powerguard

Technical Description
Of the
PS System
Generator/Inverter Controller
For
Business, Domestic and Mixed Load Applications

0.25 kVA - 100 kVA

PRACTICAL FULLY AUTOMATIC SOLUTIONS
FOR OFF-GRID APPLICATIONS
SAVING FUEL AND REDUCING POLLUTION.

POWER IS OUR BUSINESS

Published by GC/PM - 01/06/12

Telephone: 44 (0)1507 600 688 • Facsimile: 44 (0)1507 600 621

Contents

About Us

Thank you for your interest in Powerguard off-grid systems. We hope you find this description useful.

We also manufacture standby systems used for protecting critical and essential equipment..

Powerguard is a registered trade name.

Power Systems Warehouse is a specialist supplier of Uninterruptible Power Supplies, Standby Power Supplies, Generators, Inverter Systems, Batteries, Battery Chargers, Static Switches, Manual and Semi-automatic Bypass Switches with power outputs from 50 Watts to 4000 kWatts.

Power Systems Warehouse is the largest OEM manufacturer of Central Battery Emergency Lighting Systems in the UK. We supply both DC Systems and Static Inverter Systems from 100 Watts to 100 kWatts. The Static Inverter Systems can be single or three phase input/outputs.

We have recently extended the range of standby systems to provide back up for motor driven equipment. This would include refrigerators, pumps and fans as well as many other motor driven applications. Powerguard also supply single phase to three phase converters to power motors. These are fully specified inverter systems and the three phase motor runs at full power.

Power Systems Warehouse is dedicated to providing practical and affordable solutions to reduce energy consumption and pollution. Our off-grid generator/Inverter Control systems reduce fuel consumption and maintenance by two thirds. In addition generator life increases by a factor of three. Our combined heat and power systems reduce the cost of generating electricity and providing heat for buildings or processes.

We supply and install wind turbines and PV Solar panels. We manufacture Hydro Electric controllers including charger systems. We also investigate the use of alternative fuels for the generators including used vegetable oil and gas.

Our building blocks – chargers – inverters – changeover systems – static switches – are all designed and proven to give a very high performance with exceptional reliability and long life.

The Uninterruptible and Standby Power Systems, Inverters, Static Switches, Bypass Switches, Chargers and Control Systems are state of the art products using the latest technology. They are microprocessor controlled with sophisticated software to enhance the reliability and performance.

About Us

We aim to make systems that are different. We manufacture the PS Systems, Emergency Lighting Systems, Standby Systems, Static Switches, Bypass Switches, Inverters, Battery Chargers and Control Systems entirely in the UK. This is rare nowadays but it is important to achieve the quality engineering that is essential to the service we believe we should give to our customers.

Power Systems Warehouse also stock a large range of lead acid batteries to suit standby, deep cycle and full traction applications.

You can be confident about ordering a Powerguard system because we stand behind our products absolutely. We give a no strings, no quibble, free on site warranty for the first year of ownership of the bigger systems and a two year replace or repair warranty on the smaller systems.

When you contact Powerguard you will find us very helpful with an unbeatable, in depth, technical knowledge about our products that is entirely at your disposal both before and after your order. We understand Power Systems and can help you.

If required we carry out site surveys followed by a project plan and quotation to solve your power problems in the most effective and economical way possible. We can arrange the supply, positioning, installation and commissioning of the equipment, followed by the most cost effective after sales maintenance agreements in the industry, providing total project management.

We are dedicated to giving our customers the most appropriate and cost effective power solution possible with efficiency, reliability and long life primary design objectives.

We have a proven track record, satisfied customers and reference sites.

Accreditation

Powerguard is a registered trade name owned by Power Systems Warehouse Ltd. We are able to design, build, install and commission power systems up to 4000 kVA.

Powerguard supply a range of high quality and very efficient generators for Prime-power applications.

Power Systems Warehouse is the sole UK importer and distributor for the full range of Vision batteries.

Vision is a world renown manufacturer of premium quality lead acid batteries with sales in over 100 countries.

Power Systems Warehouse is a major distributor for the full range of Eaton Powerware Uninterruptible Power Supplies.

Eaton is a leading global provider of comprehensive power quality and power management solutions, consistently delivering the high 9s of availability demanded by today's digital economy.

Power Systems Warehouse is a major distributor for the full range of SDMO generators.

Specializing in the manufacture of generating sets SDMO offers a wide range of standard sets from 1 to 3000 kVA.

Power Systems Warehouse is fully registered as a supplier on the Utilities Vendor Database for the following product/service categories:-

Uninterruptible Power Supplies • Emergency Lighting

Generators • Batteries • Installation • Maintenance.

UVDB Certificate of Registration Supplier Number - 701848

Accreditation

Power Systems Warehouse is approved to

BS EN ISO 9001 : 2000 - Quality systems.

Certificate Number - GB 8416

Power Systems Warehouse is approved to

BS EN ISO 14001 : 2004 - Environmental management systems.

Certificate Number - GB 14930

National Association for Professional Inspectors and Testers

Government Approved register holders for Part P Registered Domestic and Industrial Electrical Installers (both full and defined scope) while continuing to serve the needs of those carrying out equipment testing and electrical installation and testing in commercial and industrial sectors.

Features

- RUGGED AND RELIABLE.
- LONG LIFE.
- MULTI-MICROPROCESSOR CONTROLLED.
- SAVES FUEL.
- SAVES MAINTENANCE.
- INCREASES GENERATOR LIFE.
- HIGH EFFICIENCY SWITCH MODE CHARGER
- CONSTANT CURRENT/VOLTAGE CHARGER.
- CHARGER SOFT START TO ELIMINATE HIGH CURRENTS.
- CHARGE RATE ADJUSTED IN PROPORTION TO THE GENERATOR LOAD
- SOPHISTICATED OPERATION TO INCREASE BATTERY LIFE AND RELIABILITY.
- EQUALISES THE VOLTAGE ACROSS THE BATTERY CONTACTOR BEFORE CLOSING.
- LOW BATTERY DISCONNECT USING A MAGNETICALLY LATCHED CONTACTOR.
- TIMED OPERATION OF THE CONTACTOR TO REDUCE ARCING AND CHATTER.
- 24/7 POWER.
- VOLT FREE CHANGEOVER CONTACTS TO DRIVE A REMOTE COMMON ALARM.
- TWO BUTTON OPERATION FOR SYSTEM SHUTDOWN.

Features

- CHARGER USES COULOMB COUNTING AND CURRENT ANALYSIS TO CONTROL THE CHARGE TO ACCOMMODATE ALTERNATIVE ENERGY INPUT.
- COMPREHENSIVE MONITORING AND DISPLAY.
- AUDIBLE ALARM WITH MANUAL RESET.
- DUAL INDEPENDENT POWER SUPPLIES WITH MONITORING.
- EASY TO OPERATE.
- ECO-FRIENDLY.
- SYSTEM SHUTDOWN FROM THE FRONT PANEL.
- SAFE OPERATION.
- CLEAR LCD SCREEN.
- INVERTER INCORPORATES MUSTSTART® TECHNOLOGY.
- INVERTER INCORPORATES POWERFLOW® TECHNOLOGY
- MINIMUM 25 YEAR DESIGN LIFE.
- HIGH SYSTEM EFFICIENCY.
- ACCEPTS INPUT FROM ALTERNATIVE ENERGY SOURCES
- 12 MONTHS FREE ON SITE WARRANTY (applies to installations on the UK mainland up to 30 miles north of Glasgow)

Introduction

Powerguard is a leader in the design and manufacture of inverter systems used in energy saving applications. The key product families are PS Systems, Generator/Inverter Control Systems and Renewable Energy Products.

We provide leading edge solutions and expect to work with our customers to provide expert and professional services. Our success is based on using technology to provide practical answers to power problems. We have many years of experience and the motivation to deliver products of optimum performance and quality that will solve problems for our customers.

Our approach to renewable power systems is based on these principles and will deliver practical cost effective solutions that will provide many years of trouble free operation. Our systems are designed and manufactured to give over 25 years service with minimal maintenance.

This technical description is designed to give an in depth knowledge of how our Generator/Inverter Control System operates and the component parts used to make up the system. It will also give an insight into the aims of our design team and how the system can dramatically reduce the burning of fossil fuels and the production of greenhouse gases and pollution. In most cases fuel use, generator running time and maintenance is reduced by a minimum of two thirds.

We know that our customers want to have electricity on tap 24 hours per day seven days a week (24/7) just the same as those of us who are connected to the national grid. The only way to guarantee the availability of power 24/7 in a cost effective way is to have an engine driven generator. Our philosophy is to accept that as fact and then devise systems which reduce the need for the generator to start to an absolute minimum. In a typical PS System without renewable power the generator runs for less than one third of the time.

If you are already generating your own power then the first and most significant step to dramatically increase efficiency is to install a Powerguard PS System.

The next step is to consider CHP (Combined Heat and Power) and renewable energy sources such as wind or solar.

Non-Technical Clients

The Powerguard PS System is designed to run in conjunction with an engine driven generator set. If you use a generator system and want the increased efficiency and sheer convenience of the PS System you do not need to be technical and you do not need to read this technical description.

You can just agree the specification with our help and purchase the system. We install and commission the system or if you prefer your local electrician/plumber can do the installation. The system then operates automatically.

Some of our customers would have difficulty changing a three pin plug but they still have the savings and benefits of the Powerguard PS System.

If you do want to know how it all works then read on.

Generator

PS System runs with an auto-start generator.

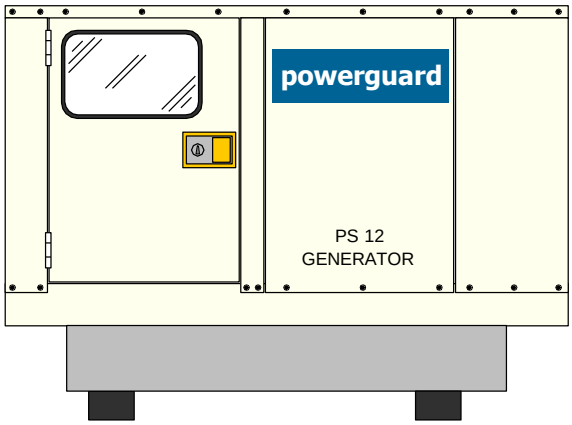
The PS System is designed to run in conjunction with an engine driven generator. The generator will need to be auto-start. Starting when a contact in the PS System closes and stopping when the contact opens.

Electric start machines can be easily upgraded.

If you already have an electric start generator then it can probably be upgraded using a module from Deep Sea Electronics or similar.

A Powerguard generator has many advantages.

If you are going to purchase a generator then one from the Powerguard range will have many advantages. The picture shows a typical Powerguard generator.



Picture of a typical Powerguard generator.

The Powerguard range of generators is designed and built to give long and reliable service.

High quality engines and generators are used.

We use Perkins engines and Newage or Leroy alternators. Spares and service are available throughout the world by factory appointed technical agents.

Most generators available are aimed at the Stand-by market.

Many generators that are available are designed for stand-by applications only starting if the main supply fails. This type of set is given a higher rating as they are not expected to operate for extended periods. Fuel use is also a secondary issue. This is because the costs involved in purchase, installation, maintenance and testing far outweigh the relatively small amount of fuel used during intermittent operation. They are often built using cheaper less efficient engines and alternators. The smaller sizes often use 2 pole alternators and run at 3000 RPM causing more wear and tear. Most of these generators perform well in the stand-by application they are designed for.

Often built using cheaper less efficient engines and alternators.

The generator should be designed and built for Prime-power applications.

Prime-power is where the generator provides most of the power required for an application. The generator will run for longer periods and fuel use is a major issue.

Powerguard generators are rated for prime-power and are designed and

Generator

built to give the highest efficiency practicable. Powerguard single phase generators use dedicated single phase alternators as opposed to the multi wound types that can be configured for single or three phase. This increases the efficiency by at least 5% against the best alternative and by up to 20% compared to some others.

Powerguard generators have dedicated alternators for efficiency.

This dedication to achieving the most fuel efficient solution means that Powerguard customers enjoy the lowest ongoing generating costs possible.

Components are chosen for efficiency giving low ongoing costs.

The PS System will completely automate the generator and it will operate with very little attention from the user.

The PS System is automatic.

Powerguard generators are housed in an acoustic canopy reducing noise levels to less than 75db at 1 metre and can be sited outside if necessary.

Acoustic canopy.

Most standby sets are sold with water jacket heaters to guarantee starting in cold weather. These are powered from the mains supply and a typical size fitted to a 12kVA generator would be 750 Watts. On the PS System we do not want to load the inverter with an extra 750 Watts reducing efficiency and increasing battery size. Powerguard generators are fitted with pre-heaters to guarantee starting in cold weather. This is the same system fitted to cars with diesel engines and is reliable and efficient.

Powerguard generators are fitted with glo-plugs to increase efficiency.

The speed of the Powerguard generator is monitored using a tacho to increase reliability and prevent spurious shutdowns caused by distortion.

