cause renewable sources to produce large voltages (much larger than the battery voltage) on battery terminals and DC wiring. Such voltages can be lethal. They can also damage the PS1. Only suitably trained and qualified personnel should disconnect any DC power connection, including battery cell connections, and only with suitable procedures and safety precautions.

1.7 Generator

Please read the safety information provided by the generator supplier.

The generator produces hazardous voltages.

The generator installation should follow relevant standards and practices for the installation of fuel storage, for ventilation and dispersal of exhaust gas. Exhaust gas in enclosed spaces can kill.

The generator installation should include a means of isolating the generator automatic control inputs from the PS1. The generator must be isolated from the PS1 during servicing.

The PS1 automatically starts and/or restarts and may restore power or start the generator at any time.

Never work on equipment or investigate a problem without following appropriate safety isolation procedures, including turning off isolating switches and disconnecting the generator start battery.

1.8 Renewable Sources

Please read the safety information provided by the supplier.

Renewable sources can produce hazardous voltages.

Shorting or disconnecting renewable wiring which is energized or carrying current can produce dangerous DC power arcs which are difficult to extinguish.

2 Site Selection

The inverter performance rating is dependent on the environmental operating conditions, in particular ambient temperature and ventilation. There are also safety considerations that must be addressed. Appropriate site selection and preparation are fundamental to getting the optimum performance from the PS1.

The site should be selected and prepared to provide:

- A dedicated lockable power room/area for PS1 and associated equipment.
- No access to unauthorized personnel or children.
- Maintenance of the ambient temperature within the product specification (see Appendix A).
- Adequate ventilation, away from hot equipment. Ensure unobstructed airflow through the ventilation holes in the inverter case (sides and door top). See A.9 Mechanical Details for air flow.

- A dry location away from water, condensation, electrolyte and corrosive aerosols.
- A location free from the risk of explosive gas mixtures occurring, such as hydrogen from batteries or diesel fuel fumes. The inverter contains arcing contacts which may ignite such mixtures. Never mount the PS1 above batteries.
- Rodent proof.
- A mounting surface and method suitable for the inverter weight with adequate safety margin (see Appendix A.1 Product Specifications for unit weight). If the inverter is wall mounted the mounting method must be in accordance with the installation instructions using the fasteners specified.
- Sufficient space available in front of the inverter to open the inverter door and work on the inverter internals.

Following the guidelines below will help maintain the system reliability and maximise the life of the PS1, generator and other components.

- Reduce operating temperatures. All equipment will provide longer and more reliable service if protected from high temperatures and regular wide temperature variations. PS1 power capacity is reduced when operating in high ambient temperatures.
- In hot areas a shed or room with a shade roof above and on walls exposed to direct sunlight and with reasonable ventilation will reduce maximum temperatures.
- In areas with wide temperature variation between day and night, insulate the building and fit ventilation controlled by internal room temperature to dispose of excess heat.
- Install the generator in an area with good ventilation and well separated from the PS1 and the batteries. Do not allow heat or exhaust from the generator to heat the PS1, the battery or other equipment.

- Follow the instructions for routine monitoring and maintenance.
- Monitor the performance of the system by periodically reviewing the PS1 logged data. The logged data may indicate the system is not performing optimally and system settings changes or some maintenance may be required. A telephone line and a modem connected to the PS1 will allow the logged data and settings to be reviewed remotely.

3 PS1 Wiring

The electrical wiring recommendations herein apply to Australia and New Zealand, and are based on standard AS4509 – Standalone Power Systems.

The PS1 has been designed to comply with AS/NZS 3100 - General Requirements for Electrical Equipment and as such can be installed into a system and be compliant with AS/NZS 3000 - Electrical installations as required by AS4509.

For other regions, the installation and wiring should comply with relevant national standards and practices.

3.1 External Wiring Schematic

Figure 1 is a typical schematic of wiring connected to the inverter via the site switchboard. This wiring scheme facilitates inverter bypass and also isolation of the inverter, generator and loads at one location.

Note: This schematic is intended to guide the designers of systems using the inverters. Do NOT use this typical schematic to trace actual site wiring, which may differ in detail from that shown below.

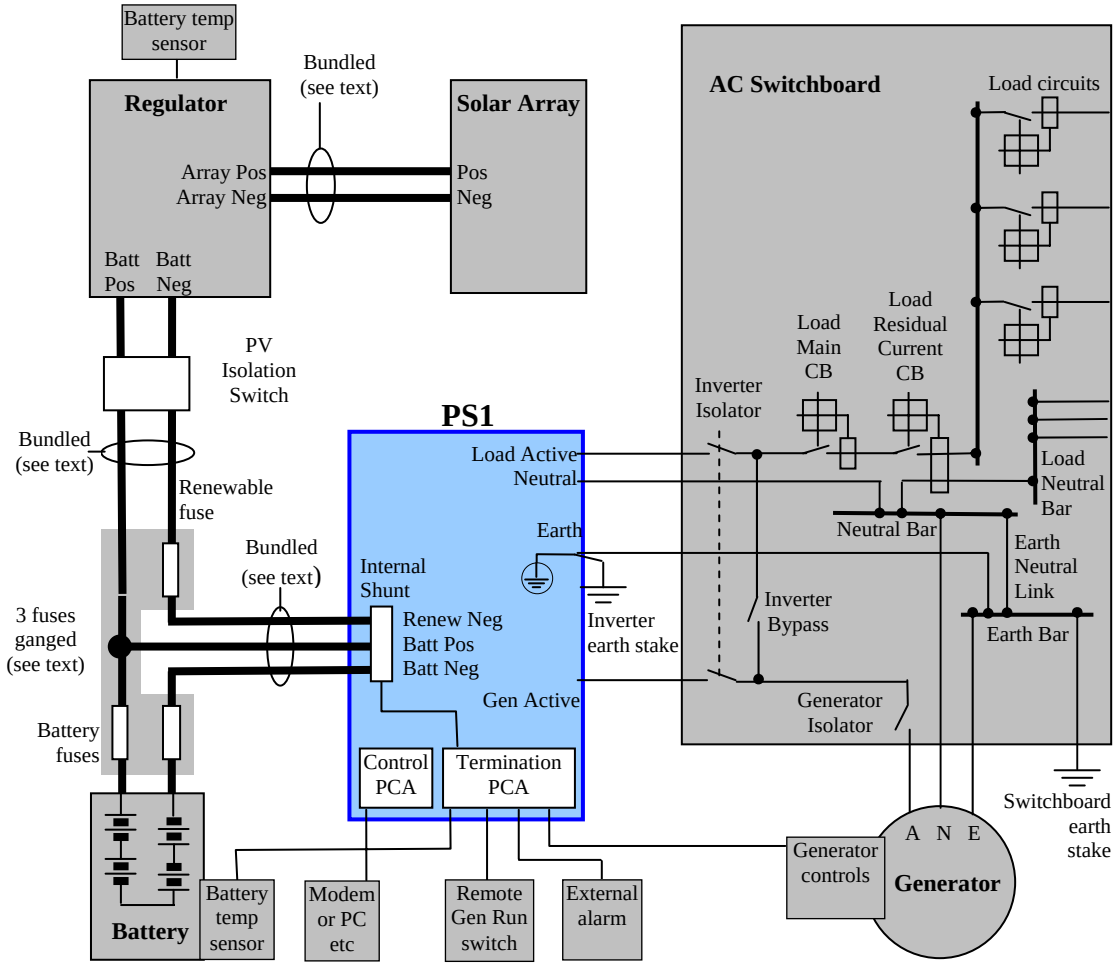


Figure 1 External Wiring Schematic 1

Figure 2 is a typical schematic of wiring connected to the inverter with the generator wiring connected directly to the inverter rather than via the site switchboard. Isolation of each component must be performed at different locations. The generator cannot be connected directly to the loads without going through the inverter.

Note: This schematic is intended to guide the designers of systems using the inverters. Do NOT use this typical schematic to trace actual site wiring, which may differ in detail from that shown below.

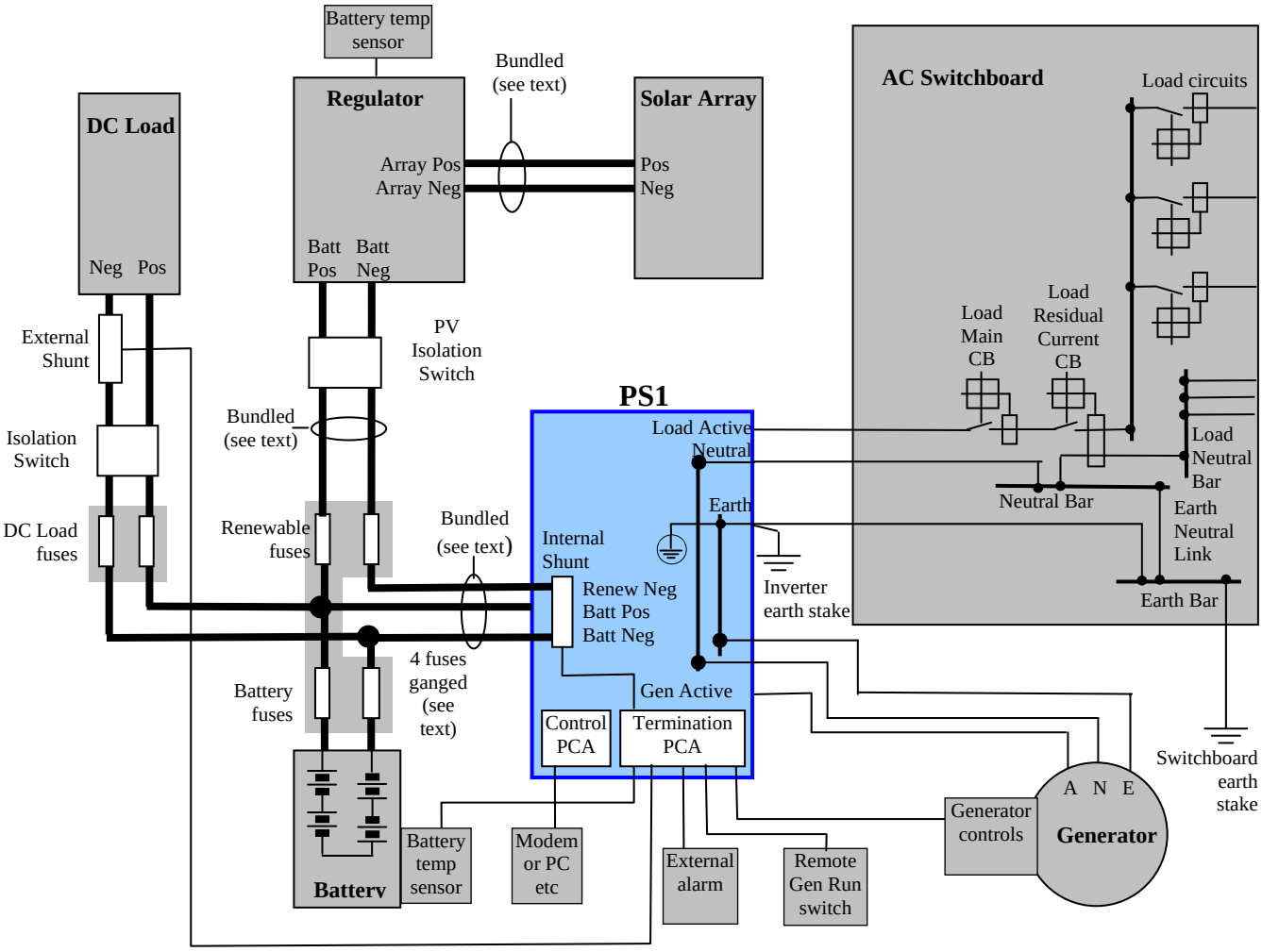


Figure 2 External Wiring Schematic 2

3.2 DC Power Wiring

The following sections refer to the 3.1 External Wiring Schematic.

3.2.1 Fuses

The battery fuses shown (or circuit breakers if desired) are necessary to protect the DC wiring. The fuses should be rated to handle the maximum current flow during normal operation. The renewable fuses should be rated to protect the wiring from back feed from the battery. The fuse ratings should be coordinated with conductor sizes and temperature ratings.

For recommended fuse sizes refer to §A.8 Battery Fuse Recommendation.

It must not be possible to supply renewable power to the inverter with the battery disconnected, since the inverter can be damaged by uncontrolled sources which are not voltage-limited by the battery. Therefore the renewable and battery fuses should be "ganged" together in one physical assembly to ensure they are all removed together.

The removable ganged fuse assembly also allows isolation of the renewable source, the battery and the inverter from each other before working on them.

To prevent dangerous DC arcs, it must be possible to ensure that negligible DC current is made or broken when connecting or disconnecting any DC Power Wiring. For example before working on the battery wiring, the inverter is switched off via its **On/Off** button, the renewable regulator is switched off, and the battery is isolated from the renewable source and from the inverter by removing the ganged fuse assembly.

3.2.2 DC Cables

The high current wiring within the battery stack, and between the battery and the inverter, should be as direct as possible, with the positive and negative cables bundled close together. This minimizes the wiring inductance which assists the overall efficiency of the inverter system.

For recommended battery cable sizes refer to A.6 Battery Cable Recommendation.

The DC terminals for battery and shunt connection are M8 studs. Suitable lugs must be used for connection to these studs.

Similarly the high current wiring between the battery and the renewable regulator, and between the regulator and the renewable array, should be bundled and as direct as possible.

The DC cabling should be kept separated from the AC cabling.

3.2.3 DC Earth and Lightning Protection

The system earthing strategy for lightning protection will depend on specific site characteristics hence is left to the judgement of the system designer/installer. The standard AS/NZS 1768 – Lightning Protection provides details of lightning protection schemes.

To reduce the risk of accidental short circuits, earthing the DC Power Wiring is not recommended. If the lightning protection scheme calls for the earthing of the DC wiring, the DC earth conductors must be separate the AC Earth system and the DC Earth cables must be capable of caring the battery fault current and blow the fuse before the earth cabling fails due to the fault current.

The control electronics are wired to battery negative.

3.3 AC Power Wiring

The following sections refer to the 3.1 External Wiring Schematic.

3.3.1 Circuit Breakers

The circuit breakers in the PS1 are designed to protect the wiring inside the PS1 and under normal operating conditions, including faults on sub circuits will not normally trip. External AC wiring must be protected with suitably rated external circuit breakers.

3.3.2 Residual Current Device

The Residual Current Device (RCD) installed in the AC Switchboard as shown protects the AC Load circuits ONLY. A fault in the inverter and/or the generator cabling is not RCD protected and hence will not trip the device RCD.

3.3.3 AC Cables

AC cabling must be sized appropriately for the application.

AC cabling should be kept separated from the DC cabling.

3.3.4 AC Generator Connection

The generator should be hard wired into the inverter system.

If the generator is to be plugged into the system, if disconnected while synchronised, voltage from the inverter may be present on the plug. In this arrangement the requirements of AS4509.1 must be adhered to.

3.3.5 Earthing

It is recommended the inverter be earthed to its own earth stake adjacent to the inverter, and also to the switchboard. Ensure the earth cable is suitable to carry the fault current and not fail before the circuit breakers trip. Using the same size conductors as the AC cables ensures the earth wiring will carry the fault current.

High Earth Leakage Current. Unit must be earthed before connecting to supply or operating unit.

Do not use the protective earth terminal for battery earthing.

3.3.6 Labelling

Multiple power sources (inverter and generator) which may start or re-start at any time provide power to the AC Switchboard. It is recommended that a warning label be fitted to all electrical power terminations at each location and to isolators feeding the location, together with a basic electrical diagram indicating the power sources and isolators.

Suggested warning label:

Multiple Hazardous Energy Sources
Ensure that all energy sources are isolated before working on connected wiring.
Inverter or Generator may Start Automatically
The generator may start or power may be restored by the inverter at any time.

A sheet of labels with the above text is provided with each PS1.

3.4 External Alarm Wiring

The external alarm is provided by an isolated NO/NC (normally open or normally closed) relay contact. This relay contact is NOT fused. Any external wiring connected to this contact must be fused to protect the wiring and relay contact.

See A.4 Alarm Interface Specification for contact ratings.

An alarm condition is indicated with the coil being de-energised. With the inverter in the Off state, the external alarm should be active.

The following is an example showing how a light could be connected to the alarm relay.

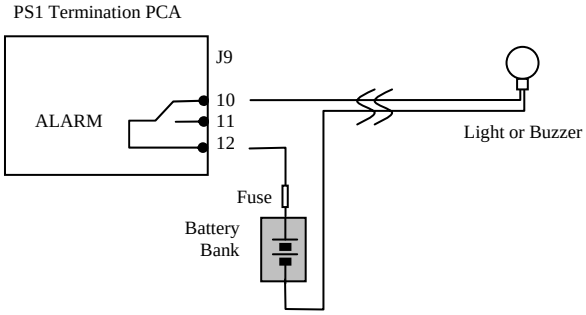


Figure 3 External Alarm

3.5 Generator Control Wiring

3.5.1 Wiring Diagrams

There are many different generator controllers and generator start/stop control schemes. The PS1 generator controller has been designed to interoperate with as many different types of controller as possible. Depending on the type of controller these wiring diagrams will need to be adapted to suit the particular controller.

All diagrams include a Generator Available control switch. This switch should be located as close as practicable to the generator. This switch is used to prevent the PS1 automatically starting the generator whilst being serviced. When in the open state (as shown) the PS1 will indicate that the generator is not available and will not attempt to automatically start the generator.

The diagrams also include information regarding other control inputs to the PS1. They are shown separately on each diagram for clarity only – they may be used together or in any combination.

See A.3 Generator Control Interface Specification

3.5.1.1 Generator Run by contact closure

The following diagram shows a generator controller that only requires a voltage free contact closure to run and stop the generator.

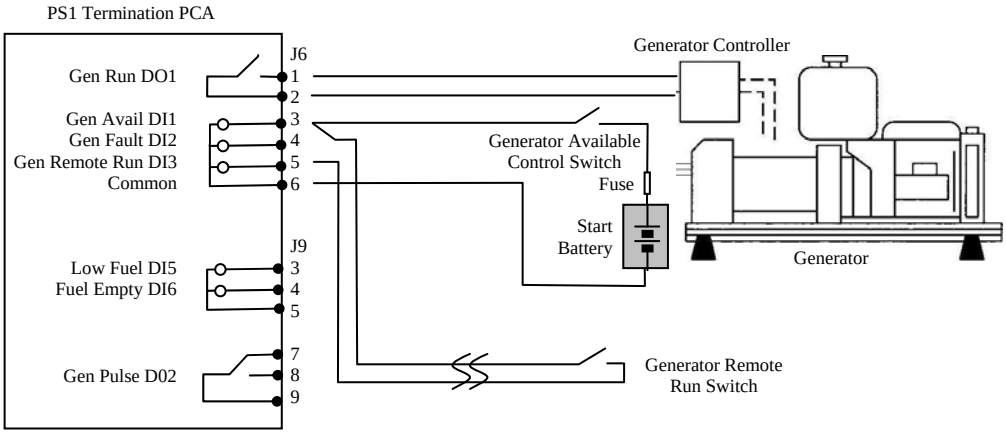


Figure 4 Generator Run

The diagram also includes a generator remote run switch. Closing the switch will cause the PS1 to start the generator. This switch can be located in a convenient place away from both the generator and PS1.

3.5.1.2 Generator On and Start by contact closures

The following diagram shows a generator controller that requires a voltage free contact closure to turn the generator ON and a pulsed control to start the generator. The time between when the Run relay closes and when the Pulse relay closes is adjustable and for how long the pulse relay remains closed is also adjustable.

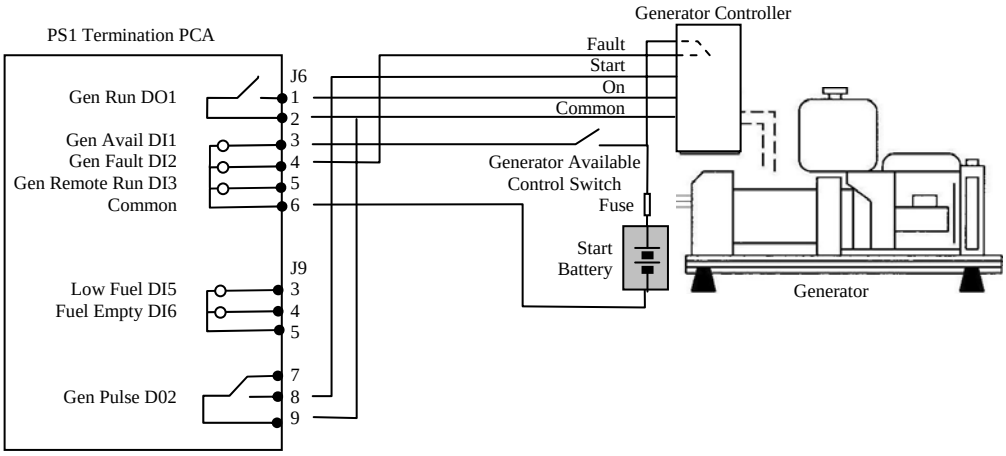


Figure 5 Generator On Start

This diagram also includes an input from the generator indicating the generator has a fault. In this diagram the fault output is a voltage free relay contact from the generator controller. It is necessary in this case to feed volts from the start battery through this and then to the fault input.

3.5.1.3 Generator Pulsed On and Off by voltage inputs

The following diagram shows a generator controller that requires high level voltage input on one control line to start the generator and a high level voltage input on a separate control line to stop the generator. In this case the control signals must be transposed so the pulse signal is on DO1 and the run signal is on DO2.

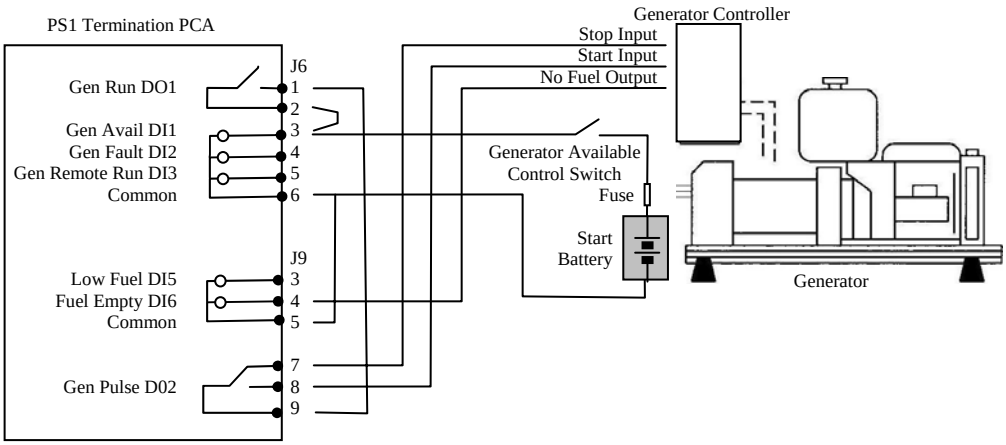


Figure 6 Generator Pulse Start Pulse Stop

This diagram also includes an input from the generator indicating the generator has run out of fuel. In this diagram the no fuel is a high voltage level output which feeds directly into the PS1 input. Note that the additional common connection has been connected back to the start battery negative.

3.5.2 Control Signals

The generator run and the generator pulse signals are provided by either an isolated NO or NO/NC relay contact. These relay contacts are NOT fused. Any external wiring connected to these contacts must be fused or limited by other means to protect the wiring and relay contact.

These are control outputs only and not designed to take high generator running or start currents.

See A.3 Generator Control Interface Specification for contact ratings.

The generator control input signals are provided by current limited control inputs. These inputs are NOT fused. Any external wiring connected to these inputs must be fused or limited by other means to protect the wiring and control input.

See A.3 Generator Control Interface Specification for input ratings.

3.6 Shunt Wiring

3.6.1 Wiring Diagrams

The diagrams are indicative only. Each site will have differing requirements and these diagrams will need to be adapted to suit the required configuration.

The PS1 provides one internal shunt connected between the Renewable Negative and Battery Negative terminals as shown in Figure 8.

3.6.1.1 Renewable Only – Shunt 1

The following diagram shows a basic configuration with the renewable connected and monitored by Shunt 1. The regulator output and the battery are connected in parallel, via the PS1 Shunt 1 which is to be used to measure the renewable current. The Shunt settings do not need to be changed as this is the default configuration.

