(54) Title: AN ELECTRICAL POWER SUPPLY SYSTEM

(57) Abstract: An electrical power supply system comprising an electrical energy storage device, typically in the form of a battery bank, and an inverter for supplying AC electrical power, derived from the electrical energy storage device, to a load. The system further includes an electricity generator for charging the electrical energy storage device and for supplying the load when the storage device is being charged. The electricity generator is switched on when the electrical energy stored by the electrical energy storage device drops below a predetermined first level, and is switched off again when the electrical energy stored by the electrical energy storage device reaches a predetermined second level above the first level.
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An Electrical Power Supply System

Field of the Invention

The present invention relates to an electrical power supply system, in particular for providing an electrical power supply output equivalent to a grid-connected supply.

Background to the invention

At present, diesel generators are typically used to provide an electrical power supply in remote areas where a national grid supply is not available, or to provide a back-up electrical power supply. However, diesel generators are not fuel efficient, they are noisy, and their output is often unreliable and of poor quality.

It is an object of the present invention to provide an improved electrical power supply system in which, at least in certain embodiments, one or more of these disadvantages are avoided or mitigated.

Summary of the Invention

According to a first aspect of the present invention there is provided an electrical power supply system comprising an electrical energy storage device; converting means for supplying AC electrical power, derived from the electrical energy storage device, to a load; a primary electricity generator for charging the electrical energy storage device; and control means for switching the electricity generator on when the electrical energy stored by the electrical energy storage device drops below a predetermined first level, and for switching the electricity generator off again when the electrical energy stored by the electrical energy storage device reaches a predetermined second level above the first level.

Typically, said primary electricity generator is a fuel powered generator. The converting means typically comprises a DC to AC converter, or inverter. The
electrical energy storage device conveniently comprises at least one battery, or battery bank.

During normal use, the electrical energy storage device serves as the main energy source for the load and the primary electricity generator is switched off. In preferred embodiments, the electrical energy storage device does not supply the load when being charged by the primary electricity generator and so, conveniently, the primary electricity generator supplies electrical power to the load during charging, i.e. when the primary electricity generator is switched on.

Conveniently, the primary electricity generator supplies electrical power to the load via said converting means. The converting means advantageously includes switching means for supplying electrical power to the load from one or other of said electrical energy storage device or said primary electricity generator.

In preferred embodiments, the control means includes means for monitoring the output level of the electrical energy storage device and generating a signal when said output level falls below a predetermined threshold. The monitoring means may also be arranged to generate a signal when said output level exceeds a predetermined threshold.

Preferably, the control means includes means for selecting to supply said load from one or other of said electrical energy storage device or said primary electricity generator depending on the amount of electrical energy stored in said electrical energy storage device.

Preferably, the system further includes input means for receiving electrical energy from at least one natural-powered electricity generator also for charging the electrical energy storage device.

A second aspect of the invention provides a method of supplying electrical power to the load in the system of the first aspect of the invention, the method comprising
switching the electricity generator on when the electrical energy stored by the electrical energy storage device drops below a pre-determined first level, and switching the electricity generator off again when the electrical energy stored by the electrical energy storage device reaches a predetermined second level above the first level.

A third aspect of the invention provides a computer program product comprising computer program code for causing a computer to perform the method of the second aspect of the invention.

The invention allows the construction of an improved power supply system which can be made more fuel efficient, less noisy and with a greater reliability and quality of grid voltage replication than diesel generators, and which is easy to install and avoids the need to run cables over long distances or difficult terrain.

In the present specification, a “fuel-powered electricity generator” means an electricity generator which is powered by a consumable fuel such as diesel, liquid petroleum gas (LPG) or natural gas. Such a generator is operable in all conditions provided the appropriate fuel is available. By contrast, a “natural-powered electricity generator” means an electricity generator which is powered by a renewable source, typically a natural phenomenon such as sunlight, wind or wave motion. These generators cannot be relied upon to provide electrical energy at all times since the relevant natural phenomenon could be absent.

Further advantageous aspects of the invention will become apparent to those ordinarily skilled in the art upon review of the following description of specific embodiments of the invention and with reference to the accompanying drawings.
Brief Description of the Drawings

Embodiments of the invention are now be described, by way of example, and with reference to the accompanying drawings in which like numerals indicate like parts and in which:

Figure 1 is a block diagram of an electrical power supply system embodying the invention; and

Figure 2 is a block diagram of a preferred electrical power supply system embodying the invention.

