(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(54) Title: AUTONOMOUS HYBRID RENEWABLE ENERGY CONTROLLER



Figure 1

(57) Abstract: An integrated hybrid renewable energy controller for on-grid or off-grid renewable power related devices is disclosed. The integrated controller autonomously monitors and controls renewable power devices, such as solar arrays, wind turbines, inverters, to efficiently charge batteries without overloading or damaging the power sources or the batteries.

FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL,
NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG,
CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

# AUTONOMOUS HYBRID RENEWABLE ENERGY CONTROLLER

## FIELD OF THE INVENTION

[0001]    The present invention relates to an integrated controller for on-grid or off-grid renewable power related devices.  More specifically, the invention relates to a device for autonomously monitoring and controlling renewable power devices, such as solar arrays, wind turbines, inverters, , to efficiently charge batteries without overloading or damaging the power sources or the batteries.

## BACKGROUND OF THE INVENTION

[0002]    The global market for renewable energy systems, such as solar / photovoltaic and wind turbine power generation systems, has grown by more than 25% per year over the last decade, and a continuation of such trend is anticipated. However, today, many of renewable power devices are not controlled or controlled through localized and application specific device, such as wind turbine controllers, solar power controllers, inverters, charge controllers, etc. Each of the devices are manually operated or controlled with very limited functionalities specific to the power device.

[0003]    When more than one renewable power devices are installed, it is often required to control the renewable power devices in real-time to make sure that they operate efficiently and productively. If the power devices are not controlled properly in time, such failure could cause the power devices to be damaged, including overcharging batteries, overloading wind turbine, etc.

[0004]    Even worse, these existing application specific controllers are often not network ready, and do not have capability for remote monitoring and controlling.

[0005] As the demand for renewable power devices increases, it is evitable that a more sophisticated and integrated real-time controller solution is necessary for mass deployment of these power devices.

## SUMMARY OF THE INVENTION

[0006] The object of the present invention is to provide, a practical and reliable solution towards the existing problems of integrating renewable energy sources together with other power sources. Another aim of the present invention is to provide more reliable, economical and functional power control systems that minimize the needs for other devices / components, and enables the users to effectively manage the variability associated with renewable energy sources such as solar panels and small wind turbines.

[0007] The object of the present invention is to provide an autonomous hybrid renewable energy controller for autonomously controlling various types of renewable power devices in real-time to improve the reliability of operations of renewable energy sources, and therefore, significantly encourage adoption of renewable energy technologies to households. This will be done by effective control topography, careful monitoring of renewable energy system components that will link directly with the control of the system.

[0008] Another object of the present is to provide an autonomous hybrid renewable energy controller that can be remotely communicated for monitoring and controlling the renewable power devices, and, thus, enables further integrations over a communication network.

[0009] Yet another object of the present invention is to provide an autonomous hybrid renewable energy controller that stabilizes power from renewable energy sources and improve efficiency of capturing and harnessing all power generation from the renewable energy sources.

[0010]    Yet further object of the present invention is to provide a single autonomous hybrid renewable energy controller that accommodates and controls various types of renewable energy sources and devices, thus eliminates the requirements of installing various controlling and monitoring devices for space and cost saving.

**BRIEF DESCRIPTION OF THE DRAWINGS**

[00010]    The invention will now be described in more detail with reference to the accompanying drawings, in which:

[0011]    Figure **1** shows an overview of an autonomous hybrid renewable energy controller of a preferred embodiment of the present invention;

[0012]    Figure **2** illustrates a functional block diagram of a load diversion controller of the preferred embodiment of the present invention;

[0013]    Figure **3** illustrates a functional block diagram of a load diversion voltage regulator of the preferred embodiment of the present invention;

[0014]    Figure **4** illustrates a functional block diagram of an AC rectifier circuit of the preferred embodiment of the present invention;

[0015]    Figure **5** illustrates a functional block diagram of a motherboard of the preferred embodiment of the present invention;

[0016]    Figure **6** shows a perspective view of a LCD/keypad of the preferred embodiment of the present invention;

[0017]    Figure **7** shows a menu structure of the preferred embodiment of the present invention;

[0018]    Figure **8** shows a menu display on the LCD of the preferred embodiment of the present invention;

[0019]     Figure **9** shows the main menu of the Graphical User Interface of the preferred embodiment of the present invention;

[0020]     Figure **10** shows the detailed screen of the Graphical User Interface of the preferred embodiment of the present invention;

[0021]     Figure **11** shows the Graphical User Interface illustrating a graph of emissions saving estimation data over time of the preferred embodiment of the present invention;

[0022]     Figure **12** shows the Graphical User Interface illustrating a graph of power measurement over time of the preferred embodiment of the present invention; and

[0023]     Figure **13** shows the process flow chart for automatic relay connect / disconnect for solar panel(s).

## DETAILED DESCRIPTION OF THE INVENTION

[0024]     **System Overview**:

[0025]     Figure **1** shows a system overview of an autonomous hybrid renewable energy controller **20** of a preferred embodiment of the present invention. The autonomous hybrid renewable energy controller **20** comprises a load diversion controller **22**, an AC rectification circuit **27**, a motherboard **21**, a sensors **24, 28a, 28b** and **28c**, and safety system with monitoring and controlling software, comprising firmware and control application software, in an enclosure. Power bus **23** aggregates and interconnects between Load Diversion Controller **22**, Battery **32** and Inverter **33**.

[0026]     The enclosure is designed for optimal cooling and ease of use. All connectors and switches are laid out in logical order and for easy access by a user.

[0027]     **Load Diversion Controller**:

[0028]    The load diversion controller **22** is designed to properly charge batteries, e.g. lead-acid batteries, and to control renewable energy devices, such as wind turbine(s) and solar array(s).  The load diversion controller **22** monitors a system voltage for controlling and routing the power from the renewable energy devices.  For example, as the system voltage approaches the optimal value, where for a 48VDC system, optimal charge voltage is 56.7V DC for lead-acid batteries, the load diversion controller **22** reduces the current going to the batteries and diverts the power to a resistive dump load.  This is important for controlling the speed and output of the wind turbine(s).  If the turbine(s) were not properly controlled, the turbine can be over-driven and exceeds its rated power output, and thus, damages itself.

[0029]    Figure **2** shows a block diagram of the load diversion controller **22**.  The load diversion controller **22** comprises a power circuit **110** for retrieving power from the batteries for making the load diversion controller **22** self-powering.  In a preferred embodiment of the present invention, the power circuit **110** of the load diversion controller **22** is able to take in a voltage from 12 to 60 VDC to provide a steady power supply of 24V DC up to 2A.  This can be achieved by using on-chip buck DC-DC converter.  This power circuit **110** may be used to supply power to the remaining active components of the autonomous hybrid renewable energy controller **20**, including the motherboard **21**.

[0030]    The load diversion controller **22** further comprises battery charger **120** for charging the batteries.  The method of charging lead-acid batteries could be three-stage (bulk, float and absorption) or two-stage (bulk and float) charging; however, in the preferred embodiment of the present invention, pulse width modulation (PWM) method of charging is used as this is the most effective method of charging lead-acid batteries.  Please note that the method of charging may be selected for the technology used for the battery of choice.  The battery charger **120** can be programmable for a number of different charging methods, or can be specific to a particular type of batteries.  The battery charger **120** may comprises more than one type of battery charging methods for supporting charging more than one type of batteries at the same time.