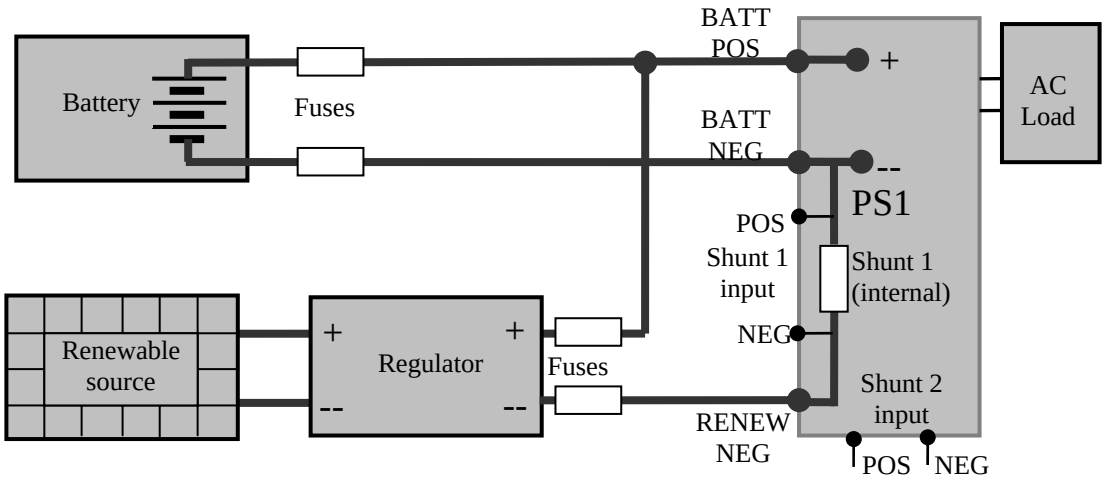


Figure 7 Renewable Connection

Since Shunt 1 is used to measure the renewable input no additional shunt sense wiring is required.

3.6.1.2 Renewable and DC Load – Shunt 1 and Shunt 2

In Figure 8 the internal shunt is used to monitor the renewable source using via shunt input 1. The Shunt 1 menu setting is configured to **`Renewable ON`** and **`DC Load OFF`** hence will interpret the measure current as a renewable source current. A DC load connected to the battery and regulator can be monitored by the PS1 using an external shunt via shunt input 2. The Shunt 2 menu setting is configured to **`DC Load ON`** and **`Renewable OFF`** and hence will interpret the measure current as a load current.

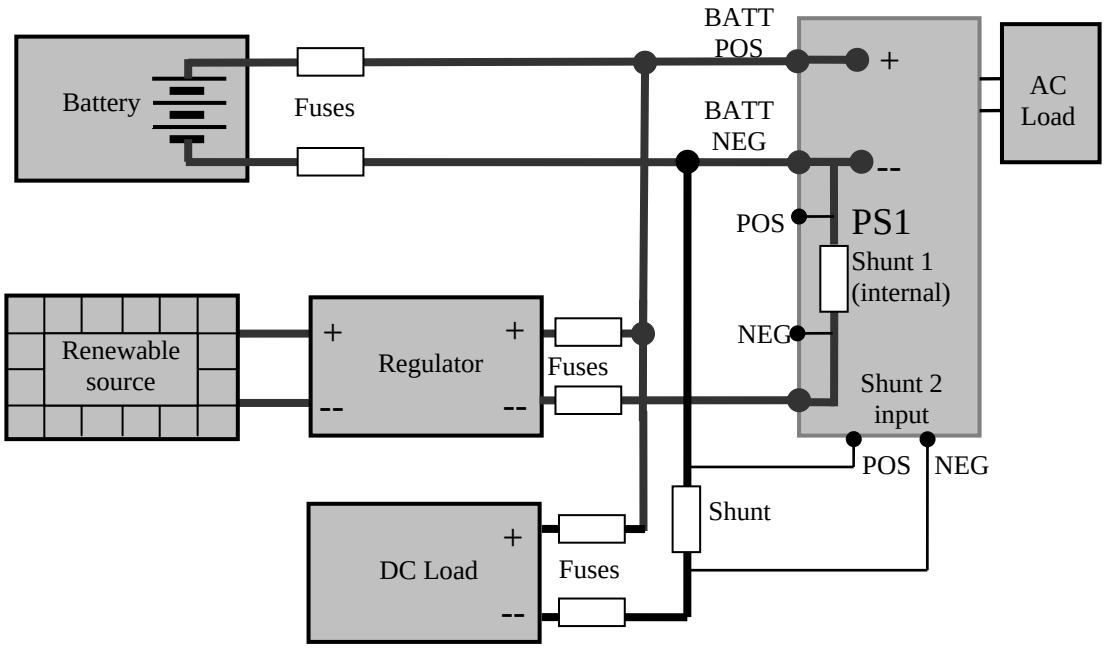


Figure 8 Monitoring Renewable and DC Load

3.6.1.3 Net Renewable and DC Load – Shunt 1 Only

In Figure 9 the internal shunt is used to monitor the renewable source and the DC load using an internal shunt via shunt input 1. The Shunt 1 menu setting is configured to **`Renewable ON`** and **`DC Load ON`** and hence will interpret a positive measure current as a renewable source current and a negative measured current as a load current. The overall result is the net current into the battery.

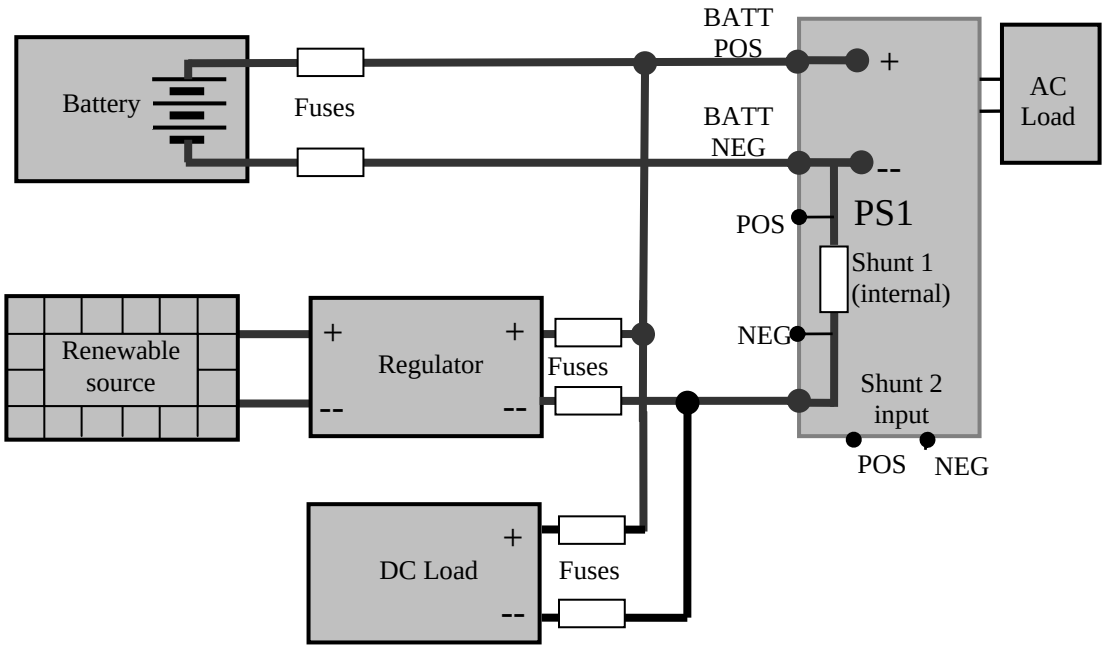


Figure 9 Monitoring Net Current with Shunt 1

3.6.2 Shunt Inputs

The shunt monitoring is provided by two high impedance differential inputs – Shunt 1 and Shunt 2. These inputs are NOT fused. Any external wiring connected to these inputs must be fused or limited by other means to protect the wiring and shunt input.

See A.5 Shunt Interface Specification for input ratings.

The internal 100A/50mV shunt is factory connected to the Shunt 1 input. This may be disconnected and used to monitor an external shunt as required.

Both Shunt 1 and Shunt 2 can be wired and configured to monitor a renewable source, a DC load or both simultaneously resulting in a net current reading. See §6.5 Shunt Settings for details of configuration options.

4 Installation

PS1 installation should be performed only by suitably trained and qualified personnel.

Ensure that the installation site is in accordance with 2 Site Selection.

4.1 Inspection

Before shipment the PS1 was rigorously tested and dispatched in perfect working order. Due to the freight distances and handling involved, the inverter should be inspected as follows before installing it or connecting power to it:

1. Inspect packaging for signs of damage.
2. Remove packaging from unit and examine the inverter case and ensure there are no obvious signs of damage.
3. Remove the PS1 from the shipping pallet by removing the two (2) bolts underneath the pallet.
4. Inspect the top of the pallet and the underneath of the PS1 and ensure there are no obvious signs of damage.
5. With a suitable screwdriver unscrew the two front door retaining screws and open the door, to view the various Printed Circuit Board Assemblies (PCA), interconnecting cables and connectors. See 7.1 Inverter Internal View.
6. Check all cable connectors to ensure they are properly seated in their sockets. Avoid pulling on the cables or straining their connections. Note: Three pin cable under Power PCA is not connected.
7. Visually check all connections to circuit breakers and contactors.
8. If all connections are sound and there are no signs of damage to the inverter cabinet, proceed with installation. If there are problems, please contact the inverter distributor.

Please retain the inverter packing material for use if the inverter needs to be shipped.

4.2 Mounting

The PS1 can be shelf or wall mounted. One half of the wall mounting bracket is pre assembled to the PS1. This may be removed if not required.

The mounting position must ensure an adequate airflow. A minimum clearance of 150mm must be provided adjacent to the ventilation inlet and outlet areas (see Appendix A.9 Mechanical Details for ventilation area details).

The shipping pallet must not be used for mounting the PS1.

All wiring to the PS1 must pass through the inverter bottom. Ensure the mounting position allows for all of the required cabling, taking note of the minimum bend radius of heavy DC wiring.

The PS1 is heavy. Ensure appropriate lifting techniques and mechanical lifting aids are used when moving and mounting the PS1. Four eye bolts (provided) can be screwed into the top of the PS1 cabinet for attaching a lifting harness. Unscrew and remove the four M4 hex bolts and the fibre washers from the top of the cabinet and retain. Screw the four eye bolts with the fibre washers into position. The eye bolts should be removed and the hex bolts replaced when the mounting has been completed.

4.2.1 Shelf Mounting

For shelf-mounting, the inverter can simply sit on the shelf, or can optionally be bolted to the shelf via M8 bolts up into the inverters rubber feet. See A.9 Mechanical Details for feet locations. It is recommended that the PS1 be bolted into position.

The shelf must allow for the wiring beneath the inverter.

4.2.2 Wall Mounting – Hanging Bracket

The wall mount position must be on a concrete or masonry wall using at least five (5) 8mm bolt diameter Dynabolt sleeved anchors or equivalent of suitable length for the wall material, evenly spaced and fitted according to manufacturer's instructions.

Wall-mounting procedure:

- The cabinet mounting bracket and two rubber bumpers are attached to the rear of the PS1 during manufacture. Verify all bracket mounting bolts are tight.
- Mount the Rear Hanging Bracket. Use the bracket as a template, with the bracket horizontal, mark the hole positions on the wall. At least five evenly spaced mounting holes must be used.
- Install the anchors as per the anchor manufacturer's recommendation.
- Raise the PS1 and lower it onto the hanging bracket ensuring the location slots in the cabinet mounting bracket mate with the hanging bracket location tongues.
- Rest the lower portion of the PS1 against the wall on the two rubber buffers.

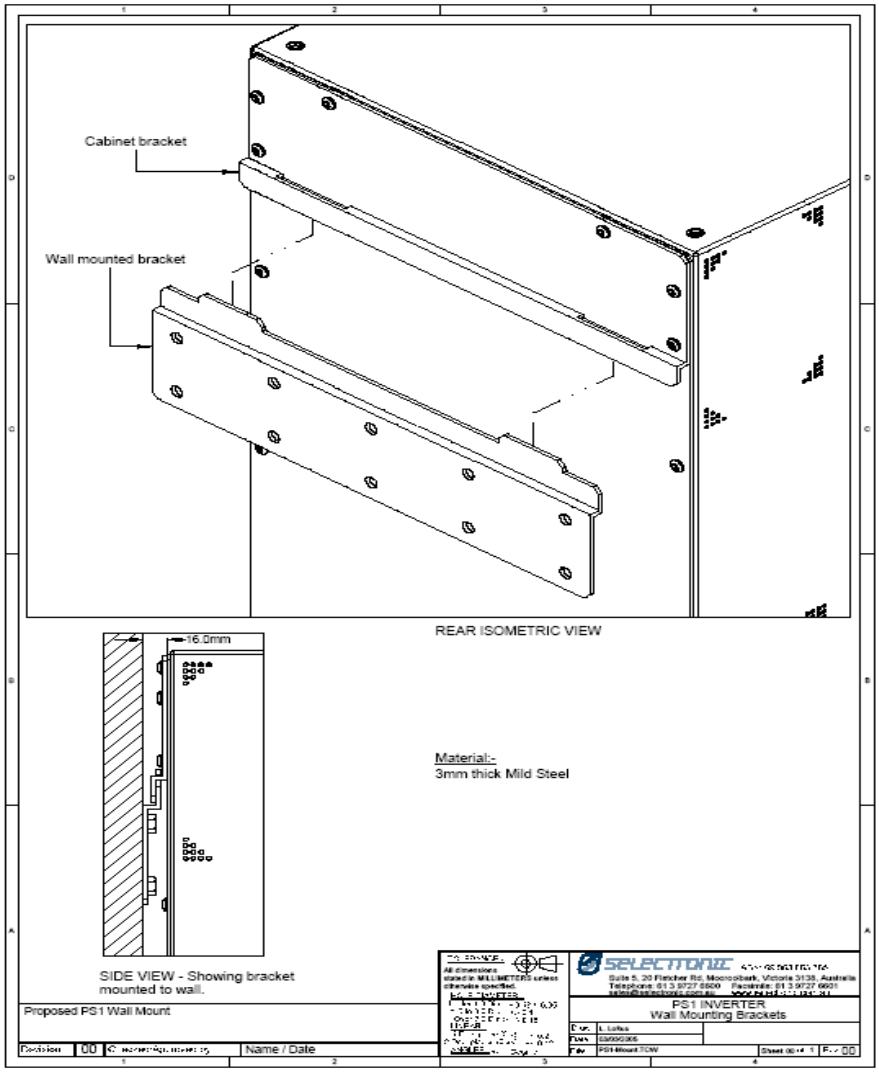


Figure 10 Wall Mounting Brackets

The PS1 stays in position due to its own weight.

4.3 Additional Componentry

If any additional components are to be installed into the PS1 cabinet, they may be installed onto the raised DIN rail. Take care to ensure that any disturbed internal wiring is re-connected to the same location. Special attention is drawn to the small EMI leads fitted into the top of the AC and DC circuit breakers and into the top of the neutral terminal.

DO NOT DRILL into the internal chassis of the PS1. The primary transformer is located directly behind the chassis. The un-used pressed inserts in the chassis may be used to mount additional components. Use the shortest possible (6mm) M4 Zinc Plated Steel screws.

Ensure that hazardous voltages cannot contact with the chassis or any other wiring. Check the clearance of additional components to ensure the door will close correctly.

DO NOT utilise the chassis earth screw and stud points for any mounting or additional earth wiring.

4.4 Wiring

This section provides information regarding the wiring of the PS1 only.

Ensure all wiring is de-energised when making connections to the PS1. Ensure other power sources cannot automatically start and energise wiring.

All wiring feeds up through the bottom of the PS1. A gland plate and cable gland nuts are provided for the installation of all cable. Any unused cable cut-outs should be fitted with gland plugs to keep out vermin.

Suitable grommet edging material should be fitted to protect the wiring from sharp edges.

See Appendix A.9 Mechanical Details for cut-out details.

Wiring locations referred to in the following sections are indicated in Figure 11 DC and AC Wiring Locations and Figure 12 Control Wiring Locations below. The same labels are also on the inside door of the PS1.

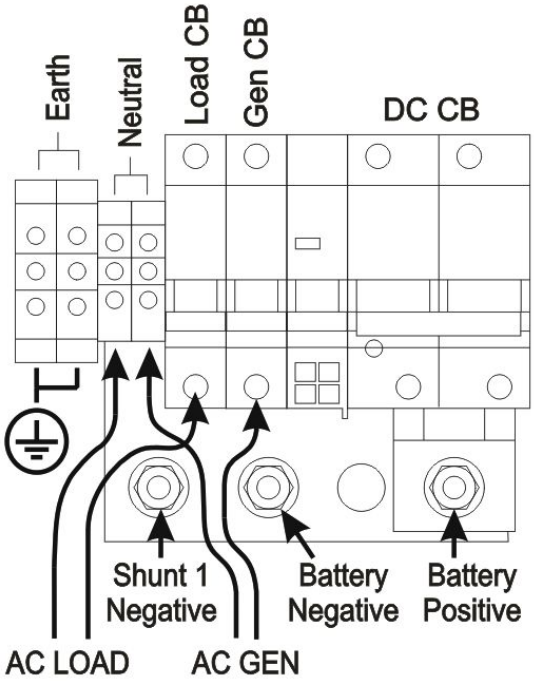


Figure 11 DC and AC Wiring Locations

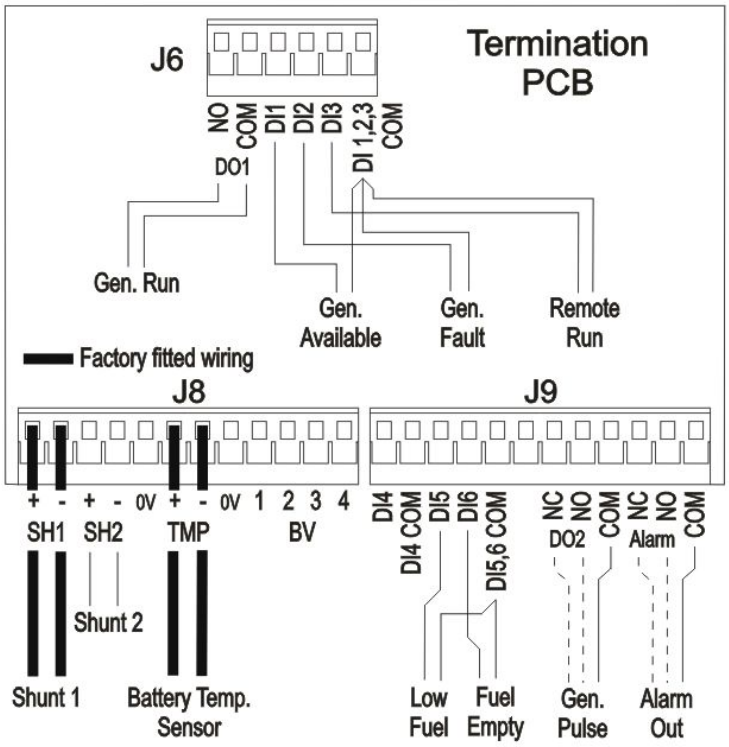


Figure 12 Control Wiring Locations

4.4.1 DC Wiring

DC wiring should be fed up through the appropriate cut out and terminated to the PS1. Ensure the protective plastic cover remains in place after connecting DC cables.

Connect the lugged battery negative lead to the inverters Battery Negative terminal under the load washer ensuring the face of the lug is directly against the PS1 contact surface. Tighten the nut with a calibrated torque wrench to 8 Nm.

If required, similarly connect the renewable negative lead to the inverters Shunt 1 Negative terminal.

Similarly connect the battery positive lead to the inverters Battery Positive terminal.

4.4.2 Battery Temperature Sensor

A battery temperature sensor is supplied pre-wired within the inverter. Pass the sensor and its wiring out through the inverter bottom cut-out, and mount the sensor in thermal contact with the centre of the side of a battery. It is good practice to insulate the sensor from the ambient air by covering the sensor when mounted to the battery with insulating material.

If the sensor cabling is not long enough, disconnect the sensor wiring from J8 on the termination PCB and add the additional cable. Ensure to insulate the joins.

The sensor is polarity sensitive – ensure that the correct polarity is maintained.

4.4.3 Shunt Monitoring

The sense wires for the externals shunts should be fed up through the appropriate cut out and terminated to the PS1. The sense cabling should be kept as short as possible. “CAT5” type cabling or any multi conductor multi strand cable is suitable for shunt sense wiring. Remember that these small cables are connected to battery negative and an inadvertent short circuit with either lead to battery positive would short circuit the battery bank. It is recommended that both these wires be separately fused.

The polarity of these shunt leads is not important if the shunt is to be used for either a renewable input or a DC load. The shunt settings compensate for the direction of current flow. If the shunt will be used to measure the Net between renewable and load then the polarity is very important. Ensure the positive shunt connection goes to the positive shunt sense and that the current is flowing in the correct direction.

See 6.5 Shunt Settings.

4.4.4 Earth Wiring

Earth the inverter by connecting earth wiring from the switchboard earth stake to the inverter earth stake, and from the inverter earth stake to the inverter Earth terminal.

4.4.5 AC Wiring

AC wiring should be fed up through the appropriate cut out and terminated to the PS1. Ensure the protective plastic cover over the DC connections remains in place.

Connect the AC load wiring to the PS1: earth to either earth terminal, neutral to either neutral terminal, and active to the Load Circuit Breaker.

Connect the AC generator wiring to the PS1: earth to either earth terminal, neutral to either neutral terminal, and active to the Generator Circuit Breaker.

4.4.6 Generator Control

Generator control wiring should be fed up through the appropriate cut-out and terminated to the PS1. "CAT5" type cabling or any multi conductor multi strand cable is suitable for all control wiring. The green screw terminals can be plugged in and out of the termination PCA for ease of wiring.

Check what the generator controller requires to start and stop the generator and what type of outputs it provides. See A.3 Generator Control Interface Specification.

4.4.6.1 Minimum Control Wiring

The generator run output must be connected so the PS1 can signal the generator to start and stop.

The generator available input should be fitted to indicate the generator is available to be automatically started. If not fitted, the generator available override in the software must be set to ALWAYS. See 6.3 Generator settings.

Without the generator available installed, ensure that the PS1 start signal does not start the generator when working on or servicing the generator.

4.4.7 External Alarm

Connect the External Alarm wiring to the inverter. "CAT5" type cabling or any multi conductor multi strand cable is suitable. The green screw terminals can be plugged in and out of the termination PCA for ease of wiring. Ensure appropriate fuses are fitted to protect the wiring and relay.

The alarm should activate since the inverter is presently out of service.

4.4.8 Serial Port cable

The serial port cable should be connected into J16 on the Control PCA (see Figure 14 Behind Front Door) and fed out through an appropriate cut-out. This allows for connection to the internal serial port without the need for opening the PS1 front door. This cable can be left unconnected if not required. The serial port is isolated from the PS1 and no hazardous voltages are present on the interface cable.

When installed check that the cable does not foul on any internal cables or components.

5 Commissioning

This procedure is for the test and commissioning of the PS1. It does not cover other components in the system however many of the tests described may exercise those components.

5.1 Inspection

No power should be applied at this stage.

5.1.1 Wiring

All connected wiring should be checked and tested for continuity and short circuits.

Check that no wiring feeding through the bottom cut-out is pressing against any sharp edges.

Check that any removed screw terminal plugs from the Termination PCA have been re-connected, correctly aligned and are pressed firmly home.

Ensure that the DC stud insulating cover is in place.

Check that the DC and AC wiring is separated as much as possible.

5.1.2 Polarity

Ensure battery polarity is correctly wired to the PS1.

Ensure Active and Neutral terminals are correctly connected.

5.2 Initial Power Up

Read and understand the procedure below before proceeding.

Ensure that all the inverters front panel DC and AC circuit breakers are open. Renewable inputs should not be connected at this stage. Ensure that the connected generator is shutdown and cannot start.

5.2.1 Door Open

Hazardous voltages are generated by the inverter and may also be fed into the inverter by external wiring from multiple sources. The hazardous voltages may be stored in capacitors after the inverter is switched off and disconnected from external wiring. The procedures below are to be performed only by suitably qualified and trained personnel, taking appropriate safety precautions.

