Research on integrated power generation control system based on wind, rainwater and energy store battery

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Abstract: The exploitation and utilization of new energy is the current trend of the energy industry. By analyzing the characteristics of wind energy, rainwater energy, graphene and energy store battery, an overall scheme of wind, rainwater and energy store integrated power generation system for urban buildings is designed, so is its control system. The design of control system includes hardware design and software design. By this control system, it achieves the goal of charge control and discharge control. This system takes the microcontroller as the data acquisition and controller, the data which has processed is displayed in the screen, by this SX1278 wireless communication module, and the data is transmitted to the computer.

1. Introduction
With the energy crisis caused by the intense consumption of fossil energy in the world and the fashionable of the low-carbon economy, it is extremely urgent to find alternative energy sources and develop clean energy. At present, the energy supply and demand gap is constantly increasing in China, making its external dependence increasingly higher, which has become a factor that threatens national security [1]. Under the current increasingly severe pressure on energy conservation and emission reduction, accelerating the development of renewable energy has become a top priority in China [2]. At the same time, water pollution is serious, resulting in significant degradation of water ecology, water quality is generally deteriorating, various sudden water pollution incidents occur frequently, and water shortages are becoming increasingly prominent.
At present, the single power generation mode of wind energy or rain energy has been extensively researched and developed. However, wind or rain power generation is greatly affected by the environment, and it is extremely unstable compared to the traditional power generation method. The top of the city building has rich wind resources; furthermore the top of the building can collect a lot of...
rainwater for hydropower generation. Graphene has a unique property as a new type of nanomaterial that graphene can generate electricity when it interacts with rainwater. In view of the shortcomings of the single power generation mode, this paper proposes an efficient integrated power generation system based on wind, rainwater and energy store battery, which suitable for urban buildings by the research of wind power generation technology, hydropower generation technology, energy storage technology and graphene power generation technology. Due to the difference in power generation modes, it is necessary to design an effective control system to realize the comprehensive operation, energy storage and grid connection of the integrated power generation system [3]. In this paper, by the research of the integrated power generation system, a control system based on single-chip microcomputer is proposed to ensure the normal operation of the integrated power generation system.

2. The integrated power generation system based on wind, rainwater and energy store battery

At present, wind power generation technology is relatively mature, while rainwater power generation is mostly a method of hydroelectric power generation after rainwater is collected. Rainwater has a certain kinetic energy when it falls from a high altitude. In order to make full use of wind energy and rain energy, wind power generation is mainly used, and a rainwater collecting tank is arranged on the wind turbine blade to constitute a wind turbine blade of the wind-rain linkage generator, thereby generating electricity. It has been found that rainwater can generate electricity when it flows through the surface of graphene film or through the three-dimensional structure prepared by graphene oxide [4-6].

By the in-depth research of wind power, rain energy, and graphene respective power generation technologies and energy storage technologies, a integrated power generation system which consists of wind energy, rainwater energy and energy storage fits for urban buildings are proposed. The working principle diagram of the integrated power generation system is shown in Figure 1.
The working principle of this power generation system:

1) Small wind turbines are placed on the top of urban buildings. They can take advantage of the abundant wind energy at the top of the buildings to generate wind power in rainless and windy weather.

2) In the rainy weather, the huge roof at the top of the city building can collect a large amount of rainwater, collect and filter the rainwater, then use the tubular hydroelectric generator arranged in the drainage pipeline to generate hydropower.

3) The rainwater collecting trough is covered on one side of the wind turbine blade, and the other side is still smooth, which constitutes the wind turbine blade of the wind-rain linkage generator. In the weather of wind and rain, the wind turbine blades of the wind-rain linkage generator can collect the flushing rainwater on one side, and apply the potential energy and kinetic energy of the rainwater to the wind turbine blades, so that the wind turbine blades rotate and convert into the mechanical energy of the wind turbine blades. The adjustment mechanism is adjusted so that the rotation direction of the wind turbine blade is the same as the rotation direction when the wind force acts alone. In this way, the kinetic energy and potential energy of the wind energy and the rain energy are converted into the mechanical energy of the wind turbine blade, and then converted into electrical energy.