Tacho speed pickup.

Some generator specifications are optimistic about the power rating and will struggle when running for long periods at a sustained load. The PS System aims to charge the batteries in less than 8 hours. The charge rate is automatically adjusted to use the surplus power and this means that the generator will be consistently loaded.

Some generator specs are optimistic and will struggle under sustained load.

It is worth spending a bit more and going for a good quality generator that is reliable and efficient with a rotational speed of 1500 RPM.

Go for a good quality generator.

As a guide a typical rating for a domestic application will be about 12 kVA.

Efficiency and Service Life

The PS System increases efficiency and reduces pollution and the production of greenhouse gases.

There are two main reasons why our customers purchase a PS System. The first is that the system increases efficiency reducing the need to burn fossil fuel thereby reducing costs, pollution and the production of greenhouse gases. The second is the sheer convenience that a fully automated system brings.

The first reason is important in a more global context in that all of us are trying to minimise the pollution we cause. There is no question that installing a Powerguard PS System to operate with a generator increases the system efficiency dramatically. We sold a system to a farmer in Norfolk who has built a new house on his farm. The new house was built but the cost of connecting to the national power grid was prohibitive so he installed a 15 kVA generator. The generator was running most of the day for most days and consumed about 18 litres of diesel fuel per day. He contacted Powerguard and purchased a PS System. The system was installed and commissioned.

Reduced fuel consumption from 18 to 6 litres per day.

The generator run time and maintenance is reduced by at least two thirds.

The generator run time is now less than 8 hours in 24 and the fuel consumption is about 6 litres per day. Electrical power is available 24/7.

Type of inverter and charger chosen for high reliability.

We have chosen the type of inverter and charger that we use not only to give the highest efficiencies practicable but also for long term reliability.

How efficient is a system that breaks down and needs expensive repairs?

System fuel use is the ultimate test of efficiency & the PS System is top.

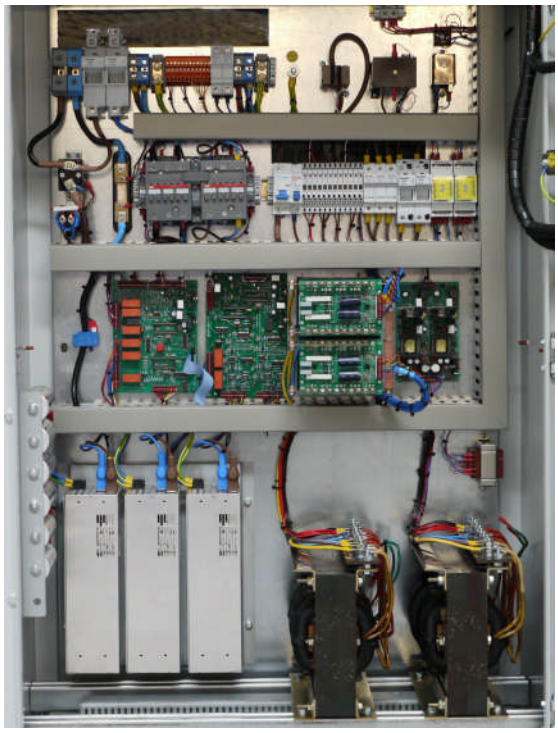
The overall efficiency dictates the amount of fuel used so this is the ultimate measure of any system and the Powerguard PS System comes out on top.

Another reason for the technology is that it is very scaleable. We can easily design and build systems to suit an application. For example if efficiency could be improved by adding another 20 Amps to the charge current we can easily do that. This would raise the overall efficiency of the system and that is the most important factor.

Scaleable and flexible technology.

We believe service life and reliability should be taken into consideration when considering efficiency. Not only is the pollution caused when building

Efficiency and Service Life



A typical internal layout

the system in the first place offset by the increased operating efficiency. It is effectively reduced by the system's long working life. Powerguard PS Systems are designed and built to give over 25 years reliable service with minimum maintenance.

To manufacture the systems causes pollution so life span is important.

25 years min working life with little maintenance.

If maintenance is required the systems are built so that all of the parts are accessible and can be replaced easily - please see the above picture showing a typical internal layout. We also include full circuit diagrams with the operators manual making it easier for third parties to provide service.

Maintenance and repairs are easy because of the layout of the system as per picture.

Circuit diagrams included with the operators manual.

The life of the generator in a typical PS System is also increased by a factor of three reducing the pollution footprint by delaying the need for a replacement.

Generator life increased by factor 3.

The PS System is fitted with an input for power from a renewable energy source such as wind power, solar PV or hydro. The PS System will monitor and integrate the input into the system reducing the generator run-time even further and increasing efficiency.

Integrates alternative energy.

We want to sell you a system that is literally fit and forget. One that will give many years of reliable automatic operation - a system with a high overall efficiency. A system that saves money from day one that also has immediate and tangible benefits.

The system saves money and has immediate and tangible benefits.

Mode of Operation

If you generate your own power you need a PS System

General Information

If you generate your own power you need a Powerguard PS System. The PS System is designed for applications where the load varies over 24 hours and the prime source of electrical power is an engine driven generator. It is assumed that the user will require electricity 24/7.

Electricity 24/7.

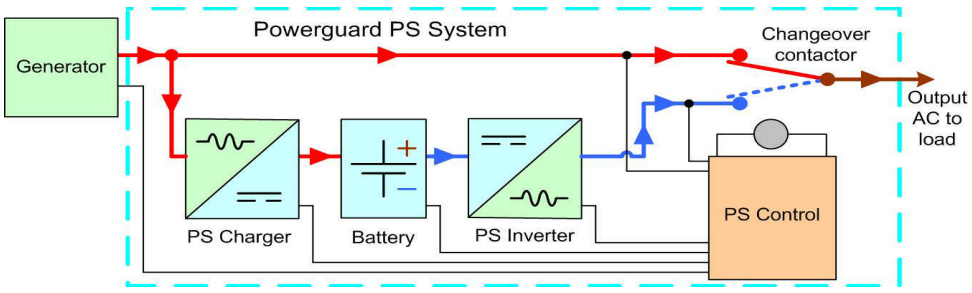
The system works by storing spare energy when the generator is not fully loaded into the batteries and then using the stored energy via an inverter to power the load when the generator is not running.

System stores spare energy in a battery and then uses it to power the load.

The generator has to be auto-start. It must start and stop on a signal from the PS System.

The PS System is completely automatic and there is no need for operator intervention during normal operation.

The system is completely auto-matic.



Simplified schematic of a PS System.

A simplified schematic showing a typical PS System

The above schematic shows the main components of a typical Powerguard PS System. The components shown within the dotted line are all part of the PS System and are housed in a standard floor mounted steel enclosure. The batteries are separate and are usually mounted on an adjacent rack.

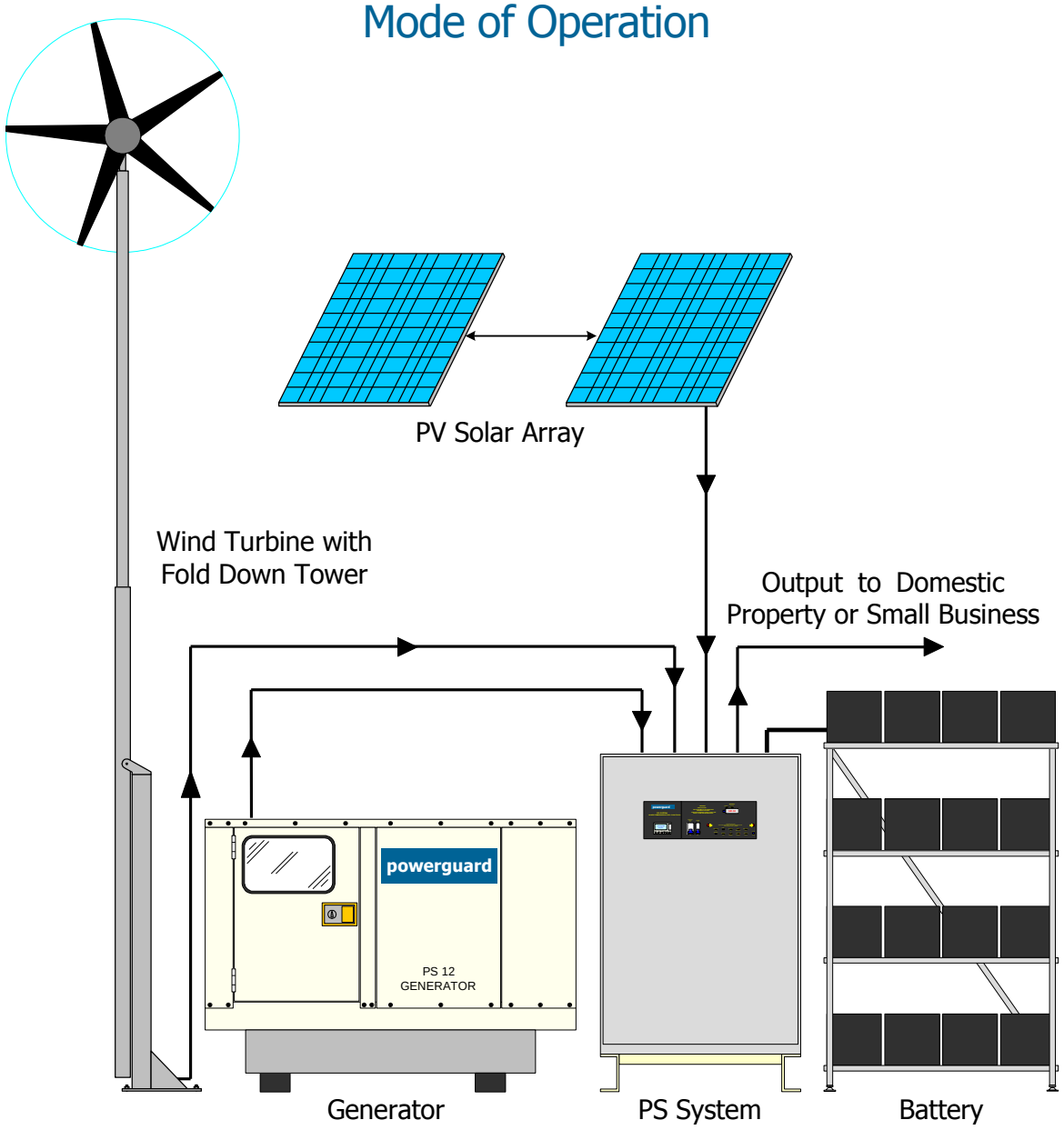
Generator powers the load shown by red arrows.

When the generator is running it supplies power to the load via the changeover contactor. At the same time the generator powers the charger recharging the batteries. The path is shown by the red arrows.

Inverter powers the load shown by blue arrows.

When the PS System shuts down the generator the inverter is started and the load is powered via the changeover contactor. The path is shown by the blue arrows.

Mode of Operation



The above sketch shows a typical system layout. The Powerguard PS System controls all of the power generation and supplies the load with power 24/7. The PS System accepts inputs from an engine driven generator, PV solar, wind turbine, hydro or other renewable energy source if they are available. The batteries are charged with surplus power from the generator or the renewable energy source when it available. The PS System monitors and controls the inputs and outputs and supplies the load efficiently without operator involvement.

Typical system layout.

Accepts inputs from renewable energy sources.

Automatic operation.

Mode of Operation

Real time clock and calendar.

Machine set at factory but can be altered.

The generator must run to charge the battery.

Must-run periods the generator will run.

Can-run periods the generator can shut down if conditions are OK.

PS System automatically starts and stops the generator.

Must-run periods.

O/l 100% 60 m.

O/l 115% 30 m.

O/l 130% 15 m.

O/l 150% 10 secs.

Low battery.

Timed Periods

The control incorporates a real time clock and calendar so it can be programmed to operate in the most convenient way for the user. The machine is set at the factory but can be altered on site if required.

Remember the generator, in the absence of renewable energy, has to run for a long enough period each day to ensure the batteries are fully recharged.

The control can be set with two types of timed periods must-run and can-run.

The generator will run in the must-run periods. Must-run periods are set to cover periods when the user knows that loads too big for the inverter are going to be used. When a must-run period ends the generator will shutdown when the load is lower than the inverter 115% load rating.

The generator will start at the beginning of a can-run period but will automatically shut down within a 15 minute period during which the load on the generator has been stable below the inverter 115% load rating and the battery is fully charged.

Start/Stop Conditions

The PS System will automatically start and stop the generator according to the monitored parameters. If the generator is stopped the system changes over to the inverter and vice versa.

The generator starts and the inverter stops:

1) During the pre-set must-run timed period.
2) If the inverter is overloaded more than 100% for 60 minutes.
3) If the inverter is overloaded more than 115% for 30 minutes.
4) If the inverter is overloaded more than 130% for 15 minutes
5) If the inverter is overloaded more than 150% for 5 seconds.
6) If the battery has been discharged below a pre-set capacity the generator will start for 30 minutes to partially recharge the battery.