[0031]    In the preferred embodiment of the present invention, the load diversion controller **22** further comprises a load diversion voltage regulator **140**, which is a pulse width modulated (or PWM) switch.

[0032]    Referring to Figure **3**, a resistor divider (not shown) divides the voltage output from the renewable power source, e.g. wind turbine. A 2.5V Reference (REF) voltage (not shown) is derived from a 5V REF voltage output (not shown) of the pulse width modulated switch **112** and another resistor divider (not shown). In the preferred embodiment of the present invention, the pulse width modulated switch **112** is TI TL494, the teachings of the data sheet of Texas instruments TL494 Pulse-Width-Modulation Control Circuits SLVS074E-January 1983-Revised February 2005 are incorporated herein by reference. The two REF voltages are fed into an error amplifier (which is a portion of TL494, 1IN+, 1IN- and FEEDBACK) (not shown). This amplifier is inverting and gain-limited to 100. A combination of a resistor and a capacitor dictates the PWM frequency. In the preferred embodiment of the present invention, the prescribed values of the resistor and the capacitor yield 10 kHz, as this is the optimal frequency between 0 and 50 kHz. The duty cycle of the PWM switch output is gradually increased as the wind turbine output voltage approaches 57.6V for the 48V system (in the case of 24V system, this target voltage is 28.8V). This corresponds to the recommended absorption voltage for charging lead-acid batteries.

[0033]    The output of the PWM switch **112** is arranged in an emitter-follower configuration. When on, the PWM switch **112** drives the totem-pole driver and lights the dump load **130** (or dump LED) via a current limiting resistor or MOSFETs **116**. The driver outputs roughly about 10V to the MOSFETs **116**, which in turn switches on the dump load **130**. Diodes (not shown) are placed before the MOSFETs **116** for protecting the MOSFETs **116** from any voltage kickbacks resulting from inductance in the dump load **130** resistor. A transient voltage suppressor diode (not shown), filtering capacitor (not shown), and snubbed circuit (not shown) are also included as protection for guarding the MOSFETs **116** against voltage spikes that may arise from switching.

[0034]    The load diversion controller **22** further comprises a plurality of diodes **119** for preventing backflow from the battery to the renewable energy source(s), e.g. wind turbine(s) for protection.

[0035]    The load diversion controller **22** yet further comprises a power circuit **110** for supplying sufficient and stable power to the remaining portion of the load diversion controller **22**. In the preferred embodiment of the present invention, the power circuit **110** portion of the load diversion voltage controller **22** comprises a high-voltage adjustable regulator (e.g. TI TL783) and a power converter, i.e. National Semiconductor's LM 2592 HVADJ, the teachings of the data sheet of the LM 2529 HVADJ, namely the data sheet entitled "LM2592HV SIMPLE SWITCHER power Converter 150 kHz 2A Step-Down Voltage Regulator," August 2001 is incorporated herein by reference. The TL783 in conjunction with programmable resistors R20 and R21, generates a fixed voltage of 12V, which powers the load diversion controller **22**.

[0036]    The load diversion controller **22** further comprises a temperature sensor (not shown) for monitoring ambient temperature around the batteries, and provides a temperature compensation for charging the batteries more effectively according to the measured temperature. A voltage detection circuit change the voltage divider to provide the correct voltage feedback for the PWM chip to allow an increase or decrease in charging voltage. The temperature compensation is done through the microcontroller and a digital potentiometer.

[0037]    In the preferred embodiment of the present invention, the temperature compensation for lead-acid batteries is 3mV increase per cell per degree Celsius decrease, and 3mV decrease per cell per degree Celsius increase.

[0038]    The voltage detection circuit is not limited to lead-acid temperature compensation, for example it could be adjusted for Gel cell, Ni-MH, etc.

[0039]    **AC Rectifier Circuit**:

[0040]    The AC rectifier circuit **27** takes three phase unregulated power from a wind turbine up to 1500 watts, and converts the power to an unregulated DC voltage.

Figure 4 shows the AC rectifier circuit 27, comprising diodes 202a and 204a, 202b and 204b, and 202c and 204c for receiving three phases. Due to the high power, the physical packaging of this AC rectifier circuit 27 must consider adequate cooling of these diodes for preventing any failure / damage. In the preferred embodiment of the present invention, the AC rectifier circuit 27 further comprises a large black anodized aluminum heat sink.

[0041]    **Motherboard**:

[0042]    Referring to Figure 5, the motherboard 21 comprises a microprocessor 502 in communication with digital conditioning circuit 504, LCD driver 510, analog multiplexer 512 for receiving a plurality of sensor inputs, serial communication port 514, TCP/IP port 516, audible alarm driver 518 and data storage device 520 (e.g. RAM, flash memory, etc). The motherboard 21 acquires measurements from the sensors 24, 28a, 28b and 28c for monitoring via the plurality of the sensor inputs, logs measured data, and controls the renewable energy sources / devices.

[0043]    **Microprocessor**:

[0044]    The microprocessor 502 performs a plurality of tasks simultaneously and efficiently, while consuming little power and physically a small space in the motherboard 21. The microprocessor 502 also comprises a plurality of analog input ports for receiving the plurality of the sensor inputs and digital input/output port(s). In the preferred embodiment of the present invention, the analog input ports further comprises at least one analog to digital converter for digitizing the sensor data. The Input / Output signals from the microprocessor are driven at 3.3VDC for energy efficiency.

[0045]    **Digital Conditioning Circuit**:

[0046]    The digital conditioning circuit 504 is for ensuring that logic high is 5VDC and logic low is 0V for maintaining the signal integrity by preventing noise and floating value.

[0047]    **Relays**:

[0048]    The microprocessor **502** drives the relay driver **506** to actuate and to control relays **508**. The control relays includes two relays, the first relay **118** (in Figure **3**) for controlling the power from the solar array(s), and the second relay is for connecting/disconnecting an inverter. The second relay for connecting / disconnecting the inverter may be optional.

[0049]    The microprocessor **502** monitors the condition of the battery, and when the batteries are fully charged, the microprocessor **502** re-routes the power to the dump load **130** resistor to dump the power via **118** in Figure **3**, and actuate the relay to disconnect the solar array(s) to ensure that the batteries are not over-charged. In the preferred embodiment of the present invention, the first relay is rated at 40A or so.

[0050]    Figure **13** illustrates the process flow chart for the first relay operation process of the preferred embodiment of the present invention. The autonomous hybrid renewable energy controller **20** monitors the solar array(s) at step **902** and wind turbine(s) at step **904**. If the solar array(s) is connected from step **908** through **910** to **912**, the controller **20** measures the voltage at the batteries and determines whether the voltage is greater than 95% of its capacity at step **912**. If so **(914)**, if further measures the current flowing from the wind turbine(s) and determine if the current is greater than 0mA. If so, the batteries are full, thus disconnect the solar array(s) by actuating the first control relay at **916**.