4) The use of graphene materials with rainwater to generate electrical energy can be used for secondary power generation. A graphene film is plated on the smooth surface of the wind turbine blade of the wind-rain linkage generator to generate electrical energy. A sandwich layer structure that containing graphene oxide sheets is arranged in the drainage pipe for the urban buildings rainwater, the purified rainwater flows through the sandwich layer structure then generate electrical energy.

5) The converted electrical energy is processed and stored in a battery. It can convert into chemical energy. The battery can be connected to an electrical device or connected to a step-up and grid-connected circuit. Convert chemical energy into electrical energy according to electricity demand, directly use or connect to the grid by the DC/AC converter [7].

The rainwater flowing out of the sandwich layer structure enters the hydroelectric generator, at last the rainwater enters the reservoir after power generation, which can meet the needs of urban non-potable water, such as greening, air dust removal or car washing. The innovation of this power generation system is that it not only utilizes natural wind and rainwater to generate electricity, but also reduces the sulfur cycle to protect the environment, and solves the water shortage problem to some extent.

Wind power generation, hydropower generation and graphene power generation are the main sources of this electricity, converting wind and rain energy into electrical energy. The controller mainly regulates the charging control of the battery by the power generating device. The computer collects and monitors the information, and detects the running state of each unit to switch the switch and control the field device. When the input power is detected to meet the requirements of the powered device, it can be directly used by the powered device or stored in the battery. The inverter mainly provides a stable and reliable working voltage for the AC load. The surplus power can be stepped-up and connected to the grid where power is needed to create social value. When the power generated by the power generation group is insufficient, the power is supplied by the battery to satisfy the normal
use of the power device. The integrated power generation system framework diagram is shown in Figure 2.

![Figure 2. Frames of integrated power generation system based on wind, rainwater and energy store battery.](image)

1-Wind Power Current; 2-Hydroelectric current; 3-Rainwater-graphene generation current; 4-Control charging current; 5-Rainwater-graphene charging current; 6-Battery voltage; 7-Battery output voltage; 8-Inverter output voltage;

3. The design of control system
   
   In the integrated power generation system based on wind, rainwater and energy store battery, the core is the control system, and the normal operation process of the power generation system requires the control system to adjust. The main functions realized by the control system are charge or discharge control of the battery and the control of the wind power generation unit, the hydropower unit, and the rainwater-graphene power generation group.

   3.1 The design of hardware in control system
   
   The MCU has rich instructions, flexible software programming, good accuracy and real-time performance, small control system, low power consumption, and easy data acquisition and control functions which by the use of the expansion of peripheral circuits [8]. The control system uses a single-chip microcomputer as a control chip, and realizes charging control and discharge control of the system by combining software programming methods. Considering the characteristics of the power supply object, the AVR microcontroller mega16 is selected as the control core of the system. The core of AVR has a rich instruction set and 32 general purpose working registers. All registers are directly connected to the arithmetic logic unit (ALU), allowing one instruction to simultaneously access two independent registers in one clock cycle. This architecture greatly increases the efficiency of code and has up to 10 times the data throughput rate of a typical CISC microcontroller. The ATmega16 is a low power 8-bit CMOS microcontroller based on an enhanced AVR RISC architecture. Thanks to its advanced instruction set and single clock cycle instruction execution time, ATmega16's data throughput is as high as 1 MIPS/MHz, which can alleviate the contradiction between power consumption and processing speed. The pins of the ATmega16 are shown in Figure 3.
Figure 3. Pin diagram of ATmega16.

Among them, port A (PA7...PA0) is the analog input of the A/D converter. Port B (PB7...PB0) is an 8-bit bidirectional I/O port with a programmable internal pull-up resistor. Port D (PD7...PD0) is an 8-bit bidirectional I/O port with a programmable internal pull-up resistor.

