

SYSTEM AND METHOD FOR REMOTELY MONITORING OF POWER LOSS TO ELECTRICAL EQUIPMENT

Field of the Invention

[0001] The present invention generally relates to systems and methods of detection and notification, and more particularly to a system and method for remotely monitoring of power loss to electrical equipment.

Background of the Invention

[0002] Electrical equipment or appliance (equipment) is omnipresent nowadays in every household and commercial residence. Certain electrical appliances have to be operated continuously; otherwise malfunctioned appliances will result in inconveniences and financial losses for the owners. For example, a non-functioning refrigerator results in not only great inconveniences but also monetary losses due to content spoilage. Other examples include the water aeration and filtration systems that are critical to the survival of many expensive ornamental fishes in aquarium shops, chillers for chilled meat, and freezers for ice creams or reagents for researches. Non-functioning of these systems will certainly result in huge losses to the business. One effective way to mitigate the losses derived from the malfunction of an electrical appliance is providing immediate notification so that timely remedies can be taken.

[0003] Equipment may lose its power supply in two ways; one is due to power outage of the utility power supply line; and the other due to equipment power failure. There are prior arts disclosing of detection and notification of power outage. For example, US 2004/0061616 discloses an outage notification system for detecting a power outage at a customer location. The disclosed system employs multiple outage notification devices to determine whether the power outage is systemic or local. In addition, US 6,711,908 discloses an apparatus for monitoring power outages in a household appliance. The unique feature of this apparatus is that it has an intelligent control adapted for determining the duration of a power outage without notification mechanism. However, the prior arts fail to

teach or suggest a detection and notification system and method that can detect the power loss of equipment due to either power outage or equipment power failure.

[0004] Therefore there is an existing need of a system and method for detection of power loss to electrical equipment and instant notification of the user. Furthermore, the system and method are able to distinguish the power supply loss due to power outage from the one due to power failure. This invention satisfies this need by disclosing of a system and method of detecting power outage and/or power failure of equipment. Other advantages of this invention will be apparent with reference to the detailed description.

Summary of the Invention

[0005] The present invention provides a system for detection and notification of power supply to electrical equipment. The system detects and notifies the user of the power loss to the electrical equipment either due to power outage or power failure. In one aspect of the present invention, the system comprises a power loss detection device having: a means for detecting mains power outage and restoration, and outputting the detected power outage and restoration; a means for detecting the power failure of the electrical equipment, and outputting the detected power failure; a first microcontroller for obtaining the outputting signals from both of the detecting means, processing the obtained signals, and transmitting the processed signals; an encoding means for encoding the information from the first microcontroller; and a wireless transmitting means for transmitting the encoded information from the encoder; and a communication device having: a wireless receiving means for receiving the transmitted information from the wireless transmitting means and transmitting the received information; a decoding means for decoding the encoded information from the wireless receiving means; and an information transmitter means for acting on the decoded information and issuing proper notification to the user of the electrical equipment. The invention further provides a method for detection and notification of power supply to an electrical equipment, wherein the method comprises detecting of power outage and restoration at a monitoring point of a utility power supply line; detecting of power failure of the electrical equipment; processing the signals of power outage and equipment power failure; and notifying a user of the electrical equipment of whether there is a power outage or equipment power failure.

[0006] One objective of the present invention is to provide a self-contained detection and alert system that is affordable and reliable.

[0007] Another objective of the present invention is to provide a detection and alert system that is easily scalable and wireless so that it is able to remotely inform users of power loss to electrical equipment.

[0008] Yet another objective of the present invention is to provide a detection and alert system that has a diagnostic ability of determining whether the electrical equipment failure is due to power outage or power failure.

[0009] Yet another objective of the present invention is to provide a detection and alert system that is designed to function at a localized electrical power point and not just within a power loop. Thus it is able to determine and inform users of the exact location where power loss occurred.

[0010] The objectives and advantages of the invention will become apparent from the following detailed description of preferred embodiments thereof in connection with the accompanying drawings.

Brief Description of the Drawings

[0011] Preferred embodiments according to the present invention will now be described with reference to the Figures, in which like reference numerals denote like elements.