[0051]    If the solar array(s) is not connected **(909)**, then the controller **20** monitors the battery voltage is smaller than, say, 92% of the capacity or there is no current flowing in from the wind turbine(s) (step **911**). If so **(913)**, then the controller reconnects the solar array(s) at step **917**.

[0052]    The second relay is used for connecting/disconnecting the inverter before the voltage drops below the minimum operational voltage. If the voltage drops below the minimum operational voltage, some inverters shut themselves off by themselves, but when it happens, the inverter would not be able to re-engage when the voltage

comes up above the minimum operational voltage. Thus, the second relay is for shutting off the inverter before the voltage drops the minimum operational voltage and re-engage the inverter when the voltage is sufficiently high for stable operation. Please note that the shutdown threshold and re-engage threshold should have sufficient gap to prevent imminent relay operations. In the preferred embodiment of the present invention, the second relay should be rated pursuant to the specification of the inverter.

[0053]     **LCD Driver**:

[0054]     Referring to Figure **5**, the LCD driver is for interfacing with LCD and keypad 530 (shown in Figures **5** and **6**) for displaying information on the LCD to allow a user to view the information and to receive inputs from the user via the keypad. The LCD driver **510** uses buffers for the signal to be transmitted to the LCD.

[0055]     In the preferred embodiment of the present invention, the LCD and keypad **530** is a combined preassembled unit that has a LCD display and keypad as illustrated in Figure **6**. However, it is to be noted that the LCD driver **510** may be other type of a standard input output driver that may handle different type of display and/or keypad/keyboard.

[0056]     **Analog Multiplexer**:

[0057]     In the preferred embodiment of the present invention, the analog multiplexer **512** is Analog Devices ADG408 8-bit multiplexer, which switches one of eight inputs to a common output as determined by the 3-bit binary address lines A0, A1 and A2. This allows conserving the use of lines on the microprocessor for other tasks and adding eight analog inputs. In the preferred embodiment of the present invention, analog input range is 0 to 10V, which is selected in sequence using the 3-bit binary address lines. The analog multiplexer **512** has low power consumption, high switching speed, and a low on resistance.

[0058]     **Serial Port**:

[0059]     The motherboard **21** comprises the serial port **514** to allow communications to a computing device, such as a computer. In the preferred embodiment of the present invention, the serial port **514** is RS-232.

[0060]     **Network Port**:

[0061]     The motherboard **21** further comprises a TCP/IP port **516** for network connectivity. This allows the autonomous hybrid renewable energy controller **20** to be connected to any intranet or Internet, remotely display information and enter inputs to the autonomous hybrid renewable energy controller **20** for controlling the renewable energy devices. This also enables a user to display information in a graphical user interface (GUI) on any computer on the network.

[0062]     **Audible Alarm**:

[0063]     The audible alarm is a useful feature for alarming any unusual condition(s) at the autonomous hybrid renewable energy controller, while alarm signal may be transmitted to the LCD/keypad and/or to the remotely connected computer(s) via the network.

[0064]     **Data Storage Device**:

[0065]     In the preferred embodiment of the present invention, the data storage device **520** comprises a total memory of at least 2MB, which allows up to 1 year of data storage. Preferably, the data storage device **520** is connected with the microprocessor **502** via Serial Protocol Interface (or SPI), which allows a number of other devices to be connected on the one interface, using only a few data lines. Up to 16MB of the data storage device can be added for future expansion.

[0066]     In the preferred embodiment of the present invention, the data storage device is ATMEL's AT45DB161D, which is a 2.5-volt or 2.7-volt, serial-interface sequential access Flash memory ideally suited for data-storage. The AT45DB161D supports RapidS serial interface for applications requiring very high speed operations. RapidS serial interface is SPI compatible for frequencies up to 66 MHz. Its

17,301,504 bits of memory are organized as 4,096 pages of 512 bytes or 528 bytes each. In addition to the main memory, the AT45DB161D also contains two SRAM buffers of 512/528 bytes each. The buffers allow the receiving of data while a page in the main Memory is being reprogrammed, as well as writing a continuous data stream. Unlike conventional Flash memories that are accessed randomly with multiple address lines and a parallel interface, the DataFlash uses a RapidS serial interface sequentially to access its data. The simple sequential access dramatically reduces active pin count, facilitates hardware layout, increases system reliability, minimizes switching noise, and reduces package size. This device has low-pin count, low-voltage and low-power consumption.

[0067]    **Sensors**:

[0068]    The sensors comprise a plurality of current sensors and voltage sensors **24, 28a, 28b** and **28c** as shown in Figure **1**, monitoring renewable power sources and devices.

[0069]    In the preferred embodiment of the present invention, the current sensors are ACS754-100-CBs from Allegro.

[0070]    Each of the current sensors comprises a precision, low-offset linear Hall sensor circuit with a copper conduction path located near the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. The accuracy of the current sensor is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper stabilized BiCMOS Hall IC, which is programmed for accuracy at the factory.

[0071]    The output of the device has a positive slope (>VCC / 2) when an increasing current flows through the primary copper conduction path, which is the path used for current sensing. The internal resistance of this conductive path is typically 100 $\mu\Omega$, providing low power loss. The thickness of the copper conductor

allows survival of the device at up to 5°— over current conditions. The terminals of the conductive path are electrically isolated from the sensor. This allows the current sensor to be used in applications requiring electrical isolation without the use of opto-isolators or other costly isolation techniques.

[0072]    The current sensor is fully calibrated prior to shipment from the factory. To increase the accuracy, the current sensors are further calibrated to detect any offset from the zero mark and compensate by an appropriate multiplier.

[0073]    The voltage sensors are voltage attenuators achieved by using 1% resistor in voltage dividers to ensure the analog voltage does not exceed 10V. This analog input can only read a maximum of 10V.

[0074]    **Safety System**:

[0075]    Safety in a renewable system is paramount for both testing and future use. The safety system comprises a plurality of breakers (not shown) for over current and short circuit protections. The safety system further comprises a breaker on the battery/inverter. In the preferred embodiment of the present invention, the breaker is rated for 125A at 60VDC, and 40A at 48VDC for the solar array(s). The safety system yet further comprises a plurality of diodes for the solar array(s) to prevent back flow of current from the battery to the solar panels. These diodes may be included in or integrated with the sensor pack.

[0076]    The safety system yet further comprises an electrical brake for each wind turbine for stopping the wind turbine in moderate to light wind conditions for a maintenance purpose. In the preferred embodiment of the present invention, this brake is implemented by shorting all three phases of the wind turbine to cause electrical resistance, and thus effectively stopping the wind turbine.

[0077]    **Software**:

[0078]    The software comprises firmware or device drivers for driving hardware components, and Graphical User Interface for displaying information on a remote computer via a network.

[0079]    Figure 7 shows a menu structure of the preferred embodiment of the present invention. The main menu **600** may be display on the LCD as illustrated in Figure **8**, wherein the menu comprises 1). Power Display, 2). Battery Voltage, 3). Savings Menu,4). Setup and 5). About. For example, choosing 3). Savings Menu by the keypad causes a submenu for Saving Menu **602** to be displayed on the LCD, listing 1) Cost Savings, 2) Emission Savings, 3) Power Production, and 4) Return to Main Menu. Choosing 1) Cost Savings will cause the motherboard to extract the data stored in the data storage device and estimate the cost savings over the time based on the power production data measured over the time.