In this control system, the system analog input has 8 channels of battery voltage, wind power current, hydroelectric current, rainwater-graphene generation current and other currents. The digital output includes 8 channels of battery overcharge, over discharge protection and system working status indication. The control system structure is shown in Figure 4.

1-Input Analog Voltage; 2-Output status display indicator light on or off signal; 3-Output Charge or Discharge Control Signal; 4- Output wireless communication data

Figure 4. Control system structure.

In order to ensure the normal operation of the system, each power supply unit must be tested and controlled [9]. For the signal acquisition of the 8 input signals in the system, the system selects the
Hall sensor to detect the current, and uses the transmitter to convert the output signal of the sensor into a signal that can be recognized by the controller. For the output signal of the battery charge or discharge protection control, the system uses relays for protection.

3.2 The design of software in control system

ATmega16 has a complete set of programming and system development tools, including: C compiler, macro assembly, program debugger / software simulator, emulator and evaluation board. ICCAVR is a tool for developing MCU programs in accordance with the ANSI standard C language. The designed control system software is written in C language under the mega16 MCU development software ICCAVR environment. The AVR JTAG emulator is used as the program loading and debugging operation. The whole program is mainly divided into data acquisition and processing module, status display module, battery charging control module and battery discharge control module, SX1278 wireless data communication module and scheduling policy control module. Figure 5 shows Software flow chart.

The data acquisition and processing module is mainly responsible for collecting and processing various parameters of the recorded controlled system. The A/D conversion has the function of converting an analog signal into a digital signal that can be recognized by a single chip microcomputer. Firstly, the sampling measurement value of each parameter is obtained by A/D conversion, and then stored in the corresponding registration unit after processed by digital filtering. The program uses continuous acquisition of multiple sets of data, and performs arithmetic average operation on the measured values of each parameter as the current collection. The final value is stored. The current data indicating that the indicator light is on or off is processed and displayed on the status display screen. The single-chip microcomputer outputs an electric signal to realize the closing or opening of the control relay. Data is transmitted to the computer via SX1278 wireless data communication.
The working state of the battery has a great influence on the performance and working life of the battery, so it is very important to correctly judge the working state of the battery. There are three states when the battery is operating: over-discharge, normal, and over-charge. Reasonable control of the battery charging method is the key to the service life of the system. In the entire system, the charge or discharge control of the battery is determined by the current state of the battery. When the battery is in the over-discharge state, the system cuts off the power supply of the battery by the control relay to prevent the battery from being further discharged to protect the battery and emit an audible and visual alarm signal displayed by the indicator light. When the battery is in the overcharge state, it is necessary to issue an alarm signal in time to step up the surplus power into the grid. If the weather conditions are not good enough to generate enough power, start the battery to supply power to the load. When the battery terminal voltage drops to the set value, stop the power supply to the load.

In the judgment of the state of the battery, a threshold control method is adopted, which can prevent frequent relay action and alarm due to battery voltage instability. The status of the battery can be displayed by the indicator of the status display module. The over-discharge, over-charge, and normal status are displayed by three indicators. The status switch also has a buzzer as an alarm.

4. Conclusion
1) Based on the working principle of wind energy, rain energy, graphene and energy storage, a integrated power generation system based on wind, rainwater and energy store battery which suitable
for urban buildings is designed. It is feasible in principle. This integrated power generation system can make full use of natural wind, rain, and has the green environmental characteristics.

2) The MCU is used as the data acquisition and controller, and the control system is designed. By the use of the SX1278 wireless data communication module, wireless communication and real-time monitoring are realized.

3) The threshold control method is used to determine the state of the battery, and the charging control and discharge control of the system are realized by the software programming.

4) The design of control system software adopts modular, which making the development speed faster. In addition, by the use of modular the program become more concise, easier to modify, and has a strong program portability.

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