The initial DC connection is performed with the door open. The inverter's front panel DC Circuit Breaker remains open during this step.

Apply DC power to the inverter wiring by closing the external ganged battery/renewable DC fuse assembly (or circuit breakers if used) - a small spark may be observed. Stop immediately and investigate if any fuse blows or circuit breaker trips.

Check the RED LEDs on the lower edge of the power board. See 7.1 Inverter Internal View

LED1 should be ON

LED2 should be OFF

If LED1 is off, either power is not connected to the unit or the DC is connected in the reverse polarity. DO NOT proceed until this corrected.

If LED1 is flashing, the connected DC voltage is incorrect. This is sometimes due to the initial power connection. Press the front panel ON/OFF button once to reset the unit. LED1 should now be ON. If LED continues to flash check battery voltages.

5.2.2 Door Closed

The front panel door should now be latched closed.

Press and release the PS1 On/Off button. The indicator LEDs will come on and flash during self test.

When the LCD displays "Please close DC CB", close the PS1 front panel DC Circuit Breaker. The self test will complete and the PS1 will start. A low buzzing noise will be heard from the PS1.

The PS1 will now be producing 240VAC 50Hz output.

If self test fails, the error code will be displayed on the front panel LCD. See B.3 Self Test Fault Codes for details.

Check the View Readings screens – (see PS1 User Manual)

Reading	Menu Reference #
Battery voltage and current readings	1.1
Power readings should all be 0	1.2
Temperatures should be close to ambient	1.6.1

5.3 Configuration

The PS1 is configured with default values for all settings; at least some of these are likely to be unsuitable for your installation. Access the Installer menus via the front panel LCD and set up the system parameters to suit the site requirements.

Importantly, before using the system, ensure that the settings for **`Batt Size Ah`** (6.2 Battery Settings) and **`Gen:Max kW`** (6.3 Generator settings) are configured to suit the battery and generator size installed, and that all battery charger settings (6.6 Charger Settings) are suitable for the battery type installed and conform to the battery manufacturer's recommendations.

If the Batt Size Ah setting is modified it is necessary to power cycle the PS1 for the correct SoC calculations to be displayed.

The PS1 incorporates a number of other settings that effect the system operation. The following should be considered when setting the system to suit the site requirements

- SoC generator start levels and times - See 6.3 Generator settings
- Load power generator start levels - See 6.3 Generator settings
- Minimum generator run time – See User Manual
- Frequency and voltage tolerance for generator input. Note: Some generators have low frequency cut-outs; the Low Freq Tol must be set above these limits. When setting the voltage and frequency limits, allowance must be made for the difference in frequency and/or voltage when the generator is cold. The default low frequency tolerance is 48.0Hz. See 6.4 AC Output settings

5.4 AC Load

Ensure all circuits at the distribution board are open.

Close the AC Load circuit breaker on the inverter, while ensuring there is no change in inverter operation.

Close each load circuit breaker at distribution board and load test the PS1.

Reading	Menu Reference #
Verify power readings as each load is applied	1.2

Open the AC Load circuit breaker on the inverter.

5.5 Generator Synchronisation and Stability

The objective of these tests is to set the highest Gen Type setting whilst still maintaining stable generator operation. Generally, a generator will operate satisfactorily with the PS1 set to Gen Type 0, however optimum generator performance (steady ramping to power and agile response to load change) may not be achieved at this setting.

Stable generator operation is defined as when there is no oscillatory variation or "bouncing" in the generator output. On abrupt changes in load, the generator may "bounce" briefly and then return to stable operation. An easy way to detect "bouncing" is to look for flickering in a low wattage incandescent light globe connected to the system.

This procedure should be carried out with the battery bank partially discharged to enable the largest battery charge load to be applied to the generator. Ideally the inverter will be limiting on battery charge current with battery voltage below the charge voltage.

5.5.1 Configuration

If a generator available control switch has been installed, then set it to the open position. See 3.5 Generator Control Wiring. No other configuration of the generator control relays or inputs is required.

Set Gen Type to 0 (Default setting). See 6.3 Generator settings

Check the front panel LED indication Gen NOT available. This must be ON. By default with no generator control wiring the indication is ON. If OFF, check generator available control switch (if installed) and Gen Avail setting is "Follow I/P" (Default setting). See 6.3 Generator settings

Manually start the generator.

5.5.2 Test – Generator Synchronisation

Once the generator has started, close the generator circuit breaker.

The PS1 will attempt to synchronise and connect to the generator. The PS1 will display Manual Gen Start when synchronised and the front panel LED indication "Inv – Sync" will be active.

If the generator voltage and/or frequency is out of range the Gen Freq Error or Gen Volt Error LED indications will be active. If required, adjust 6.4 AC Output settings

5.5.3 Test – Generator Stability

The inverter will start to apply load to the generator by ramping up the charge power to the battery bank. Check that the generator remains stable through this process.

If the generator is stable, close the AC Load circuit breaker and then switch various AC loads ON and back OFF again. The AC loads will be firstly powered by the inverter and then transferred to the generator. Check that the generator remains stable through this process.

If the generator is not stable on Gen Type 0 – See 9 Troubleshooting

Press and hold the 

button for one second. The PS1 will display Gen NOT Available then Manual Gen Stop. The PS1 will disconnect from the generator. Since the generator is still running, the PS1 will however attempt to re-synchronise.

Open Generator circuit breaker.

If a Gen Type proves unstable, then there is no need in testing the remaining types. In this case, set the Gen Type back to the previous setting.

To ensure the charging process is reset, it is necessary to wait at least two minutes between each test.

Repeat the steps 5.5.2 and 5.5.3 above with Gen Type set to 1, 2 and 3 to determine the most suitable setting for the generator.

Once the correct setting has been achieved -

Manually shutdown the generator and open AC Load circuit breaker.

5.6 Automatic Generator Control

5.6.1 Configuration

Set the generator control relay configuration to suit the generator controller. Generator controllers using only the Gen Run signal do not require any changes. Controllers using the Gen Pulse signal may require the Pulse Time and Pulse delay times adjusted to suit. See 6.3 Generator settings.

5.6.2 Test

Check the front panel LED indication Gen NOT available. If ON, close the externally wired generator available control switch. See 3.5 Generator Control Wiring. If no control switch is installed (not recommended) set the generator available override in the software to ALWAYS. See 6.3 Generator settings.

Gen NOT available LED indication should turn OFF.

Press and hold the OK button for 1 second. The PS1 will display Gen Start and then display the PS1 voltage and frequency and generator voltage and frequency plus the variation in generator frequency.

```
** Gen Starting **
      240       251
    50.00     52.38
Delta Gen Hz    0.47
```

If the generator fails to start, press and hold the OK button for 1 second. The PS1 will display Gen Stop. Verify the generator control wiring.

Once the generator has started, close the generator circuit breaker.

The PS1 will attempt to synchronise and connect to the generator. Check the front panel LED indications for Inv – Sync indication. If the generator voltage and/or frequency is out of range the Gen Freq Error or Gen Volt Error LED indications will be active.

Reading	Menu Reference #
Verify generator, inverter and load power readings.	1.2

Press and hold the OK button for 1 second. The PS1 will display Gen Stop. The PS1 will attempt to stop the generator.

If the generator doesn't stop, check control wiring. Note: The generator may have a cool down period before stopping.

Open the externally wired generator available control switch. Ensure the front panel LED indication Gen NOT available comes ON.

Open Generator circuit breaker.

Check other control inputs (if fitted) to ensure the work as expected.

5.7 Shunt Inputs

5.7.1 Enable Shunts

The shunt inputs must be enabled and set to measure the renewable input or DC Load. If only the internal shunt (Shunt 1) is being used to measure renewable then no changed to the default settings is required. For other configurations, see 6.5 Shunt Settings and set the shunt configuration according to usage.

5.7.2 Zero Offset

Ensure no current is flowing through shunts.

Reading	Menu Reference #
Verify that the shunts connected are reading 0.0 +/- 0.1 Amps	1.3

If the reading is greater than 0.1Amps then the zero offset requires adjustment.

5.7.2.1 Set Shunt Zero Offset

The following screens can be found in 6.5 Shunt Settings.

The procedure is the same for Shunt 1 and Shunt 2. Shunt 1 is shown here as an example.

Set both shunt type settings to ON - Renewable and DC load to ON.
Set **`Shunt 1 A/mV`** to 1.0
Adjust **`Shunt 1 Zero`** to the negative of Shunt 1 amp reading. (e.g. reading +1.5 enter -1.5, reading -2.5 enter +2.5). The indicated Shunt Amp reading will reduce to 0 +/- 0.1. The Shunt Amp reading is averaged so the change can take up to a minute to settle to the new value.

```
Shunt1 Amp                  0.0
Shunt 1 Zero               -1.5
>          -5.0 <           5.0
PREV|NEXT              EDIT|MENU
```

Reset the shunt type (Renewable ON/OFF and/or DC Load ON/OFF) and shunt size settings as required.

5.7.3 Shunt Size

The size of external shunts must be configured into the PS1. Shunt 1 by default is set to the size of the internal 100A/50mV shunt.

The following screens can be found in 6.5 Shunt Settings.

The shunt size is set in Amps/mV or the number of amps flowing to give a 1millivolt reading.

The table below list some common shunt types and the associated setting:

Shunt	Setting
100A / 50mV	2.0
100A / 75mV	1.3
200A / 75mV	2.7
50A / 50mV	1.0

5.7.4 Shunt Readings

Connect renewable to unit.

Verify current readings are as expected. Compare the reading on the renewable regulator with what is indicated on the PS1.

Verify the sign (+ or -) of the reading. If set to DC Load reading should be negative, if set to Renewable reading should be positive.

5.8 System Operation

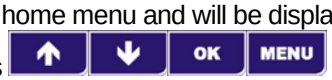
The PS1 is can now be set for normal operation. Close all circuit breakers and fuse assemblies.

Verify system operates as expected.

6 PS1 Installer Menus

6.1 Menu Structure

The PS1 provides two levels of menus to configure and manage the system. User Menus that are used for day to day operation of the system and Installer Menus are used to set up the system and thereafter are not generally required by or accessible to the user.

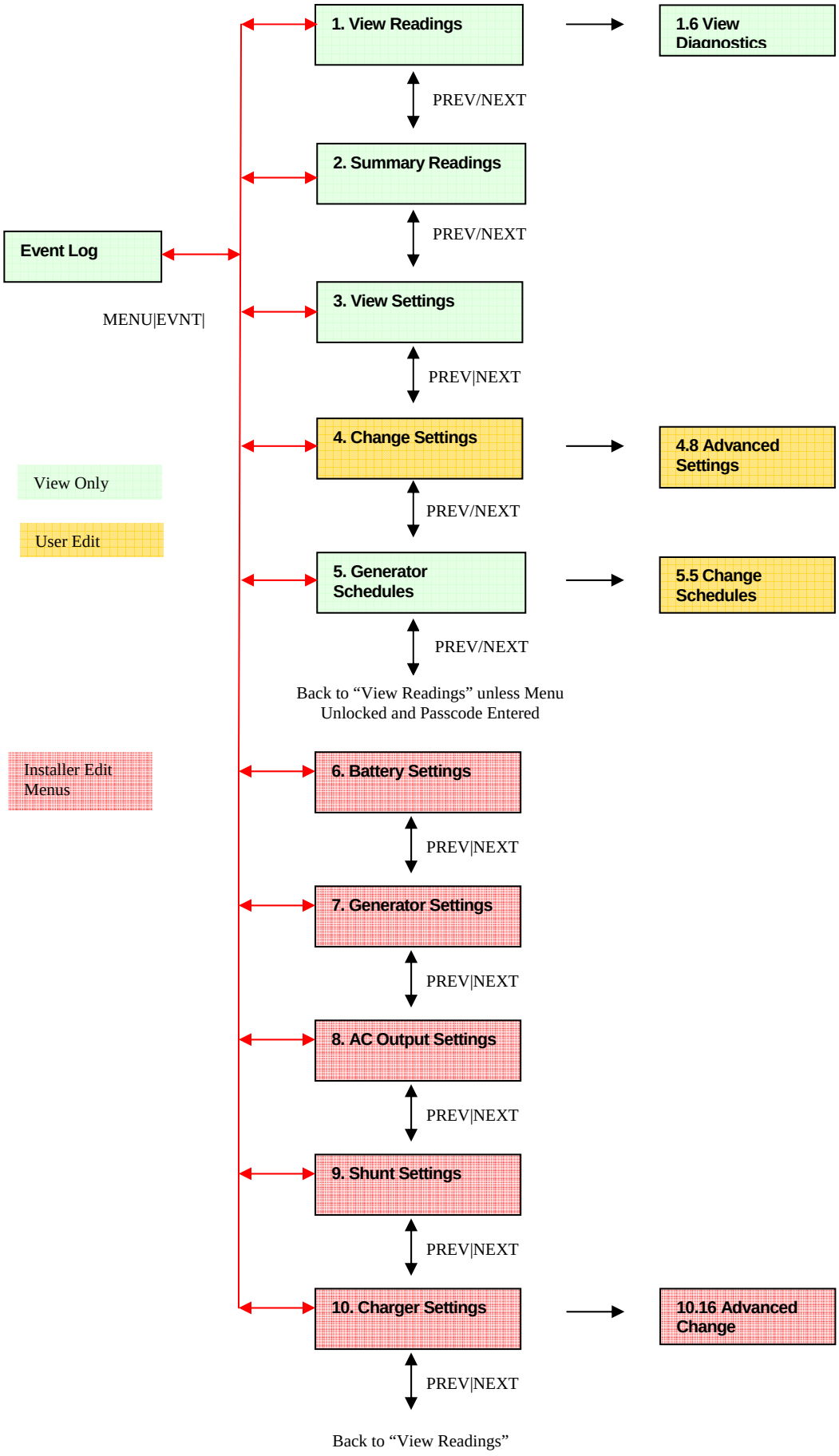
The diagram below shows the menus structure for the PS1 settings and readings. The View Readings menu is the home menu and will be displayed when the PS1 has completed power up. Use the four pushbuttons 

and associated LCD text to navigate the menu structure. Refer to PS1 User Manual – User Interface for full details.

The View Readings, Summary Readings, View Diagnostics, View Settings, Generator Schedules and Event Log menus allow viewing of system settings, readings and event history without the possibility of inadvertent modification. The information provided in these screens is sufficient to monitor the day to day system operation and resolve system problems. The Change Settings, Advanced Settings and Changes Schedules menu allow modification of the PS1 User settings and generator run schedules. Refer to PS1 User Manual – PS1 User Menus for full details.

The Battery Settings, Generator Settings, AC Output Settings, Shunt Settings, Charger Settings and Advanced Charger Settings menus allow modification of the PS1 Installer settings and are only accessible with installer access.

A screen number is written in this document with each display to assist with identifying the display e.g. 6.4 = Main Menu Item 6(Battery Settings), Sub Item 4(Lvl 3 SoC%).


1. View Readings
1.6 View Diagnostics
PREV/NEXT
2. Summary Readings
PREV/NEXT
Event Log
3. View Settings
MENU|EVNT|
PREV|NEXT
4. Change Settings
4.8 Advanced Settings
View Only
PREV/NEXT
User Edit
5. Generator Schedules
5.5 Change Schedules
PREV/NEXT
Back to "View Readings" unless Menu Unlocked and Passcode Entered
Installer Edit Menus
6. Battery Settings
PREV|NEXT
7. Generator Settings
PREV|NEXT
8. AC Output Settings
PREV|NEXT
9. Shunt Settings
PREV|NEXT
10. Charger Settings
10.16 Advanced Change
PREV|NEXT
Back to "View Readings"

6.1.1 Installer Menu Access

Installer settings are not accessible to the end user. Proper configuration of these settings requires in-depth knowledge of the system requirements and parameters. Only suitably qualified and trained installation, commissioning and maintenance personnel should access these menus.

To unlock the Installer menus:

1. Switch OFF the inverter using the **ON/OFF** pushbutton.
2. Open the inverter door and switch ON SW2 switch 7 on the Control PCA (see §7.1 Inverter Internal View).
3. Close the inverter door and switch ON using the **ON/OFF** pushbutton.
4. Edit the **Passcode** parameter in the Advanced User Settings menu.
5. Use the UP/DOWN buttons to enter the passcode (passcode is 41) and press OK.
6. The Installer menus will now be accessible for 2 hours.
7. The menus may be re-enabled after the 2 hours by repeating steps 4 and 5 above.

Subsequent unauthorised access to these menus by can be prevented by:

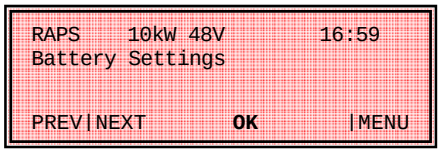
1. Switch OFF the inverter using the **ON/OFF** pushbutton.
2. Open the inverter door and switch OFF SW2 switch 7 on the Control PCA (see §7.1 Inverter Internal View).
3. Close the inverter door and switch ON using the **ON/OFF** pushbutton.

Failure to switch OFF SW2 switch 7 will allow a user, with knowledge of the static passcode, access to the installer menus.

6.2 Battery Settings

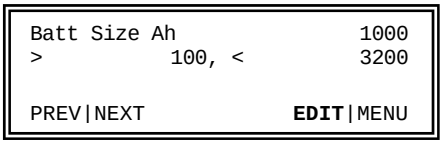
Refer to the battery manufacturer's recommendations when setting battery parameters. Battery longevity may be adversely affected by incorrect settings.

6.



Press OK to enter the View Settings screens. Within screens, press MENU at any time to return to this point.

6.1



Battery Settings=>

`Batt Size Ah:` set battery size in ampere-hours configured in the system. This will be set according to the battery size installed and the typical charge discharge profile.

Unit – Amp hours

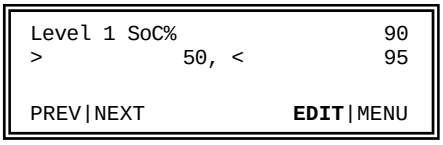
Default 1000

Range 100 -> 3200

It is important to correctly configure this setting as State of Charge calculations and system decisions are based on it.

Refer to the battery manufacturer's documentation when setting the parameter.

6.2



Battery Settings=>

See 8.1.3 Battery Charger Operation.

`Level 1 SoC%:` the battery state of charge below which the generator will start in the preferred generator run hour.

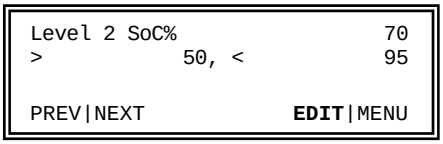
Unit - Percentage

Default 90

Range 50 -> 95

Level 1 is normally set as the highest SoC% level.

6.3



Battery Settings=>

See 8.1.3 Battery Charger Operation.

Level 2 SoC%: the battery state of charge below which the generator will start during the preferred generator run period.

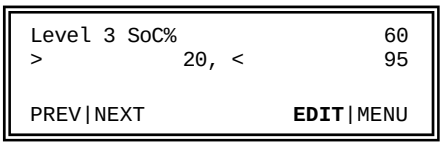
Unit - Percentage

Default 70

Range 50 -> 95

Level 2 is normally set as the mid SoC% level.

6.4



Battery Settings=>

See 8.1.3 Battery Charger Operation.

Level 3 SoC%: the battery state of charge below which the generator will start during the non-preferred generator run period.

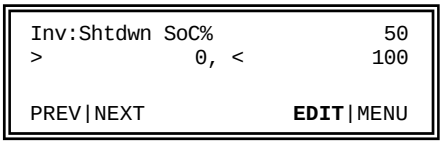
Unit - Percentage

Default 60

Range 20 -> 95

Level 3 is normally set as the lowest SoC% level.

6.5



Battery Settings=>

See 8.1.3 Battery Charger Operation.

Inv:Shtdwn SoC%: the battery state of charge below which the PS1 will be shut down to prevent over-discharge of the battery.

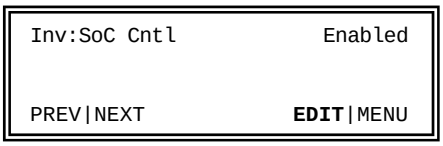
Unit - Percentage

Default 50

Range 0 -> 100

A value of zero means that state of charge is not used to trigger PS1 shutdown.

6.6



Battery Settings=>

See 8.1.3 Battery Charger Operation.

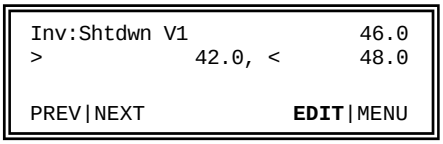
Inv:SoC Cntl: Inverter State of Charge Control enables or disables generator automatic starting based on the battery state of charge. If set to disable it overrides and disables the settings for parameters **Begin Lvl 1 Hr, Level 1 SoC%, Begin Lvl 2 Hr, Level 2 SoC%, Begin Lvl 3 Hr and Level 3 SoC%.**

Default Enabled

Options Enable, Disable

It is recommended that SoC% be used as the basis for battery charging and this setting remains enabled. This should only disabled if the SoC control is not suitable for the particular application. If disabled the PS1 would control the battery based on voltage only.

6.7



Battery Settings=>

Inv:ShtdwnV1: battery voltage at which the PS1 will shut down on load less than 10% of inverter power rating.

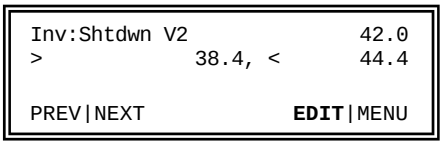
Unit – Volts DC

Default 46.0

Range 42.0 -> 48.0

The configuration for the generator start voltages (**Gen:Start V1** and **Gen:Start V2**) should be considered when setting this parameter.

6.8



Battery Settings=>

Inv:ShtdwnV2: battery voltage at which the inverter will shut down on load more than 10% of inverter power rating.

Unit – Volts DC

Default 42.0

Range 38.4 -> 44.4

The configuration for the generator start voltages (**Gen:Start V1** and **Gen:Start V2**) should be considered when setting this parameter.

6.9

```
Inv:Restart V              52.3
>            50.4, <       62.4

PREV|NEXT             EDIT|MENU
```

Battery Settings=>

Inv:Restart V: battery voltage that must be reached to recover from a Inv:Shtdwn V1 or V2 shutdown..

Unit – Volts DC

Default 52.3

Range 50.4 -> 62.4

Due to reduced load the battery voltage is likely to rise as soon as the inverter shuts down. Therefore this parameter should be set substantially above **Inv:Shtdwn V1** and **Inv:Shtdwn V2** so that shutdown is not re-entered immediately a load is applied.

With the inverter in the shutdown state, any battery recharge will be via renewable source or external charger.

6.10

```
Inv:Shtdwn HV              64.8
>            60.0, <       66.0

PREV|NEXT             EDIT|MENU
```

Battery Settings=>

Inv:Shtdwn HV:.Inverter Shutdown High Voltage is the upper limit of battery voltage.

Unit – Volts DC

Default 64.8

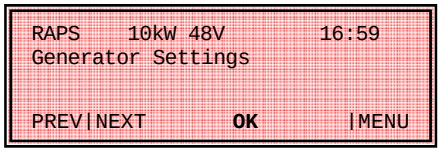
Range 60.0 -> 66.0

The inverter will shutdown when the battery voltage is above this limit and restart immediately the voltage falls back below this limit.

6.3 Generator settings

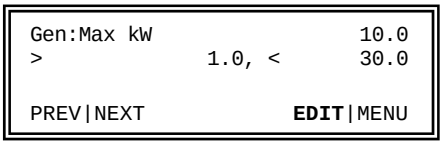
Refer to the generator manufacturer's recommendations when setting generator parameters.

7.



Press OK to enter the View Settings screens. Within screens, press MENU at any time to return to this point.

7.1



Generator Settings=>

Gen:Max kW: Generator capacity in kW connected to the system. The maximum power the PS1 is allowed to draw from the generator at 240VAC, 50Hz.

Unit – kilowatts

Default 10.0

Range 1.0 -> 30.0

Generators ratings are typically given in kVA at a particular power factor, typically 0.8. The value entered must be in kilowatts – multiply the kVA rating by the given power factor to obtain the kilowatt value to be entered.