Mode of Operation

The generator stops and the inverter starts:

7) After the pre-set must-run timed period is over. The generator will not shut down at the end of the must-run timed period if the load is above the 115% inverter load level.

Inverter starts.

8) During the can-start pre-set timed period if the load on the generator is stable within the rating of the inverter and the battery is fully charged. When both these conditions are met for a 15 minute period the generator will stop. The generator will not shut down at the end of the can-run period if the load is higher than the inverter 115% load rating.

End of timed periods if conditions are OK.

9) If the generator has started outside of the timed period because of inverter overload it will go off again if the load is stable within the inverter rating for 15 minutes.

Generator started because of over-load.

The inverter will be switched off:

10) After 1 minute if the inverter is overloaded and the generator fails to start. It will not reset to come on again until the generator starts and power is applied to the system.

Inverter switched off if it is overloaded

The inverter will be switched off if overloaded and the generator fails to start

Automatic Operation

The PS System is designed to be automatic and will operate effectively without operator involvement except for routine maintenance.

Auto operation without operator involvement.

The PS System is multi-microprocessor controlled and has many monitoring and display functions. The display is via a front panel mounted PCB using LEDs to indicate the status of the system. Some alarm conditions are accompanied by an audible alarm with a manual reset (the audible alarm resets automatically if the alarm condition is removed). The system is fitted with a battery voltage and charge/discharge current meter. The user interface control has an LCD showing the generator output current, the inverter output current and system output voltage.

Comprehensive display.

Mode of Operation

Shutdown

The inverter can be shut down from the front panel.

Enclosure

Rugged enclosure.

The system is housed in an enclosure fabricated using 1.6mm sheet steel and is epoxy powder coated. Enclosure access is by a hinged door on the front. Cable entry is though an undrilled gland plate mounted at the top of the enclosure.

Cable entry at the top.

Control

The Powerguard PS System has a very powerful control system. There are five microprocessors and a programmable logic controller. It has a real time clock and calendar. It automatically adjusts itself for British Summer Time. It can control the same timed periods every day or different timed periods every day. It can be programmed months and years into the future if required.

Very powerful control system.

Real time clock.

The control monitors the battery charge/discharge current and the battery voltage. It monitors current coming into the battery from renewable sources such as a wind turbine, PV solar or hydro. The control measures the amps per second going into and coming out of the battery to keep track of the power from the renewable source so that the battery is not overcharged. However this cannot be dead accurate because the batteries are electro-chemical and affected by temperature, state of charge and age. To restore accuracy the control re-calibrates itself every week and if there is an error it will automatically compensate for it.

Monitors vattery charge/dischar ge and voltage.

Measures amp per second into and out of the battery.

Compensates for inaccuracy.

The control monitors the output load current and voltage. When the generator is supplying the power it will adjust the load by altering the rate of charge going into the battery. This keeps the generator running near the optimal load. When the inverter is running it will allow an overload to run for a period before deciding to start the generator. The level of the overload determines the amount of time it is allowed to run. The load will not be transferred from the generator back to the inverter until the control has analysed the load current and decided that it is the optimum time. This level of control reduces the generator starts to a minimum.

Monitors output current and volt-age.

Generator runs at optimal load.

Reduces genera-tor starts due to overload.

The control monitors the electricity taken out of the system and automatically adjusts itself for the optimum generator run-time. If less electricity is used the generator will run for a shorter time and consume less fuel.

Automatically adjusts the gen-erator run time to the average electrical load.

Only a few of the functions are mentioned but the control monitors and analyses hundreds of parameters every second using the information to extract the maximum amount of electrical power out of every drop of fuel burnt reducing pollution and cutting costs.

The object is to make every drop of fuel count.

Contactors

Overview

Contactors are electro-mechanical but careful design makes them very reliable.

Contactors have to withstand the arduous task of making and breaking the power circuits. This causes wear and tear until the contactor eventually fails. Some contactors have a weakness closing the contacts under load and others a weakness opening the contacts under load.

Contact bounce and arcing must be reduced to increase life.

When a contactor closes the contacts can bounce causing arcing, this can weld them together. When it opens again the welds are broken damaging the contacts. Sometimes it will weld so effectively that it will not open when required causing a system failure.

Conversely, when a contactor opens whilst supplying a load an arc is produced which is extinguished as the gap between the contacts is increased or the AC current is reversed. This causes heat and in some cases will burn the contacts and cause failure.

Still the best solution in many applications.

However, contactors are still the best way of switching power in a lot of circumstances with five main advantages over the semiconductor alternative: -

Easily switched.

Coil isolated.

Virtually 100% efficient.

Disconnects the load from the supply.

Cost less.

1) They are easily switched by energising or de-energising the coil.
2) The coil is isolated from the supply and the load.
3) When they are conducting they are nearly 100% efficient and do not require additional cooling.
4) When the contactor is open the load is isolated from the supply.
5) The cost of implementation is considerably lower.

Careful design gives long life.

Our design engineers have spent a lot of time mitigating and sometimes eliminating the weaknesses. They have achieved this by sophisticated programming of the micro-controllers.

Battery Contactor

Batter contactor prevents permanent damage to the batteries.

The battery contactor is required to protect the battery from damage due to deep discharge. When it is open there is no drain on the battery. The

Contactors

contactor has to open to shut the system down. This would require a normally open contactor that could fail open disconnecting the battery and shutting the system down without warning. To protect the system against contactor failure the Powerguard PS System uses a contactor that is latched shut with a permanent magnet and only requires a pulse to open or close it.

Normally Open but magnetically latched to prevent failure.

When the system first powers up, the charger increases the voltage until it is approximately equal to the battery voltage. Then a pulse is applied to the battery contactor coil closing the contacts and connecting the battery.

Equalises the voltage across the contactor before closing.

Before the battery contactor opens to isolate the battery the inverter is shut down and the load removed.

Switches off the inverter before opening.

This virtually eliminates arcing and minimises wear and tear on the contactor increasing the life and reliability.

Very little wear and tear.

Changeover Contactor

The PS System is fitted with heavy duty contactors to change the load over from the generator to the inverter and vice versa. The contactor has to be rated to carry and switch the generator output current. On a 12 kVA generator the full load current is 53 Amps and the contactor fitted will be AC3 rated (AC3 is an arduous rating that can tolerate the inching of electric motors). However the system is controlled so that virtually all of the changeovers occur at or below the inverter full load current. A few will occur at the inverter overload current. On a 3.0 kVA inverter the full load current is 13 Amps and the maximum overload current is 20 Amps.

Heavy duty changeover contactor.

Rated AC3 for full load.

Only switches 11 Amps usually in this example.

The changeover contactor is operated well below the maximum rating and will give many years of reliable operation.

Long and reliable life.

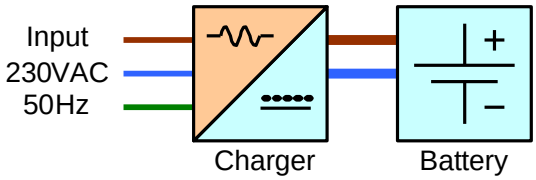
Charger and Charging

Total charging system for max life from battery.

Introduction

The Powerguard high frequency battery charger is a total charging system designed to ensure maximum life and reliability from the battery.

Charger block diagram.

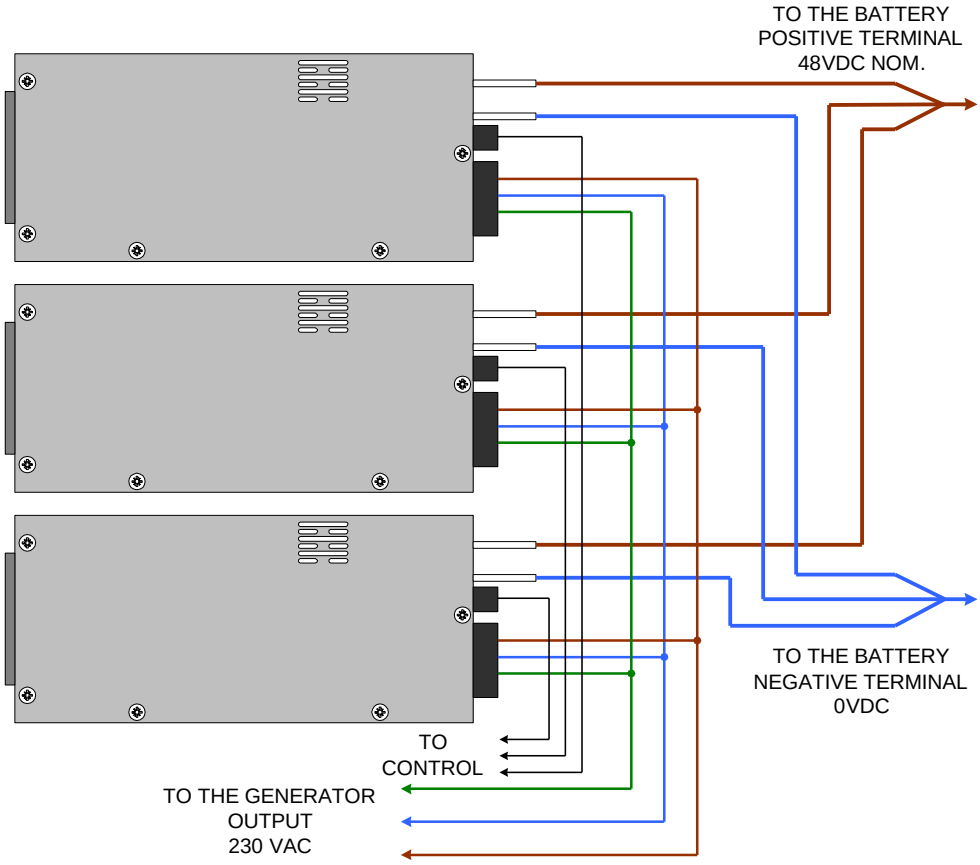


The size is based on recharge in <8 hours.

In a PS System the charger represents a significant load to the generator when it is charging the batteries at full power. The size of the charger is chosen to recharge the batteries in less than 8 hours to increase the overall system efficiency. However to prevent overloading the generator the system monitors the load on the generator and adjusts the charge rate accordingly. This is in four steps 0%, 33%, 66% and 100% of the charge current.

Automatically adjusts the charge rate to suit the generator load.

Sketch showing a simplified schematic.



Charger and Charging

The sketch shows a simplified schematic of the charger. A typical charger is made up of three high frequency modules. Each one is over 90% efficient and can operate on its own or in parallel with the other two. When operating together they share the load. Each module has an output of about 57 VDC or 65VDC depending on the type of battery to be charged. Each module has a current of 28 Amps or 56 Amps depending on the size of the PS System and battery bank. The chargers are controlled by the system and are switched in and out in proportion to the generator load. When the charge current can be supplied by one or two modules the others will be switched off increasing long term reliability.

3 high frequency modules each one >90% efficient.

Modules are controlled and switched to maintain the generator load.

The output from the charger is constant current/constant voltage and has a low ripple current of less than 500mV peak to peak enhancing battery life and reliability.

Ripple <500mV pk to pk.

The charger input has a low distortion and the input power factor is better than 0.95 reducing the generator load increasing efficiency and saving fuel.

Input power factor better than 0.95.

Normally the maximum system charge current equates to about 10% of the battery capacity. For example the charge current into an 800 Amp/hour battery bank would be limited to about 80 Amps.

Charger rated at C10.

Charging

When the charger is powered up into a discharged battery the current is constant at its maximum level. The voltage control is set to ensure that the current is maintained for a longer period which charges the battery quicker. As the battery becomes charged the voltage rises and the current reduces. The amount of charge is monitored and because the level of the battery capacity is known the system can adjust the charge regime for optimum efficiency, cutting generator run-time, saving fuel and reducing pollution.

Constant current - constant voltage.

The battery capacity is accurately calculated.

Valve Regulated Lead Acid Deep Discharge Batteries

Different types of lead acid batteries require different methods of charging. For example a valve regulated lead acid (VRLA) battery is charged more slowly than a vented full traction rated battery. This is because the VRLA is

Different charge regimes for different types of battery.

Charger and Charging

The VRLA battery is virtually sealed.

Cannot be topped up with water.

Last 20% of charge is inefficient.

The PS System dramatically reduces charge inefficiency.

virtually sealed and cannot be maintained. So if it is overcharged the liquid cannot be replaced and the operating life is reduced. As a VRLA battery becomes charged the charge efficiency reduces. Up to 80% of the full charge is efficient but after that the efficiency reduces because the chemical reaction is not uniform all over the battery with some parts more charged than others. This causes heat to be generated and charge efficiency to drop.

The Powerguard PS System reduces these problems by careful control. The system accurately calculates the Amp/seconds (coulombs) going into and out of the battery using Hall-effect sensors, filters and micro-controllers.

No good keeping the generator running for last few Amp/hour.

The charge efficiency drops more and more as the battery capacity nears 100%. To keep the generator running to put in the last few amp/hours is not very efficient. Powerguard have developed a charge regime to minimise these problems and give an Amp/hour efficiency better than 92%.