[0012] FIG 1 shows the isometric view of the Detection Device and Communication Device of the Power Outage and Equipment Monitoring System (POEMS) in accordance with one embodiment of the present invention.

[0013] FIG 2A is the functional block diagram of the Detection Device in accordance with one embodiment of the present invention.

[0014] FIG 2B is the functional block diagram of the Communication Device in accordance with one embodiment of the present invention.

[0015] FIG 2C is the functional block diagram of the Communication Device in accordance with another embodiment of the present invention.

[0016] FIG 3 is an exemplary circuit implementation of the Detection Device in accordance with one embodiment of the present invention.

[0017] FIG 4 is the flow chart of the operation of the Detection Device in accordance with one embodiment of the present invention.

[0018] FIG 5 is a functional block diagram of the Power Outage and Equipment Monitoring System (POEMS) in accordance with another embodiment of the present invention.

Detailed Description of the Invention

[0019] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

[0020] Throughout this application, where publications are referenced, the disclosures of these publications are hereby incorporated by reference, in their entireties, into this application in order to more fully describe the state of art to which this invention pertains.

[0021] The present invention provides a system and method that monitors utility power supply and equipment current load so as to detect and notify power loss to electrical equipment. The system monitors the power supply by checking the presence or absence of electrical power at an electrical outlet to detect power outage and restoration. The system monitors the equipment current load by checking whether the equipment is drawing electrical power so that the system can distinguish the equipment power failure from a utility power outage. The system also employs wireless transmission so that the power supply status of equipment may be monitored remotely. It is to be appreciated that the principles of the present invention may be implemented in different ways so that the specific embodiment including specific electrical circuit provided below is for purpose of illustration only. In addition, many components are well known to those skilled in the art so that no detailed description of such components will be provided herein in order not to obscure the present invention.

[0022] As is used herein, 'power outage' means the loss of power due to the failure of a utility power line; 'power failure' means that equipment does not take any power due to its malfunction; and 'power loss' means that equipment is without power due to either

power outage or power failure. Furthermore, the 'user' refers to any party who has the responsibility for the power loss to electrical equipment.

[0023] In one preferred embodiment, the power outage and equipment monitoring system (POEMS) **1** as shown in FIG 1 comprises a detection device **10** and a communication device **20**. The detection device **10** as shown in FIG 2A comprises a Mains Voltage Sensor **11** for mains power outage and restoration detection, an Equipment Load Current Sensor **12** for equipment power failure detection, a Microcontroller **13** for decision making, an encoder **14** for encoding the information from the Microcontroller, and a Wireless Transmitter Module **15** for transmitting the encoded information from the Microcontroller. The detection device also comprises a back-up rechargeable battery for providing the detection device with power when a power outage happens. The communication device **20** as shown in FIG 2B comprises a Wireless Receiver Module **21** for receiving the encoded information from the Wireless Transmitter Module **15**, and a decoder **22** for decoding the information from the Wireless Receiver Module, and an information transmitter module **23** for outputting the decoded information from the decoder to a designated SMS-enabled Device **30** for user notification.

[0024] Now referring to FIG 3, there is provided an exemplary electrical circuit for the detection device **10**. The Mains Voltage Sensor **11** for mains power outage and restoration detection is implemented in functional block A, the Power Outage & Restoration Detector circuit that senses the presence or absence of the AC mains voltage at the monitoring point. The monitoring point may be a local power socket. The Power Outage & Restoration Detector circuit comprises an electromagnetic relay (EMR) that is electrically connected to the mains voltage at the monitoring point (e.g., local power socket). The relay has a single pole, double throw (SPDT) switch S1 that switches to one contact position X under non-energized state and to the other position Y when the relay is energized by the mains power. The switch may be debounced by a standard debouncing circuit, an S-R latch, to prevent spurious logic states due to switch bounce.