[0080]    On the other hand, choosing 4). Setup Menu from the Main Menu 600 causes a submenu Setup Menu 604 to be displayed. The submenu, Setup Menu **604** further leads to Component Setup **606** submenu, IP Address Setup **608** submenu, and Maximum Value **610** submenu.

[0081]    **Graphical User Interface**:

[0082]    In the preferred embodiment of the present invention, the software further comprises a server (not shown) for communication with a client software on a remote computer. The server can be any server software using a suitable communication protocol. The server may be a proprietary software or may be a web server.

[0083]    Figure 9 shows the main menu of the Graphical User Interface of the preferred embodiment of the present invention. When the user accesses from a remote computer via a communication network to the autonomous hybrid renewable energy controller **20**, and after the certain authentication process, the main screen **650** appears on the remote computer as shown in Figure **9**, displaying Battery Bank **652** for displaying the amount of power being charged, Inverter input **654**, Input 3 **656**(e.g. solar array if connected), and Input 4 **658** (e.g wind turbine if connected).

The remote user may select to view Full system display or detailed view on selected one of the renewable power devices.

[0084]    Figure **10** shows the detailed screen of the Graphical User Interface **700** of the preferred embodiment of the present invention, when the remote user selected Battery Bank. The detailed screen for Battery Bank shows Power **702**, Current (charging) **704** and System Voltage **706** of the autonomous hybrid renewable energy controller **20**.

[0085]    Figure **11** shows the Graphical User Interface **750** illustrating a graph of emissions saving estimation data over time of the preferred embodiment of the present invention. This screen **750** appears when the remote user selects Data Graphs **752**, and further specifies Emission Savings as the variable for the Graphical Unser Interface screen.

[0086]    Figure **12** shows the Graphical User Interface **800** illustrating a graph **802** of power measurement over time of the preferred embodiment of the present invention. In this example, it shows the power generation by the Wind Turbine connected to the autonomous hybrid renewable energy controller.

[0087]    **Method of Estimating Cost Saving:**

[0088]    By providing an average cost per kWH value to the controller, cost saving by renewable power sources can be calculated by the controller or at a remote computer, by measuring and calculating the power production by the renewable power sources (in real-time or based on logged data).

[0089]    **Method of Estimating Emission Saving:**

[0090]    In a similar manner to the estimation of cost saving, by having average green gas emission amount per kWH value, estimating emission savings can be calculated by the controller or at a remote computer, based on power production by the renewable power sources based on real-time measurement data or measurement data that has been logged at the controller or at the remote computer.

[0091]    Since such controllers are connected to a network, measurement data in
relation with estimating cost savings and emission savings can retrieved by a remote
computer from a plurality of the controllers.  By knowing the geographical locations
of the controllers, such measurements can be done for a particular region(s) to
calculate the regional cost and emission savings.

[0092]    It is to be understood that the embodiments and variations shown and
described herein are merely illustrations of the principles of this invention and that
various modifications may be implemented by those skilled in the art without
departing from the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. An autonomous hybrid renewable energy controller, comprising

   - a controllable battery charger in communication with a port for receiving
   power from a renewable power source and in communication with a port
   for charging a rechargeable battery, having a plurality of modes for
   charging the rechargeable battery;

   - a power bus aggregating and interconnecting the load diversion controller
   and a port for connecting to a rechargeable battery;

   - a battery sensor for monitoring the port to the battery;

   - a renewable energy sensor for monitoring the port for connecting with
   the renewable energy source; and

   - a processor being in communication with the controllable battery charger
   and receiving data from the battery sensor and the renewable energy
   source sensor to determine and to control the controllable battery charger
   in an optimal mode for charging the battery.

2. The autonomous hybrid renewable energy controller as recited in claim 1
   further comprises a temperature sensor in communication with the processor
   for compensating temperature to determine the optimal mode of charging
   battery.