Detailed Description of the Drawings

Referring to Figure 1, there is shown, generally indicated as 5, a first embodiment of an electrical power supply system. The system 5 comprises a battery bank 10 comprising at least one, but typically a plurality of, batteries, for example BP Power bloc batteries. In normal use, the battery bank 10 supplies AC (alternating current) electrical power upon demand to an external load 12 via an inverter 14, more particularly a DC (direct current) to AC inverter. The battery bank 10 provides DC electrical power to the inverter 14. The inverter 14 converts the DC output of the battery bank 10 to AC and supplies a corresponding AC output to the load 12. In preferred embodiments, the arrangement is such that the output of the inverter 14 replicates a national grid power supply and supplies to the load 12 an output at, for example, 230 volts at 50 Hz and/or 110/240 volts at 60 Hz.

The electrical charge level of the battery bank 10 tends to diminish as power is supplied to the load 12. To maintain the charge on the battery bank 10 and ensure a substantially constant supply to the load 12, the system 5 further includes a fuel-powered electricity generator 16, herein referred to as the primary generator. In this embodiment, the primary generator 16 is driven by an LPG or natural gas engine (not shown) such as a Marathon Minotaur Gas Engine. Alternatively, a diesel generator
can be used, such as a Genmac Bulldog 14L diesel generator. The primary generator 16 typically produces an AC output, for example a 48V AC output.

In order to charge the battery bank 10 from the primary generator 16, the system 5 may include charging means, which is represented in Figure 1 as charger 20. In a simple form, the charger 20 may comprise an AC to DC rectifier which, for example, converts an AC output from the primary generator 16 to a DC signal for charging the battery bank 10.

The system 5 further includes means for controlling the operation of the system 5. In Figure 1, this is shown as controller 18. The controller 18 is typically microprocessor based, but may take any other suitable form. The controller 18 may monitor the charge level of the battery bank 10 directly or indirectly in any convenient manner. In preferred embodiments, the charge level of the battery bank 10 is determined by monitoring the power output level, or output voltage level, of the battery bank 10. Conveniently, this may be performed at the inverter 14. The preferred inverter 14 may therefore include means, typically comprising a suitably programmed micro-processor or other controller, for monitoring the DC signal supplied to it by the battery bank 10 and for generating at least one signal to indicate the level of the battery bank 10 output. Any such monitoring means may be considered to comprise part of the controller 18. The controller 18 further includes means for activating and de-activating the primary generator 16 in response to signals produced by the monitoring means. Figure 2 illustrates a preferred system 105, that is generally similar to system 5 and in respect of which similar descriptions apply, in which the DC output of the battery bank 10 is monitored at the inverter 14 and, when the DC output of the battery bank 10 drops below a threshold, a signal is provided to the controller 18 in response to which the controller 18 causes the generator 16 to start.

Hence, in use, the charge level on the battery bank 10 is monitored directly or indirectly by the controller 18. The engine of the generator 16 is normally off, but when the controller 18 determines that the charge on the battery bank 10 has fallen
below a predetermined threshold, which in this embodiment is approximately 75% of its maximum charge, the controller 18 switches on (starts up) the engine of the generator 20. The output of the generator 16 then charges the battery bank 10 via the battery charger 20. The controller 18 stops the generator engine when it determines that the battery bank 10 is fully charged, or at least that the charge level exceeds a predetermined threshold. In the preferred embodiment of Figure 2, the monitoring means at the inverter 14 signals to the controller 18 when the battery bank 10 is fully charged, or when the charge level exceeds a predetermined threshold.

In preferred embodiments, while the battery bank 10 is being charged, it is not used to supply electrical power to the load 12. During charging, the primary generator 16 may be used to supply electrical power to the load 12. Advantageously, the primary generator 16 supplies power to the load 12 via the inverter 14, as illustrated in the embodiment of Figure 2. In preferred embodiments, therefore, the inverter 14 includes switching means (not shown) for supplying electrical power to the load 12 derived either from the output of the battery bank 10 or from the generator 16, and means for selecting which of these power sources to use. Conveniently, the selecting means is provided by the micro-processor or other controller that is provided at the inverter 14 in preferred embodiments. The selecting means may, for example, be directly responsive to the presence of a DC supply from the generator 16 to select the generator 16 output, or may be responsive to a signal received from the controller 18 indicating that a supply from the generator 16 is available. Similarly, the selecting means may select to use, or revert to, the supply from the battery bank 10 when it detects that the battery bank 10 output is above a predetermined threshold, or at its maximum level, or may be responsive to a signal from the controller 18 indicating that the battery charging is finished.

Typically, an AC to DC rectifier 28 is provided between the generator 16 and the inverter 14 to covert the AC output of the generator 16 to a DC signal. The inverter 14 then converts the DC signal to an AC signal with the appropriate characteristics for supplying the load 12. In embodiments where the output supply generated by the generator 16 matches the supply required by the load 12, the rectifier 28 is not
required and the inverter 14 does not need to invert the output of the generator 16 — it may simply supply same to the load 12 via the switching means.