[0025] When AC mains voltage is absent due to power outage, the relay is de-energized, effecting S1 to switch to contact position X. This produces a debounced high logic state at the output of the Power Outage & Restoration Detector. When the relay is energized by the presence of AC mains voltage (either without power outage or power restoration after the power outage), the switch S1 will be at the contact position Y,

generating a debounced low logic state at the output of the Power Outage & Restoration Detector. It is to be appreciated that the assignment of logic state to each contact position is arbitrary. A manufacturer may assign any functional logic state to each contact position. Table 1 shows an exemplary correspondence among the AC power status, the Switch S1 position, and the logic state output of the Power Outage & Restoration Detector.

[0026] Table 1. An exemplary correspondence among the AC power status, the Switch S1 position, and the logic state output of the Power Outage & Restoration Detector

[0027]

AC Power status	Switch S1 position	Logic state of Power Outage & Restoration Detector
Power outage	X	High
Power presence	Y	Low

[0028] Still referring to FIG 3, the Microcontroller 13 may be any simple low-cost microcontroller circuit, such as an 8051-based microcontroller or state machine, that has unique device identification information pre-coded in its memory. In other embodiments, the microcontroller may read in the logic states of a user-settable array of switches that produces many possible combinations of identification codes. The Microcontroller is normally put in a sleep mode to reduce power consumption, and is awakened by an event trigger pulse to read in the new logic state at the Power Outage & Restoration Detector. The event trigger pulse occurs whenever the logic state of the detector changes. This event trigger pulse may be generated by a transition detector as shown in function block B of FIG 3. Whenever a transition of the logic state at the Power Outage & Restoration Detector occurs, the transition detector B will generate a momentary negative-going pulse to awaken the Microcontroller from sleep mode to check the output logic state at the detector. For example, a high state will indicate a power outage condition while a low state will indicate that power is present or restored.

[0029] Referring to FIG 3 again, the Equipment Load Current Sensor 12 for equipment power failure detection is implemented in functional block C, Load-Current Detector Circuit. The Load-Current Detector Circuit detects equipment power failure by sensing a loss of load current to the equipment. For certain equipment such as auto-defrost

refrigerator, the power failure is determined by the loss of load current over a period of time, such as five minutes. The Load-Current Detector Circuit as shown in functional block C has an LED and a light dependent resistor (LDR). It is common knowledge that there are many ways to implement this detection, such as using a current sense transformer or opto-isolator device to sense the loss of load current to the equipment.

[0030] In this exemplary implementation, the load current flowing to the equipment passes through the LED, where the LED is suitably protected by a limiting resistor R1 and a series of diodes. The R1, together with D1, D2, and D3, limits the current flowing into the LED. D4 protects the LED from the reverse cycle of the AC mains voltage. When the equipment load draws current and a small portion of this current will pass through the LED, the LED will emit light toward the LDR. When the LDR receives the light from the LED, the LDR drops its resistance causing the output of the load-current detector to register a low logic state. When there is no load current (e.g. equipment is faulty resulting in a loss of load current), the LED will not turn on. Hence the LDR's resistance will be high, resulting in a high logic state at the output of the load-current detector. It is to be appreciated that the assignment of logic state to resistance status is arbitrary. A manufacturer may assign any functional logic state to each resistance status. Table 2 below illustrates an exemplary correspondence among the equipment power failure, LED status, LDR resistance status and logic states of the Load-Current Detector.

[0031] Table 2. Illustration of an exemplary correspondence among the equipment current status, LED status, LDR resistance status, and logic states of the Load-Current Detector

[0032]

Equipment Power Failure	LED Status	LDR Resistance	Logic State of Load-Current Detector
Yes	OFF	High	High
No	ON	Low	Low

[0033] The Load-Current Detector Circuit may optionally comprise a Variable resistor VR1 that is used to adjust the sensitivity of the Load Current Detector circuit.

[0034] The Microcontroller 13 as discussed above is normally in sleep mode to reduce power consumption. When the logic state of the load-current detector changes, an event trigger pulse (interrupt) is generated by a transition detector D as shown in functional block D of FIG 3. The interrupt pulse will awaken the Microcontroller to check the output logic state of the Load Current Detector. A high state will indicate an equipment fault condition resulting in a loss of load current while a low state will indicate that the equipment is still drawing load current (functioning). The Microcontroller may be programmed to decide that the equipment is faulty only after sensing a no-load current condition over a pre-determined period (e.g., 5 minutes). This is especially applicable for equipment of which its current may be temporarily cut off due to normal thermostat control.

