



power solutions australia

generator interactive sinewave inverter

Introduction

The Power Solutions Australia Generator Interactive Inverter System provides mains quality power efficiently and automatically. It uses batteries to store energy for periods when power demand is low and automatically starts a diesel generator set when demand is high or when the batteries require recharging.

This mode of operation ensures that diesel fuel is efficiently converted to electricity by only running the generator at medium to heavy loads and only for a small proportion of the day. Power is drawn from the batteries and converted to a mains quality sine wave by a microprocessor-controlled inverter. The generator is automatically started and stopped by the inverter. While the generator is operating it supplies power to the load and the inverter recharges the batteries. However if heavy loads occur both the inverter and the generator can supply the load giving a peak capacity equal to the sum of the inverter and generator ratings. This allows smaller generators to be used compared with inverter charger systems.

An alpha numeric LCD display allows inverter variables to be displayed and allows suitably qualified technicians to adjust operating parameters to optimise system performance.

Hardware and software provide electronic protection against most types of abuse. The inverter is fully self-resetting against all recoverable fault conditions, for example if the generator fails to start and the load persists the inverter shuts down before damage to the batteries occurs. If renewable inputs recharge the battery to a reasonable level the system will then restart automatically.

Data logging operates continuously in the inverter to record power, voltage temperature and current variables. Most variables are averaged over 15 minute periods but minimum and maximum values of selected variables during each 15 minute period are also recorded. Data covering up to 8 days of testing is stored in non-volatile memory in the inverter.

A single day of data or all stored data can be retrieved over a serial link or remotely via a modem or via sat phone. The oldest day's data is automatically cleared and overwritten as each new day of logged data is added. There is no need to clear logged data from the inverter. Remote monitoring and analysis of data allows performance to be monitored and problems anticipated. Remote diagnosis allows remote units to be fixed in a single visit and allows expert staff to assist with systems anywhere in the world.

An IBM compatible PC program is provided which converts logged data from the inverter into spreadsheet format and extracts event records. These record the times when units start, start and stop the generator or change mode as well as other events associated with inverter operation including protective actions. The data can be graphically displayed by copying it into a pre-prepared spreadsheet.

Normal Operation

Inverter Self Test

The inverter performs a self-check as it starts up. During the self test all the LED indicators on a module flash. Only if no faults are detected will the inverter start. Normal operation is indicated by steady illumination of the top green indicator light.

A flashing green indicator at the top indicates the self-test has detected a fault and the inverter will be not be able to start. If the top green indicator is flashing record the pattern of indicators that are illuminated and advise your supplier.

Starting and Stopping the Generator Manually

Pressing the Enter button on the front panel for less than a second when in normal display pages will start the generator, charge the batteries complete charging and shut down automatically. If the generator is running a short push will disconnect the inverter from the generator and shut the generator down.

The generator may also be started and stopped manually from the generator control box. The inverter will automatically charge the batteries whenever AC power is available. Once charged, the battery voltage will be reduced to hold the battery in float.

Automatic Generator Control

The generator is started and stopped to achieve the following objectives:

- Limit the depth of battery discharge to give maximum battery life
- Perform boost charging periodically to maintain all battery cells in a high state of charge to minimise risk of cell failure and loss of battery capacity
- Meet demands for heavy loads by starting as soon as a very heavy load is applied and sustained.
- Deliver energy efficiently by supplying sustained large loads direct from the generator.
- Ensure the generator is loaded to the highest possible level while running to achieve best efficiency in converting diesel fuel to electricity.
- Ensure that the generator does not do frequent starts and stops which degrade life expectancy and increase maintenance
- Only start late at night if absolutely necessary because of heavy loads or a deeply discharged battery.
- If energy from solar or wind sources is available to only start if the battery is still being discharged and topping up from diesel is necessary.
- With a normal household load the battery will be discharged at a modest but fluctuating rate. The generator will start when 25% of the battery capacity has been used. The generator will stop when the battery is close to fully recharged but will stay on if there is a load sufficiently high to supply directly and efficiently from the generator.
- When very heavy loads (up to twice the inverter rating) have to be supplied the generator will start almost immediately, to share the load and prevent over heating of the inverter. After the large load is removed the generator will remain on to charge the batteries back to full capacity or if sufficient load remains to be efficiently supplied direct from the generator.
- When sustained loads are present that can be efficiently supplied by the generator, the generator will be started. It will only stop when the load has dropped and the batteries have been recharged.
- Around 6 PM the generator will start to make sure the batteries are fully charged for overnight provided they are at least partly discharged. After 11 PM the generator will shut down unless there is a heavy load on the system. It will only start if the batteries are seriously discharged or if heavy or sustained high loads are present. This ensures that under most conditions the generator will not be running or start in the early hours of the morning.
- At 8am the generator will probably start to replace the charge used overnight if it exceeds the normal 25% discharge level.
- If solar or wind energy is sufficient to hold the battery charged in the presence of load the generator will not start, however as soon as the battery state of charge falls the generator will start to restore charge to full conditions before shutting down. In this situation it will only run for a short time infrequently.

Generator Start and Stop

The inverter will automatically start and stop the generator providing:

- The generator control switch is in the Auto position.
- The generator starting battery is charged.
- The generator has fuel, oil and water.

Generator Start

The generator will be started for the following reasons:

- A sustained high load requires the load on the inverter to be reduced.
- A sustained medium load can be more efficiently supplied directly from the generator.
- The battery has been discharged to such a level that it requires recharging.