For six days the battery is charged with to a charge capacity of 95%.

6 days at 95% of capacity - 1 day at a pre-set current.

On the seventh day the battery is charged to 100% of capacity.

After 21 days a charge to reset 100% capacity.

Every 21 days the battery is charged to a level where there is no significant change in the value of charge current for three hours ensuring a full charge.

Full Traction Rated Vented Lead Acid Batteries

Traction batteries are ideal for off-grid applications.

These batteries are used in electric vehicles especially fork lift trucks. They are designed for regular daily discharge and have a long working life. They are ideal for off-grid applications. They can be maintained and we would expect them to last longer than the VRLA batteries discussed earlier. However they require a different charge regime.

Require different charge regime.

The batteries are wet and charging can cause stratification of the sulphuric acid in the battery because the charge is not uniform across the plates. When this happens the more concentrated acid drops to the bottom of the battery causing corrosion and reducing the operating life. Conversely the weak acid at the top of the battery reduces the charge capacity and causes damage to the top of the plates further reducing operating life.

Charger and Charging

The batteries have to be subject to a charge regime that will cause vigorous gassing to mix the sulphuric acid properly. This has to be done in a controlled manner reducing the loss of water in the form of hydrogen and oxygen to a minimum.

Stratification of acid causes damage and reduces life.

As in the case of the VRLA batteries keeping the generator going to complete the charge every day is not very efficient. Powerguard have developed a charge regime that ensures long battery life but keeps generator run-time to a minimum. For six days the batteries are charged to about 95% of capacity. On the seventh day the batteries are charged to about 100% capacity. On the twenty first day the batteries are charged with an additional pulsed period to ensure that the battery cells are equalised and to ensure they perform to specification.

Controlled by vigorous gassing.

Reduce generator run-time.

3 different charge regimes for maximum efficiency.

Equalising charge.

Conclusion

Powerguard chargers are the result of many years of design, development and experience. Battery life, reliability, performance and efficiency are the four most important design criteria with battery life and reliability top of the list. The control ensures that every aspect of the charger is monitored and the appropriate action taken. This protects the battery from overcharge and damage. For example the system knows how long the battery should take to charge and if the time extends beyond this the charger is shut down and an alarm given. This does not stop the system working but draws attention to a possible fault within a battery cell that can be put right before the whole battery starts to deteriorate.

Chargers are the result of many years of development.

A high degree of control ensures long battery life.

Careful design has resulted in robust performance and long battery life.

Powerguard chargers are designed for "fit and forget" and will give many years of reliable service even in the most demanding environments.

Robust performance and long battery life - fit and forget.

Batteries

System requires a battery that is designed for deep cycling.

Type of Battery

A Powerguard PS System requires a battery that can be charged and discharged on a daily basis. Most batteries do not last very long under these circumstances so the choice of battery is very important.

Two types of battery available: traction and VRLA.

Powerguard supply two types of high quality lead acid batteries for this application that will give a good service life at a reasonable cost. One is a high quality full traction rated vented battery and the other a Valve Regulated Lead Acid (VRLA).

High quality European manufacture.

Vented requiring maintenance.

Cost effective.

The full traction rated vented battery is high quality. It is similar to the batteries fitted to fork lift trucks and is designed for daily charge/discharge cycles. They are vented and will require topping up with water when the generator is serviced. However it is the most cost effective battery because of its high performance and long life. Traction batteries are usually rated at the 5 hour rate. This means that a battery with a capacity of 700A/hour will give the full 700A/hour capacity if discharged over a 5 hour period. The batteries should not be regularly discharged more than 80% of their capacity otherwise the operating life will be reduced. A Powerguard PS System is designed to discharge the batteries no more than 50% on a regular basis.

Rated at the 5 hour rate.

PS System discharges batteries less than 50%.

VRLA manufactured by Vision.

The VRLA batteries are imported direct from Vision the manufacturer. Vision is a world renown manufacturer of premium quality lead-acid batteries with sales in over 100 countries. Vision is a leader in innovative battery technology with ranges of lead-acid batteries encompassing AGM, Gell, long life and deep cycle technologies.

The FM range is used on our emergency lighting systems.

The Vision FM range are 10 year life batteries and are supplied with most of our emergency lighting systems.

D range for deep cycle.

The Vision D range of deep-cycle batteries supplied with the PS System is also a 10 year life battery designed specifically for the application. It is a Valve Regulated Lead Acid (VRLA) battery which is virtually sealed and

Batteries

requires no maintenance. This is very convenient for some applications where the owner may not want to maintain the batteries. The batteries can also be shipped without restriction all over the world by any form of transport including airfreight. We do not expect the VRLA batteries to have such a long operating life as the traction batteries however we have had them installed and operating on PS Systems for more than 5 years without significant degradation.

No maintenance.

IATA approved for airfreight.

Reasonable operating life.

VRLA batteries are usually rated at the 20 hour rate. This means that a battery with a capacity of 700A/hour will give the full 700A/hour capacity if discharged over a 20 hour period. If the batteries were rated at the 5 hour rate the 700A/hour would be reduced to about 620A/hour. The batteries should not be regularly discharged more than 50% of their capacity otherwise the operating life will be reduced. A Powerguard PS System is designed to discharge the batteries no more than 40% on a regular basis.

Rated at the 20 hour rate.

700 reduced to 620A/hour.

Keep normal discharge less than 40%.

As with all batteries the actual life will depend on how it is used. The PS System is designed to enhance battery life by sophisticated control of the charge, discharge and depth of discharge.

PS System enhances batter life.

Battery life is extended by the addition of a renewable energy source such as a wind turbine, PV solar or hydro. This is because the regular depth of discharge will be reduced.

Renewable energy source increases life of batteries.

The battery discharge will vary when used on the PS System according to the average power usage on the inverter.

Even if we are connected to the national electricity grid most of us want to reduce the amount of energy we use because of the high cost and pollution caused. The same applies to the PS System reducing the average load reduces fuel consumption and pollution and increases battery life.

Save energy - save money and increase battery life.

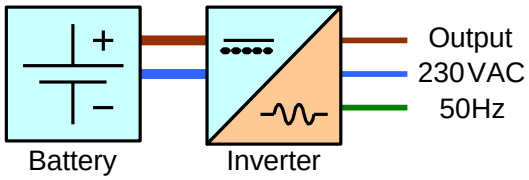
Inverter

DC power from a battery converted to AC mains.

General Information

An Inverter converts Direct Current (DC) power from a DC source usually a battery into Alternating Current (AC). The mains supply that we use every

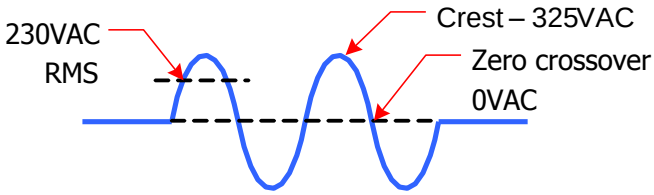
Inverter block diagram.



Normal mains power is 230VAC - 50Hz - sine-wave.

day to power our homes, offices, shops and factories is AC with a voltage of 230 Volts and a frequency of 50 Hz. The mains supply is a sine-wave an example of which is shown in the following sketch.

Sketch of a sine-wave.



Sketch showing a sine-wave

The output is an exact mimic of the normal mains supply.

Powerguard Inverters have an output which is an exact mimic of the mains supply - 230 VAC - 50 Hz - sine-wave and will power all standard electrical equipment as well as or better than the mains supply.

Ideal for sensitive or critical loads.

Powerguard Inverters have a regulated low distortion output ideal for computers, sound systems and telecommunications equipment.

Inverters used extensively in emergency systems.

Most of the inverters we manufacture are used in emergency systems. They have to be rugged and reliable because they are installed in critical applications where safety is the paramount concern. They are installed in hospitals, theatres, cinemas, office blocks, factories and many other public buildings.

Very reliable giving a long service life.

Powerguard inverters are very reliable and will give long and trouble free service with the minimum maintenance.

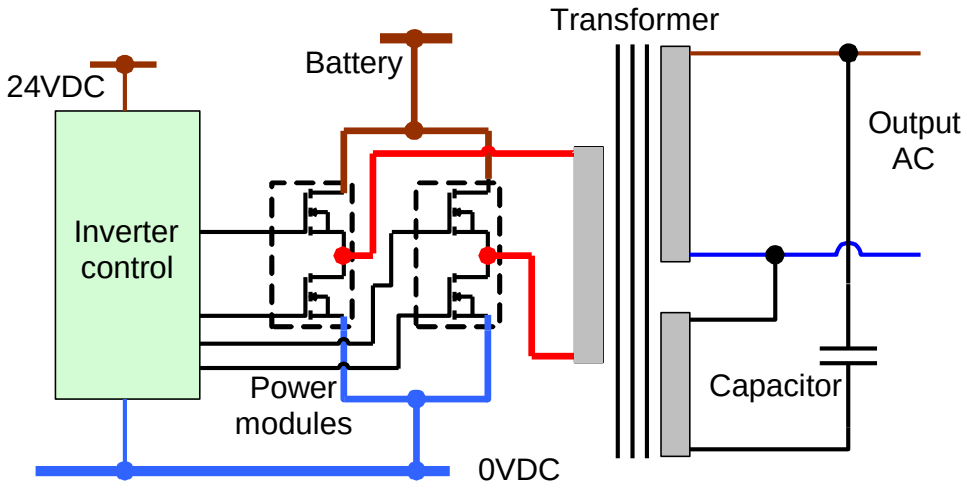
Inverter System

The inverter is made up of three basic parts:

Inverter

1)Inverter control
2)Power modules
3)Transformer

Three parts to the inverter.



Sketch showing a typical inverter schematic

Sketch showing a typical inverter schematic.

Inverter Control

Powerguard inverters are microprocessor controlled for the maximum reliability and efficiency. The control continually monitors and adjusts all of the parameters of the system and drives the display.

Microprocessor control reliability and efficiency.

The control also generates the waveforms required for the power module drivers.

Power Modules

Powerguard power modules are designed and built to switch the heavy DC currents needed to drive the transformer and load. Each module is a two channel design to facilitate push-pull, half-bridge or full-bridge requirements.

Unique power modules for switching large DC currents.

Each channel can be fitted with up to five power Field Effect Transistors (FET).

Each FET is rated at 90 Amps giving a notional output per channel of 450 Amps however it is Powerguard policy to rate the transistors at 50% of the 75°C rating giving 37 Amps per device and 185 Amps per channel.

The power modules are rated conservatively for long term reliability and efficiency.

Inverter

Power modules can be paralleled for high currents.

The power modules are designed to work in parallel allowing large DC currents to be reliably and efficiently switched.

New state of the art drivers.

Powerguard have just developed a new state of the art power module driver. This not only switches the power modules very efficiently but can detect a fault and shutdown within 10 µS protecting the machine from severe overloads and short circuits increasing the reliability.

Transformer

Transformers developed over 25 years.

Powerguard transformers are the latest versions of a pedigree going back 25 years. They are ferro-resonant and have many characteristics that make them ideal for most inverter applications. We have designed them so that if the output is short circuited the current is limited to twice the normal full load current. This helps to protect the electronics increasing reliability.

Short circuit proof and very reliable.

The transformers provide a filtered and regulated output ideal for all electrical equipment designed to run on the normal mains electricity supply.

Conclusion

Many years of design and development giving a very robust performance, high reliability and efficiency.

Powerguard inverters are the result of many years of design, development and experience.

Careful design has resulted in robust performance for example the output of a fully loaded inverter can be short circuited for longer than 5 seconds and when the short is removed the load will power up again as normal. The output can be overloaded 150% for 15 minutes and overloaded 125% for 30 minutes.

Inverters are ideal for the PS System.

Powerguard inverters are ideal for the PS System - they can be severely overloaded on a regular basis without damage - they will just keep going.

Fit and forget.

Powerguard inverters are designed for "fit and forget" and will give years of reliable service even in the most demanding environments.

Power Supply

In systems that have a battery voltage over 24 VDC a DC-to-DC power supply is fitted to provide 24 VDC to power the control circuits from the battery.

The power supply has full parallel redundancy and is very reliable.

The DC-to-DC power supply has two independent switch mode converters operating in parallel redundancy each one feeding through diodes. Each of the converters is monitored by the control and if one fails a visual alarm is given.

Monitored and alarmed.

This gives a very reliable system giving an alarm and allowing time for service. The failure of both supplies during operation is extremely unlikely.

Virtually impossible for both supplies to fail at the same time.

Volt Free Alarm Contacts

Volt free common alarm contacts for a remote panel.

