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Design of Control System for Small Wind Turbine

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Abstract: The existing small wind power generation system has some problems, such as low energy conversion efficiency, short battery life, simple control and lack of complete system power control. Therefore, it is of great significance for small wind power generation to improve the charging speed of batteries, reduce the charging loss, correctly monitor the status of batteries, ensure the correct use of batteries and prolong the service life of batteries. The purpose of this design is to design a simple, efficient and highly reliable wind turbine controller based on the analysis of the existing small wind power generation system, so as to realize the reliable and optimal operation of the wind power system.

Keywords: Generator, Rectifier, Lithium Battery, Environmental Protection.

1. Introduction

With the development of modern industry and the progress of society, people's demand for power supply continuity and power supply quantity is becoming higher and higher. With the decrease of coal and oil, the development of new energy has become one of the hottest topics in today's society. As a natural resource, wind energy has many advantages, such as inexhaustible, clean and pollution-free, so it is called "green resources" by people. The use of renewable energy can save energy and protect the environment, and wind power has more competitive potential than other renewable energy, so it develops rapidly.

2. System Hardware Design

2.1 Control Schematic Diagram

Battery charging and non-charging can be judged by collecting battery voltage, and battery protection can be judged by collecting current. The controller is composed of some electronic components, which acts as a "switch". When the output AC of the generator passes through rectification, if the voltage of lithium battery is less than 3.0V set by the system, the controller turns on the charging circuit and the generator begins to charge the lithium battery. When the voltage of lithium battery rises to 3.7V, the charging control switch circuit closes, and the generator stops charging the lithium battery, so as to avoid the overcharge of the lithium battery affecting its life. On this basis, the service life of lithium battery is guaranteed.

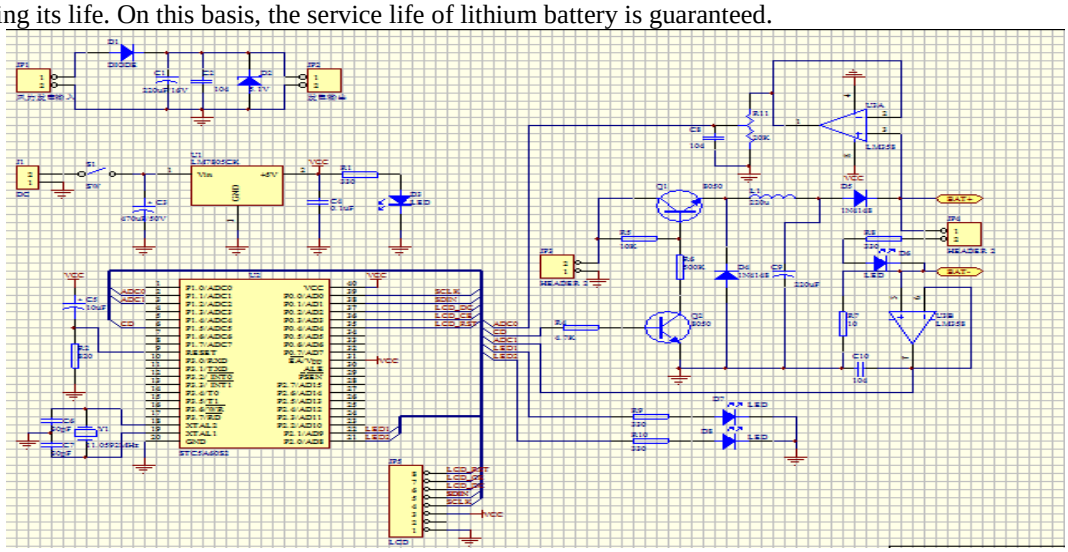

Figure 1. Controller schematic diagram

2.2 Half-wave Rectifier Circuit

The secondary winding of the transformer is connected with the load, and a rectifier diode is connected in series in the middle, which is called half-wave rectifier. By utilizing the unidirectional conductivity of the

diode, only half of the cycle has the current flowing over the load, while the other half cycle is blocked by the two transistors, and there is no current. In this circuit, the DC component flows through the transformer, which reduces the efficiency of the transformer. The impulse component of the rectifier current is too large, which requires high filter circuit. Only suitable for small current rectifier circuit. The rectifier circuit is shown in figs. 2 and 3.

