ELECTRICAL POWER DISTRIBUTION CONTROL METHODS, ELECTRICAL ENERGY DEMAND MONITORING METHODS, AND POWER MANAGEMENT DEVICES

RELATED PATENT DATA

The present application is a continuation of and claims priority to U.S. patent application Ser. No. 10/461,137 filed on Jun. 13, 2003 now U.S. Pat. No. 7,149,605, entitled "Electrical Power Distribution Control Methods, Electrical Energy Demand Monitoring Methods, and Power Management Devices", naming David P. Chassin, Matthew K. Donnelly, and Jeffrey E. Dagle, as inventors, the disclosure of which is incorporated herein by reference.

TECHNICAL FIELD

This invention relates to electrical power distribution control methods, electrical energy demand monitoring methods, and power management devices.

BACKGROUND OF THE INVENTION

Consumption of and reliance upon electrical energy is increasing. Usage of electrical energy is ubiquitous in almost every aspect of life. Businesses, entertainment, communications, etc. Are heavily dependent upon electrical energy for fundamental operation. Power distribution systems or grids provide electrical energy to households, businesses, manufacturing facilities, hospitals, etc. Such systems are typically reliable, however, numerous systems employ backup electrical supplies in case of failure of the power distribution system being utilized.

Some electrical power distribution systems are ever-changing dynamic systems and operations are often concerned with balancing generation with load. Frequency of the voltage of the electrical energy may be used as an indicator of variances between generation of electrical energy and usage of electrical energy by loads coupled with the electrical power distribution system. For example, when demand exceeds generation, the frequency of the electrical energy on the electrical power distribution system may drop, and conversely, when there is excess electrical energy available, the frequency increases. Over a given 24 hour period, it is desired to balance energy surplus and deficit so the average frequency is 60 Hz, or other desired frequency.

Typically, control of the state of the electrical power distribution system is implemented by controlling operations of generators coupled with the system. For example, at times of increased demand, the output of generators may be increased and/or other generators may be brought on-line to assist with supplying the electrical energy. In addition, spinning reserves may be utilized to accommodate unexpected significant fluctuations in demand for electrical energy. Provision of spinning reserves is costly, and much of the time, not used.

Some electrical power distribution approaches have been designed to curtail peak loads through the utilization of Demand Side Management (DSM). DSM techniques include direct load control wherein a utility has the ability to curtail specific loads as conditions warrant. In these arrangements, a utility may broadcast a control signal to specific loads when curtailment is desired (e.g., during peak usage periods).

Other electrical power distribution approaches attempt to stabilize bulk-power transmission corridors using external Flexible AC Transmission System (FACTS) devices to improve dynamic performance of transmission systems. FACTS devices, such as Static-Var Compensation (SVC) and Thyristor-Controlled Series Capacitors (TSCSs), are designed to provide stability enhancements allowing transmission facilities to be loaded to levels approaching their ultimate thermal capacity. These devices may supply reactive power to support voltage or provide modulation to damp electromechanical oscillations.

Utilities may use other devices at distribution points (e.g., substations and/or switchyards) to manage electrical power distribution operations. Exemplary management devices include underfrequency and undervoltage relays. These devices may "black out" entire neighborhoods when a grid is in trouble allowing the grid to recover before power is reapplied to the blacked out customers.

Oscillations of power flows within electrical distribution systems are of concern to utilities. Some techniques utilize large power flow controllers within high capacity transmission lines to reduce or minimize oscillations of power flows. These devices are typically relatively expensive and require significant investment by a utility.

Aspects of the present invention provide improved apparatus and methods for supplying electrical energy.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the invention are described below with reference to the following accompanying drawings.

FIG. **1** is a functional block diagram of an exemplary electrical power distribution system according to one embodiment.

FIG. **2** is a functional block diagram of an exemplary power management device according to one embodiment.

FIG. **3** is an illustrative representation of a plurality of exemplary operational states of the power management device according to one embodiment.

FIG. **4** is a flow chart illustrating an exemplary control methodology for applying electrical energy to a load according to one embodiment.

FIG. **5** is a flow chart illustrating another exemplary control methodology for applying electrical energy to a load according to one embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

According to one aspect of the invention, an electrical power distribution control method comprises providing electrical energy from an electrical power distribution system, applying the electrical energy to a load, providing a plurality of different values for a threshold at a plurality of moments in time and corresponding to an electrical characteristic of the electrical energy, and adjusting an amount of the electrical energy applied to the load responsive to an electrical characteristic of the electrical energy triggering one of the values of the threshold at the respective moment in time.

According to another aspect of the invention, an electrical power distribution control method comprises providing electrical energy from an electrical power distribution system, applying the electrical energy to a load, randomly selecting a value of a threshold corresponding to an electrical characteristic of the electrical energy of the electrical power distribution system, and adjusting an amount of the electrical energy applied to the load responsive to the electrical characteristic of the electrical energy triggering the value of the threshold.