The battery bank 10, together with the inverter 14, primary generator 16, controller 18 and battery charger 20 may be packaged in a weather-proof, tamper-proof acoustic enclosure 22. Optionally, the system 5, 105 has inputs for receiving electrical energy from one or more external, natural-powered, secondary electricity generators such as a wind turbine 24 or solar panel 26. The outputs from these external generators may be used to charge the battery bank 10 via the battery charger 20 and may also be used to supply the load 12 when the battery bank is charging (for example in a manner similar to that described above for the primary generator 16), thereby reducing the frequency and duration of operation of the generator 16. However, the primary generator 16 is advantageously fuel-powered to ensure that the charge on the battery bank 10 can be maintained even when natural sources of energy are not available.

The wind turbine 24 can be a Bergey 7.5kW Wind Turbine and the solar panel 26 can be a BP Solar BP275 PV Photovoltaic Module.

The advantage of using the battery bank 10 as the main supply source for the load is that the primary energy source 16 alone may not be able to respond to rapid or step load changes so the battery system is employed to store energy for this purpose and also to reduce the running hours on the primary energy source. Advantageously, the battery system will be sized to match the load requirement such that the maximum discharge is typically not more than 75% of the battery capacity so as to prolong the life and cyclic capability of the batteries.

As an alternative to using batteries 10 as the electrical storage device one could use, for example, a bank of capacitors, flywheel storage devices, regenerative zinc-air fuel cells or fuel cells whose hydrogen fuel is derived by electrolysis of water using the generator output as the electrical source for the electrolysis.

In addition to controlling the on/off switching of the primary generator 16, the controller 18 may monitor all of the relevant operating parameters — engine status,
temperature, oil pressure, alarm condition, running hours, etc. This data can be viewed in real time via a GPRS modem (not shown) on a web page for control and monitoring. Essentially the controller 16 will look at all of the parameters relevant to the safe and reliable operation of the system 5, 105.

Although the inverter 14 and battery charger 20 are shown separately in the drawing, they may conveniently be combined into one unit to reduce the number of components and to provide enhanced reliability. Similarly, at least some of the functionality of the controller 18 may be incorporated into the inverter 14, for example in a suitably programmed micro-processor.

The invention is not limited to the embodiments described herein which may be modified or varied without departing from the scope of the invention.
CLAIMS:

1. An electrical power supply system comprising an electrical energy storage device; converting means for supplying AC electrical power, derived from the electrical energy storage device, to a load; a primary electricity generator for charging the electrical energy storage device; and control means for switching the electricity generator on when the electrical energy stored by the electrical energy storage device drops below a pre-determined first level, and for switching the electricity generator off again when the electrical energy stored by the electrical energy storage device reaches a predetermined second level above the first level.

2. A system as claimed in Claim 1, wherein said primary electricity generator is a fuel powered generator.

3. A system as claimed in Claim 1 or 2, wherein said converting means comprises a DC to AC converter.

4. A system as claimed any preceding claim, wherein said electrical energy storage device comprises at least one battery.

5. A system as claimed in any preceding claim, wherein said primary electricity generator supplies electrical power to the load when switched on.

6. A system as claimed in Claim 5, wherein said primary electricity generator supplies electrical power to the load via said converting means.

7. A system as claimed in Claim 6, wherein said converting means includes switching means for supplying electrical power to the load from one or other of said electrical energy storage device or said primary electricity generator.
8. A system as claimed in any preceding claim, wherein said control means includes means for monitoring the output level of the electrical energy storage device and generating a signal when said output level falls below a predetermined threshold.

9. A system as claimed in any Claim 8, wherein said monitoring means is arranged to generate a signal when said output level exceeds a predetermined threshold.

10. A system as claimed in any preceding claim, wherein said control means includes means for selecting to supply said load from one or other of said electrical energy storage device or said primary electricity generator depending on the amount of electrical energy stored in said electrical energy storage device.

11. A system as claimed in any preceding claim, wherein the system further includes input means for receiving electrical energy from at least one natural-powered electricity generator also for charging the electrical energy storage device.

12. In an electrical power supply system comprising an electrical energy storage device; converting means for supplying AC electrical power, derived from the electrical energy storage device, to a load; and a primary electricity generator for charging the electrical energy storage device; a method of supplying electrical power to the load, the method comprising switching the electricity generator on when the electrical energy stored by the electrical energy storage device drops below a predetermined first level, and switching the electricity generator off again when the electrical energy stored by the electrical energy storage device reaches a predetermined second level above the first level.

13. A computer program product comprising computer program code for causing a computer to perform the method of Claim 12.