[0035] One feature of the present invention is that the POEMS may monitor both power outage and equipment power failure together. The outputs of the two transition detectors (B and D) can be combined using a logic AND gate to generate a common interrupt trigger that awakens the Microcontroller to check the logic states of the Power Outage & Restoration Detector and Load Current Detector. When the Microcontroller wakes up from an interrupt, it determines whether there is a power outage or equipment power failure based on the logic states at the Power Outage & Restoration Detector and the Load Current Detector respectively. Table 3 illustrates as an example the determination of whether there is a power outage or equipment power failure.

[0036] Table 3. Illustration of the determination of whether there is a power outage or equipment power failure

[0037]

Power status (logic state)	Equipment status (logic state)	Diagnosed condition
High	High/Low	Power outage
Low	High	Equipment power failure, no power outage
Low	Low	Normal (Power on/restored, no equipment power failure)

[0038] Still referring to FIG 3, the encoder **14** is implemented in the Encoder Circuit that encodes the information from the Microcontroller for further transmission via the Wireless Transmitter Module **15**. The Wireless Transmitter Module **15** is implemented in the RF Transmitter Circuit. It is to be appreciated that any suitable encoder and Transmitter means is applicable for the present invention. In one embodiment, when the Microcontroller determines there is a power outage condition, it may embed a '00' data string into a message stream, which includes device identification information, via the Encoder Circuit and transmits it out via the RF Transmitter Circuit to the Communication Device. When the Microcontroller determines there is an equipment power failure condition only, it may embed a '01' data string into the message stream via the Encoder Circuit and transmits it out via the RF Transmitter Circuit to the Communication Device. When the Microcontroller determines there is a power on/restored condition with no equipment power failure, it may embed a '10' data string into the message stream via the Encoder Circuit and transmits it out via the RF Transmitter Circuit to the Communication Device.

[0039] Immediately after sending any of the above, the Microcontroller will follow up by embedding an '11' code into a message stream via the Encoder Circuit and transmits it out via the RF Transmitter Circuit to the Communication Device. This is necessary to reset the receiver unit of the Communication Device.

[0040] As shown in FIG 3, the detection device comprises a Back-up Battery & Battery Charger Module for providing the detection device with power when power outage happens. This module can be any commercial available one. It is to be appreciated that the Battery Module may be substituted by other backup power sources such as super capacitors of a type known in the art. Preferably the power source including the Battery Module is charged or recharged by the external power source while the equipment is operating normally; it functions as a backup power source that is only needed during times of power outage.

[0041] Now referring to FIG 4, there is provided a flow chart showing the functional connections of different components within the Detection Device. When the Detection Device is plugged into a local power socket **40**, it will continuously check whether there is a change of power supply and equipment current load **41**. If no, no further actions will be taken by the Detection Device. If the Power Outage & Restoration Detector

and/or the Load-Current Detector detect any change of the power supply and equipment current load, the transition detectors (B and D) will generate an interrupt pulse to awaken the Microcontroller to read in the logic state of power supply and equipment current load 42. If the Microcontroller determines there is a power outage condition (the logic state of power supply is high), it embeds a '00' data string into a message stream via the Encoder Circuit and transmits it out via the RF Transmitter Circuit to the Communication Device 43. If the Microcontroller determines there is an equipment power failure condition only (the logic state of power supply is low, while the logic state of equipment current load is high), it embeds a '01' data string into a message stream via the Encoder Circuit and transmits it out via the RF Transmitter Circuit to the Communication Device 44. If the Microcontroller determines there is a power on/restored condition with no equipment power failure (the logic state of power supply is low and the logic state of equipment current load is low), it embeds a '10' data string into a message stream via the Encoder Circuit and transmits it out via the RF Transmitter Circuit to the Communication Device 45. Then, immediately after sending any of the above, the Microcontroller will follow up by embedding an '11' code into a message stream via the Encoder Circuit and transmits it out via the RF Transmitter Circuit to the Communication Device 46. Then, the Microcontroller goes into sleep mode 47.