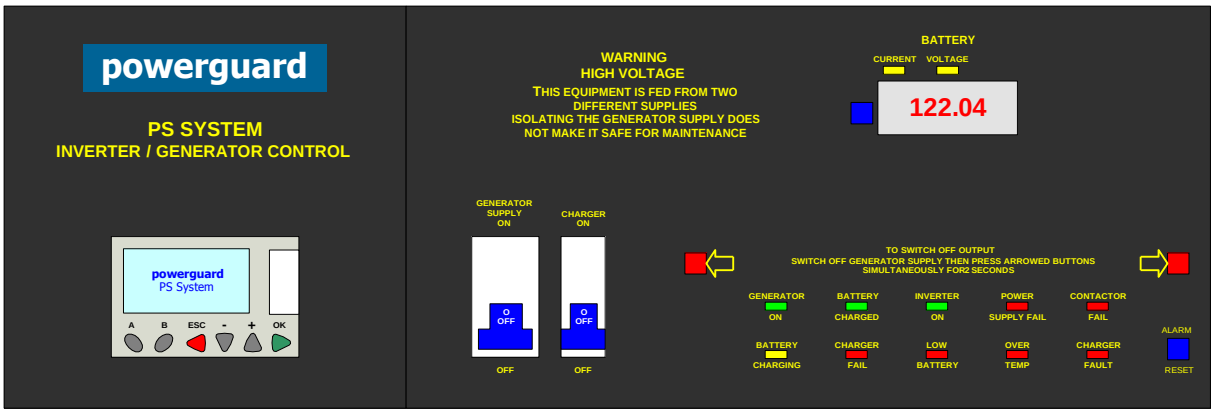
A set of volt free common alarm contacts can be fitted as an option if required. They are wired to three orange screw terminals adjacent to the input and output terminals.

These allow an interface to either a remote common alarm or a building management system.

If any of the systems alarms are triggered the contacts operate.

Powerguard can supply a standard remote alarm panel if required.

Fascia Panel



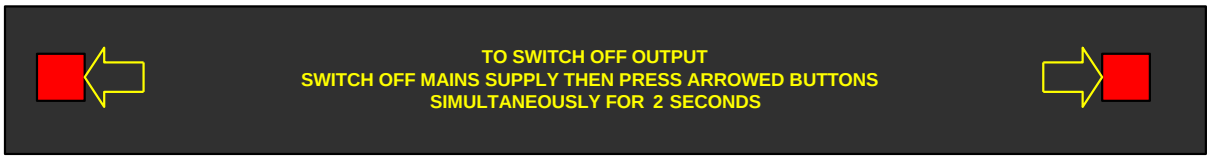
Sketch showing a typical full fascia panel

MCBs

The front panel is fitted with two MCBs as per the above sketch:

The one shown on the left is the generator supply and protects the generator output to the load through the changeover contactor.

The one on the right protects the charger input. If the generator is running and the charger is switched off the batteries will not be charged.

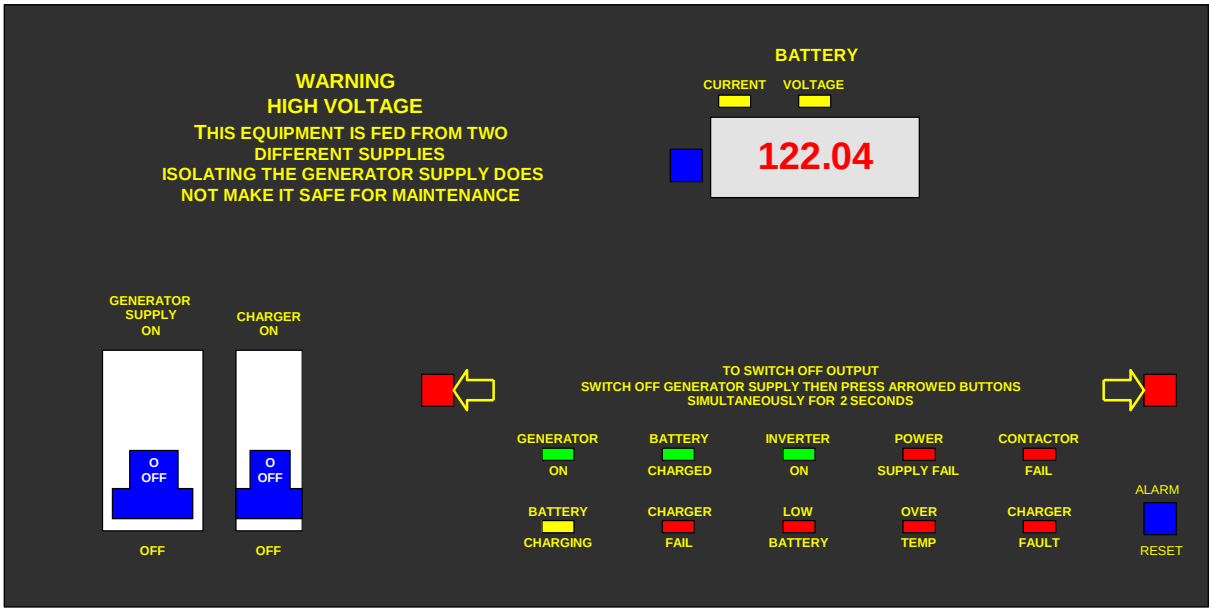


Switching Off The System

Before the system can be switched off the incoming power from the generator must be switched off. Either turn off the generator externally or switch the power off via the "Generator Supply" MCB and the "Charger" MCB situated on the front fascia panel.

Press the two red arrowed buttons shown on the above sketch simultaneously for 2 seconds and the system will shutdown.

Fascia Panel



Sketch showing the LEDs and digital meter

Generator On– LED

The green "Generator On" LED is on when the generator is running supplying the load and recharging the batteries.

Battery Charged – LED

The green "Battery Charged" LED is on when the batteries are fully charged. The charger has recharged the batteries and to protect the battery from overcharge the system automatically switches the chargers off. The chargers will switch back on for occasional short periods to keep the batteries fully charged.

Inverter On– LED

The green "Inverter On" LED is on when the inverter is supplying the load from the batteries.

Power Supply Fail – LED

The system is fitted with a dual power supply with two independent outputs. If one or both of the power supplies fails the Red LED is on.

24 VDC systems do not have an internal power supply board.

Contactor Fail – LED

The red "Contactor Fail" LED is on when a failure has been detected on the changeover contactor.

Charging – LED

Fascia Panel

The amber "Charging LED" is on to indicate that the bulk charge phase is taking place prior to the system switching to float mode.

Charger Fail – LED

The red "Charger Fail" LED is on when the battery charging system has a fault and is not charging.

The LED is off when the system is running from the batteries.

Low Battery – LED

The red "Low Battery" LED is on when the battery voltage falls to a predetermined level to warn of impending low battery shutdown.

Temp. Out of Limits

The red "Temp Out of Limits" LED is on when the ambient temperature is less than 0°C or more than 40°C. The charger shuts down.

Low/High Volts – LED

The red "Low/High Voltage" LED is on when the charger output is too low or too high in the float mode.

Alarm Reset – Button

Pressing the blue reset alarm button silences the audible alarm.

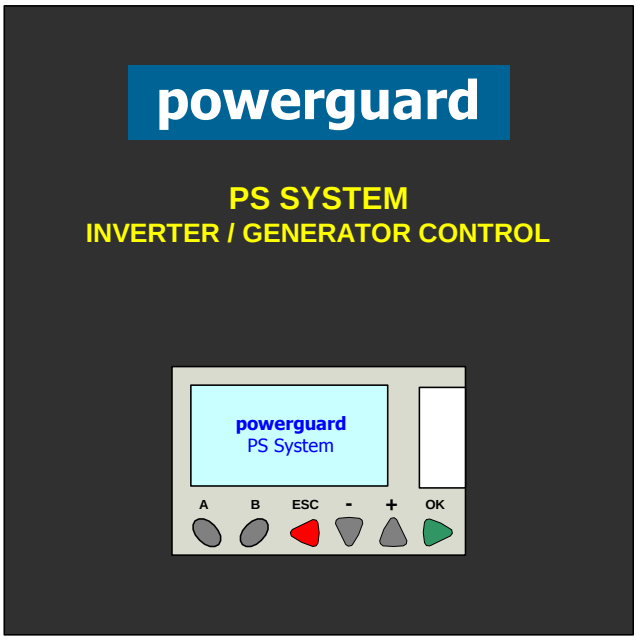
Digital LED Meter

The value is displayed on a 4 digit LED display so it can be easily seen even in poorly lit areas.

The digital meter indicates the battery voltage and current both charge and discharge. The reading is toggled between voltage and current by the adjacent push button. Two amber LEDs indicate the status of the displayed reading. A minus sign is displayed before the value if the battery is discharging.

Fascia Panel

Digital LCD and Control



Sketch showing the LCD and control

The following sketches show the information that is displayed when different modes of operation are active. The following pages show the information displayed during normal automatic operation.

```
GEN VOLTAGE:  00230
GEN CURRENT:  00065
GEN  O/RIDE PRESS A
DD.MM.YY      HH:MM
```

Page 1

The display page 1 shows the generator output voltage and the generator output current.

The display also indicates that the generator can be overridden by pressing "Button A". In this mode the generator will run continuously.

The date and time of day is also shown

```
INV VOLTAGE:  00230
INV CURRENT:  00065
GEN  O/RIDE PRESS A
DD.MM.YY      HH:MM
```

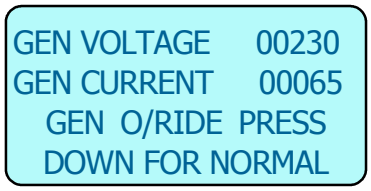
Page 2

The display page 2 shows the inverter output voltage and the inverter output current.

The display also indicates that the generator can be overridden by pressing "Button A". In this mode the generator will run continuously.

The date and time of day is also shown.

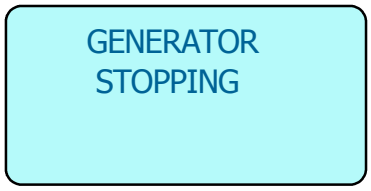
Fascia Panel



Page 3

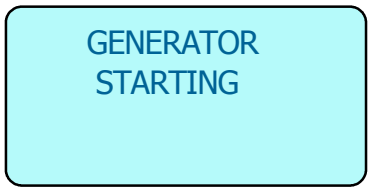
The display page 3 shows that the generator is in override (continuous operation) and can be returned to normal operation by pressing the "DOWN" button.

The date and time of day is also shown.



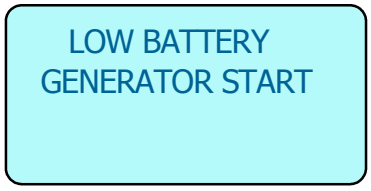
Page 4

The display page 4 shows that the generator has been switched off and is stopping.



Page 5

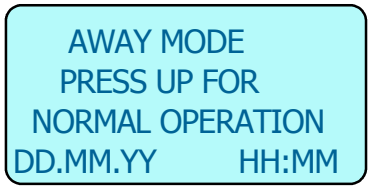
The display page 5 shows that the generator has been switched on and is starting.



Page 6

The display page 6 shows that the generator has had to start in an off period because the battery has become too discharged threatening a system shutdown.

The generator will run for 30 minutes to partially recharge the batteries.



Page 7

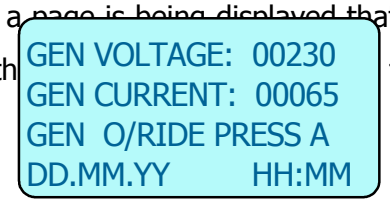
The display page 7 shows that the system is in away mode. In this mode the system will keep the generator run time to a minimum to recharge the batteries even in must-run periods.

Press the "UP" button to toggle the system in and out of Away Mode.

Fascia Panel

Setting the Time and Date

When a page is being displayed that shows the date and time such as Page 1 shown on the left - the date is DD.MM.YY format for the day, month and year.



Page 1

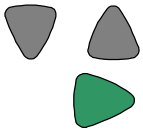
The time is HH.MM format for hour and minute using the 24 hour clock. 2:00 AM becomes 02:00 and 2:00 PM becomes 14:00.

Use the "Up" and "Down" keys to place the cursor on the data to modify.

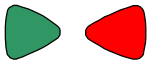
Confirm by pressing the "OK" key and the selected data will flash.

Use the "Up" and "Down"  keys to scroll to the desired value.

Confirm by pressing the "OK"  key.



Setting the Must-run and Can-run Periods

Press the "OK" and "ESC"  buttons together.

Scroll to "Parameters" using the "Up" and "Down"  buttons.

Press "OK" 

Select the FBD number

Press "OK" 

Use the "Up and "Down"  buttons to change to the FBD number required

FBD 013 = Must-run and FBD 089 = Can-run.

Press "OK" 

Use the "Up" and "Down"  buttons to move the cursor to the N number relating to the time to be changed as per the following chart.

00 = 1st on time - 01 = 1st off time

02 = 2nd on time - 03 = 2nd off time

Press "OK" 

Fascia Panel

Use the "Up and "Down"   buttons to alter the times.

Press "OK" 

Use the same procedure to alter the other preset times.

Press the "ESC"  button the required number of times to return to the normal display.

The Can-run will have a time period of ten minutes because the system will shut the generator down when the right conditions are met.