3. The autonomous hybrid renewable energy controller as recited in claim 1
   further comprises a network communication port for remotely communicating
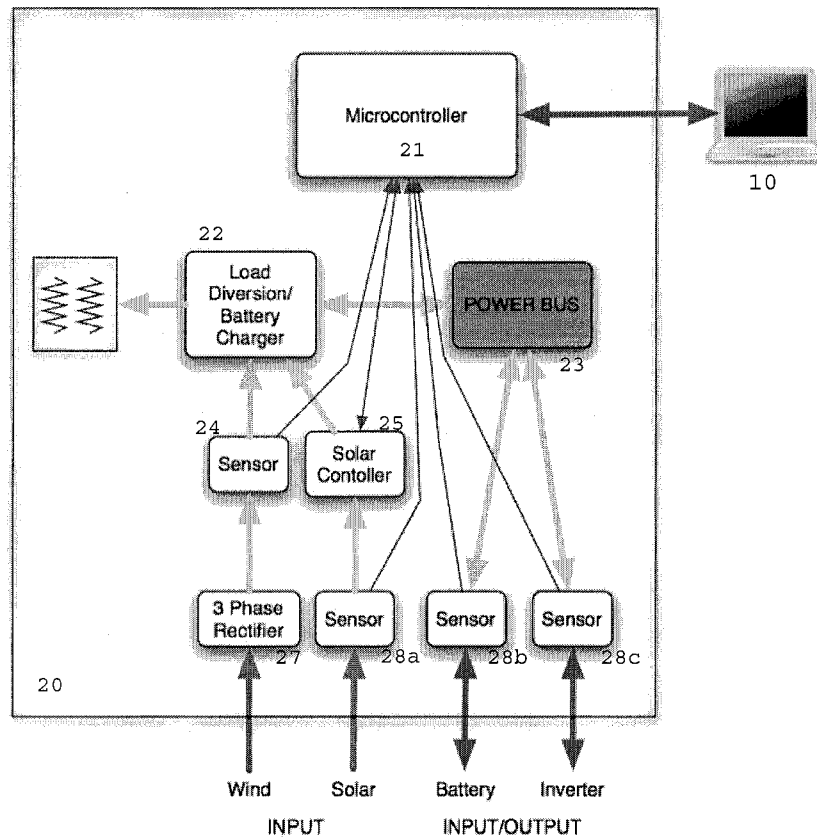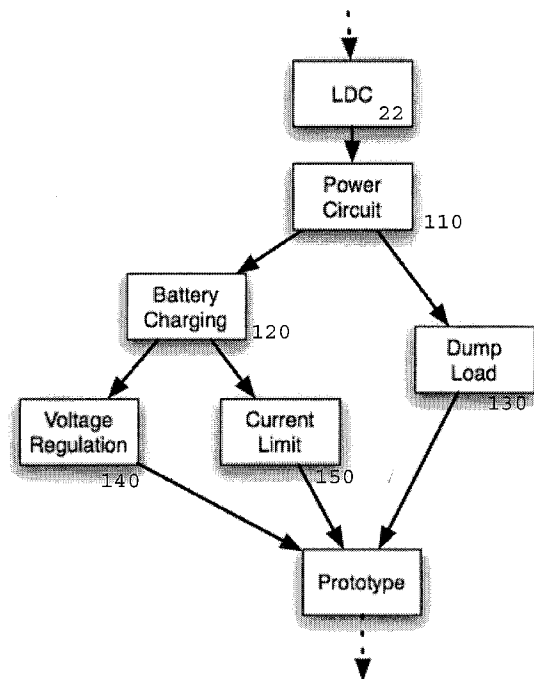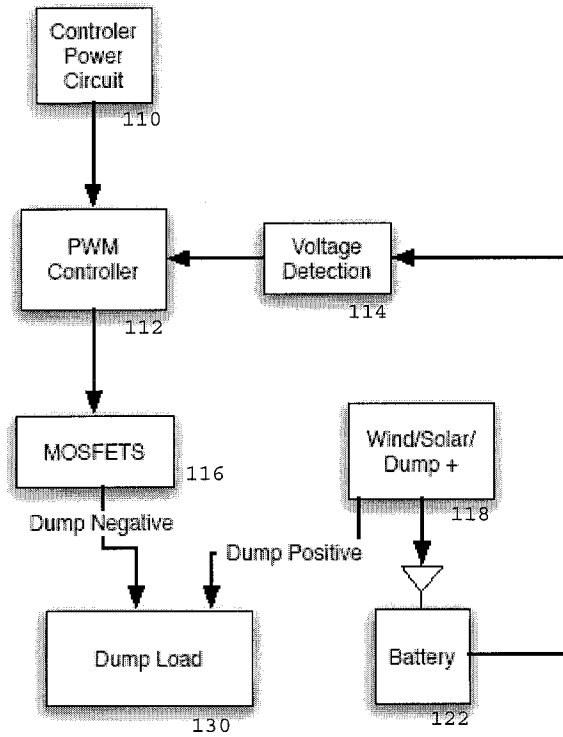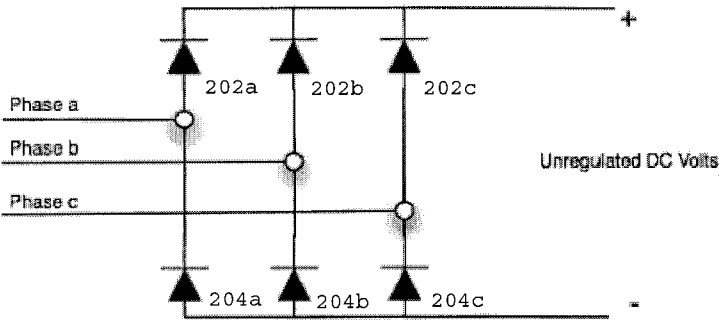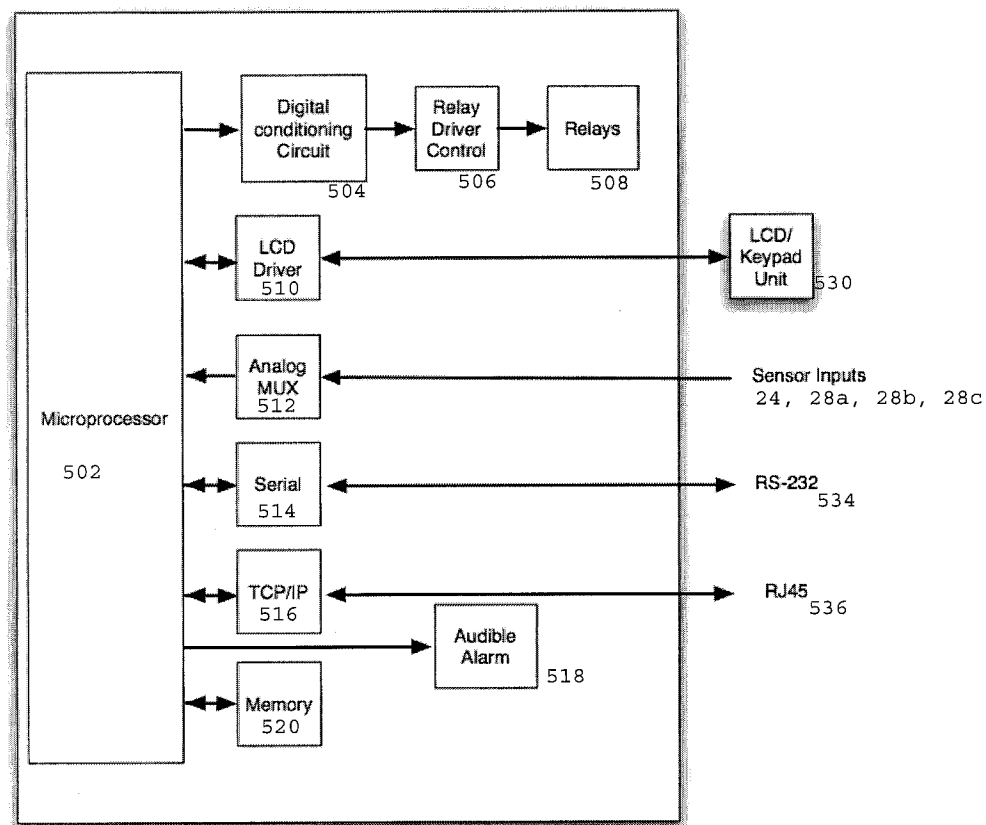   with the processor.

**Figure 1**

Figure 2

**Figure 3**

**Figure 4**

Figure 5

Figure 6



530
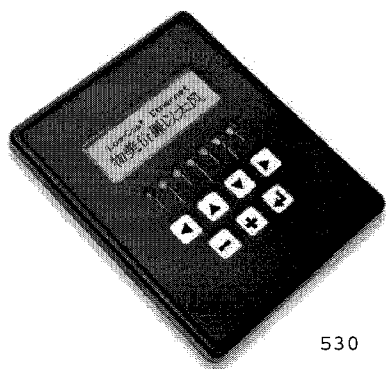
**Figure 7**



ARCS 250 Menu Structure

**Main Menu**
1) 1) Power Display
2) 2) Battery Voltage
3) 3) Savings Menu
4) 4) Setup Menu
5) 5) About...    600

**Savings Menu**
4a) 1) Cost Savings
4b) 2) Emission Savings
4c) 3) Power Production
4d) 4) Return to Main    602

**Setup Menu**
5a) 1) Component Setup
5b) 2) IP Address
5c) 3) Set Date / Time
5d) 4) Set KWH Cost
5e) 5) Firmware Update
5f) 6) Return to Main    604

**Component Setup**
i) 1) DC Input 1
i) 2) DC Input 2
i) 3) DC Input 3
ii) 4) Maximum Values
iii) 5) AC Grid Power
iv) 6) AC Calibration
v) 7) Previous Menu    606

**Maximum Values**
ii-1) 1) DC Voltage Max
ii-2) 2) DC Voltage Min
ii-2) 3) DC Input 1 Power
ii-2) 4) DC Input 2 Power
ii-2) 5) DC Input 3 Power
ii-3) 6) Battery Power
ii-4) 7) AC Current
ii-5) 8) Previous Menu    610

