

ELECTRIC POWER SUPPLY SYSTEM FOR AN ELECTRICAL EQUIPMENT

The present invention relates to an electric power supply system for at least one electrical equipment.

In certain applications, in particular in the field of electronics and microelectronics, it is necessary to employ a high-quality supply.

Such a supply must provide, permanently, a very stable frequency, that is to say, for example, with variations of less than around 1%, variations in voltage values of less than around 10%, preferably of less than for example 8%, and to do so for a power level which may reach for example 30 Megawatts.

Moreover, when there is a break or a dip in voltage in the supply, the latter must not lead to a frequency variation and voltage variation beyond the fixed limits.

Thus, the public electric power distribution networks, liable to give rise to brownouts lasting from 100 to 800 ms accompanied by a drop in the value of the voltage provided, do not make it possible to provide an adequate supply for such uses.

The purpose of the invention is to provide a supply system capable of providing a high-quality supply, that is to say one capable of meeting the requirements mentioned above.

Its subject is therefore an electric power supply system for at least one electrical equipment connected to a supply line linked to an electric power distribution network, characterized in that it furthermore comprises at least one electric power generator connected to the line and, interposed between the network and the line, means for compensating for disturbances in the supply provided to the equipment, the compensating means comprising means of active electrical energy storage which are adapted for



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exchanging active electrical energy with the electrical equipment, upon the occurrence of a disturbance.

The supply system according to the invention can moreover comprise one or more of the following characteristics, taken in isolation or according to all technically possible combinations:

- the energy storage means comprise at least one rotary mass associated with reversible means of converting a mechanical energy into an electrical energy which are linked to a supply line of the equipment;

- the system furthermore comprises frequency converter means associated with the energy storage means;

- it furthermore comprises reversible means of converting an active power delivered by the energy storage means into active power intended to be exchanged with the equipment;

- the system furthermore comprises at least one voltage step-up transformer connected between the supply line of the electrical equipment and the energy storage means.

Other characteristics and advantages will become apparent from the following description, given merely by way of example and with reference to the appended drawings in which:

- Figure 1 is a diagrammatic general view of a supply system according to the invention;

- Figure 2 is an electrical diagram showing the makeup of the means for compensating for disturbances liable to occur in the supply provided to the equipment; and

- Figure 3 is an electrical diagram of another embodiment of the compensation means.

Represented in Figure 1 is a general view of a supply system, in accordance with the invention. It is intended for supplying one or more electrical equipment, designated by the general numerical reference 10.

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Within the framework of the present description, the expression electrical equipment is understood to mean any type of device or installation which consumes electrical power, such as electronic power devices, motors, etc.

As mentioned previously, the installation 10 must be supplied by means of a high-quality supply, that is to say one exhibiting a stable frequency, with variations for example of less than around 1%, voltage variations for example of less than 10%, preferably less than 8% and no voltage dips occurring in the presence of a brownout or a short-circuit in an electrical power distribution network.

For example, the voltage to be provided to the equipment 10 is several tens of kV, for a power of several tens of Megawatts.

As may be seen in Figure 1, the supply system comprises a supply line 12 plugged into a polyphase electric power distribution network R, in this instance the public distribution network, and into which are plugged a set of electrical power generators, such as 14, consisting for example of appropriate gas-operated motors or turbines.

The number of generators 14 used depends on the needs of the equipment 10, that is to say on the total power to be provided, on the power of each generator, and on the impact of maximum allowable load, that is to say the frequency variation engendered when electrically plugging in the equipment 10.

For example, for generators 14 each delivering a power of 3.8 Megawatts, eight identical generators 14 are used and plugged into the supply line 12 in parallel, in such a way as to obtain an overall power of around 30 Megawatts.

It may be seen moreover in Figure 1 that each generator 14 is associated with a voltage step-up transformer, such as 16, capable of stepping the voltage provided on the line 12 up to the voltage level

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to be provided to the equipment 10, that is to say up to a voltage equal to 20 kV, for example.

Moreover, the supply system is furnished with means for compensating for disturbances liable to occur in the supply provided to the equipment 10, these means being designated by the general numerical reference 18 and represented succinctly in this figure.