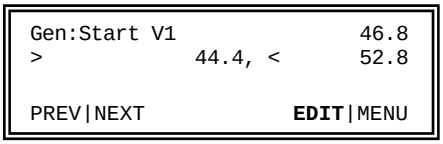
The ambient operating temperature of the generator should be considered and factored into when setting the maximum power limit.

The inverter will use this setting and the variation of generator output voltage and frequency from nominal (240VAC, 50Hz) to estimate the amount of power available from the generator - **Gen:Avail kW**. The PS1 will limit the power drawn by the inverter to **Gen:Avail kW**.

As the generator frequency and voltage vary above and below nominal, **Gen:Avail kW** will adjust higher and lower accordingly.

At nominal, the **Gen:Max kW** equals the **Gen:Avail kW**

7.2



Generator Settings=>

Gen:Start V1: battery voltage (for five minutes) below which the generator will be started on load less than 10% of inverter rating to prevent over-discharge of the battery.

Unit – Volts DC

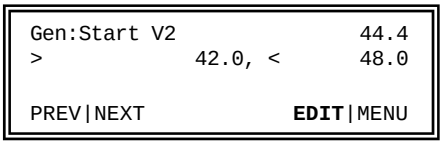
Default 46.8

Range 44.4 -> 52.8

The generator will run until the battery recharge cycle is complete.

The configuration for the inverter shutdown voltages **Inv:Shtdwn V1** and **Inv:Shtdwn V2** should be set to lower values than the generator start voltage.

7.3



Generator Settings=>

Gen:Start V2: is the battery voltage (for five minutes) below which the generator will be started on load more than 10% of inverter rating to prevent over-discharge of the battery.

Unit – Volts DC

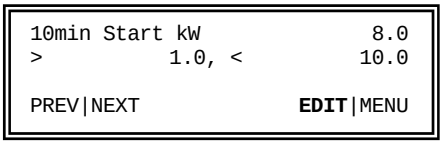
Default 44.4

Range 42.0 -> 48.0

The generator will run until the battery recharge cycle is complete.

The configuration for the inverter shutdown voltages **Inv:Shtdwn V1** and **Inv:Shtdwn V2** should be set to lower values than the generator start voltage.

7.4



Generator Settings=>

`10min Start kW`: 10 minute average load power setting to start the generator.

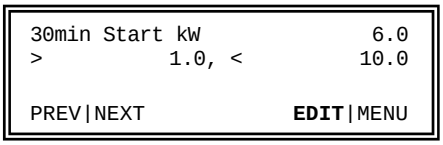
Unit – kilowatts

Default 8.0

Range 1.0 -> 10.0

The generator will run until the average power level is below the threshold or at least the minimum generator run time (**`Gen:Min Run min`**). The generator may continue to run due to other settings. See 8.3.4 Generator Automatic Stopping.

7.5



Generator Settings=>

`30min Start kW`: 30 minute average load power setting to start the generator.

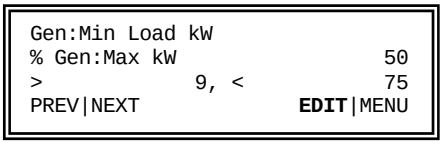
Unit – kilowatts

Default 6.0

Range 1.0 -> 10.0

The generator will run until the average power level is below the threshold or at least the minimum generator run time (**`Gen:Min Run min`**). The generator may continue to run due to other settings. See 8.3.4 Generator Automatic Stopping.

7.6



Generator Settings=>

Gen:Min Load kW % Gen:Max kW: The percentage of the Gen:Max kW setting, above which the inverter will keep the generator running to supply the load.

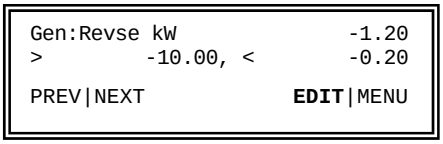
Unit – Percentage

Default 50

Range 9 -> 75

If the load is below this level, the generator will be stopped unless other stop conditions, such as battery charge cycle completion, are not met. See 8.3.4 Generator Automatic Stopping.

7.7



Generator Settings=>

Gen:Revse kW: Generator Reverse kW. The reverse inverter power limit after which the inverter will disconnect from the generator.

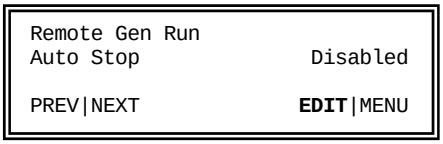
Unit – kilowatts

Default -1.2

Range -10.0 -> -0.2

If the generator fails while running, for example due to running out of fuel or is manually turned OFF, then AC power may flow into the generator and drive it as a motor causing the inverter to produce a reverse power flow i.e. back to the generator. This limit protects the generator from such a condition.

7.8



Generator Settings=>

`Remote Gen Run – Auto Stop`:

Default Disabled

Options Enabled, Disabled

This setting is active if the generator is started remotely via the Remote Run input. (See 8.4.1 Remote Run Input).

If Auto Stop is disabled then the generator will run for the time the input is active regardless of other factors.

If Auto Stop is enabled the generator will run for longer than the time the input is active until the battery charge cycle is complete.

The generator may continue to run due to other settings. See 8.3.4 Generator Automatic Stopping.

7.9

Generator Settings=>

`Gen Avail`:

Default Follow I/P

Options: Follow I/P, Always

If Generator Availability is set to Follow Input the inverter will use the state of the Gen Available input(DI1) to determine if the generator is available for automatic control.

If Generator Availability is set to Always the inverter assumes the generator is always available for automatic control regardless of the state of the Gen Available input(DI1).

See A.3 Generator Control Interface Specification

7.10

```
Ctrl Rlys              Standard

PREV|NEXT             EDIT|MENU
```

Generator Settings=>

`Ctrl Rlys`:

Default Standard

Options Standard, Transposed

Standard provides Gen:Run on DO1 and Gen:Pulse on DO2

Transpose provides Gen:Run on DO2 and Gen:Pulse on DO1

See §A.3 Generator Control Interface Specification

7.11

```
Gen:Pulse Delay               2
>            1, <            30

PREV|NEXT             EDIT|MENU
```

Generator Settings=>

`Gen:Pulse Delay`: Adds delay from the transition of the Gen:Run signal to the transition of the Gen:Pulse signal.

Unit – seconds

Default -2

Range 1 -> 30

See §A.3 Generator Control Interface Specification

7.12

```
Gen:Pulse Time                2
>            1, <            30

PREV|NEXT             EDIT|MENU
```

Generator Settings=>

`Gen:Pulse Time`: Adjusts the ON duration of the Gen Pulse signal.

Unit – seconds

Default -2

Range 1 -> 30

See §A.3 Generator Control Interface Specification

7.13

```
Gen Type                    0
>          0, <             3

PREV|NEXT            EDIT|MENU
```

Generator Settings=>

Gen Type: Generator Type selects a set of parameters for generator control.

Unit – count

Default 0

Range 0 -> 3

The type selected depends on the generators response to changes in load. Normally no change is required.

Types 0 – 2 parameters are fixed, type 3 has default parameters that are configurable via these menus.

The recommended procedure for adjusting Type 3 parameters is to base the initial setting of Type 3 parameters on the best performing of types 0 to 3 and then adjust the individual parameters to improve performance. The Proportional gain would be adjusted first, then the Integral gain.

Gen Type#	Prop. Gain	Integral Gain
0	30	250
1	40	235
2	60	220
3	80	200

7.14

```
Gen Type 3
Prop Gain                  80
>          5, <           255

PREV|NEXT            EDIT|MENU
```

Generator Settings=>

Gen Type 3 Prop Gain: Proportional power gain setting

Unit – count

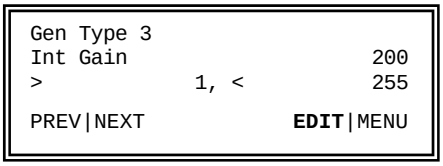
Default -80

Range 5 -> 255

This setting changes how rapidly the unit responds to changes in system load – 5:Unit responds slowly, 255:Unit responds quickly.

The proportional gain setting will have the greatest impact on stability.

7.15



Generator Settings=>

Gen Type 3 Int Gain: Integral power gain setting

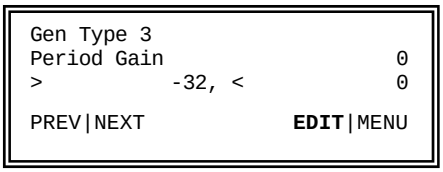
Unit – count

Default -200

Range 1 -> 255

This setting changes how quickly the unit will adjust to the required steady state or average generator power level – 1:Unit responds slowly, 255:Unit responds quickly.

7.16



Generator Settings=>

Gen Type 3 Period Gain: Period gain setting

Unit – count

Default -1

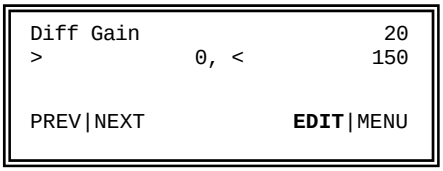
Range -32 -> 0

This setting is used to adjust how rapidly the unit responds to changes in generator frequency – 0: No change in response, -32:Unit responds slowly.

Normally this setting is not required to be changed.

Note: The period gain for Gen Types 0 – 2 is set at 0.

7.17



Generator Settings=>

Diff Gain: Differential gain setting

Unit – count

Default 20

Range 0 -> 150

This setting is used to reduce the amount of oscillatory variation or “bouncing” in response to changes in the generator power – 0: No effect, >0: Increasing effect.

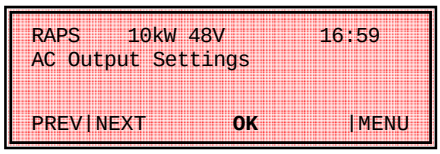
Normally this setting is not required to be changed.

Note: The differential gain applies to all generator type settings.

6.4 AC Output settings

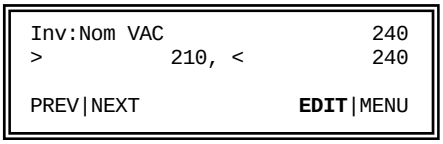
The AC Output setting allows the inverter AC output voltage to be changed and adjustment of generator tolerances.

8.



Press OK to enter the View Settings screens. Within screens, press MENU at any time to return to this point.

8.1



AC Output Settings=>

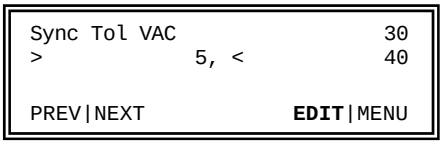
Inv:Nom VAC: the nominal output voltage of the inverter.

Unit – Volts AC

Default - 240

Range 210 -> 240

8.2



AC Output Settings=>

Sync Tol VAC: maximum generator voltage from **Inv:Nom VAC** the inverter will tolerate before switching to standalone mode.

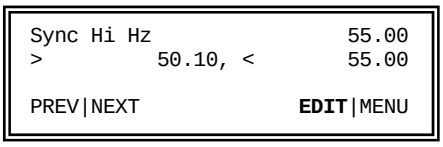
Unit – Volts AC

Default - 30

Range 4 -> 40

A setting of 30 at Inv:Nom VAC 240 allows the inverter to synchronise and remain synchronised with a generator voltage in the range of 210 to 270VAC or 240 +/- 30VAC.

8.3



AC Output Settings=>

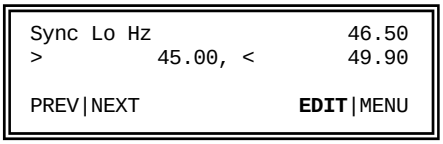
Sync Hi Hz: is the maximum generator frequency the inverter will tolerate before switching to standalone mode.

Unit – Hz

Default -55.00

Range 50.10 -> 55.00

8.4



AC Output Settings=>

Sync Lo Hz: is the minimum generator frequency the inverter will tolerate before switching to standalone mode.

Unit – Hz

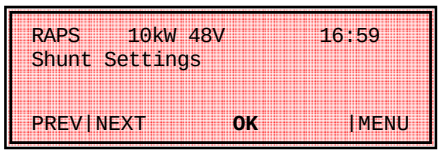
Default -46.50

Range 45.00 -> 49.90

6.5 Shunt Settings

The inverter provides two shunt inputs for monitoring of DC currents. These shunts can be used for renewable or load shunts.

9



Press OK to enter the Shunt Settings screens. Within screens, press MENU at any time to return to this point.

9.1

Shunt Settings=>

Shunt 1 Renewable:

Default On

Options On, Off

If configured for **ON** the current measured on this shunt will be considered as charging the battery.

9.2

Shunt Settings=>

Shunt 1 DC Load:

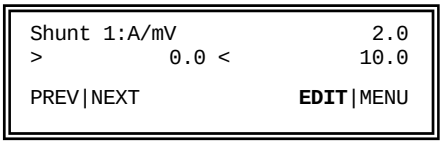
Default Off

Options On, Off

If configured for **ON** the current measured on this shunt will be considered as a DC load on the battery.

Note If both of the above options are selected for Shunt 1 the net current will be displayed.

9.3



Shunt Settings=>

Shunt 1 A/mV:

Unit – Amps / millivolt

Default -2.0

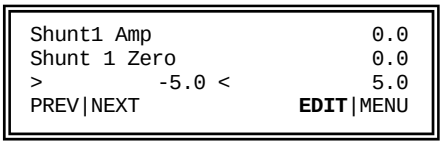
Range 0.0 -> 10.0

Shunt 1 Amperes per millivolt defines the type of shunt connected to Shunt 1 input. It allows the inverter to interpret the measured millivolts in terms of Amperes. The number to be entered is calculated by dividing the shunt rated current by the rated voltage.

e.g. a 50mV/100A shunt = 100 ÷ 50 = 2.0A/mV

The default value has been set to match the PS1 internal shunt to which it is connected

9.4



Shunt Settings=>

Shunt 1 Zero: Calibrates shunt 1 zero offset.

Unit – Amps

Default -0.0

Range -5.0 -> +5.0

Note: Shunt 1 Amp is also displayed so the zero point can be checked and adjusted from one screen. Any change in the Zero point does not take effect until OK is pressed after editing the parameter.

9.5

Shunt Settings=>

Shunt 2 Renewable:

Default Off

Options On, Off

If configured for **ON** the current measured on this shunt will be considered as charging the battery.

9.6

Shunt Settings=>

Shunt 2 DC Load:

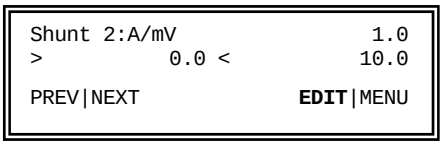
Default Off

Options On, Off

If configured for **ON** the current measured on this shunt will be considered as a DC load on the battery.

Note If both of the above options are selected for Shunt 2 the net current will be displayed.

9.7



Shunt Settings=>

Shunt 2 A/mV:

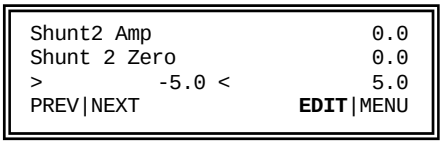
Unit – Amps / millivolt

Default -1.0

Range 0.0 -> 10.0

Shunt 2 Amperes per millivolt defines the type of shunt connected to Shunt 2 input. It allows the inverter to interpret the measured millivolts in terms of Amperes.

9.8



Shunt Settings=>

Shunt 2 Zero: Calibrates shunt 2 zero offset.

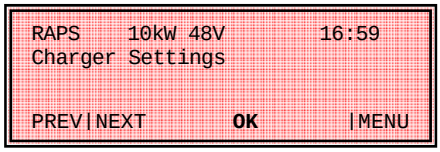
Unit – Amps

Default -0.0

Range -5.0 -> +5.0

Note: Shunt 2 Amp is also displayed so the zero point can be checked and adjusted from one screen. Any change in the Zero point does not take effect until OK is pressed after editing the parameter.

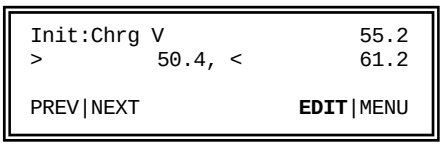
6.6 Charger Settings



Note: Charge settings will be automatically compensated when the battery temperature varies from 20°C. See 8.1.4 Battery Temperature for details

Press OK to enter the Shunt Settings screens. Within screens, press MENU at any time to return to this point.

10.1



Charger Settings=>

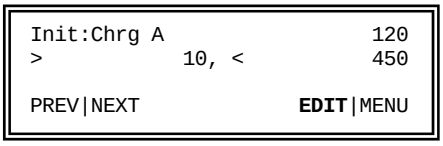
Init:Chrg V: is the set point voltage during the Initial stage of the charging cycle.

Unit – Volts DC

Default 55.2

Range 50.4 -> 61.2

10.2



Charger Settings=>

Init:Chrg A: is the battery current limit during the Initial stage of the battery charging cycle

Unit – Amps DC

Default 120

Range 10 -> 450

Note: The maximum limit is 3 times above the maximum available from the inverter. This allows for full inverter power plus any renewable input. This must not be set to a current higher than the battery bank is designed for.

10.3

```
Init:Time mins                5
>            1, <           240

PREV|NEXT             EDIT|MENU
```

Charger Settings=>

`Init:Time mins`: time in the Initial stage of the battery charging cycle once **`Init:Chrg V`** is reached.

Unit – minutes

Default 5

Range 1 -> 240

10.4

```
Bulk:Chrg V                  56.4
>         52.8, <            61.2

PREV|NEXT             EDIT|MENU
```

Charger Settings=>

`Bulk:Chrg V`: is the set point voltage during the Bulk stage of the charging cycle.

Unit – Volts DC

Default 56.4

Range 52.8 -> 61.2

10.5

```
Bulk:Chrg A                   90
>           10, <            450

PREV|NEXT             EDIT|MENU
```

Charger Settings=>

`Bulk:Chrg A`: is the battery current limit during the Bulk stage of the battery charging cycle

Unit – Amps DC

Default 90

Range 10 -> 450

Note: The maximum limit is 3 times above the maximum available from the inverter. This allows for full inverter power plus any renewable input. This must not be set to a current higher than the battery bank is designed for.

10.6

```
Bulk:Time mins              10
>           1, <           240

PREV|NEXT             EDIT|MENU
```

Charger Settings=>

Bulk:Time mins: minimum time in the Bulk stage of the battery charging cycle once Bulk:Chrg V is reached..

Unit – minutes

Default 10

Range 1 -> 240

10.7

```
Absorb:Chrg V              57.6
>           52.8, <        61.2

PREV|NEXT             EDIT|MENU
```

Charger Settings=>

Absorb:Chrg V: is the set point voltage during Absorption stage of the charging cycle.

Unit – Volts DC

Default 57.6

Range 52.8 -> 61.2

10.8

```
Absorb:Chrg A               50
>           10, <          450

PREV|NEXT             EDIT|MENU
```

Charger Settings=>

Absorb:Chrg A: is the battery current limit during the Absorption stage of the battery charging cycle**.**

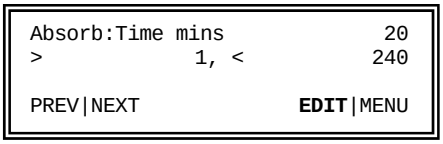
Unit – Amps DC

Default 50

Range 10 -> 450

Note: The maximum limit is 3 times above the maximum available from the inverter. This allows for full inverter power plus any renewable input. This must not be set to a current higher than the battery bank is designed for.

10.9



Charger Settings=>

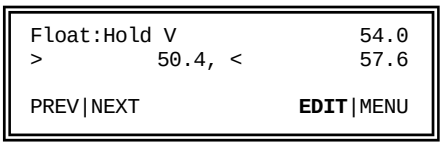
Absorb:Time mins: minimum time in the Absorption stage of the battery charging cycle once **Absorb:Chrg V** is reached.

Unit – minutes

Default 20

Range 1 -> 240

10.10



Charger Settings=>

Float:Hold V: After completion of a battery charge cycle the charger will enter Float mode and hold the battery voltage at this voltage.

If renewable charge sources are holding the voltage higher than the target, the PS1 will relinquish control of the battery voltage and the solar regulator must control the battery voltage.

The charge current in this stage is limited to **Absorb:Chrg A.**

This voltage should be set according to battery manufacturer's recommendations

Unit – Volts DC

Default 54.0

Range 50.4 -> 57.6

10.11

```
Float:Time hrs              2.0
>          1.0, <           6.0

PREV|NEXT              EDIT|MENU
```

Charger Settings=>

`Float:Time hrs`: If the battery voltage is held at or above the **`Float:Hold V`** by another charge source(e.g. renewable) for this length of time in a 24 hour period a pending Equalise cycle will be delayed by one day.

Unit – hours

Default 2.0

Range 1.0 -> 6.0

10.12

```
Eqlise:Chrg V              58.8
>          50.4, <         62.4

PREV|NEXT              EDIT|MENU
```

Charger Settings=>

`Eqlise:Chrg V`: Equalise Charge Voltage is the set point voltage during Equalisation stage of the battery charging cycle.

Unit – Volts DC

Default 58.8

Range 50.4 -> 62.4

10.13

```
Eqlise:Chrg A               15
>            1, <           50

PREV|NEXT              EDIT|MENU
```

Charger Settings=>

`Eqlise:Chrg A`: Equalise Charge Current is the set point current during the Equalisation stage of the battery charging cycle

Unit – Amps DC

Default 15

Range 1 -> 50

10.14

```
Eqlise:Time hrs              3.0
>          0.2, <           48.0

PREV|NEXT              EDIT|MENU
```

Charger Settings=>

`Eqlise:Time hrs`: is the time in the Equalisation stage of the battery charging cycle. Equalisation Time elapses when the battery voltage is between Eqlise:Chrg V and Eqlise:Limit V.

Unit – hours

Default 2.0

Range 1.0 -> 6.0

10.15

```
Eqlise:Limit V              63.6
>          52.8, <          64.8

PREV|NEXT              EDIT|MENU
```

Charger Settings=>

`Eqlise:Limit V`: Equalise Limit Voltage. During battery equalization the battery voltage will not be allowed to exceed this limit.

Unit – Volts DC

Default 63.6

Range 52.8 -> 64.8

This setting is also the compensated charge voltage limit.

6.6.1 Advanced Charger Settings

10.16

```
                        16:59
Advanced Settings

PREV|NEXT         OK         |MENU
```

Press OK to enter the Shunt Settings screens. Within screens, press MENU at any time to return to this point.

10.16.1

```
Chrg:Max hrs                6.0
>          0.0, <          48.0

PREV|NEXT             EDIT|MENU
```

Charger Settings=>Advanced Settings=>

Chrg:Max hrs: Maximum Charge time in hours.

Sets the maximum time the charger will remain in each charge stage. If the maximum time expires the charger will change to the next charge stage. It provides a safety mechanism in case the battery fails to meet the charge parameters defined for each stage. This will prevent the generator from running continuously and protect the battery bank.

Unit – hours

Default 6.0

Range 0.0 -> 48.0

Note: This setting does not apply when charger is in Float state.

10.16.2

```
Eqlise:Freq Days            14
>            0, <           31

PREV|NEXT             EDIT|MENU
```

Charger Settings=>Advanced Settings=>

Eqlise:Freq Days:. Equalisation cycle Frequency in Days.

Sets how often the battery is exposed to an Equalisation cycle. Refer to the battery manufacturer's documentation for recommendations regarding Equalisation cycles.

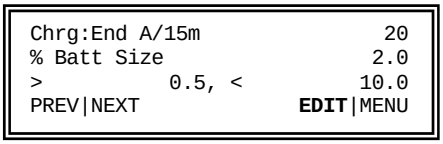
Unit – days

Default 14

Range 0 -> 31

Setting this parameter to zero will disable automatic equalisation.

10.16.3



Generator Settings=>

Chrg:End A/15m: Charge End Amperes per 15 minutes.

A slow rate of charge of the battery charging current is an indicator that the battery is no longer accepting much charge. If the rate of change of the battery charge current falls below this level the Bulk or Absorption charge stage will end and the charger will enter next charge stage.

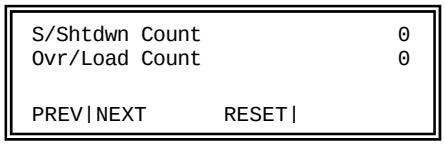
Unit – Percentage

Default 2.0

Range 0.5 -> 10.0

6.6.2 Additional Displays

The following additional menu functionality is available in the Advanced User Settings submenu whilst in the Installer mode.