[0042] Now referring back to FIG 2B, the Wireless Receiver Module 21 for receiving the encoded information from the Wireless Transmitter Module 15 is one that is compatible with the Wireless Transmitter Module, and suitable for one-to-one or multi-node wireless link. Both the Transmitter and Receiver Modules can be implemented using standard RF circuits or UHF radio modules typically used for remote gates, domestic and commercial security applications, and that are well known to those skilled in the art. The decoder 22 for decoding the information from the Wireless Receiver Module 21 is compatible with the encoder used at the Detection Device. Both encoder and decoder can be implemented using standard encoder/decoder circuit implementations well known to those skilled in the art, such as those used in cordless telephones, security systems and other remote control systems. The information transmitter module 23 acts on the decoded message stream from the decoder and issues appropriate dialing actions to initiate user notification by SMS messaging. In one embodiment, the information transmitter module comprises a microcontroller and autodialler circuit that is interfaced to an SMS-

communication device such as a fixed-line SMS phone. The microcontroller may optionally incorporate, apart from the usual memory and input-output interfaces, a real-time clock to record the nature of the power loss (power outage or equipment power failure), and the date and time of power loss and restoration in built-in non-volatile memory, such as flash memory, and hence is able to compute the duration of power loss. This information is important to the equipment user who is able to use it to determine if corrective action is required, for example, to dispose of the refrigerator's perishable contents. The autodialler can be easily implemented to emulate the keystrokes of the SMS phone by those skilled in the art. In another embodiment of the Communication Device as shown in FIG 2C, the information transmitter module **24** has a microcontroller and a GSM card phone, wherein the microcontroller directly interfaces to a GSM card phone to initiate user notification. It is to be appreciated that the implementation of user notification can be accomplished using other standard info-communication technologies known to those skilled in the art and the specific embodiments mentioned are for purpose of illustration only.

[0043] Now referring to FIG 5, there is provided a functional block diagram of the Power Outage and Equipment Monitoring System (POEMS) in accordance with another embodiment of the present invention. The POEMS **50** comprises an AC mains voltage sensor **51**, an Electrical load current sensor **52**, a Microcontroller **53**, and an Info-communication module/circuit **54**. It is noted that the sensors and microcontroller (**51**, **52**, and **53**) are identical or similar to the corresponding components as shown in FIG 2A (11, 12, and 13). As shown in FIG 5, the info-communication module/circuit **53** directly interfaces with the Microcontroller so as to communicate directly to the user without an intermediary device. The info-communication module/circuit **53** may a GSM card phone or short range RF paging transmitter. Pertinent info-communication technologies that can be used by the Detection Device to communicate with the user are well known to those skilled in the art.

[0044] Optionally, the user notification can also be implemented via a visual display at the Detection Device and/or Communication Device using light indicators or digital display, or via audio alerts. Pertinent technologies are well known to those skilled in the art.

[0045] The system and method of the present invention has broad applications. For example, aquarium outlets require continuous operations of the water aeration and waste filtration systems for the survival of their exotic fishes; an overnight electrical equipment failure (e.g. filtration pump) may result in the death of these exotic fishes amounting to a lost of tens of thousands of dollars. Chilled meat outlets require a chiller for storage as well as for display at the point of sales; a power outage/equipment power failure would render these chillers ineffective and its content unfit for human consumption within a short span of a few hours.

[0046] While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the invention scope is not so limited. Alternative embodiments of the present invention will become apparent to those having ordinary skill in the art to which the present invention pertains. Such alternate embodiments are considered to be encompassed within the spirit and scope of the present invention. Accordingly, the scope of the present invention is described by the appended claims and is supported by the foregoing description.