Must-run and Can-run Periods

Two must-run and one can-run period per day.

7 day timer

The system is set up for two must-run and one can-run periods per day on a 7 day timer. The system can be set for more periods or for different periods on different days if needed but these have to initialised at the factory and transferred to site using a memory module.

Generator must run long enough to recharge batteries.

It has to be remembered that the generator must run long enough to recharge the batteries ready for the periods when the inverter should run.

When the inverter runs the generator noise, fumes, fuel consumption and wear and tear are not taking place.

Generator reduced to less than 8 hours per day.

In a 24 hour period we aim to reduce the generator run time to less than 8 hours.

Must-run periods cover loads bigger than inverter.

During a must-run period the generator must run. These periods should be chosen to cover the times during which it is known that loads will be applied that are greater than the inverter 100% load rating. This will reduce the times the generator starts due to inverter overload.

During the can-run period the generator will run until two conditions are met for a 10 minute period.

Can-run enables the generator to shut down ASAP.

1) The generator load is stable at less than the inverter 100% load rating.
2) The battery is charged to the correct capacity.

Mixture of must-run and can-run the best.

It can be seen that a mixture of must-run and can-run periods will be the most efficient way to operate the system. Must-run to reduce inverter overload and can-run to allow the generator to shut down as soon as possible.

The typical times set at the factory are as follows:-

Must-run - 06:30 to 09:00 and 12:00 to 12:10

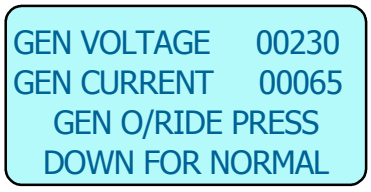
Factory set times.

Can-run - 17:00 to Auto shut down.

Generator Override and Away Mode

Generator Override

The system can be put into "Generator Override" mode by pressing the "A" button. 



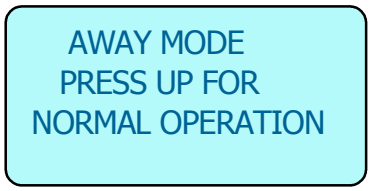
Page 3

It can be returned to normal automatic operation by pressing the "DOWN" button. 

Generator override would be used to cover an unusual period outside the normal must-run periods when it is known that loads greater than the maximum inverter load will be applied. It is used to reduce the generator startups caused by inverter overload.

Away Mode

The system can be put into "Away Mode" by pressing the "Up" button. 



Page 7

It is returned to normal timed operation by pressing the "Up" button again.

Away mode is designed to minimise the generator run time when the building is unoccupied. This could be when the occupants are on holiday or away on business for a few days.

The must-run periods become can-run periods and the generator will be shut down as soon as possible when the following criteria are met for a 10 minute period:-

1) The load is stable at less than the inverter 100% load level.
2) The battery is charged to the correct capacity.

Choosing a PS System

It would be better to monitor the load pattern over 24 hours.

If there is an existing generator supplying power it would be relatively easy to monitor the generator output over a typical 24 hour period to give us an accurate pattern of load usage allowing us to specify the PS System accurately. However in new installations where the generator is installed with the PS System we must estimate the loads on the system. In fact most systems are estimated and this can be done reasonably accurately.

Virtually all systems are estimated.

Our object is to reduce generator run time to a maximum 8 hours per day so we will base all our calculations on this starting point. We will build into the system extra capacity so that the PS System control can reduce the generator run time to the lowest practicable period.

Extra capacity built into the system to reduce generator run time.

The generator must have a rating large enough to supply the heavy loads such as washing machines, dish washers and cookers and at the same time recharge the batteries. The battery charger will automatically adjust its charge rate to allow peak loads to run but we still have to recharge the batteries within the 8 hours. The system is more efficient if the ratings of the generator and inverter are kept as accurate as possible but it is better to err on the high side rather than risk overloading the system.

Generator must have spare capacity to charge the battery.

The generator load should be estimated by adding up the appliances that will be running in a relatively short time period. We will then add the charger load when it is determined. A generator sized to run a typical three bed room medium domestic property would be about 12 kVA.

The generator load is appliances that will run for a short time.

The inverter rating must be estimated to run all of the off peak loads these will include lights, television, computers and maybe a 2 kW kettle. A typical size for a medium domestic property would be 3 kVA.

The inverter load is all of the off peak loads.

The average inverter load must be estimated and this is the most difficult to do. This includes the above averaged out with the period of very light load usually when everybody has gone to bed. It may include some security lighting and small load appliances. An effort should be made to keep the average inverter load as small as possible.

The inverter average load is the average over the 16 hours.

Choosing a PS System

Lets opt for a system similar to one that was recently installed as follows:-

Generator prime power rating - 12 kVA

12 kVA generator.

Inverter rating - 3 kVA

3 kVA inverter.

Average inverter load - 1 kVA

1 kVA average load.

Generator must-run periods - 06:30 to 09:00 and 12:00 to 12:10

Generator can-run period - 18:00 to auto-stop.

Must-run and can-run periods.

We chose the battery to supply the average inverter load for a minimum of 16 hours.

Inverter average current - 26 Amps.

Battery Amp/hours - 26 Amps x 16 hours = 416 Amp/hours.

Battery to supply average inverter load for 16 hours.

To ensure that the batteries have a large enough capacity to reduce the average depth of discharge and handle the occasional higher load it is good economy to double the size of the battery.

Battery capacity x 2 to increase battery life.

Battery Amp/hours - 416 Amp/hours x 2 = 832 Amp/hours.

The battery we will use is 4 strings of 200 Amp/hour deep cycle batteries giving - 4 x 200 Amp/hours = 800 Amp/hours.

800 Amp/hours battery capacity.

The charger rating is based on C10 which is the battery capacity divided by 10 = 80 Amps. If the calculated requirement was higher than C10 we would increase the size of the battery capacity.

Charger C10 rating.

The calculated charge rate - 416 Amp/hours ÷ 8 hours ÷ 0.9 losses = 58 Amps. The C10 rating of 80 Amps provides spare capacity to reduce the charge time making the system more efficient.

80 Amp charger gives some spare capacity increasing efficiency.

The PS System is designed with input terminals to easily connect a renewable energy source such as a wind generator. This would make the system more efficient by charging the battery and reducing generator run time.

Interface renewable energy sources.

Examples

Two examples one a farm in Norfolk the other a private house near Cambridge.

General Information

Recently two Powerguard PS Systems were installed in typical domestic applications. One at a farm in Norfolk the other at a private house near Cambridge.

Norfolk

Mains connection too expensive so a 15 kVA generator installed.

This is a new farm house built in a place where connection to the mains power grid was prohibitively expensive. Instead a 15 kVA generator was installed and was running for extended periods because electricity was required most of the day every day. The generator consumed more than 18 litres per day of diesel fuel. This was not very efficient and Powerguard was contacted about a PS System.

Running costs too high. Install a PS System.

Our calculations are based on the generator running for a maximum of 8 hours and the inverter running for the remaining 16 hours out of the 24 period.

In situ picture of the PS System at the Norfolk farm.

2.5 kVA inverter.

48 VDC battery pack.

The inverter rating required to run the off peak loads was estimated at 3 kVA. The battery voltage required to run a 3 kVA inverter is 48 VDC. The average inverter load over the 16 hour off peak period was estimated at 1 kVA.

1 kVA average load.

The battery discharge current for an average inverter load of 1 kVA is about 26 Amps. Multiply this by the 16 hours running time and we have 416 Amp/hours.

Battery discharge current 28 Amps.

To reduce the average depth of discharge and increase the life of the battery we doubled the required 416 Amp/hours to 832 Amp/hours. We used 4 strings of 200 Amp/hour deep cycle batteries giving a total of 800

448 Amp/hours required.

Examples

Amp/hours. Increasing the size of the battery also caters for the occasional higher load.

Battery capacity doubled to 800 Amp/hours to increase battery life.

The charger has got to be rated correctly or it can let the whole system down. With this particular type of battery we prefer to keep the charge rate below C10 which is the capacity - 800 Amp/hours divided by 10 = 80 Amps. This charge rate easily exceeds the current rating needed to replace the system requirement of 416 Amp/hours in 8 hours which calculates to about 63 Amps. The increased charge rate makes the system more efficient by reducing generator run time. This PS System was fitted with an 80 Amp charger.

80 Amp charger gives some spare capacity.

Cambridge

The generator at this location is 13.3 kVA and was switched on and off when required to save fuel. This became more and more inconvenient to the aging owners. It was decided to contact Powerguard to purchase a PS System. The operation of the system is similar to the Norfolk unit but the size is different.

Manual operation of the generator became too burdensome decided to automate with a PS System.

The inverter is 2 kVA and the average inverter load was estimated at 500 VA.

3 strings of 200 Amp/hour deep cycle batteries giving a total of 600 Amp/hours at 48 VDC.

The charger is continually rated at 60 Amps.

In situ picture of the PS System installed near Cambridge.

13.3 kVA generator.

2 kVA inverter.

500 VA average load.

60 Amp charger.

Installation, Commissioning and Maintenance

Installation

The installation of this equipment must be carried out by properly trained personnel adhering to all the requirements of the IEE Wiring Regulations 17th Edition and any other applicable national or international standards that apply to electrical installations generally and engine driven generator and battery installations in particular.

Commissioning

Only properly trained and experienced personnel should commission the system.

Maintenance

The Powerguard PS System should be maintained by properly trained personnel in accordance with the manufacturers instructions and applicable national and international standards. The PS System must be isolated from the incoming mains/generator supply and the battery supply before any maintenance work is carried out.

Please make sure that the air flow is not restricted.

Renewable Energy

PV Solar, Wind Turbine, Hydro and Other Renewable Energy

Having taken the first and most important step to make your electricity generation more efficient by installing a Powerguard PS System other steps can be taken to reduce costs even further. The PS System works by using excess power from the generator to charge the batteries and then utilising this stored power via an inverter to power light loads. This significantly reduces the generator run time by two thirds saving fuel and maintenance.

However the generator has to run for a certain period up to 8 hours per day to recharge the batteries. It can be seen that if an alternative method was used to recharge the batteries such as PV solar, wind turbine or hydro the generator run time could be reduced substantially.

The PS System is designed to monitor and integrate power from a renewable energy source efficiently and effectively.

The addition of a renewable energy source to recharge the batteries adds significantly to the efficiency of the system and would reduce pollution and the production of greenhouse gases.

PV solar, wind turbines and hydro have been used on the PS System to achieve high efficiency.

Wind generators used in conjunction with a PS System are generally cheaper and more efficient because they are producing power to charge batteries and do not have to be synchronised and run at a constant speed.

Renewable Generator Fuel

Most diesel engines can be converted to run on renewable fuel such as vegetable oil. Powerguard can advise on the implementation of renewable fuel if required.

Combined Heat and Power

Roughly speaking if we produce 10 kW of electrical power using an engine driven generator we waste 20 kW of the energy as heat - 10 kW into the water jacket and 10 kW up the exhaust pipe. After installing a PS System a significant proportion of the wasted heat can be recovered and utilised to reduce space heating and hot water costs.

Powerguard has a lot of experience in these systems and can offer practical and cost effective solutions.

Efficiency

General Information

Reliability, long life and efficiency main design objectives.

When designing the PS System two main design objectives were given priority:

1) Reliable long life.

2) High system efficiency.

The system is very reliable.

The first objective does not need detailed explanation - the system will give long and reliable service. However the second probably does because the overall system efficiency directly affects the amount of fuel you use and so the cost of your power. At Powerguard we are certain that the PS System is the most efficient off-grid 24/7 power system available.

Efficiency is very important.

Comparison with a competitors product.

We offer the following explanations of some of the features which make the Powerguard PS System very efficient so that the advantages can be seen if a comparison is made with alternative products.

High efficiency saves money.

High system efficiency means significant cost savings over a long period of time. On a typical system with oil priced at over 65 pence per litre an extra 10% on system efficiency gives an annual saving of more than £140.

System Operation

Generator provides the power.

The generator has to run to provide the base power of the system.

The batteries have to be charged correctly to maximise battery life.

Batteries must be charged correctly and not over discharged.

The battery discharge must be kept to a minimum to maximise battery life.

Efficient operation.

Operation must be predictable and the system must operate in the most efficient way possible within the requirements of the user.

System Losses

The following simplified sketch shows the layout of the PS System.

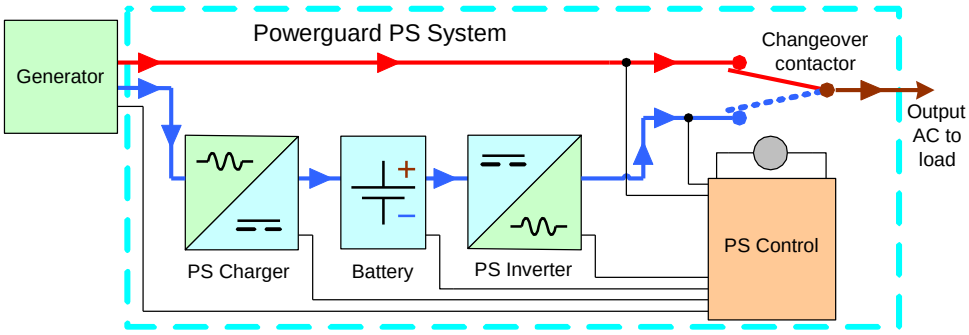
Generator to load shown in red.