1.6.6 	Press RESET to reset both counters and force a restart attempt if the inverter is in shutdown. Provided for service purposes so the inverter may be restarted immediately a shutdown or overload fault is cleared. Note: Restart may take up to 15seconds after reset.

7 PS1 Technical Description

7.1 Inverter Internal View

This shows the view inside the inverter. The circuit breakers, DIN mounting rail and wiring looms have been removed for clarity. The location is shown of the wiring terminations, connectors, quick connects, mounting screws and nuts referred to elsewhere in this document.

The unlabelled connectors are not used. Connectors are shown with names as used on the schematic, and numbers (J3 etc) as marked on the actual Printed Circuit Assemblies (PCA).

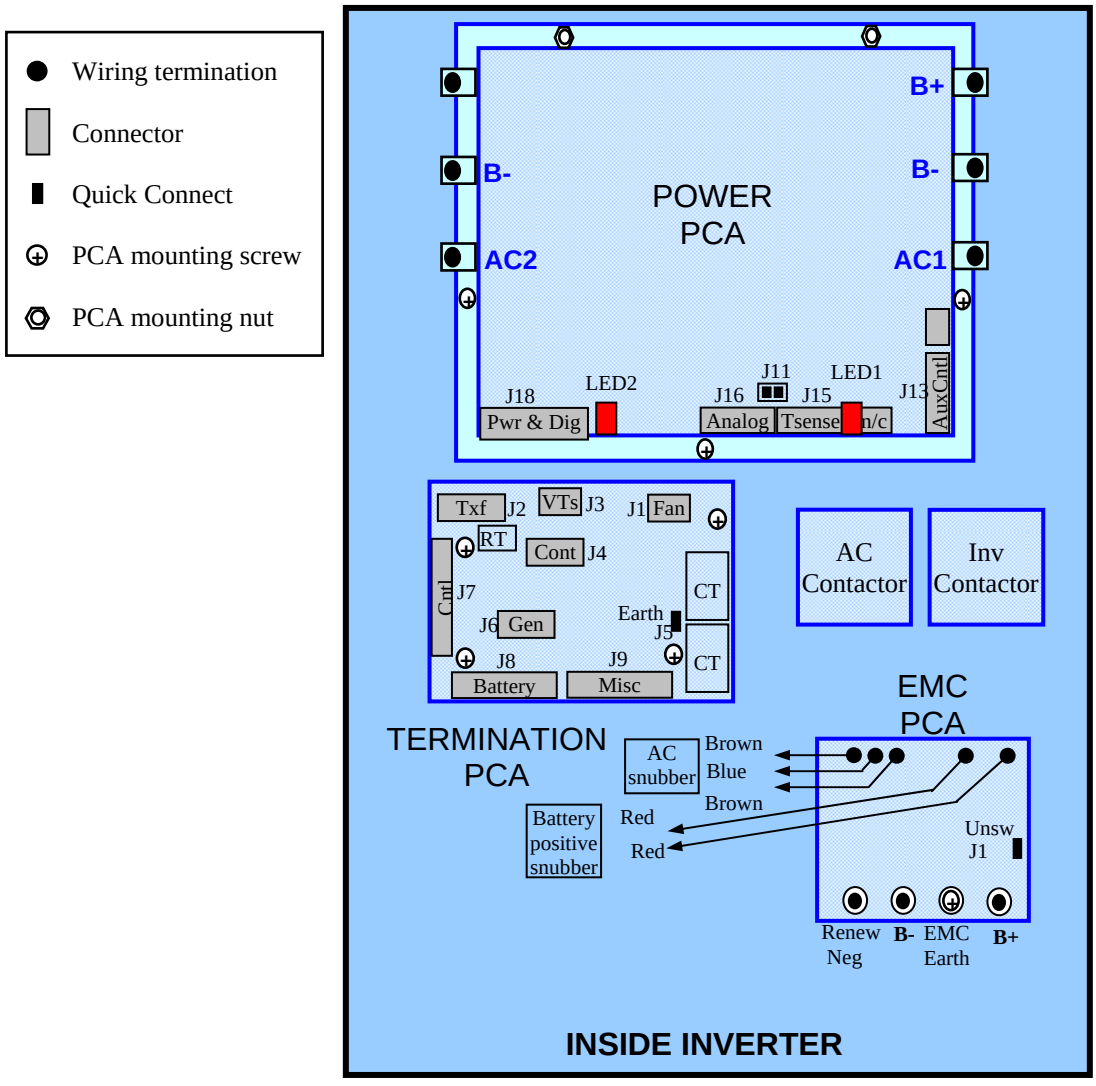


Figure 13 Inside Inverter

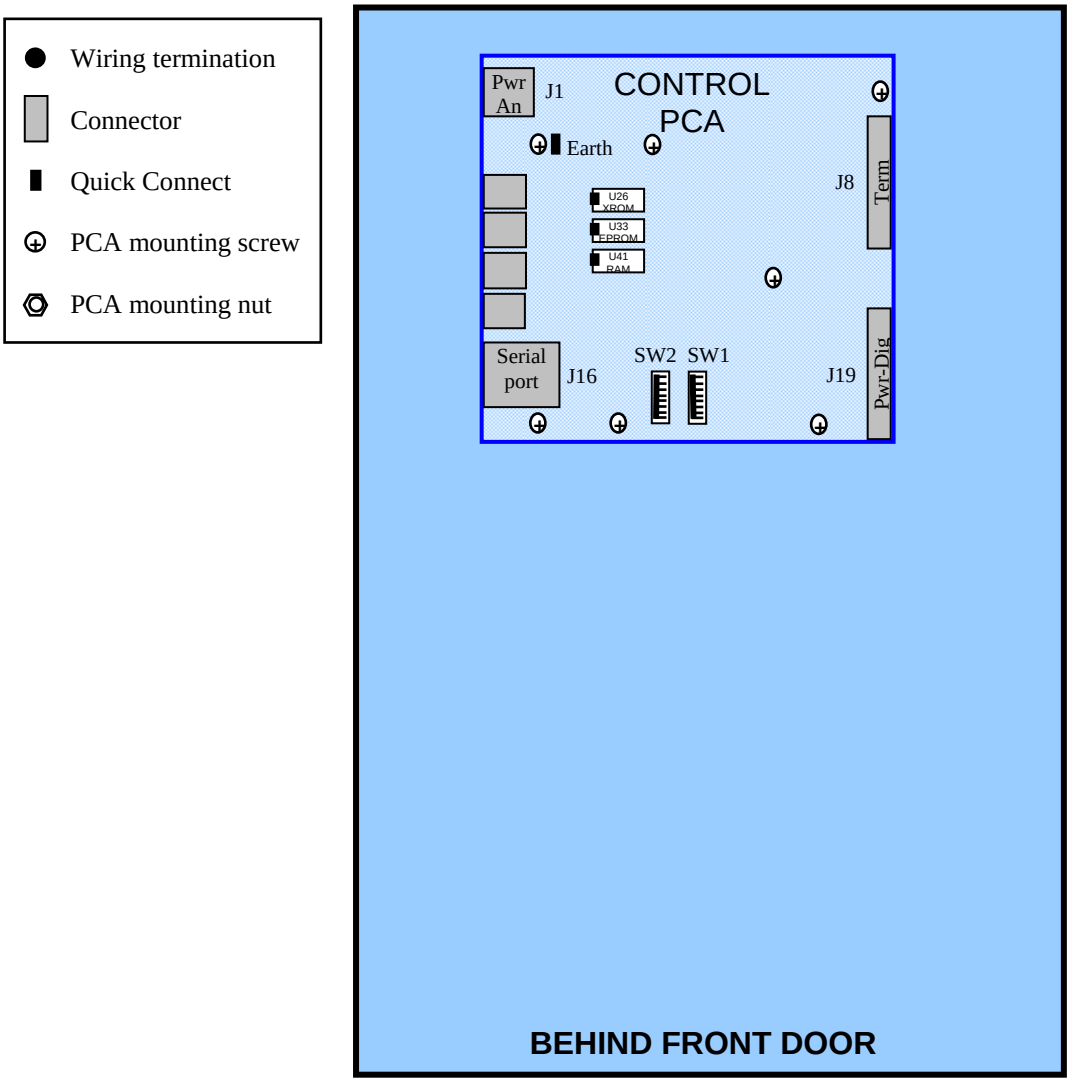


Figure 14 Behind Front Door

7.2 Inverter Block Diagram

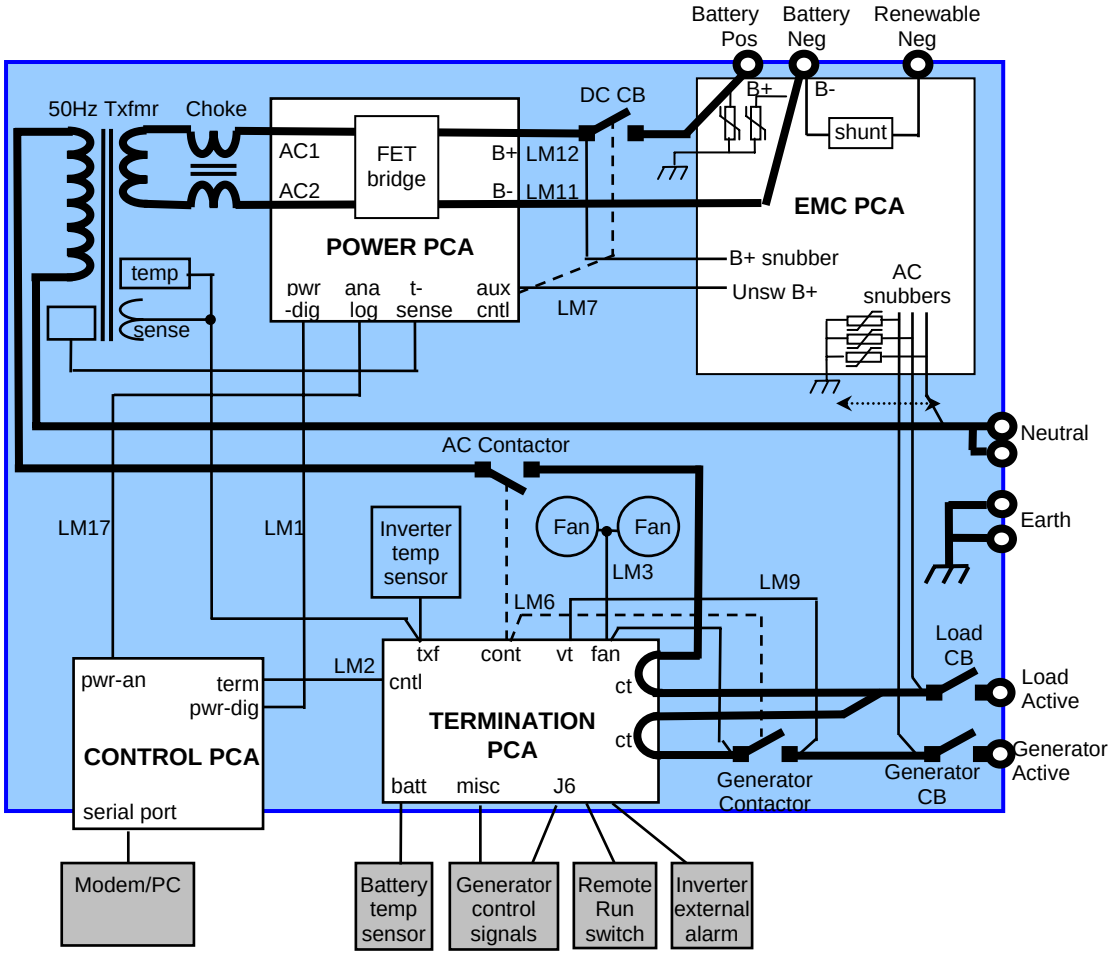


Figure 15 Inverter Block Diagram

The block diagram above shows the main components and a simplified view of the inverter wiring.

7.2.1 DC and AC Power Circuits

These circuits are shown in heavy lines in Figure 15 Inverter Block Diagram above.

While the battery is supplying the load, DC power from the battery flows via the DC Circuit Breaker into the Power PCA (Printed Circuit Assembly) where a FET (Field Effect Transistor) bridge chops it at several kHz and feeds it via a filter choke to the 50Hz transformer. The FETs are turned on and off by drive signals from the microprocessor on the Control PCA via wiring loom LM1. The microprocessor software varies the chopping duty cycle (on-off ratio) so the average voltage fed to the transformer is a 50Hz AC sine wave. The transformer steps up this AC voltage to the required generator level, and isolates the battery/renewable circuits from the AC circuits. The AC power is fed to the load via the AC Contactor and the Load Circuit Breaker.

AC power from the generator connects to the inverters Generator Active terminal. While the generator is charging the battery, generator power flows into the inverter via the Generator Circuit Breaker, Generator Contactor and AC Contactor through the 50Hz transformer into the Power PCA where the FET bridge rectifies it to DC to charge the battery via the DC Circuit Breaker. The software varies the FET drive signals to control the DC output voltage and current. The generator can supply the load via the Generator Circuit Breaker, AC Contactor and Load Circuit Breaker.

If the software stops, the FETs are not driven, so the inverter passes no power in either direction.

The AC circuits pass through two Current Transformers (CTs) on the Termination PCA, for current measurement. Note that the direction of the wiring through the CTs is important for correct determination of AC power flows by the software.

The DC Circuit Breaker incorporates over-current trip for fault protection and (except the 24volt model) a device to prevent closure in case of battery under-voltage or reversed battery voltage. The Power PCA trips this Circuit Breaker via loom LM7 to isolate or shut down the inverter in case of battery over-voltage. The software trips this Circuit Breaker via a signal in loom LM1 in case of excessive battery discharge etc. The Circuit Breaker trip coil is powered from battery DC.

The Generator Circuit Breaker and Load Circuit Breaker incorporate over-current trip for fault protection. The Control PCA software controls the AC Contactor and Generator Contactor via signals in loom LM2 then LM6. The AC Contactor coil is powered by DC fed from the Power PCA via looms LM1 and LM2. The Generator Contactor coil is powered by generator voltage from loom LM9, and with the inverter switched off is energized so the load can be supplied from the generator.

While the generator is disconnected or not running, generator voltage is absent so the Generator Contactor cannot close, thus inverter AC output voltage cannot become connected to the generator. If generator outage occurs while the inverter is already connected to the generator, the inverter software automatically detects the outage (due to power flow *into* the generator for example) and disconnects the generator by opening the Generator Contactor.

7.2.2 Inverter Management

The Control PCA manages the inverter. It contains a microprocessor which runs the inverter software, memory chips (which contain the software and logged data), and the inverter time/date chip. The Control PCA also incorporates the front panel LCD display and buttons, and a serial port for connection of inverter remote management via modem etc (see User Manual for details).

Via loom LM2 to the Termination PCA the software;

controls;

- the AC Contactor and Generator Contactor.
- the inverter cooling fans, running them only when needed. The fans are AC powered via loom LM3 from the Generator Contactor.
- the inverter external alarm and generator control outputs.

and monitors;

- AC currents from the two Current Transformers (CTs) on the Termination PCA.
- AC generator voltage and frequency from a Voltage Transformer (VT) on the Termination PCA, fed via loom LM9 from the Generator Contactor.
- the transformer AC voltage and temperature, from the transformer assembly via the sensor wiring (part of the transformer assembly).
- the inverter internal air temperature, from a sensor mounted on the sensor wiring connector at the Termination PCA.
- the battery temperature from a sensor mounted on the battery.
- the generator control input signals and **Remote Run** switch.

The software monitors DC voltage and current from the Power PCA via signals in loom LM17.

From the measured voltages and currents, the software calculates other values such as AC power flows and battery ampere-hours. Based on such measured and calculated values, the software controls the contactors and adjusts the FET bridge drive signals as required to control inverter synchronisation to the generator, battery charging and AC supply to the load. The software displays important measured and calculated values on the LCD display and records them in the data logging.

The software watches for unacceptable values, and takes appropriate action. For example it shuts down the inverter for battery under-voltage or excessive inverter temperature, restarts the inverter when the condition recovers, and displays the condition on the front panel LED indicators.

During inverter start-up self-test, the software similarly monitors inverter internal fault conditions such as FET drive or bridge malfunction, aborts start-up if necessary, and displays the fault condition on the front panel.

7.2.3 Power to the Inverter Electronics

The inverter internal electronics power supplies are derived on the Power PCA from the battery DC, then flow via loom LM1 to the Control PCA, then via loom LM2 to the Termination PC. To initially power the electronics before the DC Circuit Breaker is closed, power is obtained from the EMC PCA (unswitched B+) and loom LM7 to the Power PCA.

The inverter will not run if the battery is disconnected or the battery voltage becomes too low. Before the inverter will run, the batteries will need to be replaced or charged for example from renewable power.

7.2.4 Electromagnetic Interference (EMI) Filtering

The DC and AC power circuits are connected to the EMC PCA which snubs (absorbs) surges and filters EMI to prevent interference with other electronic equipment.

EMI is also filtered by various ferrite cores, chokes and capacitors in the wiring looms and the transformer assembly.

8 PS1 Operation

The following section describes in detail the operation of the PS1. A good understanding of the operation of the unit is not necessary but by knowing how the system works will enable you to understand the programmed settings and change the user settings to suit your own needs as required.

The PS1 Battery management continuously monitors the system operation. This monitoring allows the PS1 to automatically start the generator to keep the battery system charged or if the load is sufficient, start to supply the load directly. The monitoring includes any input from renewable sources and any loads directly connected to the battery bank.

The PS1 uses a five stage temperature compensated battery charging system. This system gives a high degree of flexibility so it can charge the multitude of battery types available.

The PS1 incorporates a programmable generator scheduler. These schedules can be set to meet regular system loads. At a particular time the generator can be running ready to meet those loads which are better powered directly from the generator.

Note: This section is a repeat of what is in the PS1 User Manual. It is included here for completeness.

8.1 Battery Management

Please refer to the battery manufacturer's documentation for recommendations regarding settings for your particular battery. Inappropriate settings may have a detrimental affect on your battery life and performance.

The PS1 provides comprehensive battery management settings and control to allow a charge regime to achieve optimal battery life.

PS1 battery management features include:

- State of Charge monitoring and control.
- Battery voltage monitoring and control.
- Charging initiated by battery state of charge and/or battery voltage.
- Five stage charge cycle: Initial, Bulk (0-90%), Absorption (90%~100%), Float and Equalise.
- Shutdown on very low battery voltage, battery state of charge, or both.
- Battery Temperature compensation of charging voltage based on battery temperature.

The PS1 may be configured to automatically start the generator when a battery charge cycle is required.

It is important that the battery manufacturer's recommendation be adhered to for ongoing monitoring and maintenance of batteries.

8.1.1 Battery State of Charge (SoC) monitoring and control

The PS1 has no direct means of measuring the battery state of charge; it uses measurements of the currents flowing in and out of the battery to estimate the charge remaining in the battery. The resultant net current is expressed as a percentage of the battery size set in the PS1 (**`Batt Size Ah`**). There is no compensation for the rate at which the current is drawn from or fed into the battery.

Current into the battery during a charge cycle and current measured on either of the shunts, when configured as Renewable, add to the battery state of charge estimate.

Current out of the battery to supply the load and current measured on either of the shunts, when configured as Load, deduct from the battery state of charge estimate.

If the shunt is configured as Renewable (+) and Load (--) the net result is added to the battery state of charge estimate.

The state of charge is used to automatically start the generator and begin charging the batteries. Different levels apply at different time of the days to ensure the generator is only used when required. Refer to 8.3.1 Generator Control based on SoC

At completion of charge cycle the battery SoC based on the estimation will be close to 100% but may vary depending of the charge and discharge rates.

8.1.2 Battery Voltage monitoring and control

The PS1 directly measures the battery voltage.

The battery voltage is used to automatically start the generator and begin charging the batteries. Normally the battery voltage would not reach the levels set as the state of charge control levels would be reached first. Different levels are used depending on the load on the system.

The battery voltage is used to protect the system by shutting the unit down should the battery voltage go above or below set limits. The shutdown limits must be set to higher than the maximum charge voltage and less than the generator start limits. For the low voltage shutdown limits the unit again employs different levels depending on system load. The system will always attempt to start the generator before shutting the unit down due to low voltage.

8.1.3 Battery Charger Operation

The PS1 charges the battery in a five-stage cycle with each stage controlled by voltage, current and time settings. These settings are fully configurable in your unit however they should not require changing after initial installation unless some aspect of the battery installation changes. The configured value of each setting can be viewed on the LCD display (see User Manual for details).

Each voltage setting is battery temperature compensated. The values displayed do not change. See Battery Temperature.

Refer to the Battery Charging Cycle graph of the following page.

8.1.3.1 Initial

The PS1 charges at the initial charging current (**Init:Chrg A**) until the battery voltage rises to the initial charge voltage (**Init:Chrg V**), holds this voltage for **Init:Time mins**, then starts the Bulk stage.

8.1.3.2 Bulk

The PS1 charges at the bulk charge current (**Bulk:Chrg A**) until the bulk charge voltage (**Bulk:Chrg V**) is reached, then holds this voltage for at least **Bulk:Time mins** and until the battery is approaching a high state of charge as indicated by the rate of change of charging current falling to **Chrg:End A/15m**. The Absorption stage is then started.

8.1.3.3 Absorb

The PS1 charges at the absorb charge current (**Absorb:Chrg A**) until the absorb charge voltage (**Absorb:Chrg V**) is reached, then holds this voltage for at least **Absorb:Time mins** and until the battery is approaching a high state of charge as indicated by the rate of change of charging current falling to **Chrg:End A/15m**. At completion of this stage the charger will enter the Float stage unless a battery Equalise cycle is due, in which case an Equalise cycle will complete before entering Float.

8.1.3.4 Float

The PS1 holds the battery voltage at the **Float Hold V** and will provide up to the absorb charge current to maintain the **Float Hold V**. The charge current is limited to **Absorb:Chrg A** in this stage. The PS1 will remain in this charge state until the generator has been shutdown.

8.1.3.5 Equalise

Periodically, as set by **Eqlise:Freq Day,** the PS1 performs an equalise charge in which the battery is held at a higher voltage between **Eqlise:Chrg V** and **Eqlise:Limit V** for several hours (**Eqlise:Time hrs**).

This restores to full charge any partially discharged cells in the series battery bank. To disable the Equalise function **Eqlise:Time hrs** may be set to zero.

The Equalise cycle will be automatically delayed by one day for each day the battery has been in above the **Float:Hold V** for the Float time set during installation.