They are interposed between the electric power distribution network R and the supply line 12.

The compensating means 18 comprise electrical energy storage means 20 consisting of a rotary mass associated with reversible means 21 of converting the mechanical energy delivered or absorbed by the latter into electrical energy, and which are linked to the supply line 12.

Represented in Figure 2 is a first exemplary embodiment of the compensating means 18.

It may be seen in this Figure 2 that the energy storage means 20 of the compensating means 18 are connected between two inductance coils 22 and 24 plugged in on one side to the electric power distribution network R and on the other to the supply line 12, so as to allow an exchange of energy with the electrical equipment and the network when a disturbance occurs in the supply, for example a brownout generated by the supply network R, or a malfunction of one of the generators 14, with a view to keeping the supply voltage of the equipment 10 constant.

The energy storage means 20 are plugged into the coils 22 and 24 by way of a voltage step-up transformer 26 capable for example of providing an active power of 5 MW.

They comprise several identical branches 28, 30 and 32 arranged in parallel and plugged into the transformer 26 by way of appropriate switching devices, such as 33.

Each of the branches 28, 30 and 32 is adapted for exchanging active power with the electrical

equipment 10 and the network R for compensating for the disturbances liable to occur in the network supply.

To do this, each of the branches 28, 30 and 32 comprises a rotary mass 34, 36 and 38, consisting of an inertial flywheel of conventional type, associated with reversible means of converting a mechanical energy into an electrical energy, respectively 40, 42 and 44, with a view to converting, on the one hand, the mechanical energy provided by the inertial flywheels 34, 36 and 38 into electrical energy and, on the other hand, the electrical energy to be absorbed on the line of the supply 12 into corresponding mechanical energy for rotating the inertial flywheels.

For example, each of the inertial flywheels is an inertial flywheel capable of delivering an active power equal to 1650 kW for 10 s.

The operating point of these inertial flywheels is adjusted in such a way as to be positioned in the middle of their operating range, so as either to absorb or equally to deliver active power.

Moreover, they are each associated with motor means (not represented) enabling them to be set into rotation, when the system is started up.

The energy converter means 40, 42 and 44 are furthermore linked to a frequency converter, respectively 46, 48 and 50, of conventional type, capable of providing, as output, a frequency equal to 50 Hz compatible with the supply frequency of the electrical equipment 10.

Each of the branches 28, 30 and 32 is furthermore supplemented with a converter, 52, 54 and 56, consisting for example of an alternator, capable of transforming the active power provided by the inertial flywheels 34, 36 and 38 into corresponding active power, with a view to its injection onto the supply line 12 and to transforming the active power tapped off from the latter into corresponding active power, so as to be stored in the inertial flywheels.

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Three inertial flywheels being used within the framework of the exemplary embodiment envisaged, it is possible to exchange a power equal to around 5 Megawatts with the supply line 12, thereby making it possible to counter the momentary failure of one of the generators 14 and to limit the impacts due to a brownout occurring in the distribution network R.

When a short-circuit occurs in the network R, the coils 22 and 24 limit the transmission of electrical energy towards the incriminated portion of network for as long as a circuit breaker 58 with which the network R is conventionally equipped is not actuated, this cutting in conventionally after a period of time of up to 500 ms.

Consequently, the effects of such a short-circuit are limited.

It will be noted that the switching elements, such as 33, with which the energy storage means are equipped, are driven by means of a conventional electronic device whose response time is negligible relative to the response time of the circuit breaker 58, thereby contributing to limiting the effects of a malfunction occurring in the network R.

With reference to Figure 3, another embodiment of the compensating means 18 will be described.

According to this embodiment, the energy storage means 20 are connected between two wound-rotor rotating machines 62 and 64, one, 62, plugged into the electric power distribution network R and the other, 64, plugged into the supply line 12, so as to allow an exchange of energy with the electrical equipment and the network when a disturbance occurs in the supply, for example a brownout generated by the supply network R, or by a malfunction of one of the generators 14.