**IP Address Setup**
i) 1) View IP Address
ii) 2) Manual IP Select
iii) 3) Previous Menu    608
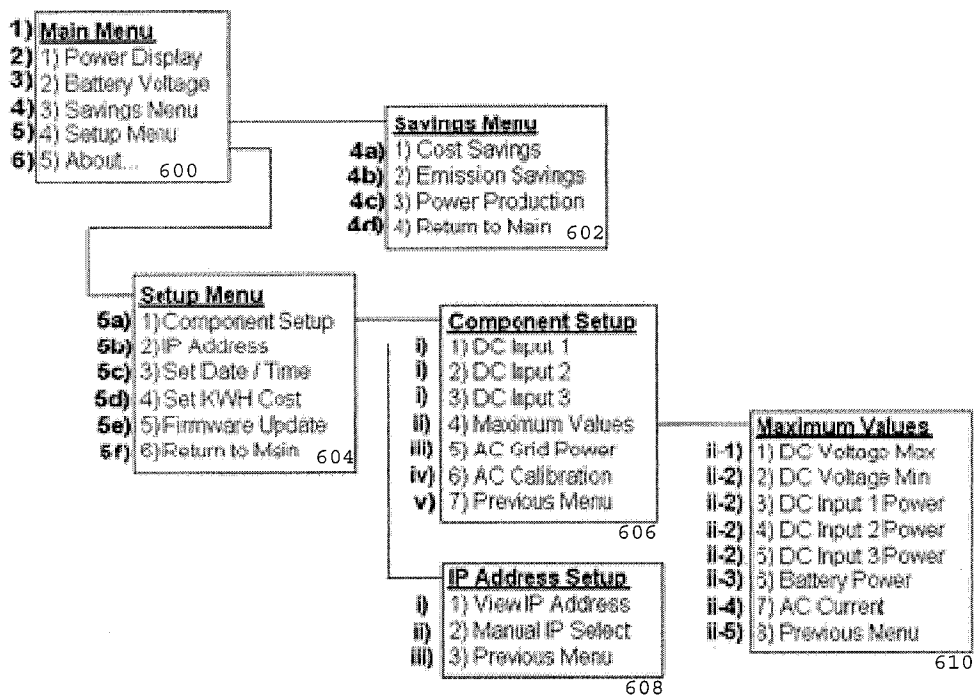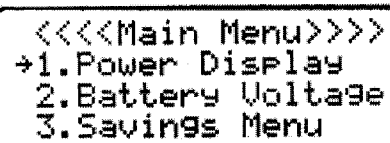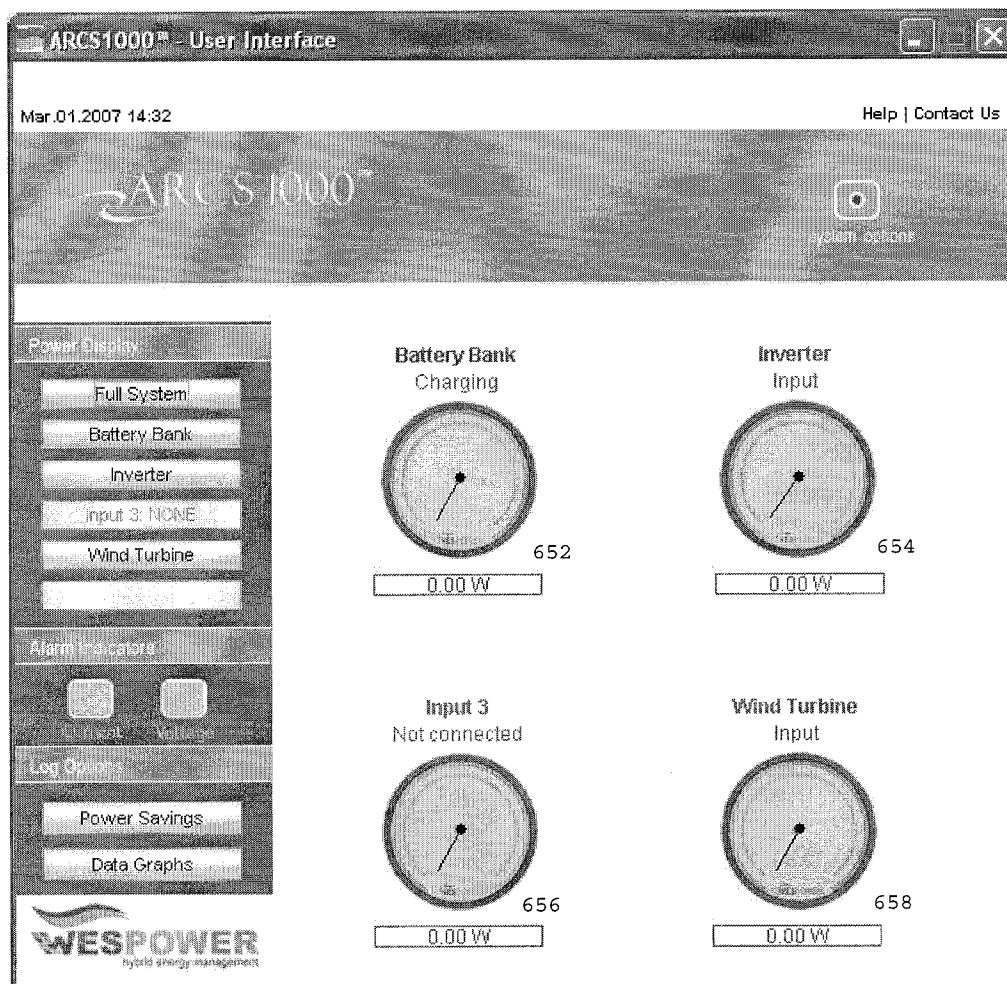
Figure 8

```
<<<<Main Menu>>>>
→1.Power Display
  2.Battery Voltage
  3.Savings Menu
```