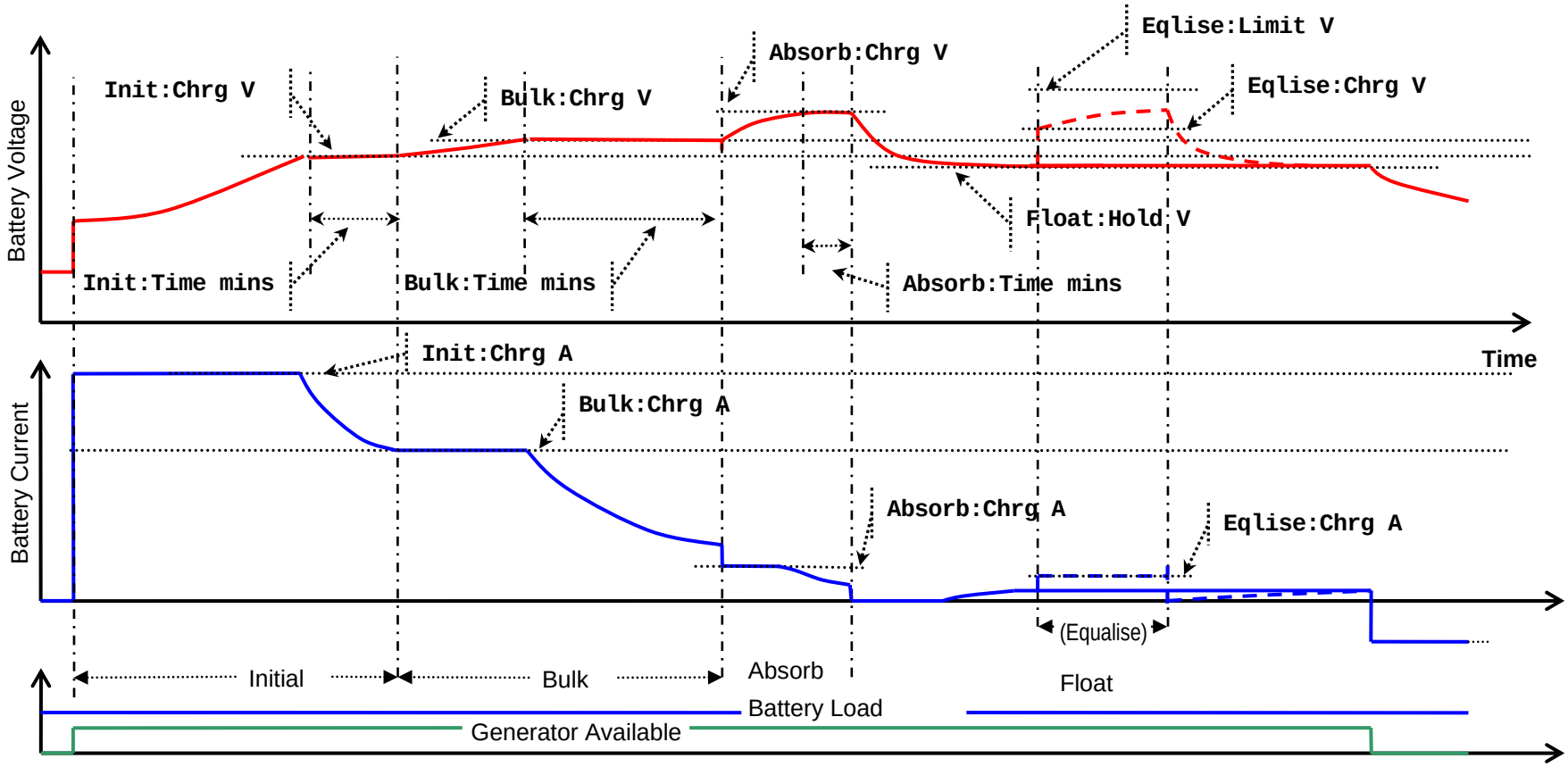


Figure 16 Battery Charging Cycle

8.1.4 Battery Temperature

The PS1 monitors the battery temperature via the sensor provided. The supplied battery temperature sensor is mounted in thermal contact with the centre of the side of a battery. If the sensor is not in thermal contact with the battery bank the batteries will not be correctly charged.

The charge voltage set points are compensated by battery temperature. The compensation applied is --5mV/°C/cell with zero compensation at 20°C.

e.g. **`Init:Chrg V`** = 55.2, Battery Temperature = 26°C, No. Battery Cells = 24.

Compensated Charge voltage = 55.2 + ((20 - 26) x 0.005 x 24)

= 54.48

`Absorb:Chrg V` = 57.6, Battery Temperature = 6°C, No. Battery Cells = 24.

Compensated Charge voltage = 57.6 + ((20 - 6) x 0.005 x 24)

= 59.28

During all charge stages, the compensated charge voltage will not exceed **`Eqlise:Limit V`**.

Compensation improves battery performance and prevents battery overheating.

The charge current is also limited by battery temperature. Battery temperatures above 40°C cause the battery charger to reduce the charge current limit point. This will help prevent battery overheating.

8.2 Renewable Management

The PS1 feeds renewable power to the AC load, and any excess is stored in the battery for later usage. If the battery is fully charged and the DC load is not on, the excess is wasted (the renewable power is reduced or disconnected by the regulator). Such waste can be reduced by reducing the level to which the generator charges the battery, or particularly for solar renewable, by not running the generator in the morning.

If battery charging is in progress and renewable output increases sufficiently to cause the generator charge power to become negative when averaged over 2 minutes, the PS1 terminates the charge cycle after the generator minimum run time has expired. If equalize charging was in progress, it is terminated and rescheduled for the next day Such conditions occur when renewable output exceeds the sum of the load demand plus the required charge power.

8.3 Automatic Generator Control

The PS1 may be configured to automatically control the generator as required to supply the load and charge the attached battery or to allow manual control of the generator by the user. Generally automatic control of the generator is recommended for daily operation.

The generator will only run in automatic mode if the Gen NOT Available LED (LED7) is off. If this LED is ON, the PS1 will not automatically start the generator. This is controlled via a digital input to the PS1 - Generator Available or can be permanently enabled via an installer setting.

As part of the installation, the PS1 settings are configured to automatically run the generator to:

- Limit the depth of battery discharge, for maximum battery life.
- Deliver energy efficiently by supplying sustained large loads direct from the generator.
- Load the generator to the highest possible level while running, to efficiently convert fuel to electricity.
- Not frequently start and stop the generator, which would reduce its life and increase maintenance.
- Avoid noise by starting the generator late at night only for heavy loads or a deeply discharged battery.

In the PS1 RAPS system, the PS1 automatically runs the generator for the following reasons:

- Battery conditions, in particular state of charge (SoC), require the generator to charge the battery (see 8.3.1Generator Control based on SoC and 8.3.2 Generator Control based on Battery Voltage).

- Load conditions are such that the PS1 ratings are exceeded or a sustained load is large enough to efficiently load up the generator hence running the generator will be the most efficient method to supply the load. For loads exceeding the generator rating the PS1 draws power from the battery, adding its power output to that of the generator (see 8.3.3 Generator Control based on AC Load).
- Time Schedules are set to regularly run the generator at times of expected peak loads or at convenient times (see User Manual for details).
- The generator has not been run for the Exercise period days. The PS1 will start the generator at the **`Begin Lvl 1 Hr`** or 12 noon if **`Begin Lvl 1 Hr`** is disabled. Normal automatic stop conditions apply.
- Backup Schedules are set to run the generator in case of PS1 shutdown to power vital equipment (see User Manual for details)

8.3.1 Generator Control based on SoC

The PS1 may be configured to start the generator to charge the battery based on the battery **S**tate **o**f **C**harge (SoC). This method of generator control is recommended to efficiently and reliably maintain the battery charge.

The battery SoC is estimated by the PS1 and displayed as a percentage of the battery capacity and represented throughout this manual and in the menu system by the symbol SoC%.

A daily profile of preferred generator start times and battery charge levels may be configured to allow the PS1 to automatically start and stop the generator. The profile provides the flexibility to accommodate for individual site characteristics such as renewable availability, usage patterns and generator noise considerations.

Several PS1 settings are configured to divide the day into three periods (refer Figure 17):

- **Preferred Hour:** The one hour when it is most preferable to run the generator. This is a period starting at **`Begin Lvl 1 Hr`**, typically about 5 or 6pm. During this period the generator is started if the battery is discharged below **`Level 1 SoC%`** to perform a full battery charge.
- **Preferred Period:** The period from **`Begin Lvl 2 Hr`** to **`Begin Lvl 3 Hr`**, when you prefer the generator to run if the battery state of charge warrants it. The preferred period includes the preferred hour. During this period the generator is started if the battery is discharged below **`Level 2 SoC%`** to perform a full battery charge.
- **Non-Preferred Period:** The period from **`Begin Lvl 3 Hr`** to **`Begin Lvl 2 Hr`**, when you prefer the generator **not** to run. This period is usually overnight to avoid noise. During this period the generator will be started only if the battery is seriously discharged (below **`Level 3 SoC%`**) and will only perform a partial recharge.

If the PS1 starts the generator within the non-preferred period it will run the generator for time determined by the **`Gen:Min Run min`** setting. At other times, once the generator is started, it is run until the battery is fully charged.

Once the charging is completed the generator will stop unless the load or schedules keep it running. See 8.3.4 Generator Automatic Stopping

The starting time for each of the periods (**`Begin Lvl 1 Hr`** , **`Begin Lvl 2 Hr`** and **`Begin Lvl 3 Hr)`** can be set via the User menus. The battery state of charge levels (**`Level 1 SoC% Level 2 SoC%`** and **`Level 3 SoC%)`** are set by the installer at the time of installation.

8.3.1.1 Example Configuration 1 – Solar + Generator

The generator starting strategy depends on individual site requirements. In systems with high solar contribution the **`Begin Lvl 2 hr`** could be delayed until later to provide an opportunity for solar to charge the battery (see Figure 17 below).

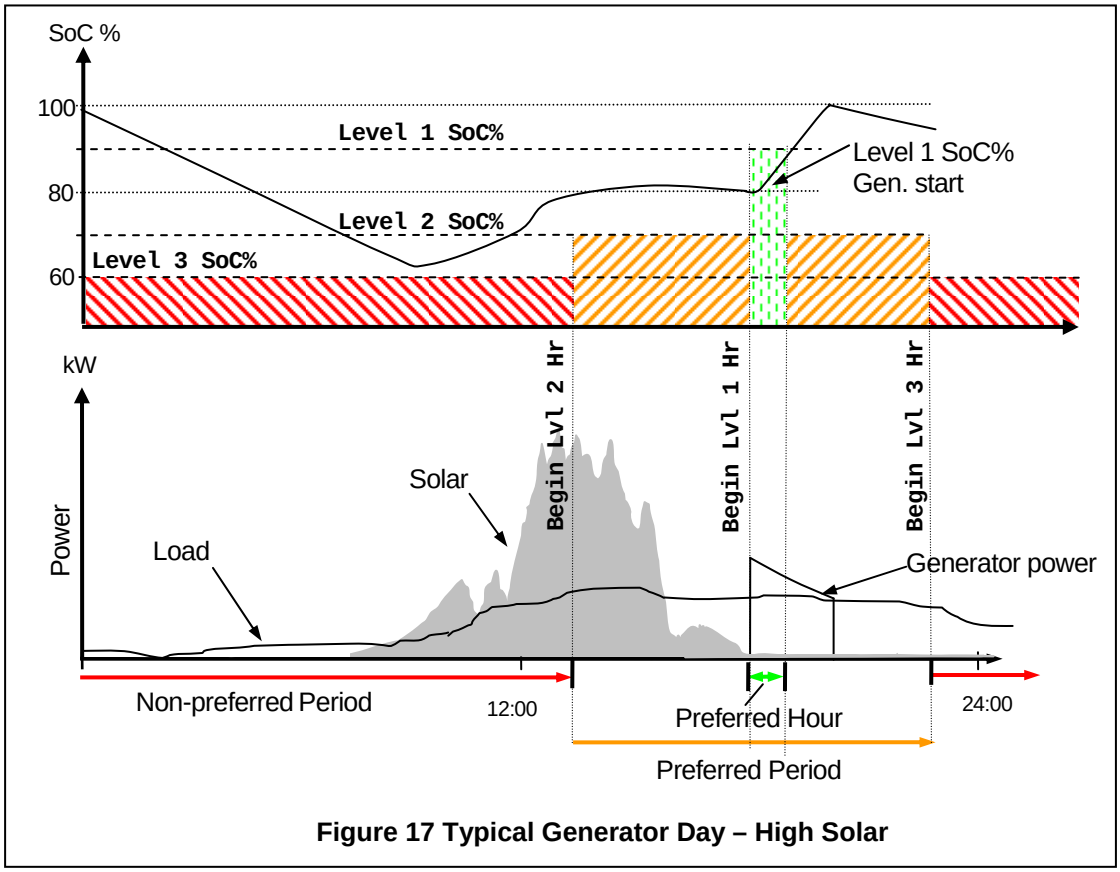


Figure 17 Typical Generator Day – High Solar

8.3.1.2 Example Configuration 2 – Generator Charger

In a generator/charger system, or systems with low solar contribution, this period would begin early in the morning to start the generator and replace the charge used overnight (see Figure 18 below).

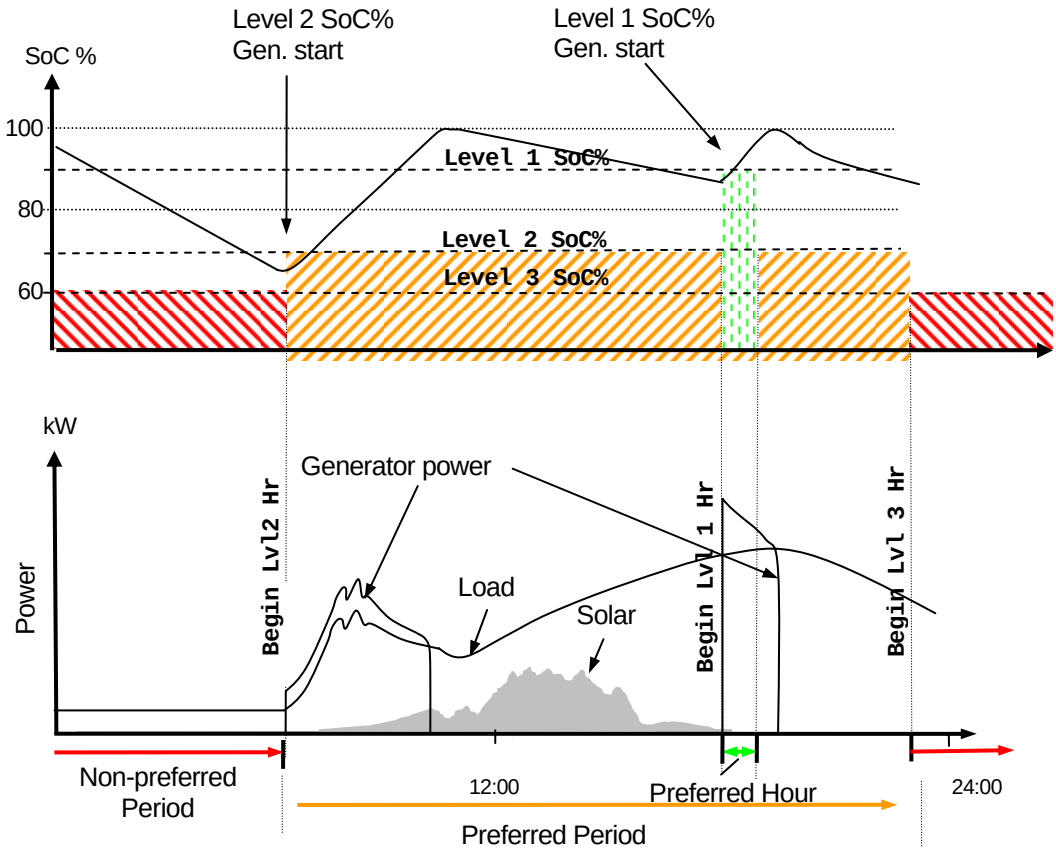


Figure 18 Typical Generator Day – Low

8.3.1.3 Example Configuration 3 – Poor Setup

Figure 19 illustrates a system with levels and times unsuited to the load requirements resulting in failure to charge the battery adequately to accommodate the overnight load. The battery SoC falls below the Level 3 threshold and the generator is started during the night to stop the battery becoming excessively discharged. A better generator run strategy would be set the Level 1 or Level 2 settings to cause a charge late in the day to fully charge the battery before the Level 3 period starts thus averting the generator start overnight.

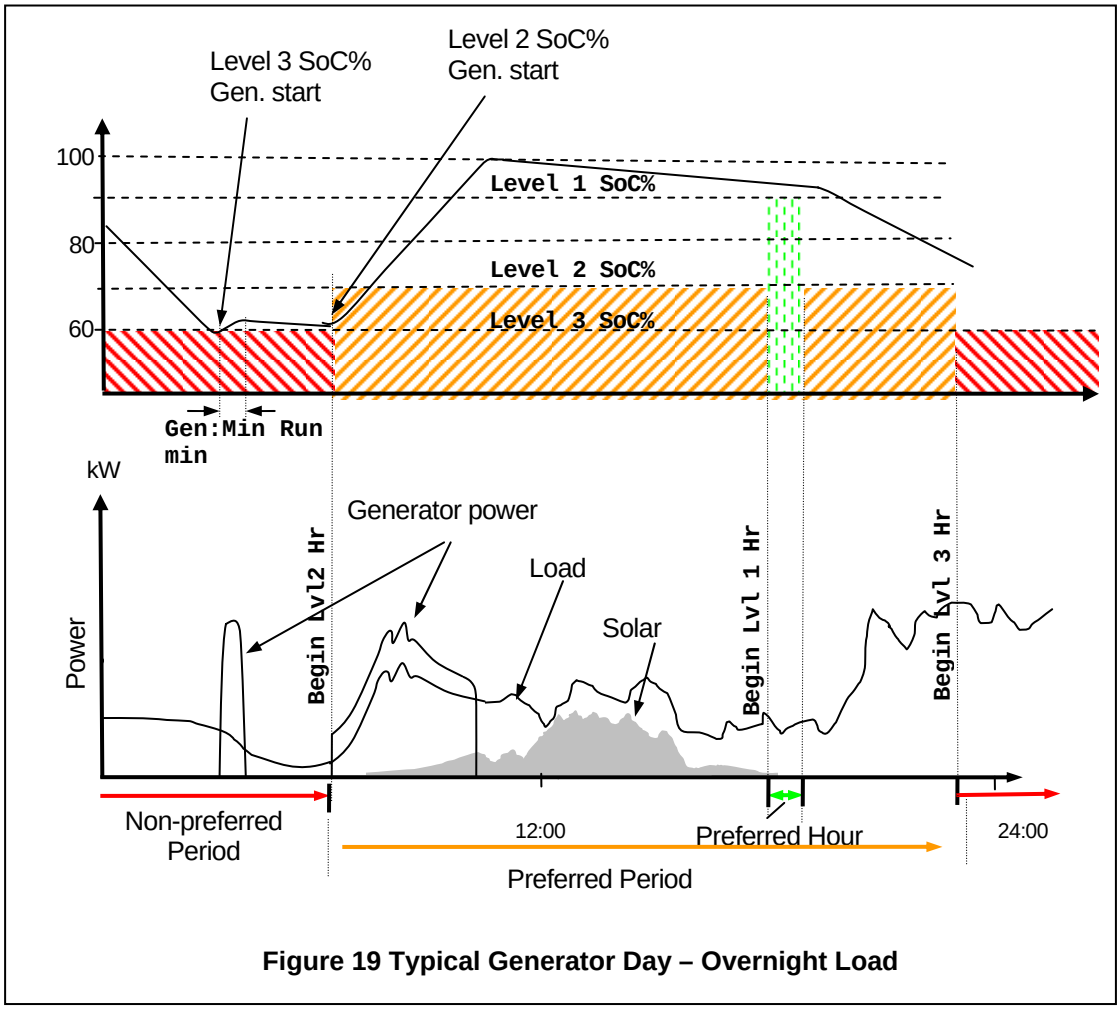


Figure 19 Typical Generator Day – Overnight Load

8.3.2 Generator Control based on Battery Voltage

The PS1 will start the generator based on battery voltage. Normally these limits are not met as the SoC control will have already started the generator.

The generator will start at any time should any of the pre-configured limits be met.

If the generator starts in the Preferred Period, the PS1 will perform a full battery charge. If the generator starts in the non-preferred period, the PS1 will perform a partial battery charge.

When complete, the generator will be stopped (see 8.3.4 Generator Automatic Stopping).

8.3.3 Generator Control based on AC Load

The PS1 will automatically start and stop the generator based on the average power delivered to the load over the time period of the limit. Two factory-configured and two installer configurable settings determine the power levels at which the generator will be started.

- The 30 second limit is factory set at 120% of the PS1 rating.
- The 2 minute limit is factory set at 100% of the PS1 rating.
- The 10 minute and 30 minute limits are installer configurable.

The generator will continue to run until the average load power falls below all start limits and all other stop criteria are met (see 8.3.4 Generator Automatic Stopping).

8.3.4 Generator Automatic Stopping

The PS1 will automatically stop the generator when it is not required for charging the battery or supplying the load.

If the generator is automatically started in the preferred period, the PS1 will stop it after completion of a battery charge cycle unless:

- A generator scheduled run is in progress (see 8.3.5 Generator Scheduling).
- The average load kW exceeds one of the four configured start limits (see 8.3.3 Generator Control based on AC Load).
- The minimum generator run time (**`Gen:Min Run min`**) has not expired
- The generator load is greater than **`Gen:Min Load kW`**.
- The remote run signal is active.

If the generator is automatically started in the non-preferred period, the generator will be stopped after the minimum generator run time set by **`Gen:Min Run min`** unless:

- A generator scheduled run is in progress (see 8.3.5 Generator Scheduling).
- The average load kW exceeds one of the four configured start limits (see 8.3.3 Generator Control based on AC Load).
- The generator load is greater than **`Gen:Min Load kW`**.
- The remote run signal is active.

The generator will be stopped at midnight if the generator and system load is low except if an equalize charge is in progress.

8.3.5 Generator Scheduling

Two schedule types are available each with four configurable start times and durations. See User Manual for full details.

8.4 Manual Generator Control

The generator can be manually controlled via:

- The generator local controls. The PS1 generator available signal from the generator switch must be inactive indicated by the Gen NOT Available LED (LED7) being ON.
  Note: To prevent reverse power flow into the generator, before manually stopping the generator it is advisable to open the Generator AC Circuit Breaker and wait until the PS1 LEDs no longer indicate **Inv Sync**. After the generator is stopped, close the Generator Circuit Breaker ready for the next generator start. .
- The **OK** pushbutton on the front panel.
- A **Remote Run** input that can be wired from the PS1 to a switch in a convenient location such as in a residence. Several such switches can be wired in parallel. The Gen NOT Available LED (LED7) must be OFF.

8.4.1 Remote Run Input

The **Remote Run** switch operates as follows:

- A switch closure longer than 0.5 seconds and shorter than 2 seconds causes the PS1 to start the generator. Another such closure stops it, else it is stopped automatically when the battery reaches full charge and any sustained large load ceases. The switch is typically a non-latching pushbutton.
- A switch closure longer than 2 seconds causes the PS1 to start the generator, and stop it when the switch is opened. The switch is typically a latching toggle.

Regardless of how the generator is started (manually or automatically), while the generator is running the PS1 automatically charges the battery whenever sufficient generator power is available, and when fully charged will hold the battery in float charge.

8.5 Generator Fault Recovery

If the PS1 fails three consecutive times to detect significant generator voltage for one minute after a generator start or, if voltage is detected but fails to synchronise for five minutes, a Generator Fault alarm will be asserted. The PS1 will then use the following sequence of generator start attempts:

- After 15 minutes
- After 1 hour
- Daily at the **`Begin Lvl 1 Hr`** (or 12 noon if **`Begin Lvl 1 Hr`** is disabled

A Gen Fail event will be generated and logged each time a start attempt fails.

Note: To force the PS1 to immediately restart the generator toggle the Generator Available input so that the generator changes to NOT Available then back to Available. Use the **OK** pushbutton to start the generator.

8.6 Generator Control Interface

The PS1 starts and stops the generator via the control signals shown below. The signals are wired between the PS1 and the generator local control equipment. The PS1 supports several different generator start/stop schemes, using some or all of the signals. The system supplier may modify the generator local control equipment to create the signals, which may have different names within the generator local control equipment.

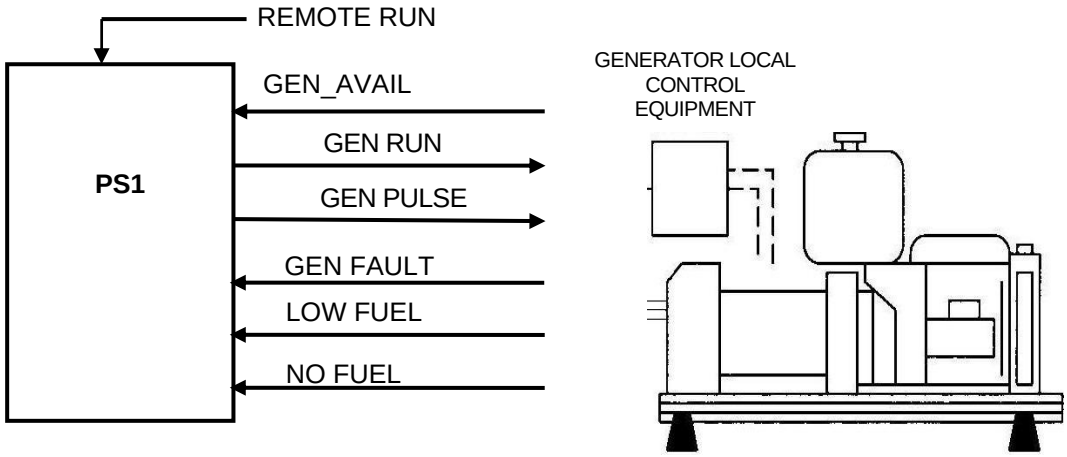


Figure 20 Generator Control Signals

Below is a description of the interface operation, for specifications for the generator control interface signals see Appendix A.3 Generator Control Interface Specification.