The path from the generator to the load is shown with the red lines. This is the most efficient way to use the power from the generator as long as the load is kept within an optimum band.

Optimum load.

The alternative path to the load is through the charger, battery and inverter

Efficiency



Simplified sketch of PS System.

shown with blue lines. This path is less efficient because of the losses incurred converting AC power from the generator to DC power to charge the batteries and then back into AC power for the load.

Generator to charger, battery and inverter in blue.

Even in the PS System with very sophisticated charge and system control these losses can be up to 22%. It is false economy to have a system that uses too much power via the inverter.

Even in the PS System the losses can be up to 22%.

The PS System is designed to supply the heavy loads from the generator and at the same time utilise the spare capacity to recharge the batteries. This means that the generator is kept near its most efficient loading and the inverter is used to power the lighter loads. This increases efficiency and keeps fuel use to a minimum.

It is better to run the heavier loads direct from the generator.

Battery Life

Battery life is directly related to the depth of discharge. The deeper the regular discharge the shorter the battery life.

Battery life directly affected by depth of discharge.

The PS System manages the system so that the generator is run to recharge the batteries regularly which reduces the depth of discharge.

Control

The PS System uses sophisticated control to enhance the performance and efficiency. Each PS System has five powerful micro-controllers monitoring all of the parameters in the system including:

PS System monitors and controls all parameters.

1) Battery voltage, current and capacity.

2) Output voltage and current

Efficiency

3) Temperature

4) Renewable energy input voltage and current

By gathering all of the data the PS System adjusts to run efficiently.

By gathering all of the data the PS System can adjust to operate in the most efficient way possible saving fuel and reducing pollution.

Generator

The Powerguard PS System can operate with any auto-start generator. However the Powerguard PS Generators are designed for prime power applications and can be up to 20% more efficient.

Powerguard PS Generators can be 20% more efficient.

For example PS Generators have high efficiency alternators.

Battery Charging

The Powerguard PS System is fitted with a high frequency charger that is over 90% efficient. The output has very low ripple for enhanced battery life.

High frequency battery charger over 90% efficient.

The charger input causes minimum distortion and is power factor corrected to >0.95 to ensure the generator operates at maximum efficiency saving fuel and reducing pollution.

Power factor >95%.

Overall system efficiency can be affected by the type of charge control that is used. In our experience only the Powerguard PS System charges batteries with over 92% Amp/hour efficiency.

Charges with >92% Amp/hour efficiency.

Battery charge efficiency is a very important issue in the Powerguard PS System.

Because the charge gets less and less efficient the more charged the battery becomes some systems have to keep the generator running for longer to reach full charge.

Generator would have to run longer with other systems.

The Powerguard PS System reduces these problems by careful control. The system accurately calculates the Amp/seconds (Coulombs) going into and out of the battery using Hall-effect sensors and micro-controllers. Because the level of the battery capacity is known the system can adjust the charge regime for optimum efficiency, cutting generator run-time, saving fuel and

Calculates the Amp/seconds into and out of the battery.

Efficiency

reducing pollution.

Renewable Energy

The system battery pack needs charging daily. System efficiency would be increased if the battery could be charged from an alternative supply.

The system is designed with an input for a renewable energy source such as a wind generator, PV solar panels or hydro. The PS System monitors and controls the input and reduces the generator run-time accordingly.

PS System has a sophisticated charge control and this means that a small wind turbine with an output of 1000 Watts can make a significant contribution to overall efficiency.

Two 1000 Watt wind turbines would mean that on windy days the generator would not need to rum so long to recharge the batteries.

Inverter

The Powerguard PS System Inverter is a sophisticated twin channel ferro-resonant type. We have chosen the design because it has a good efficiency and meets our other major design criteria. It is extremely reliable.

The inverter can be severely and repeatedly overloaded without damage. It can be short circuited for more than 5 seconds and when the short is removed will power the load up as normal.

By sophisticated control we have increased the efficiency to a higher level than is normal for this type of inverter.

Our 48VDC systems are over 85% efficient at full load, over 85% at half load and over 80% at quarter load.

PS System runs at optimum efficiency.

Batteries need charging daily. A renewable source would be more efficient.

Small wind turbine can make a big difference.

Inverter twin channel for high efficiency.

Short circuit for >5 seconds.

Increased efficiency.

85% efficient at full and half load - 80% at quarter load.

Connections

Make sure all the inputs are isolated - generator supply and the battery supply - before making the connections to the PS System.

The input, output and control cables must be taken through the removable gland plate at the top of the enclosure using appropriate glands. Remove the gland plate before drilling to ensure no swarf goes into the system. Make sure all of the voltages are compatible before connection. Check the rating plates.

Measure the battery voltage with a meter before connecting - it should be 48VDC nom.

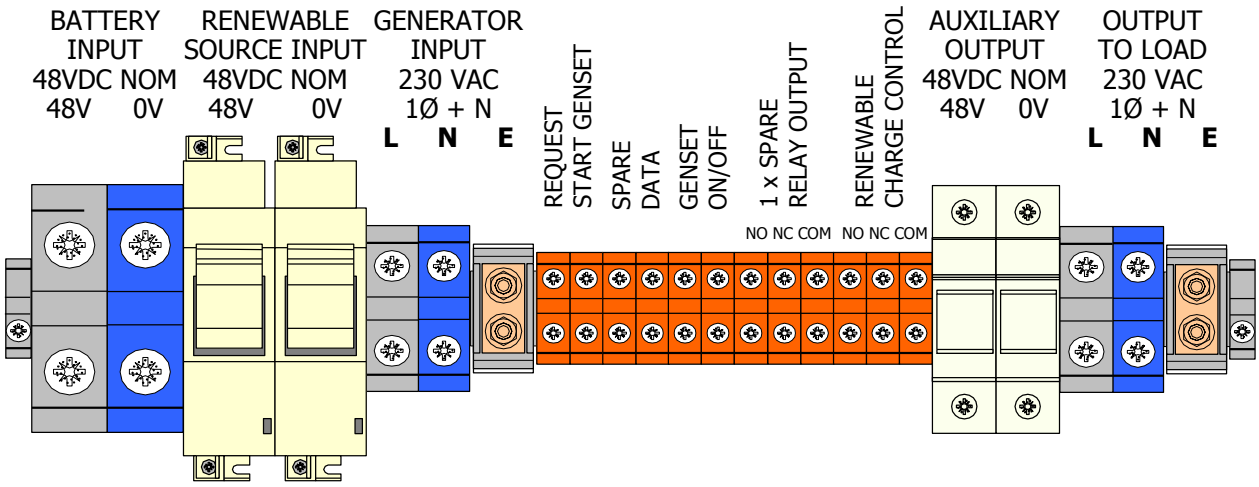
The PS System must be earthed.

Check that the battery input contactor is open.

Switch off the external battery isolator and remove the fuse carrier. Remove the splitter fuse links if there are more than one battery string and the fuses are fitted.

Connect the dead end of the cables first.

The following sketch shows the input and output connections:-



Sketch showing the input and output connections.

Connections

BATTERY INPUT 48VDC 48V 0V	The "Battery Input" is from the battery bank via the battery fused isolator. The input must be fused externally.

Connections

RENEWABLE SOURCE INPUT
48VDC
48V 0V

The "Renewable Source Input" is for directly connecting the output from a renewable source such as a wind turbine, PV solar or hydro. The input must be compatible with the PS System please check with the factory. It is monitored by the system.

GENERATOR INPUT
230 VAC
1Ø + N
L N E

The "Generator Input" is for connecting the output of the generator. It must be compatible with the PS System.

REQUEST START GENSET

The "Request Start Genset" is used to send a signal from an external control system to the PS System to tell it to start the generator. This is used by the Combined Heat and Power Module when fitted to the generator.

SPARE DATA

The "Spare Data" is reserved for future PS System developments.

GENSET ON/OFF

The "Genset On/Off" is used to start and stop the auto-start generator. A relay closes to start the generator and opens to stop.

1 x SPARE RELAY OUTPUT

The "1 x Spare Relay Output" is reserved for future PS System developments.

RENEWABLE CHARGE CONTROL

The "Renewable Charge Control" is used to send a signal to the external renewable energy control system to tell it to switch off the power being fed into the "Renewable Source Input" because the batteries are charged.

AUXILIARY OUTPUT
48VDC
48V 0V

The "Auxiliary Output" is used to supply the battery to external equipment. The output is switched by the battery contactor to prevent damage to the battery due to deep discharge when the system is off.

OUTPUT TO LOAD
230 VAC
1Ø + N
L N E

The "Output To Load" is the power output to the load - typically a domestic property, small business, workshop or office.

Connecting Example

Battery Isolator To PS System Connections

Connect the positive lead into the PS System input positive connector and connect the other end to the positive connection on the output of the battery isolator. The positive lead is usually coloured brown.

Connect the negative lead into the PS System input negative connector and connect the other end to the negative connector on the output of the battery isolator. The negative lead is usually coloured blue.

Battery Connections

Connect the battery as shown on the sketch at the back of this technical description.

Connect the link cables from the splitter fuse holders to the positive and negative connections at the centre of each battery string. The battery to splitter fuse cables are usually yellow.

Connect one of the positive leads into the battery isolator input positive connector and connect the other end to one of the battery positive connectors. The positive lead is usually coloured brown. Connect each battery string in like manner.

Connect one of the negative leads into the battery isolator input negative connector and connect the other end to one of the battery negative connectors. The negative lead is usually coloured blue. Connect each battery string in like manner.

Output Connections

Connect one end of the output Live wire to the external load distribution Live terminal - **L**

Connect the other end of the output live wire to the appropriate PS System output terminal marked - **L**

Connect one end of the output Neutral wire to the load distribution Neutral terminal - **N**

Connect the other end of the output Neutral wire to the appropriate PS System output terminal marked - **N**

Connect the Earth wire in a similar manner to the terminals marked - **E**

Signal Connections

Connect the "Genset on/off" terminals to the generator remote auto-start panel.

If applicable connect the "Renewable charge control" to the Powerguard Wind Turbine Control or other suitable renewable energy controller.

Input Connections

Connect one end of the input live wire to the appropriate PS System input terminal - **L**

Connect the other end of the input Live wire to the mains/generator output Live terminal - **L**

Connect one end of the input Neutral wire to the appropriate PS System input terminal - **N**

Connect the other end of the input Neutral wire to the mains/generator output Neutral terminal - **N**

Connect the Earth wire in a similar manner to the terminals marked - **E**

Connecting Example

Earth Connections

There are special requirements for the earthing arrangements on generators and care should be taken to ensure that best practice in compliance with any applicable national and international standards is adhered to. When the generator is the prime source of power and there is no connection to the national electricity grid then an earth electrode installed into the ground will be required to provide an electrical earth for the system. It is usual for both the generator and PS System electrical neutral to be connected to this.

Ready To Switch On

Make sure the PS System generator external isolator switch is off.

Make sure the two input MCBs "Generator supply" and "Charger" on the PS System front panel are off.

Check that all the connections are made correctly.

Check for any damage that may have been caused during the installation.

Close the enclosure doors on the PS System, renewable energy controller and all other enclosure doors except the battery isolator using the key provided.

Fit the splitter fuses links into the splitter fuse holders and close.

Check the battery voltage.

Fit the fuse carrier into the battery isolator and close the isolator.

Close the battery isolator enclosure door using the key provided.

Switch the changeover switch to the generator.

If everything is OK proceed as follows:-

Put the generator on "Manual" and start.

The generator will supply the load via the changeover switch. The load should operate normally.

Stop the generator.

Put the generator on "Manual" and start.

Turn on the PS System external isolator switch.

Turn on the two input MCBs "Generator supply" and "Charger"

The PS System will be on.

Switch the changeover switch to the PS System.

Change the generator to "Auto"

The PS System will now operate normally within the default settings.

Typical Specification

Powerguard Inverter

Type	Twin channel microprocessor controlled ferro-resonant		
Input	Voltage		48 VDC nominal
	Voltage range		40 – 60 VDC
	Current	full load	≈ 73 Amps at 48 VDC
		half load	≈ 36 Amps at 48 VDC
		no load	≈ 3.5 Amps at 48 VDC
Output	Voltage		230 VAC
	Voltage range		± 5%
	Frequency		50 Hz
	Waveform		Sinusoidal
	THD		< 5% into a linear load.
	Power		3000 VA
	Rating		Continuous
	Overload %		125% for 30 mins.
			150% for 15 mins.
	Short-circuit		Approx. 2 x full load current.
	Short circuit duration		>5 seconds
	Efficiency	full load	≈ 85 %
		half load	≈ 85 %
		quarter load	≈ 80 %

Protection: Input fuse, inherent flux de-coupling, ultra fast electronic cycle by cycle current limit and ultra fast power module spike suppression.