600

**Figure 9**

Figure 10

Figure 11
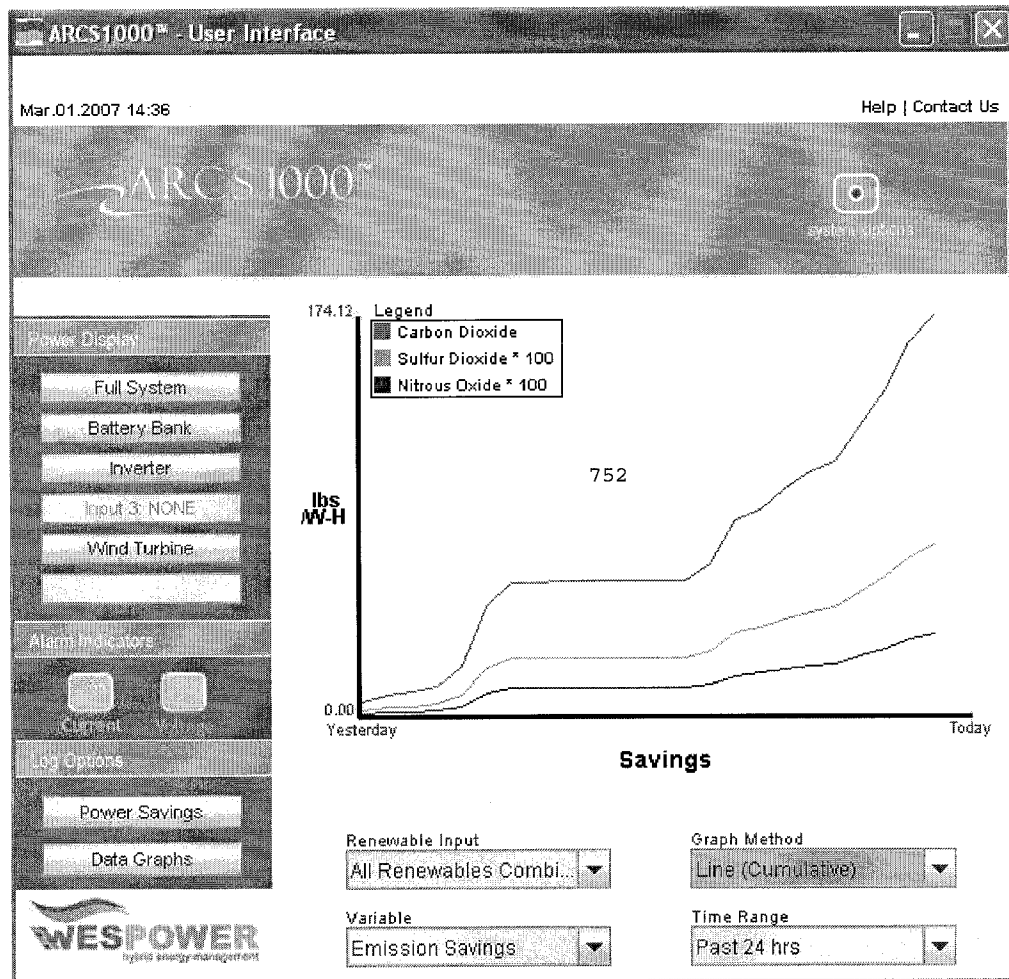
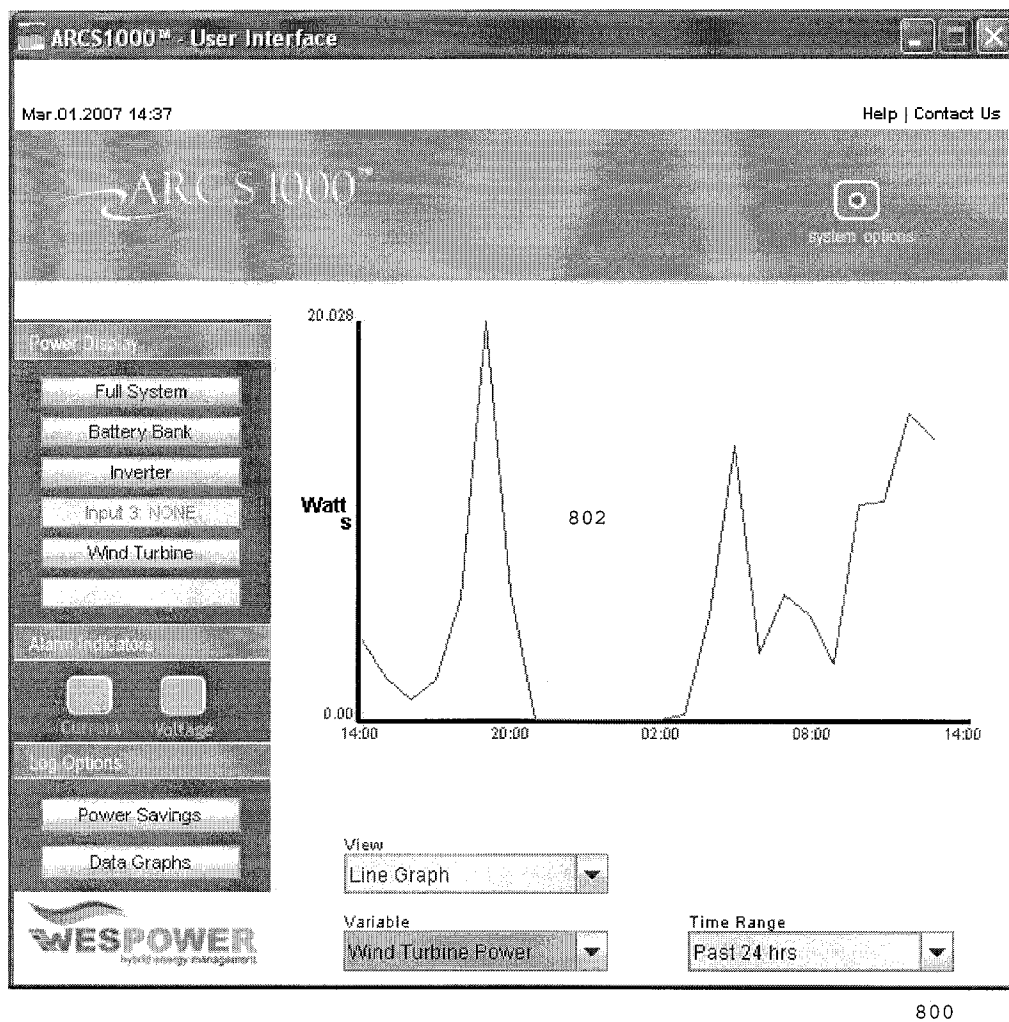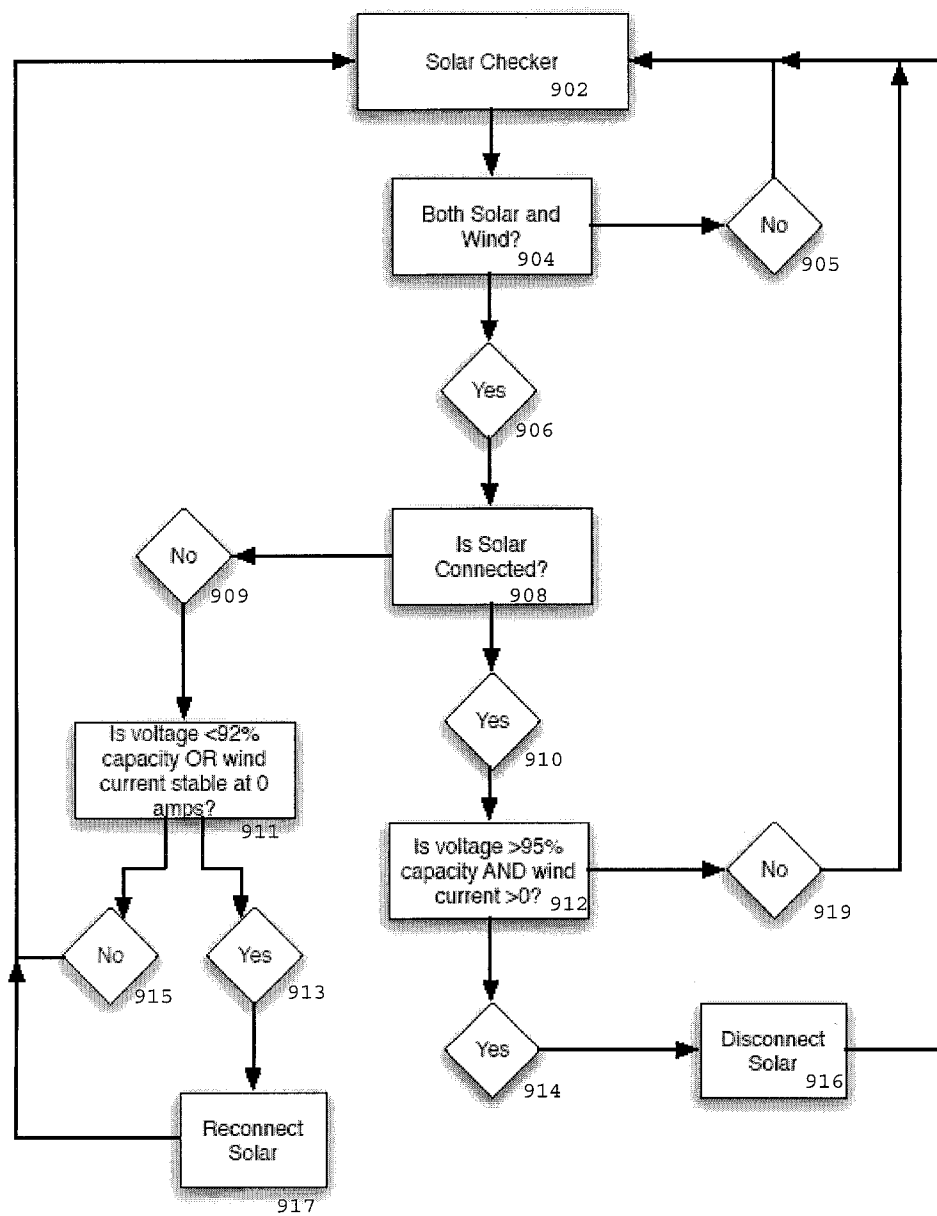**Figure 12**