CLAIMS

What is claimed is:

1. A system for detection and notification of power supply to an electrical equipment, said system comprising:
 - a power loss detection device having:
 - a means for detecting mains power outage and restoration, and outputting the detected power outage and restoration;
 - a means for detecting the power failure of the electrical equipment, and outputting the detected power failure;
 - a first microcontroller for obtaining the outputting signals from both of the detecting means, processing the obtained signals, and transmitting the processed signals;
 - an encoding means for encoding the information from the first microcontroller; and
 - a wireless transmitting means for transmitting the encoded information from the encoder; and
 - a communication device having:
 - a wireless receiving means for receiving the transmitted information from the wireless transmitting means and transmitting the received information;
 - a decoding means for decoding the encoded information from the wireless receiving means; and
 - an information transmitter means for acting on the decoded information and issuing proper notification to the user of the electrical equipment.
2. The detection and notification system of claim 1, wherein the means for detecting mains power outage and restoration comprises an electrical circuit that is able to detect the presence or absence of the mains voltage from a utility power line.
3. The detection and notification system of claim 2, wherein the electrical circuit comprises an electromagnetic relay that gives different signals for the presence of the

mains voltage when the utility power line is functioning normally or being restored after power outage or the absence of the mains voltage when the utility power line is experiencing power outage; and wherein the electromagnetic relay is electrically connected to the mains voltage at the monitoring point so as to detect the power outage and restoration at a local point.

4. The detection and notification system of claim 1, wherein the means for detecting the power failure of the electrical equipment comprises an electrical circuit that is able to sense the current load leading from a utility power line to the electrical equipment.
5. The detection and notification system of claim 4, wherein the electrical circuit comprises a LED and a light dependent resistor; and wherein when the LED is on/off, it will induce different resistances on the light dependent resistor so that the electrical circuit can output different signals indicating of whether the electrical equipment has a power failure.
6. The detection and notification system of claim 1, wherein the first microcontroller comprises a microprocessor that has enough memory for obtaining the signals from the detecting means, storing and processing the obtained signals, and transmitting the processed signals to the user.
7. The detection and notification system of claim 1, wherein the wireless receiving means may be capable of receiving the transmitted information from multiple wireless transmitting means so that the information transmitter means may notify the user of the nature of power loss and identification of the affected electrical equipment.
8. The detection and notification system of claim 1, wherein the information transmitter means comprises a microcontroller and an autodialler circuit; wherein the microcontroller receives the decoded information from the decoding means and feeds the received information to the autodialler circuit; and wherein the autodialler circuit may be interfaced to an SMS-communication device so as to give the proper notification to the user.

9. The detection and notification system of claim 1, wherein the information transmitter means comprises a microcontroller and a wireless communication means; wherein the microcontroller receives the decoded information from the decoding means; and wherein the microcontroller may directly interface to the wireless communication means to initiate user notification.
10. A system for detection and notification of power supply to an electrical equipment, said system comprising:
- a means for detecting mains power outage and restoration, and outputting the detected power outage and restoration, wherein the means is powered by a backup energy source during mains power outage so that it can be functional without main power supply;
 - a means for detecting the power failure of the electrical equipment, and outputting the detected power failure;
 - a microcontroller for obtaining the outputting signals from both of the detecting means, processing the obtained signals, and transmitting the processed signals; and
 - an Info-communication module/circuit that directly interfaces with the Microcontroller so as to communicate directly to the user.
11. A method for detection and notification of power supply to an electrical equipment, said method comprising:
- detecting of power outage and restoration at a monitoring point of a utility power supply line, wherein the detecting is powered by a backup energy source during mains power outage so that it can be performed without main power supply;
 - detecting of power failure of the electrical equipment;
 - processing the signals of power outage and equipment power failure; and
 - notifying a user of the electrical equipment of whether there is a power outage or equipment power failure.

12. The method of claim 11, wherein the step of detecting of power outage and restoration detects the presence or absence of the mains voltage from the utility power supply line.
13. The method of claim 11, wherein the step of detecting of power failure detects the current load leading from the utility power supply line to the electrical equipment.
14. The method of claim 11, wherein the step of processing the signals comprises obtaining the signals from the detecting steps, and generating proper instructions for user notification.
15. The method of claim 11, wherein the step of notification may employ wireless notification system.