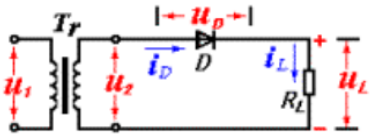

Figure 2. Half-wave rectifier circuit

It consists of power transformer Tr rectifier diode D and load resistance RL. The transformer is connected with an AC power supply at the primary stage and the AC voltage induced by the secondary stage is as follows:

$$u_2 = U_{2m} Sinat = \sqrt{2} U_2 Sinat \quad (1)$$

U_{2m} is the peak value of secondary voltage and U_2 is the effective value. The working process of the circuit is that in the positive half cycle of $U_2(\omega t = 0 \sim \pi)$, the diode is turned on by adding forward bias voltage, and the current iL flows through the load resistance RL. Because the diode is regarded as an ideal device, the voltage uL on RL is basically the same as the positive half-cycle voltage of u_2. In the negative half cycle of $u_2(\omega t = \pi \sim 2\pi)$, diode D is cut off by adding reverse voltage, no current flows through RL, and voltage uL = 0 on RL.

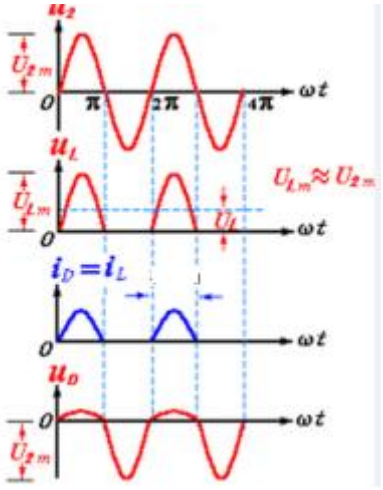

Figure 3. Rectifier waveform

Because of the unidirectional conductance of the diode, the current flowing through the load resistance is pulsating current, and the voltage is also one-way pulsating voltage. The average value of the voltage (output DC component) is

$$U_L = \frac{1}{2\pi} \int_0^{2\pi} \sqrt{2} U_2 Sinatd(at) \quad (2)$$

The average current flowing through the load is

$$I_L = \frac{U_L}{R_L} = 0.45 \frac{U_2}{R_L} \quad (3)$$

The maximum reverse voltage applied to both ends of the diode is

$$U_{RM} = \sqrt{2} U_2 \quad (4)$$

When choosing rectifier diode, these two parameters should be taken as limit parameters.

The half-wave rectifier circuit is simple and has few components, but the DC component of the output voltage is

small (only half wave). It has large fluctuation degree and low rectification efficiency. It is only suitable for the occasions of small output current, large allowable fluctuation degree and low requirement.

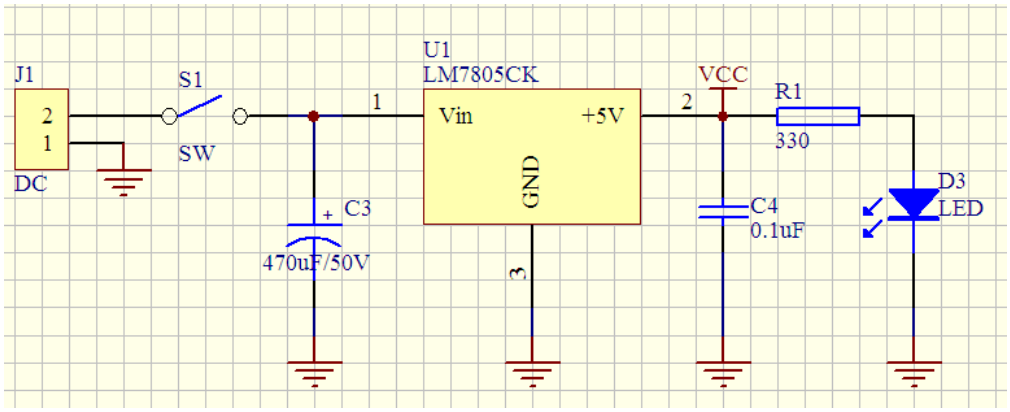

Figure 4. The power supply circuit

2.3 Display

This design uses Nokia/Nokia 5110 LCD display screen, which is a LCD module produced by NOKIA company for its 5110, 6150, 6100 series of mobile phones. Domestic manufacturers also produce similar compatible products. This product can be used not only in mobile phones, but also in display systems of various portable devices. Compared with other types of products, the module has the following characteristics:

(1). The dot matrix LCD of 84x48 can display 4 lines of Chinese characters.
(2). Serial interface is used to communicate with the main processor. The number of interface signal lines is greatly reduced. There are only 9 signal lines including power supply and ground. Support a variety of serial communication protocols (such as SPI of AVR MCU, serial mode 0 of MCS51, etc.), transmission rate up to 4 Mbps, can write display data at full speed, no waiting time;
(3). The module can be connected with PCB by conductive glue instead of cable. The module can be fixed to PCB by metal hook on the module, so it is very easy to install and replace.
(4). The LCD controller/driver chip has been bound to the LCD chip, and the module size is very small.
(5). Using low-voltage power supply, the working current of normal display is less than 200 mu A, and has power-off mode.

The LCD display circuit diagram is as follows.

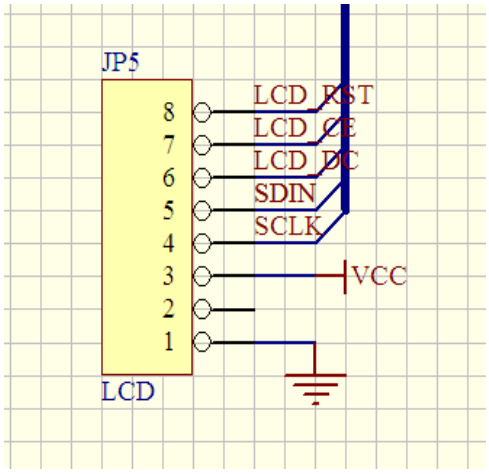

Figure 5. LCD display circuit

2.5 Selection of Lithium Batteries

This design uses a lithium battery, and the charging circuit is shown in Figure 6.

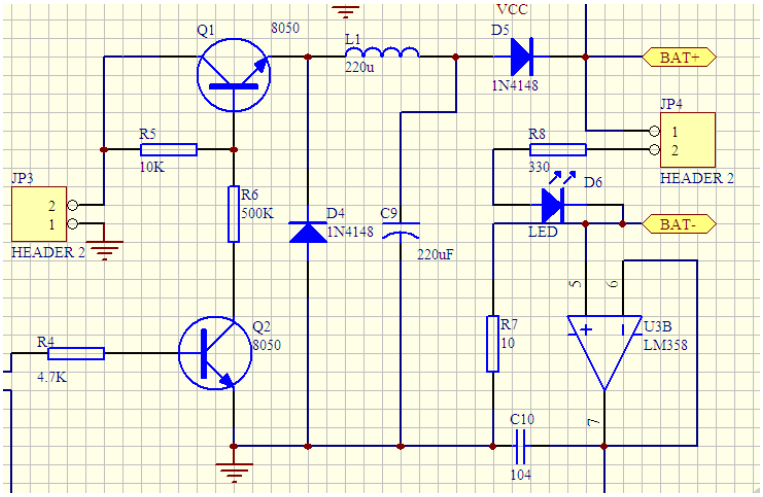

Figure 6. Charging Circuit

2.6 Detection Circuit

The detection circuit includes charging voltage detection and charging current detection.The main considerations in the design of voltage detection circuit are as follows: in the normal charging process, the range of voltage U at the battery terminal is 2.7V to 4.25V. In order to detect U by MCU, it is necessary to map the change of U to the range of O to 5V in some way; in the measurement, it is necessary to use low voltage devices to measure high voltage and strong current analog quantities, if there is no electrical isolation between analog quantities and digital quantities. Then, high voltage and high current can easily be connected into low voltage devices and burned down. In this design, precise resistance is used for proportional attenuation, which converts the range of input voltage into the range of AD converter, and then is filtered by RC and sent to AD converter for measurement. Linear optocoupler can achieve better isolation between input side and output side, and the output follows the change of input, the linearity is up to 0.01%.

Resistance detection method belongs to direct detection method. It is usually calculated by measuring the voltage signals at the two ends of the resistance in the series circuit. The upper limit of the measured current can not be too large. The electrical signal directly obtained is analog signal, which is generally weak. It needs external amplification circuit to amplify the signal, and then converts it into digital signal through A/D conversion circuit.

3. Conclusion

In this paper, a more comprehensive study of the small wind power generation system is carried outthrough the design process of a small wind turbine controller. The structure, composition, working principle of the small wind power generation system and the brief development of each component are introduced. The parts of the controller designed are selected and analyzed. The key technology of the control machine designed is detailed. Analysis and test.

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