800

Figure 13

| | |
|---|---|
| A. | CLASSIFICATION OF SUBJECT MATTER |
| | IPC: *H02J 7/00* (2006.01) , *H01M 10/44* (2006.01) |
| | According to International Patent Classification (IPC) or to both national classification and IPC |

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
  *H02J 7* (2006.01) , *H01M* (2006.01), *H02J 7* (2006.01), *H02J 9* (2006.01), *H01H 47* (2006.01)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database(s) consulted during the international search (name of database(s) and, where practicable, search terms used)
Databases searched: Canadian Patent Database, Delphion, European Patent Database, Abstracts of Japan, US Patent Database, WIPO-PCT Publications (Full text) and IEEE publications.

Keywords: Battery charger, rechargeable battery, controller, sensor or battery sensor, processor, power , renewable energy, monitor*, temperature sensor, communication or network communication, power bus, power source, multi-mode or multimode or multi-source.

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 5,767,659 (Farley), 16 June 1998,<br>-see abstract;<br>-see figs. 3 & 9;<br>-see whole document | 1 - 3 |
| A | US 7,106,027 (Sakakibara), 12 September 2006,<br>-see abstract;<br>-see fig. 1;<br>-see whole document. | 1 - 3 |
| A | US 6,459,175 (Potega), 01 October 2002,<br>-see abstract;<br>-see figs 5, 5b & 10;<br>-see whole document. | 1 - 3 |

| [ ] Further documents are listed in the continuation of Box C. | [X] See patent family annex. |
|---|---|

| * | Special categories of cited documents : | "T" | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
|---|---|---|---|
| "A" | document defining the general state of the art which is not considered to be of particular relevance | | |
| "E" | earlier application or patent but published on or after the international filing date | "X" | document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone |
| "L" | document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) | "Y" | document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art |
| "O" | document referring to an oral disclosure, use, exhibition or other means | | |
| "P" | document published prior to the international filing date but later than the priority date claimed | "&" | document member of the same patent family |

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 09 January 2009 (09-01-2009) | 23 January 2009 (23-01-2009) |

| Name and mailing address of the ISA/CA | Authorized officer |
|---|---|
| Canadian Intellectual Property Office<br>Place du Portage I, C114 - 1st Floor, Box PCT<br>50 Victoria Street<br>Gatineau, Quebec K1A 0C9<br>Facsimile No.: 001-819-953-2476 | Rajiv Agarwal<br>819- 997-2304 |

| Patent Document Cited in Search Report | Publication Date | Patent Family Member(s) | Publication Date |
|---|---|---|---|
| US 5,767,659 | 16-06-1998 | AT179034T | 15-04-1999 |
| | | DE69228918D1 | 20-05-1999 |
| | | DE69228918T2 | 30-09-1999 |
| | | EP0539640A1 | 05-05-1993 |
| | | EP0545747A1 | 09-06-1993 |
| | | EP0545747B1 | 14-04-1999 |
| | | EP0546872A1 | 16-06-1993 |
| | | JP3329858B2 | 30-09-2002 |
| | | JP6205541A | 22-07-1994 |
| US 7,106,027 | 12-09-2006 | CN1510814A | 07-07-2004 |
| | | CN100338842C | 19-09-2007 |
| | | EP1434328A2 | 30-06-2004 |
| | | EP1434328A3 | 18-05-2005 |
| | | JP3936286B2 | 27-06-2007 |
| | | JP2004208349A | 22-07-2004 |
| | | US2004135553A1 | 15-07-2004 |
| US 6,459,175 | 01-10-2002 | AU1699499A | 07-06-1999 |
| | | AU2397700A | 31-07-2000 |
| | | AU5782399A | 14-03-2000 |
| | | AU8374698A | 19-01-1999 |
| | | CA2317560A1 | 27-05-1999 |
| | | CA2355909A1 | 06-07-2000 |
| | | CA2383202A1 | 02-03-2000 |
| | | EP1023580A2 | 02-08-2000 |
| | | EP1023580A4 | 09-08-2000 |
| | | EP1032964A2 | 06-09-2000 |
| | | EP1105948A1 | 13-06-2001 |
| | | EP1147591A1 | 24-10-2001 |
| | | IL136235D0 | 20-05-2001 |
| | | IL141612D0 | 10-03-2002 |
| | | IL144071D0 | 21-04-2002 |
| | | US6152597A | 28-11-2000 |
| | | US6634896B1 | 21-10-2003 |
| | | US6866527B2 | 15-03-2005 |
| | | US6945803B2 | 20-09-2005 |
| | | US6981895B2 | 03-01-2006 |
| | | US7002265B2 | 21-02-2006 |
| | | US7039821B1 | 02-05-2006 |
| | | US7058484B1 | 06-06-2006 |
| | | US7059769B1 | 13-06-2006 |
| | | US7127623B2 | 24-10-2006 |
| | | US2003085621A1 | 08-05-2003 |
| | | US2003186592A1 | 02-10-2003 |
| | | US2003207603A1 | 06-11-2003 |
| | | US2004009702A1 | 15-01-2004 |
| | | US2006005055A1 | 05-01-2006 |
| | | WO0011763A1 | 02-03-2000 |
| | | WO0039907A1 | 06-07-2000 |
| | | WO9900004A2 | 07-01-1999 |