The rotating machines 62 and 64 are plugged into the network R and into the supply line 12 by way of two voltage step-up transformers 66 and 68 capable for example of providing an active power of 3 MW.

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As in the exemplary embodiment described with reference to Figure 2, the compensating means 18 comprise several identical branches arranged in parallel.

Each of the branches is adapted for exchanging active power with the electrical equipment 10 and the network R so as to compensate for the disturbances liable to occur in this network's supply.

The energy storage means 20 of each of the branches comprises a common energy storage rotary mass 70 consisting of an inertial flywheel of conventional type, associated with reversible means of converting a mechanical energy into an electrical energy, 72 and 74, with a view to converting, on the one hand, mechanical energy provided by the inertial flywheels into electrical energy and, on the other hand, electrical energy to be absorbed on the line of the supply 12 into corresponding mechanical energy for rotating the inertial flywheels.

For example, the inertial flywheel is an inertial flywheel capable of delivering an active power equal to 3000 kW for 3 s.

The energy converter means 72 and 74 are furthermore capable of providing, at output, a variable frequency compatible with the frequency of rotation of the flywheel 70.

Two rotating machines being used within the framework of the exemplary embodiment described, it is possible to exchange a power equal to around 6 Megawatts with the supply line 12, thereby making it possible to counter the momentary failure of one of the generators 14 and to limit the impacts due to a brownout occurring in the distribution network R, as in the exemplary embodiment described previously.

It will be noted moreover that when a short-circuit occurs in the network R, the rotating machines 62 and 64 limit the transmission of electrical energy towards the incriminated portion of network for as long

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as the circuit breaker 76 with which the network R is equipped is not actuated.

Consequently, the effects of such a short-circuit are limited.

As in the exemplary embodiment described previously, the switching elements, with which the energy storage means are equipped, are driven by means of a conventional electronic device whose response time is negligible relative to the response time of the circuit breaker 76, thereby contributing to limiting the effects of a malfunction occurring in the network R.

Finally, it may be seen that the system is supplemented with inductors and a diode bridge which are appropriate for the use envisaged.

It is appreciated that the invention just described, ensuring an exchange of energy between the storage means 20 and the supply line 12 makes it possible to compensate for the voltage drops liable to occur upon the occurrence of a malfunction in the network R, or upon the failure of one of the generators 14, or else upon a momentary voltage drop due to the plugging in of an equipment into the line 12, insofar as the compensating means 18 make it possible to inject the necessary quantity of energy to counter this failure.

It is likewise appreciated that the absorption and the injection of load on the supply line 12 makes it possible to keep the frequency of the supply stable upon the occurrence of malfunctions.

The supply system described with reference to Figures 1 and 2 is fitted with energy storage means consisting mainly of inertial flywheels.

It would however be possible, as a variant, to replace these inertial flywheels with other types of appropriate energy storage means, such as, for example, electrical energy accumulators.

Finally, it will be noted that the invention is not limited to the embodiments described, in particular

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' as regards the makeup of the compensating means, other appropriate devices being equally usable.

CLAIMS

1. A system for providing electrical power to at least one user apparatus, comprising:
 - at least one power supply line, to which a user apparatus is connected;
 - at least one electrical generator connected to the power supply line; and
 - a power supply network connected to the power supply line via at least one connection circuit, the connection circuit including a compensation means for compensating for a disturbance in the supply of electrical power to the user apparatus and comprising at least one active electrical energy storage device adapted to exchange active electrical energy with the user apparatus upon appearance of the disturbance.
2. The system of claim 1, wherein the connection circuit further comprises a frequency converter associated with the energy storage device.
3. The system of claim 2, wherein the connection circuit further comprises at least one rotary mass associated with the frequency converter for reversible conversion between mechanical energy and electrical energy.
4. The system of claim 1 or 2, wherein the connection circuit further comprises at least one pair of rotary machines coupled to a single rotary mass.
5. The system of any one of the preceding claims, wherein the connection circuit further comprises at least one voltage-raising transformer connected between the energy storage device and the power supply line.
6. The system of any one of the preceding claims, wherein the connection circuit further comprises two serially arranged inductance windings establishing direct connection between the power supply network and the power supply line.