- Three levels of discharge can apply at different times of the day. At the preferred generator run hour a small discharge will start the generator. This is typically set at the end of the day to charge the battery if renewable input has not charged the battery to a reasonable level. This also ensures the battery is well charged for overnight

Generator Stop

The generator will stop for the following reasons:

- The load on the system is low and the batteries have been recharged
- The generator has run out of fuel.
- The control switch on the generator controller has been moved to the OFF position.
- The generator has shutdown on over-temperature or low oil pressure.

Generator Won't Start

The generator will not be started if:

- The battery voltage indicates that the renewable input is meeting the load and has kept the battery charged.
- The generator is not in automatic mode as indicated by the Gen OK indicator being illuminated.
- The generator has run out of fuel or failed to start.
- The LockGen hr parameter is set to allow higher levels of discharge to make the generator less likely to start for some part of the 24 hour cycle. This can largely eliminate running at times when noise may be a problem.

Generator Start Sequence

The generator start sequence has been designed to work into a controller that accepts fuel crank and preheat input signals. The inverter generator controller is compatible with an external controller, which uses the fuel output as a run/stop signal, and internally performs multiple cranks and shuts down when the run signal is removed.

The inverter generator controller sequence involves:

- Energising the fuel solenoid output
- Energising the Glow plugs by closing energising the PREHEAT input for 20 seconds before cranking.
- Cranking the engine for up to 3 seconds by energising the START input, while monitoring for the presence of AC output volts. During cranking the PREHEAT output is de-energised. If AC output voltage from the alternator is sensed during the crank cycle it is terminated immediately.

Once the three seconds of cranking is complete the sequencer pauses for 15 seconds while monitoring for the presence of AC output from the alternator, during this period the glow plugs are energised again. If AC is detected the delay is terminated, the glow plugs de-energised and no further cranking will be attempted. If no AC is detected another crank cycle will be initiated after 15 seconds.

- After the third attempt at cranking the generator still has not started no further attempts will be made and the fuel solenoid is de-energised.
- When the inverter wishes to stop the generator it de-energises the fuel solenoid output

If the generator sequencer does not see the generator has started it will issue a stop command stopping the generator and lock out further start attempts.

Connections to the generator control system are shown in the block diagram in this manual.

Synchronisation

When the generator starts or is started manually, or a mains supply is connected to the generator input terminals the inverter will synchronise to the AC voltage and close the generator contactor. It will not synchronise if the AC voltage is out of tolerance in magnitude or frequency. It synchronises at zero power and then ramps power off the inverter and onto the generator over a period of 30 to 90 seconds until the inverter load is zero and then continues ramping until the inverter is charging the batteries.

Once synchronised the generator is used to charge the batteries and to meet the load on the system. If the load on the system is greater than the generator capacity the inverter will abandon charging and add

its output to the generator, drawing power from the batteries and limiting the load presented to the generator. Once the load falls below the generator rating it will resume charging the batteries.

Battery Charging

Battery charging is done in constant current, constant voltage mode. Once the float voltage is reached the battery will be held at that voltage. As the current drawn by the battery falls, the load on the generator decreases and when generator load falls below half the generator rating, the generator will be shut down. Hence, if there is a significant load on the system, the generator may continue to operate until that load is removed.

Two Stage Charging

The first stage of charging is at a lower voltage and higher current than the final charge voltage. This allows high rates of charge on smaller batteries. A single initial charge voltage is now available on the LCD display. The flooded and gel battery charge voltages are the final values which are used after initial charging is completed

The default initial charge value is 2.3V per cell, which is suitable for most types of batteries. The charge current applies during the initial charge phase, which continues until the battery voltage reaches the initial charge voltage and the charge current (including renewable input if measured) falls below the value set for boost charging. The maximum charge voltage is then raised to the charge voltage selected for that battery type and the maximum charge current is reduced to the boost charge value.

Boost/ Equalisation Charge

Once per week the battery will automatically be given a boost charge. It will be held at a higher charge voltage for approximately three hours. This allows any cells in the series battery bank, which may be partly discharged, to be restored to full charge. During boost charging the generator will be held on, irrespective of load and the charge indicator will flash.

Manual Boost Charge Request & Cancel

Pushing the ENTER button for 2 seconds and releasing will initiate a boost/equalise charge cycle when the next charge cycle completes. If a boost/equalise has been requested automatically or manually then pushing the ENTER button for 2 seconds will cancel the request at any time up to the time when the boost/equalise charge is complete.

Generator Charge Terminated by High Renewable Input

If battery charging is in progress, and the generator charge power becomes negative when averaged over 2 minutes due to renewable input, the charge cycle, is terminated.

If battery boost or equalisation is in progress, and the generator charge power becomes negative when averaged over 2 minutes due to renewable input, the boost cycle is terminated and rescheduled for the next day.

Operating Without the Generator

If the generator is not available the inverter can be turned off using the On/Off switch when power is not required. If available, renewable energy can recharge the battery. Turning the inverter off reduces the load on the battery and allows the batteries to be recharged even if the input from the renewables is small.

If the battery becomes heavily discharged the Low DC indicator will come on and the inverter will shut down. Turning the On/Off switch off then back to on will reset the Low DC indicator and allow the inverter to be restarted for a short time, at the expense of discharging the battery more deeply.

If the inverter shuts down on Low DC and the battery is partly recharged from renewable inputs the inverter will automatically restart. It will also automatically restart if the generator is restarted.

Note

All references to generator control switches refer to the switches normally provided on the generator manufacturer's control box that is normally supplied as part of the electric start system for the generator.