8.6.1 Generator Available Signal

The Generator Control Available signal indicates to the PS1 if the generator is **available** for automatic control (OFF) or **not available** (ON). The signal typically comes from a switch on the generator local control equipment however, it may come from other types of control equipment.

In the OFF position the generator is controlled locally via its own controls, and the PS1 will not try to start or stop it. The front panel LEDs will indicate Gen Not Available (see).

In the ON position the generator is available for automatic control by the PS1, for manual control via the PS1 **OK** pushbutton, and remote control via the **Remote Run** input signal.

Note: The PS1 may have been set up to not use this signal and assume the generator is always available for control and hence will ignore this signal.

8.6.2 Generator Start/Stop Signals:

The PS1 uses the GEN RUN and GEN PULSE signals to start and stop the generator. One or both of these signals may be used, depending on the generator local control equipment and PS1 setup:

- If used, the GEN RUN signal remains active while the generator is to run and remains inactive while the generator is not to run.
- If used, the GEN PULSE signal becomes active for a short period ("pulse") to start and to stop the generator, and is otherwise inactive. The duration of the pulse (typically several seconds), and the relative timing between the GEN RUN and GEN PULSE signals where both are used, is determined by PS1 settings configured during installation.

8.6.3 Generator Status Signals:

The GEN FAULT signal indicates a generator fault such as low oil pressure or overheating. The actual conditions and recommended action should be listed in the generator or site documentation. If the signal becomes active, the PS1 stops the generator. The PS1 front panel LEDs will indicate Gen Fault, when the generator fault is fixed and the GEN FAULT signal becomes inactive the PS1 will restart the generator if required.

The LOW FUEL signal indicates that the fuel tank needs filling as soon as possible. If the signal becomes active, the PS1 raises a Non Urgent alarm.

The NO FUEL signal indicates that the generator is out of fuel. If the signal becomes active, the PS1 stops the generator and raises an Urgent alarm. The PS1 front panel LEDs will indicate Gen Abnormal Stop.

8.7 Synchronisation

Whenever the generator and PS1 are both operating, the PS1 automatically synchronises to the generator (adjusts its AC voltage and frequency to match the generator output) and controls the power flow as described below. This occurs regardless of how the generator started (manually or automatically). The PS1 will not synchronise to the generator, nor close its relevant contactor, if the generator AC voltage or frequency is out of tolerance.

Once synchronised, the PS1 will close the Generator Contactor and the front panel LEDs will show **Inv:Sync**. If the generator AC voltage or frequency become out of tolerance the PS1 will switch to standalone mode and try to resynchronize. If unsuccessful for 5 minutes a Generator Fault alarm is asserted and an automatic restart sequence started.

To prevent the PS1 trying to stay synchronised to a generator that is spinning down, before manually stopping the generator it is advisable to open the Generator Circuit Breaker and wait until the PS1 LEDs no longer show **Inv Sync**. Similarly, if the PS1 automatically stops the generator it will not try to re-synchronise to the generator for 10 minutes while it spins down. After this period and if generator voltage is still detected, the PS1 will attempt to resynchronise potentially causing a fault when the generator eventually stops.

8.8 System Power Flow

8.8.1 No Generator/PS1 switched ON

While the PS1 and generator are both off, the AC Contactor and Generator Contactor are both open. If the PS1 is then switched on it draws power from the renewable and battery to generate AC voltage at nominal voltage and frequency, and closes its AC contactor to supply the load.

8.8.2 PS1 ON/ Generator Started

While the PS1 is on with no generator voltage present, the AC Contactor remains closed and its Generator Contactor remains open. If generator voltage is detected by the PS1 (e.g. due to generator start-up), it synchronises to the generator voltage (adjusts its AC voltage and frequency to match the generator output) then closes its Generator Contactor. At this stage all of the load power is supplied from the PS1 and zero power is drawn from the generator. The PS1 then gradually transfers load onto the generator over a period of 30 to 90 seconds until the power supplied by the inverter is zero. Power is then drawn from the generator to charge the battery.

8.8.3 Generator ON/PS1 switched ON

If the generator is running with the PS1 switched off, the AC Contactor is open, and the Generator Contactor is closed while generator voltage is present, so the generator supplies the load. If the PS1 is then switched on, it synchronises to the generator voltage (adjusts its AC voltage and frequency to match those of the generator) then closes its AC Contactor, and draws generator power to charge the battery.

8.8.4 Load Sharing

While the PS1 and generator are both on and synchronised, the PS1 charges the battery while the load is below the generator power rating. If the load exceeds the generator rating, the PS1 does not charge the battery but draws power from it, adding its power output to that of the generator to supply the load, and limiting the power drawn from the generator.

8.8.5 Reverse Power

If the generator trips while running, for example due to running out of fuel or being manually stopped, then AC power may flow into the generator. This is not a desirable condition. The PS1 detects this condition and opens its Generator Contactor.

8.8.6 Reactive Power

Reactive power flow (kVAr) occurs when the AC current in a circuit is out of phase with the AC voltage. Reactive power flow consists of energy flowing back and forth in consecutive AC half cycles. It performs no useful function, and increases the current above that due to real power flow (kW) alone, so causing increased power loss and heating which may limit the real power available.

Reactive power flow occurs in reactive system loads such as induction motors. The PS1 shares such reactive flows with the generator, by controlling the AC output voltage.

The amount of reactive power flow can be monitored using parameters **`Inv kVAr`** and **`Gen kVAr`**.

8.9 Inverter External Alarm

The PS1 provides a single alarm output which can be wired to an external alarm buzzer or light etc. An urgent alarm is indicated by a continuous ON condition and a non-urgent alarm is indicated by a slow intermittent ON/OFF condition. If the PS1 is shutdown or OFF the urgent alarm output is be asserted.

NON-URGENT conditions can be prevented from raising the alarm, via the LCD displays.

The URGENT and NON-URGENT alarms are also separately indicated on the front panel LEDs. Short term and long term event counters are provided and the users may set limits for each to generate alarms.

See User manual for full control options.

9 Troubleshooting

System problems in the field may be due to:

- Incorrect generator or renewable adjustment.
- Incorrect inverter settings.
- Failure of the generator, renewable, battery, wiring, inverter, control equipment, etc.

9.1 System General Check

If the system is not operating correctly, perform a general check as follows:

Check if the inverter front panel LCD and LEDs indicate a problem, and take the recommended action. Use the MENU button to review the past events on the LCD.

Switch off the inverter via its On/Off button for a few seconds then back on. Again check if the front panel LCD and LEDs indicate a problem, and take the recommended action.

9.2 Inverter will not Start

If the LEDs remain off when the inverter is switched on via its **On/Off** button, the inverter did not start.

This may occur if the battery is excessively discharged, since the inverter electronics are powered from the DC (battery) side not the AC (generator) side. Check the battery voltage – if less than the restart voltage (**`Inv:Restart V`**), the inverter will not start. Turn off all loads to minimize battery drain, and allow the battery several minutes to recover. If the inverter still will not start, the battery must be at least partially recharged, from renewables for example. If the battery voltage is now ok and the inverter starts, start the generator and recharge the battery bank.

9.3 No AC Power to Load while Generator Off

Check AC Load Circuit breaker has not tripped. Check distribution board circuit breakers.

Check if the inverter front panel LCD and LEDs indicate a problem, and take the recommended action.

9.4 Inverter Not Charging Battery

Check if the inverter front panel LCD and LEDs indicate a problem, and take the recommended action.

Is the AC load too high and there is no power capacity from the generator to charge the battery?

Is the DC Fuse blown or DC circuit breaker tripped? (see 9.7 DC Circuit Breaker Trips)

9.5 Inverter Shuts Down

Whenever the inverter shuts down, it attempts to restart. If the cause persists and ten restarts have accumulated within one minute, further restarts will be attempted once per minute.

The inverter shuts down automatically for the following conditions, which should be investigated:

- Overload
- DC over-voltage and under-voltage
- Over-temperature
- AC over-voltage and under-voltage

- Excessive battery discharge

Check if the inverter front panel LCD and LEDs indicate a problem, and take the recommended.

Starting a large motor can overload the inverter, especially if the motor takes several seconds to start spinning. If the overload persists, the inverter will shut down but will automatically restart. Check that the inverter will start the motor with other AC Load combinations.

9.6 Inverter – No Front Panel display

If the inverter is not running, the front panel LCD, LEDs and buttons will be dead, and no AC or DC power will flow in the inverter. (see 9.2 Inverter will not Start)

Switch off the inverter via its On/Off button for a few seconds then back on. If this does not restore normal operation, again check if the front panel LCD and LEDs indicate a problem, and take the recommended.

Is the DC Fuse blown or DC circuit breaker tripped? (see 9.7 DC Circuit Breaker Trips)

9.7 DC Circuit Breaker Trips

DC circuit breaker trip may be due to battery under voltage. Check if the front panel LEDs indicate a problem, and take the recommended.

Inspect for a short circuit in the DC wiring.

This may be due to a DC fault current. The inverter will stop operating, and may be faulty. Switch off the inverter via its On/Off button for a few seconds then back on. The built in self-test will check for any possible DC fault paths and indicate any problems on the LCD/LEDs. Take the recommended action.

If faulty, run the generator manually to supply the loads.

9.8 Inverter does not start Generator

Check that, if fitted, the externally wired generator available control switch is closed. The inverter front panel Gen NOT Avail LED indication should be OFF. If not, the inverter cannot control the generator. See 3.5 Generator Control Wiring

Check if the inverter front panel LCD and LEDs indicate a problem, and take the recommended action.

Switch the inverter On/Off button off for a few seconds then back on. If this does not restore normal operation, check if the front panel LCD and LEDs now indicate a problem, and take the recommended action.

With the inverter switched off and the externally wired generator available control switch in the open position, check that the generator can be manually started via its own controls and runs smoothly with customer load applied i.e. no fuel blockage, correct voltage and frequency.

With the inverter switched on and the externally wired generator available control switch is closed, check that the generator can be started and stopped using the OK button on the inverter front panel. If not, check wiring and interface signals.

Check that the generator running requirements are correctly set up. See 6.3 Generator settings.

9.9 Inverter does not synchronise to Generator

The inverter cannot synchronise to the generator because the generator AC voltage or frequency is too high or low. Check the LCD displays of measured generator voltage, frequency and frequency variation (readings **`Gen VAC`**, **`Gen Hz`** and **`Gen var Hz`**).

Check the inverter tolerance settings **`Sync Tol VAC`**, **`Sync Hi Hz`** and **`Sync Lo Hz`**.

The generator governor speed setting or AC voltage may need adjustment. Consult the generator user manual.

9.10 Inverter synchronises but disconnects due to reverse power flow.

There are several reasons and resolutions for the inverter disconnecting from the generator with the reason of reverse power flow.

- Bad battery temperature reading

  Check battery temperature and ensure operating correctly.

- Battery voltage held high by external charging source.

  Check external charging sources are operating correctly.

- Incorrect AVR sensing.

Check that the AVR in the alternator is correctly sensing the terminals that the load/inverter is connected to.

- Poor generator frequency stability

Test generator stability on loads without the inverter connected. Generator frequency instability or "hunting" is indicated by the noise of the generator speeding up and slowing down without any change in load. Frequency stability may be adjusted on some types of governors. Consult generator manual.

Changing to a lower Gen Type may correct this.

Decreasing (a more negative number) the PS1 Period Gain may also correct this. This requires that the Gen Type be set to 3 and adjust the Gen Type 3 settings. See 6.3 Generator settings

- Low generator frequency droop.

The generator may not droop (reduce) or not droop sufficiently in frequency when load is applied. Droop may be adjusted on some types of engine governors. Consult generator manual. Droop may be adjusted by increasing the no load engine speed. Note that this speed must be below the high frequency disconnect point and if the alternator uses compound regulator the gap will need to be adjusted to keep the output voltage within the desired range.

Decreasing the PS1 Proportional Gain may also correct this. This requires that the Gen Type be set to 3 and adjust the Gen Type 3 settings. See 6.3 Generator settings

- Poor generator voltage regulation.

The alternator output voltage may increase when load is applied or may be significantly distorted. Many AVR type regulators have adjustments to change the response of the output voltage to changing loads. The regulator may need to be upgraded to a more sophisticated device designed to be used on generators operated in parallel.

9.11 Inverter & Generator Load Sharing Incorrect

Is the load within the combined rating of inverter plus generator?

Switch off the inverter **On/Off** button, manually run the generator, and check whether the generator supplies the load in a stable manner. The generator governor speed setting may need adjustment.

Is the inverter setup correct? Check relevant settings in the menu system.

Check the generator AC voltage and current measurement

Check the inverter AC voltage and current measurement

9.12 Generator Runs at the Wrong Times

For example, the generator starts late at night and then never starts until the middle of the day.

The time of day clock may be incorrectly set (see settings **`Time:Set Hour`** and **`Time:Set Min`**).

Check that the overnight load is not excessive, and that the battery has not lost capacity and is forcing the generator to start prematurely.

9.13 The Generator Runs for a Long Time

It may be doing an Equalise charge which can take some hours to complete; check if the **Equalise** indicator is flashing. The charging setup may need adjustment.

There may be a sustained load on the system. Check to see that appliances have not been left on.

If you need to manually stop the generator. If the generator restarts a minute or so later then the battery is discharged, the battery volts are low or a load is present. You can shut the generator down permanently by opening the externally wired generator available control switch. See 3.5 Generator Control Wiring.

9.14 Incorrect Inverter AC Voltage

Check the setting for **Inv:Nom VAC** in the menu system (see 6.4 AC Output settings).

9.15 Incorrect Battery Charging

Check that the inverter battery charging requirements are correctly set up.

Check that the renewable battery charger is correctly set up.

Bad battery temperature reading

Check battery temperature and ensure operating correctly.

Check the inverters DC voltage and current measurements

10 Inverter Shutdown & Isolation Procedures

Hazardous voltages and energy are generated in the inverter, are fed into the inverter by external wiring from multiple sources, and may be stored in capacitors after the inverter is switched off and disconnected from external wiring. The procedures below are to be performed only by suitably qualified and trained personnel, and only with suitable safety precautions. Before performing any work on the inverter or opening its front door, please refer to

To avoid safety hazards or inverter damage, perform the §10.2 Inverter Isolation Procedure and the §10.3 Inverter Discharge Procedure below before disconnecting/reconnecting any cables in the inverter.

10.1 Inverter Shutdown Procedure

Use this procedure to shut down the inverter:

1. Switch off the inverter by pressing the inverter **On/Off** button for a second, checking all the LEDs go off.
2. Unless the generator is to supply the load via the inverters Generator Contactor, open the GENERATOR AC and LOAD circuit breakers.
3. Open the DC circuit breaker if desired (in any case, it will trip automatically 15 minutes after the inverter is switched off.)

To shut down and isolate the inverter from all energy sources, for example to work on it or replace it, use the Inverter Isolation Procedure below.

10.2 Inverter Isolation Procedure

Before working inside the inverter, or on the external wiring connected to its AC and DC power terminals, use this procedure to isolate the inverter and the wiring from all external AC and DC energy sources:

1. Switch OFF the inverter using the **On/Off** button, and check all LEDs go off. The generator may still be supplying the load via the inverters Generator Contactor.
2. If the generator is to supply the load while the inverter is isolated, close the inverter bypass switch on the switchboard (if fitted).
3. Remove AC voltage from the inverter terminals, by opening the inverter isolator on the switchboard.
4. Open the GENERATOR AC and LOAD circuit breakers.
5. Open the DC circuit breaker, to stop any large DC current flowing in the inverter DC wiring.
6. If the ganged DC fuse assembly does not support on-load extraction/insertion, switch off the renewable regulator to stop DC current flow through the ganged fuse assembly.
7. Open the ganged DC fuse assembly (or ganged circuit breaker if used), to remove battery and renewable voltage from the inverter terminals.
8. Open the inverter front door. Confirm with a voltmeter or voltage detector that negligible AC voltage is present on the inverter AC terminals, and that negligible DC voltage is present on the inverter DC terminals.
9. Hazardous DC voltage may remain on capacitors inside the inverter. Before working inside the inverter, discharge the capacitors using §10.3 Inverter Discharge Procedure.

10.3 Inverter Discharge Procedure

When the inverter has been isolated using §10.2 Inverter Isolation Procedure, use the following procedure to discharge the Power PCA capacitors:

1. To prevent electrostatic damage to electronic components inside the inverter, discharge yourself by touching the earthed unpainted inverter frame.
2. Momentarily join the two pins of J11 on the Power PCA (see §7.1 Inverter Internal View) for J11 location on the PCA). This will cause the Power PCA to discharge the capacitors.
3. Wait for about 30 seconds for the capacitors to discharge to a low level.

4. Ensure the capacitors have been discharged, by measuring their DC voltage between the inverters Battery Negative terminal and the inverter side of the DC circuit breaker.

10.4 Inverter De-isolation Procedure

After the inverter and its wiring have been isolated using §10.2 Inverter Isolation Procedure, use this procedure to remove the isolation and restore the inverter to service:

1. Ensure the inverters DC circuit breaker is open.
2. Close the inverters LOAD and GENERATOR AC Circuit Breakers.
3. Close the inverter isolator on the switchboard.
4. Open the inverter bypass switch on the switchboard. If the generator is running it will now be supplying the load via the inverters Generator Contactor.
5. If the ganged DC fuse assembly does not support on-load extraction/insertion, switch off the renewable regulator to stop DC current flow through the ganged fuse assembly.
6. Close the ganged fuse assembly (or ganged circuit breaker if used). Switch on the renewable regulator.
7. Switch on the inverter using the **On/Off** button, and check that the LEDs show successful inverter self-test and start-up.
8. Close the DC circuit breaker when requested by the LCD display.

10.5 Inverter Start-up Procedure

Use this procedure to start up the inverter:

1. If not already closed, close the Generator Circuit Breaker.
2. If not already closed, close the LOAD circuit breaker.
3. Switch on the inverter by pressing the inverter **On/Off** button for a second, checking the LEDs then indicate start-up (see inverter User section of this manual). If the inverter had shut down from an abnormal cause, it may be necessary to operate the **On/Off** button several times.
4. When the inverters' internal capacitors have pre-charged, the LCD will display "Please close DC CB below". Then close the DC circuit breaker.
5. The self-test will run, and when complete, the inverter will start running and synchronise to the generator.

Appendix A Specifications

A.1 Product Specifications

Parameter	Product					
	PS1 3/24	PS1 5/24	PS1 6/48	PS1 10/48	PS1 11/108	PS1 12/120
Inverter Mode						
Battery voltage nominal	24V DC	24V DC	48V DC	48V DC	108V DC	120V DC
Battery voltage default range	22-34V DC	22-34V DC	44-68V DC	44-68V DC	98-170V DC	
Continuous output power @ 25˚C	3kW	5kW	6kW	10kW	11kW	12kW
Continuous output power @ 30˚C	2.7kW	4.5kW	5.5kW	9kW	10kW	11kW
Continuous output power @ 40˚C	2.5kW	4kW	5kW	8kW	9kW	10kW
Continuous output power @ 50˚C	2.0kW	3.2kW	4kW	6.4kW	7.2kW	8kW
Continuous output power @ 60˚C	1.5kW	2kW	2.5kW	4kW	5kW	5.5kW
Max output power five minutes @ 25˚C (initial power <1kW)	4kW	6.5kW	8kW	13kW	14kW	16kW
Maximum overload 0~5 seconds	5kW	8kW	10kW	16kW	20kW	22kW
Maximum continuous output - interactive mode @ 25˚C	3kW + generator output	5kW + generator output	6kW + generator output	10kW + generator output	11kW + generator output	12kW + generator output
Maximum continuous AC output current	12A + generator current (max 63A)	21A + generator current (max 63A)	25A + generator current (max 63A)	42A + generator current (max 125A)	46A + generator current (max 125A)	50A + generator current (max 125A)
Maximum continuous DC input/output current	150A DC	250A DC	150A DC	250A DC	120A DC	
DC input inverter in auto search, no AC load	0.6A/15W	0.6A/15W	0.3A/15W	0.3A/15W	0.12A/15W	
DC Input inverter ON, no AC load	< 1.3A/ 30W	< 2.5A/ 60W	< 1.35A/ 65W	< 1.9A/ 90W	< 105W	
Auto search sensitivity range	10-40W	10-40W	10-40W	10-40W	10-40W	
Output voltage/frequency - invert mode, zero to max load	240 +1- 4%, 50Hz +/- .01%	240 +1- 4%, 50Hz +/- .01%	240 +1- 4%, 50Hz +/- .01%	240 +1- 4%, 50Hz +/- .01%	240 +1- 4%, 50Hz +/- .01%	
Total harmonic distortion, zero to max load	<4%					
Interactive Mode						
Changeover time, invert to generator	zero					
Maximum supported generator capacity	15kVA	15kVA	15kVA	30kVA	30kVA	
Load switched to generator in fault mode	Yes	Yes	Yes	Yes	Yes	
Max inverter charge rate, adjustable	0-120A	0-200A	0-120A	0-200A	0-100A	
Max inverter charge power	Continuous output power of inverter (ref above)					
No of charge stages	Four stages plus equalise					

Charge type	Unity PF: 4-state constant voltage with current and power limiting					
Charge settings	Adjustable to suit all battery types					
Generator Start Parameters						
	4 x time of day, 3 x state of charge					
	2 x adjustable power limits, 4 x back up times					
	Battery voltage, inverter shutdown					
	Inverter temperature					
Generator start method	2 or 3 wire, pulsed and/or run signal (adjustable)					
General						
Weight	72kg	72kg	73kg	87kg	93kg	
Weight packed	79kg	79kg	80kg	94kg	100kg	
Dimensions	585H, 400W (430 incl. mtg flanges), 420D (mm)					
Communications serial interface	RS232 x 2400 bps					
Memory retention of settings and logged data	Permanent via on board battery backed RAM, and EEPROM					
Number of shunts	One x 100A internal / one optional external					
Circuit breaker for generator input	63A	63A	63A	125A	125A	
Circuit breaker for AC output	63A	63A	63AA	125A	125A	
Circuit breaker for DC battery input	250A	250A	250A with electronic trip	125A with electronic trip	125A with electronic trip	
Standby battery current, inverter shutdown (DC CB closed)	400mA	400mA	245mA	245mA	120mA	
Battery current, DC CB tripped	20mA	20mA	20mA	20mA	20mA	
Standards	Ctick, AS3100					
Efficiency @10% nominal Load	92.0%	87.0%	85.0%	91.0%	90.0%	90.0%
@30% nominal Load	95.0%	91.0%	93.0%	96.0%	95.0%	95.0%
@50% nominal Load	94.0%	91.0%	93.0%	96.0%	96.0%	96.0%
@100% nominal Load	89.0%	90.0%	92.0%	93.0%	94.0%	94.5%
Safety isolation	AC output to chassis & battery 5kV, battery to chassis 1kV					
Power factor charging	Unity					
Power factor inverting	0 to 1					
Enclosure rating	IP40					
Cooling method	Thermostatically controlled fans					
Protection	Circuit breakers on all external power connections, plus electronic trip of DC breaker***** providing reverse battery protection					
On board log	Records over 200 events, alarms and data which can be accessed remotely via serial port/modem. Current day on LCD					
Four line alphanumeric backlit LCD displays:	Configuration parameters, Batt Volts, Net Batt Amps, AC Load kW, Gen kW/Volts/Freq, Av daily kWh, Shunt 1 & 2 Amps, Event log, Charge Amps, State of Charge					

***** no electronic breaker trip on 24V model

Note: Performance to specifications cannot be guaranteed if the PS1 is operated with generators that are not capable of being synchronised. Check with supplier or Selectronic if unsure.

Selectronic reserve the right to change specifications without notice.

A.2 Standards Compliance

AS/NZS 3100:2000	Approval and Test Specification – General Requirements for Electrical Equipment
AS/NZS 1044:1995 Amendment 1:1997 Amendment 2:2000	Limits and methods of measurements of radio disturbance characteristics of electrical motor-operated and thermal appliances for household and similar purposes, electric tools and similar electric apparatus.
Ctick Australia	

A.3 Generator Control Interface Specification

See 8.6 Generator Control Interface for description of the interface signals operation.