Powerguard Automatic Battery Charger

Type	High efficiency switched mode	
		Constant current – constant voltage
Input	Voltage	230 VAC
	Frequency	50 Hz
	Power factor	< 0.95
Output	Voltage	Up to 65 VDC depending on battery type
	Current	84 Amps
	Rating	Continuous
	Efficiency	> 90%

Typical Specification

	Ripple	<500mV pk/pk
Variable	The charger current automatically adjusts to make the best use of the available generator capacity.	
Protection	Input MCB – output fuses – automatic current limit	

Battery Pack

Battery	Type	Valve regulated lead acid (VRLA)
	Model	6FM200D
	Use	Cycling-charge/discharge
	Battery capacity	200 Amp/hours
	Layout	4 strings of 4 batteries
	Battery blocks	16
	Cells	24 (in series)
	Pack voltage	48 VDC nominal
	Float voltage	54 VDC
	Pack Capacity	800 Amp/hours at the 20 hour rate

Powerguard System Control

The generator may need to be upgraded using a Deep Sea Electronics control module. The generator must start when the control provides a signal and stop when the signal is removed.

The control will automatically start and stop the generator and inverter and transfer the load between the two. When the transfer takes place there will be a short beak in the supply to the load. The system is designed to minimise the disruption caused to the load by keeping the changeovers to a minimum.

Generator starts: When a relay contact closes and stops when the relay contact opens.

Enclosure: 800mm w x 1350mm h x 400mm d

Connections: Screw connections

Renewable Energy

Input	Voltage	Up to 65 VDC depending on battery type
	Current	80 Amps

Other Products and Services

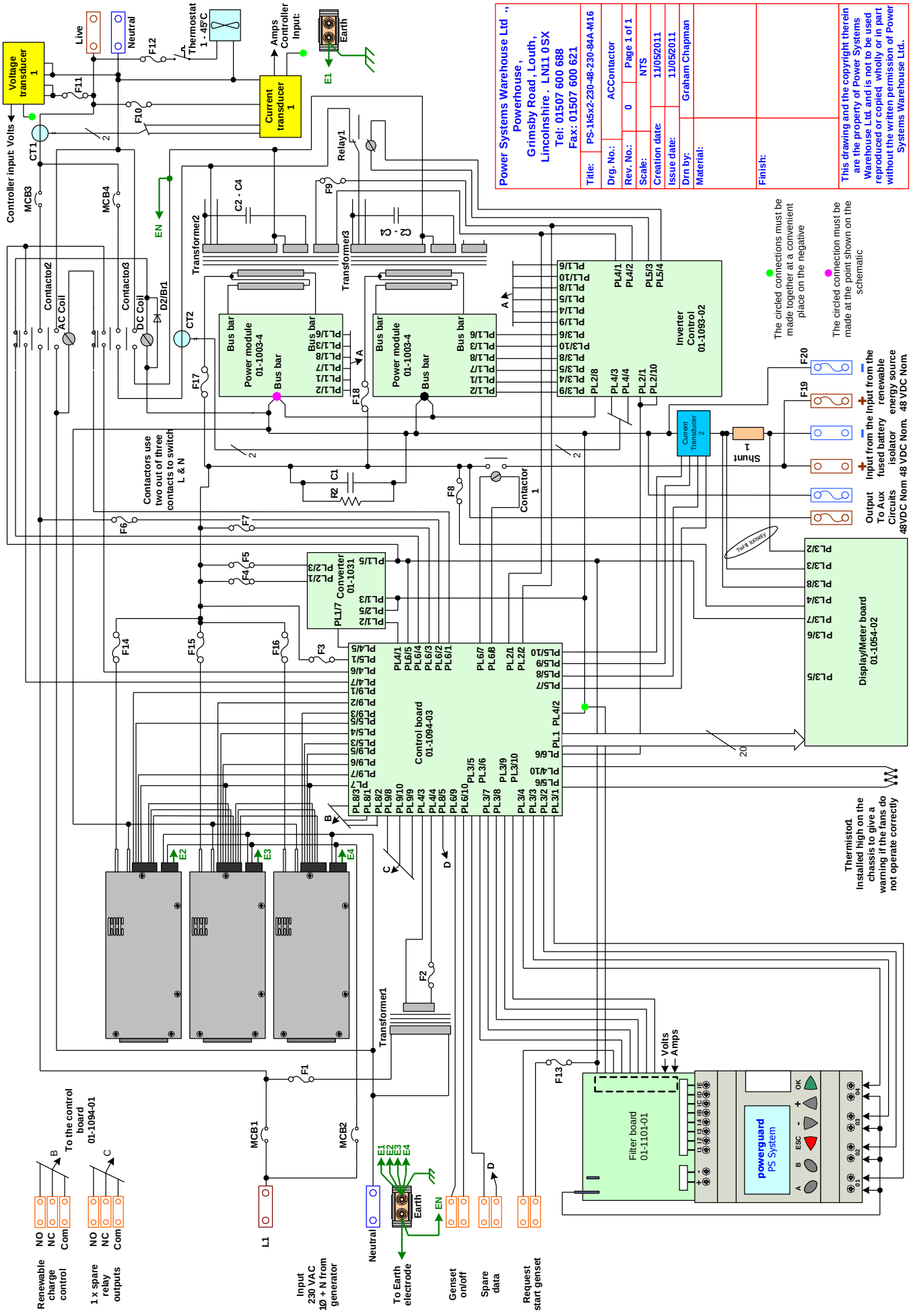
Powerguard supply a wide range of power equipment and services including: -

1) Uninterruptible Power Supplies
2) Engine driven Generators
3) Central Battery Emergency Lighting Systems
4) 5 year life Batteries
5) 10 year life Batteries
6) 15 year life Batteries
7) 20 year life Batteries
8) Deep cycle Batteries
9) Full Traction Batteries
10) NiCad Batteries
11) Battery Chargers
12) Inverters
13) Rectifier Systems for 24 VDC or 48 VDC
14) Bypass Switches
15) Static Switches
16) Site Surveys
17) Full Installation
18) Commissioning

Notes

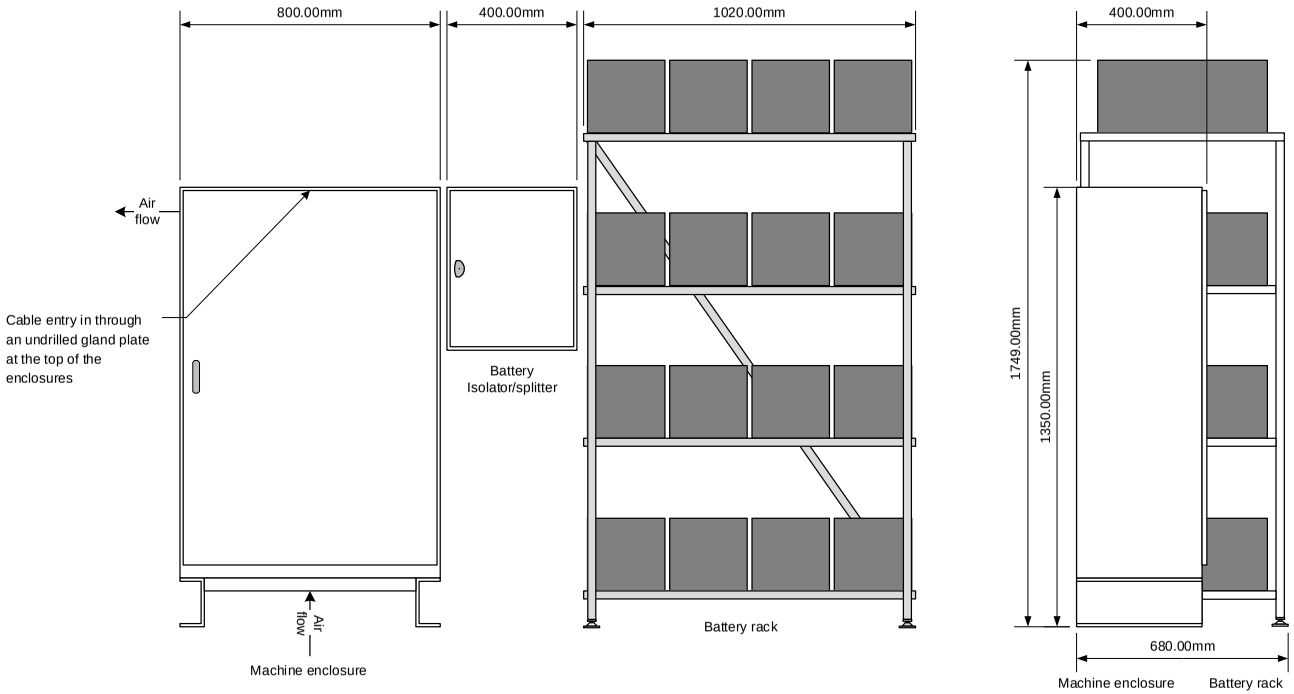
Notes

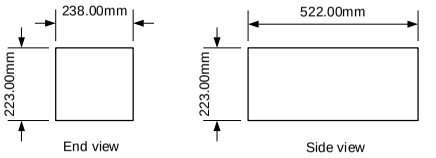
Typical Schematic



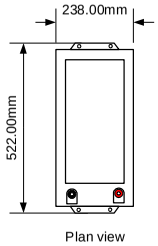
powerguard

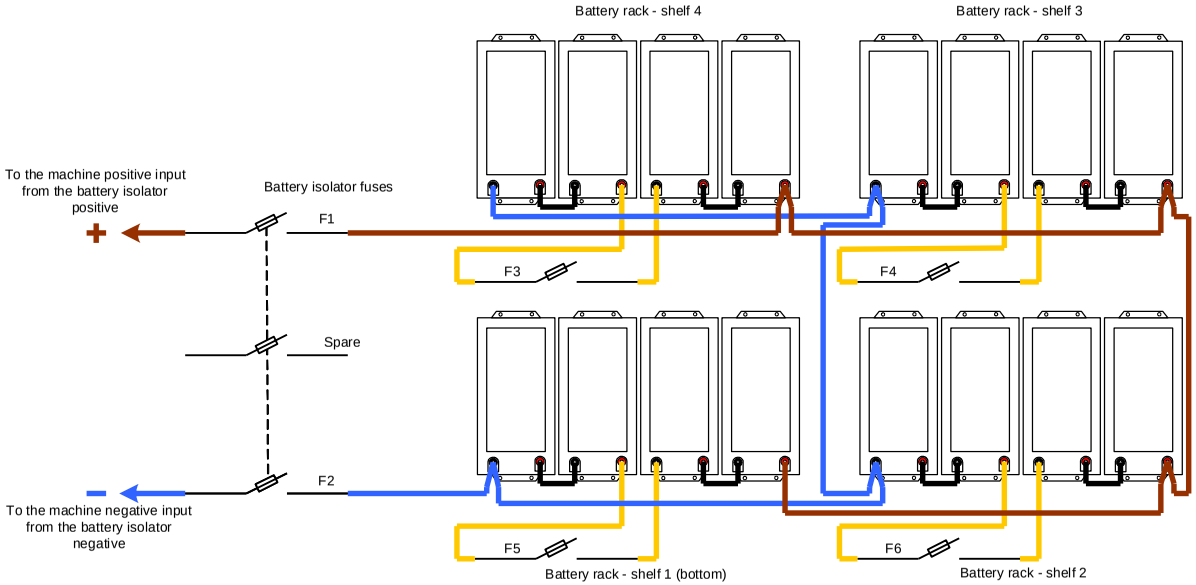
Typical General Arrangement





Dimensions of Vision battery - 6FM200D
Weight - 65 kgs
Connections - 8 mm bolt





All supplied with the system

1 x Battery isolator splitter
4 strings of 4 off 6FM200D
16 off battery blocks
24 Cells in series
48 VDC Nominal

8 off inter block links– short

8 off battery string to fuse holder links

1 off battery positive to isolator positive link
1 off isolator positive to machine positive link
3 off battery positive to battery positive links

1 off battery negative to isolator negative link
1 off isolator negative to machine negative link
3 off battery negative to battery negative links

Power Systems Warehouse Ltd.,
1 Torridon Court,
Bolingbroke Road, Louth,
Lincolnshire. LN11 0WA
Tel: 01507 600 688
Fax: 01507 600 621

Title:	PS-3k0-230-48-80A-M16	
Drg. No.:		
Rev. No.:	0	Page 1 of 1
Scale:	NTS	
Creation date:	29/01/2008	
Issue date:	29/01/2008	
Drn by:	Graham Chapman	
Material:		
Finish:		

This information is given for guidance only and it is up to the installer to make sure that the installation conforms to best practice and any applicable safety and technical standards that applyBattery shapes and wire colours shown are indicative only.
When the battery pack has been assembled use a voltmeter to check that the voltage is compatible to the rating plate on the machine