Control Relays

Digital Out1 (DO1) – NO contact – J6 pins 1, 2 – Termination PCA

Digital Out2 (DO2) – NO/NC contact – J9 pins 7, 8 & 9 – Termination PCA

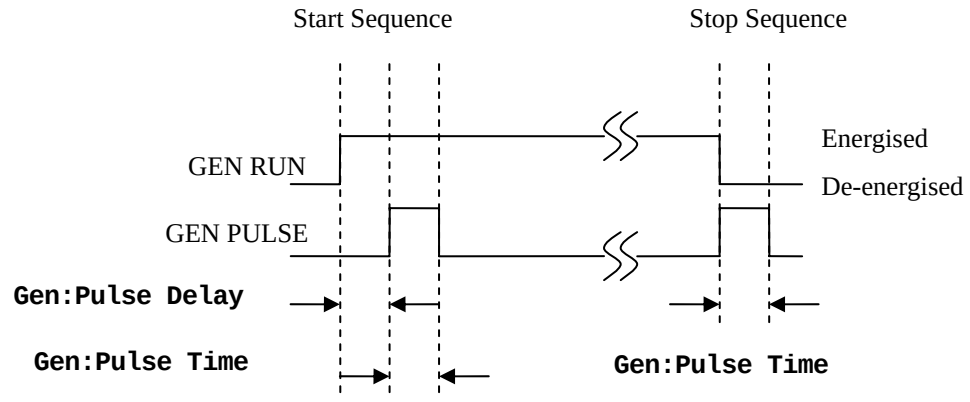
Control Output Parameter	Limit
Maximum Voltage	30VDC
Maximum Current	1 Amp

Output functions

GEN RUN – DO1 or DO2 (default DO1 when **`Ctrl Rlys`** set to Standard)

GEN PULSE – DO2 or DO1 (default DO2 when **`Ctrl Rlys`** set to Standard)

Diagram indicates coil state.



`Gen:Pulse Delay` – Pulse delay time: 1 – 30 seconds (default 2 seconds)
`Gen:Pulse Time` – Pulse time: 1 – 30 seconds (default 2 seconds)

Control Inputs

Control Inputs	Termination board connection	Function
DI1	J6 pins 3, 6	Gen Available
DI2	J6 pins 4, 6	Fault
DI3	J6 pins 5, 6	Remote Run
DI5	J9 pins 3, 5	Low Fuel
DI6	J9 pins 4, 5	Fuel Empty

Control Input Parameter	Limit
Minimum ON time	0.5 sec
Maximum ON time for pulse	2.0 sec
Maximum voltage recognised as In-active	3VDC - Polarity independent
Minimum voltage recognised as Active	8VDC - Polarity independent
Maximum voltage recognised as Active	30VDC - Polarity independent
Max Input Current @ Max Input	15mA

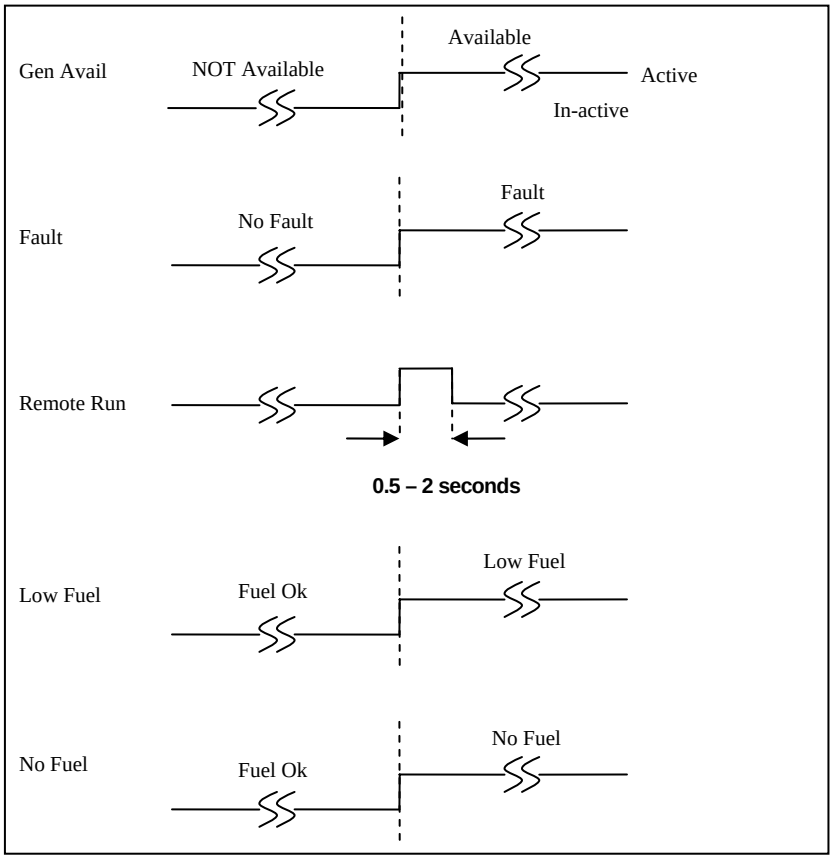


Figure 21 Control Inputs

A.4 Alarm Interface Specification

Relay

ALARM – NC/NO contact – J9 pins 10, 11 and 12 – Termination PCA

Control Output Parameter	Limit
Maximum Voltage	30VDC
Maximum Current	1 Amp

A.5 Shunt Interface Specification

Measurement Inputs

Shunt 1 – Differential Input – +ve: J8 pin 1, -ve: J8 pin 2

Shunt 2 – Differential Input – +ve: J8 pin 3, -ve: J8 pin 4

Input Parameter	Limit
Maximum Differential	100mV DC

A.6 Serial Port

The serial port on the control PCA is a RS232 compatible port and has the following pin out:

PS1 Serial Port		J16 (RJ45)
Signal Name	Signal Direction	Pin
n/c		1
DTR	Output	2
TD	Output	3
0V	-	4
0V	-	5
RD	Input	6
DCD	Input	7
n/c		8

n/c – no connection

The port is wired as a DTE device. The serial port is isolated from the battery supply.

A.7 Battery Cable Recommendation

Recommended Battery Cable Sizes:

Total distance of one conductor from PS1 to Battery terminals	Battery Cable **Minimum** Size in mm^2 and (% power loss). (V- 75, V-90 or V-90HT insulation)					
	PS1 3/24	PS1 5/24	PS1 6/48	PS1 10/48	PS1 11/108	PS1 12/120
<2m	70 (0.5)	2 x 50 (1.3)	70 (0.5)	2 x 50 (0.3)	70 (0.2)	70 (0.2)
2 - 5m	2 x 50 (0.9)	Note 1	2 x 50 (0.9)	2 x 50 (0.6)	70 (0.5)	70 (0.4)
5 -10m	2 x 50 (1.8)	Note 1	2 x 50 (1.8)	2 x 50 (1.6)	70 (1.0)/ 2 x 50 (0.7)	70 (0.9))/ 2 x 50 (0.6)
> 10m	Note 1	Note 1	Note 1	Note 1	Note 1	Note 1

Note 1: This cable length/product combination is not recommended.

A.8 Battery Fuse Recommendation

Recommended Battery Fuse Sizes:

Product	PS1 3/24	PS1 5/24	PS1 6/48	PS1 10/48	PS1 11/108	PS1 12/120
Battery Fuse Rating (A)	200	315	200	315	200	200

A.9 Mechanical Details

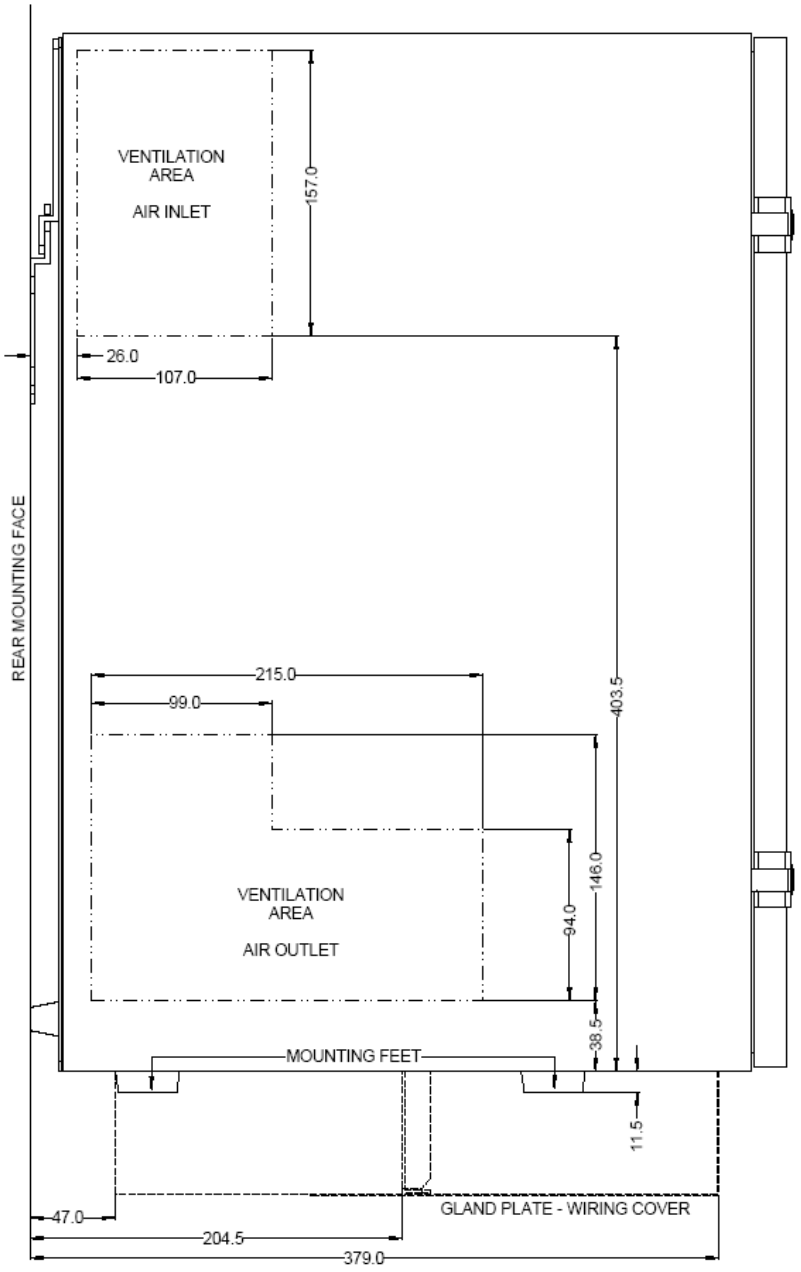


Figure 22 Side view

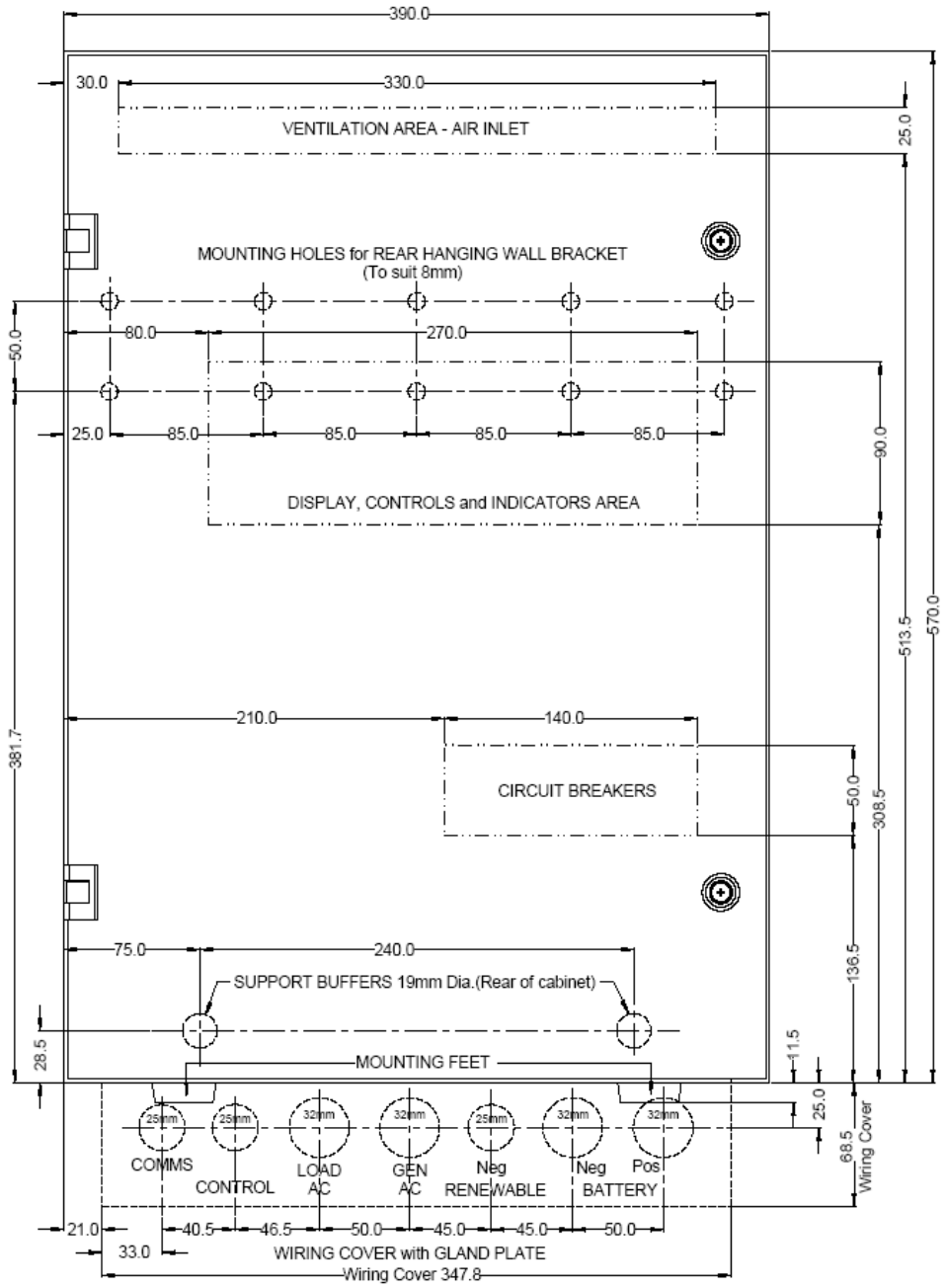


Figure 23 Front View

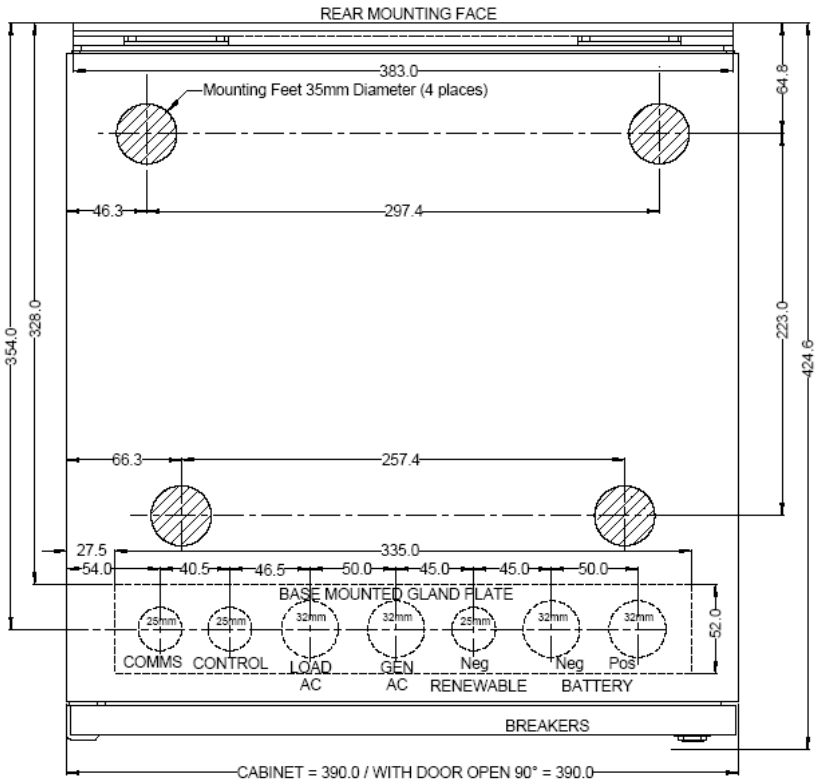


Figure 24 Top View

Appendix B Definitions

B.1 Settings Index

B.2 Event Definitions

Events displayed and logged in the PS1 are assigned an event code. The text displayed for each event on the LCD is abbreviated. The following describes in more detail each event. The table also details whether the event increments the event counters or triggers an immediate shutdown of the inverter.

Event Code	Event description	Triggers	
		Event Counter	Shutdown
0	Internal state change		
1	Generator did not start when required		
2	Generator started but inverter could not synchronise		
3	Illegal Scheduler state - Reset Scheduler		
4	Illegal Generator Control state - Reset Generator Control		
5	Illegal Inverter state - Reset inverter		
6	Generator did not shutdown when required		
7	Generator manually started via front panel control		
8	Generator manually stopped via front panel control		
9	Generator not under inverter control		
10	Generator under inverter control		
13	Hardware DC over current		Yes
14	Hardware bridge over current shutdown		Yes
15	Hardware DC over voltage shutdown	Yes	Yes
17	Control PCA initiated shutdown	Yes	Yes
18	Software initiated shutdown	Yes	Yes
19	Power PCA initiated shutdown	Yes	Yes
20	Sustained shutdown input	Yes	Yes
21	Recurring shutdown input	Yes	Yes
22	I2T 10 sec overload shutdown	Yes	
23	Sustained current limit shutdown	Yes	Yes
25	Command port overflow	Yes	
26	I2T 32 sec overload shutdown	Yes	
27	AC over voltage shutdown		Yes
31	Generator start on low DC volts, high load		
34	Battery volts high shutdown	Yes	Yes
35	Battery volts were high now OK		
38	Generator controller, shutdown on fault input	Yes	
39	Generator controller, retry generator start	Yes	
40	Generator controller, no start after 3 retries	Yes	
41	Generator started using remote start		
42	Generator stopped using remote start		
43	Generator controller, no pulse signal, volts present	Yes	
45	Generator start on low DC volts, low load		
46	Scheduler generator start on 30 sec load		
47	Scheduler generator start on 2 min load		
48	Scheduler generator start on 10 min load		
49	Scheduler generator start on 30 min load		
50	Scheduler start on level 2 SoC		
51	Scheduler start on level 1 SoC		
52	Scheduler start on level 3 SoC		
53	Low battery restart with AC volts		
54	Generator disconnect due to reverse power	Yes	
55	Generator disconnect due to bad ACV or Freq	Yes	
56	Generator disconnect due to current limit	Yes	

Event Code	Event description	Triggers	
		Event Counter	Shutdown
57	Generator disconnect due to very low AC volt	Yes	
61	Low battery reset with renewable recovery		
63	Fuel Low Alarm		
64	Fuel Low Alarm reset		
65	Fuel Empty Generator shutdown		
66	Fuel Empty reset		
67	System restart by internal reset		
69	Generator started, 14 days since last run		
70	Generator stopped during charge cycle	Yes	
73	Generator shutdown - midnight low load		
83	Setting store corrupt, reloaded default values	Yes	
84	First block of setting store bad - restored from parameter ram	Yes	
85	Second block of setting store bad - restored from parameter ram	Yes	
86	Setting store missing or bad settings, reloaded default values		
87	Restart after power up or micro reset		
88	Equalise manually initiated		
89	Equalise or Generator run manually stopped		
90	Generator disconnect due to sustained power error	Yes	
91	Generator supplying load, inverter inhibited		
92	Settings loaded OK		
93	Setting store failed	Yes	
94	Setting edit timed out, setting unchanged		
95	Setting modified		
98	Equalise terminated on max time	Yes	
99	Equalise terminated normally		
100	Equalise charge started		
101	Equalise automatically initiated		
103	Initial charge started		
104	Over temperature shutdown		Yes
106	Permanent data erased		
109	State of charge shutdown	Yes	Yes
110	Low battery voltage shutdown	Yes	Yes
111	Self test completed OK		
112	Renewable battery float achieved, equalisation deferred one day		
118	Generator start from OK pushbutton		
119	Generator stop from OK pushbutton		
120	Time of day changed		
122	Data logging restarted		
123	Remote start Generator command		
124	Remote stop Generator command		
125	Remote initiate Equalise command		
126	Remote finish Equalise command		
134	Generator start, high temp		
135	Generator start, overload shutdown		
138	Shutdown repetitive minor events		Yes
139	Non urgent alarm asserted		
144	Generator shutdown due to frequency shift		
146	Normal generator shutdown		
151	Abnormal charge end, excess Ahr		
152	Normal charge end		
154	Abnormal Equalise end, excess Ahr		

Event Code	Event description	Triggers	
		Event Counter	Shutdown
155	Abnormal charge end, reverse Generator power		
174	Run time completed in non-preferred period		
175	Generator run request after overload shutdown		
176	Emergency reset & Generator run, battery very low		
180	Skipped midnight shutdown, load high		
181	Skipped midnight shutdown, equalise in progress		
195	DC Circuit Breaker open, inverter shutdown	Yes	Yes
197	Scheduled generator start		
200	Inverter fault shutdown - 15V supply fail	Yes	Yes
201	Power board MOSFET control shutdown	Yes	Yes
202	CB open shutdown - current sustained after disable		Yes
203	Heatsink temperature high shutdown	Yes	Yes
204	TX temperature high shutdown	Yes	Yes
206	Generator contactor fault	Yes	
207	Processor turning power off		
210	Overcharge adjusted		
211	Undercharge adjusted		
215	Battery temperature senor FAILED	Yes	
216	Battery temperature senor OK		
220	Scheduled Generator stop		
221	Backup Generator start		
222	Backup Generator stop		
223	Self test fail		
226	Generator request ignored - Generator not in auto		
227	Setting store - detected write failure	Yes	
228	Setting store - cleared write failure		
229	Inverter out of service		
230	Bulk charge started		
231	Absorb charge started		
232	Absorb charge complete		
233	Charge stage timeout		
234	Equalise state aborted		
240	Manual mode Inverter auto disconnect from Generator		
241	Over temperature Generator Start		

B.3 Self Test Fault Codes

The PS1 will display a fault code on the LCD if the start-up self test fails. The following table describes each of the fault codes.

Code	Description
2	FET switch short circuit detected
4	FET switch monitor circuit failed
6	FET switch controller failed
8	Current detected during switch test
10	Current limit detected during switch test
12	FET switch control shutdown during switch test
14	Incorrect FET switch control signal detected
16	Over temperature detected.
18	Control shutdown
20	Reference voltage control failure
22	FET switch monitor not zero in idle condition
24	I/O system failure
26	FET switch not switching low
28	FET switch not switching high
32	Start disabled
34	No FET volts detected – start fail
36	No transformer detected – start fail
38	FET control not detected – start fail

Appendix C Revisions and Changes

C.1 Revisions to this Document

Revision	*Date*	*Description*
01	31 Mar 2005	Initial release
02	31 May 2005	Updated specification, manual equalise.
03	4 May 2006	Numerous clarifications
04	27-July-2006	Added information on remote LCD timeout
05	18-October-2006	Updated software version applicability

C.2 Software Version Applicability

This manual is applicable to the following software versions:

Versions	*Description*
9.AG, 9.BG, 9.CG, 9.DG, 9.EG, 9.FG	Improved DC current flow control Improved Shunt 2 logging
8.AG, 8.BG, 8.CG, 8.DG, 8.EG, 8.FG	Remote LCD timeout added for enhanced modem compatibility. Improved dynamic response of power controller. Improved generator type defaults.
7.AF, 7.BF, 7.CF, 7.DF, 7.EF, 7.FF	Remote LCD function added plus other minor functional enhancements, addition al generator control improvements. Generator control parameters not as detailed.
6.AE, 6.BE, 6.CE, 6.DE, 6.EE, 6.FE	Improved generator control functionality. Does not include remote LCD function. Not all communications commands available. Some default parameter not as detailed.
2.AD, 2.BD, 2.CD, 2.DD	Initial Software release. Does not include remote LCD function. Not all communications commands available. Some default parameter not as detailed.