ISSN: 2414-1895 DOI: 10.6919/ICJE.202306_9(6).0024

Design and Verification of Battery Power Warning System based on Micro-power Wireless Communication

Yuhao Li[a], Dongming Xu[b] and Zhishuo Wang[c]

School of Information and Communication Engineering, Xi'an University of Posts and Telecommunications, Xi'an 710121, China

[a]1124266761@qq.com, [b]xdm@xupt.edu.cn, [c]760707819@qq.com

Abstract

Nowadays, there is an increasing demand for long-distance, wide-distributed, and low-speed unmanned detection equipment in the market. However, most unmanned monitoring equipment is powered by batteries, and often faces the dilemma that the batteries are exhausted but no one maintains them. In order to solve this problem, a distributed battery detection system based on micro-power wireless communication is designed. The system consists of three parts: voltage measurement module, micro-power wireless ad hoc network and terminal display part. Using the idea of modularization, the terminal hardware circuit is designed and realized. The acquisition module of the voltage measurement module mainly realizes the acquisition and reporting of the battery voltage, and receives the information sent by the terminal. This is of great significance to promoting the development of my country's unmanned testing equipment market, bringing changes to urban management and public services, and promoting environmental protection and sustainable development.

Keywords

Micropower Wireless; Voltage Sensing; Distributed; Microprocessor.

1. Introduction

With the continuous development and popularization of the information age, more and more equipment and objects have begun to have the characteristics of intelligence and networking, and data exchange and control can be performed through the Internet. These devices can be sensors, computers, mobile phones, appliances, cars, etc., or even human implants. The development of Internet of Things technology provides the possibility to realize intelligent interconnection, information sharing and collaborative work between devices.[1] According to statistics, in the Internet of Things business, low-speed services account for 67% of the Internet of Things, and also put forward low power consumption and wide coverage requirements for communication technologies. Traditional communication technologies such as 3G, 4G and Bluetooth all have contradictions between transmission rate, transmission distance and power consumption.[1, 2] For long-distance, low-speed and low-latency sensitive business scenarios, micro-power wireless communication technology is born.

Micropower wireless communication is a communication method that uses the characteristics that electromagnetic wave signals can freely propagate in space for information exchange[3]. Wireless communication has high resource utilization rate, users only occupy resources when sending or receiving data, multiple users can efficiently share the same wireless channel; high transmission rate and reliable signal; short access time, can provide fast and timely connection, You can register and access in a few seconds; the network coverage is wide; the development cost is low, and with the help

ISSN: 2414-1895 DOI: 10.6919/ICJE.202306_9(6).0024

of existing network and technical resources, the development cycle is fast and the cost is low. In recent years, wireless communication has been rapidly developed and applied[4]. Micropower wireless communication is to transmit and receive information through micropower radio communication modules. It has the advantages of no need for wiring, high communication reliability, stable network, high communication speed, and strong real-time performance. Using wireless ad hoc network communication technology, the project installation is simple, the network is flexible and easy to maintain[5].

1.1 System Design

Among all distributed intelligent monitoring devices, how to improve system stability and reduce energy consumption is the most important. This requires our system design to be as simple as possible, to minimize intermediate links, and to use components with high stability[6]. In this design, we use a single-chip microcomputer chip to control the analog-to-digital converter to collect battery data, and then send the collected data to a local or remote client for display. This design can not only ensure the stability of the design, but also reduce the energy consumption of the equipment as much as possible. It has strong practical operability and a high fault tolerance rate.

This design selects CC1312R single-chip microcomputer as the data processing center to collect, process and transmit data. The CC1312R microcontroller integrates a complete RF system and an on-chip DC/DC converter. Sensors are processed at very low power by a programmable, autonomous, ultra-low-power sensor controller CPU with 4KB of program and data SRAM memory. The sensor controller with fast wake-up and ultra-low-power 2MHz mode is designed for sampling, buffering and processing of analog and digital sensors so the microcontroller can maximize sleep time and minimize active power consumption. It is suitable for application scenarios with long distance, low power consumption and high integration.

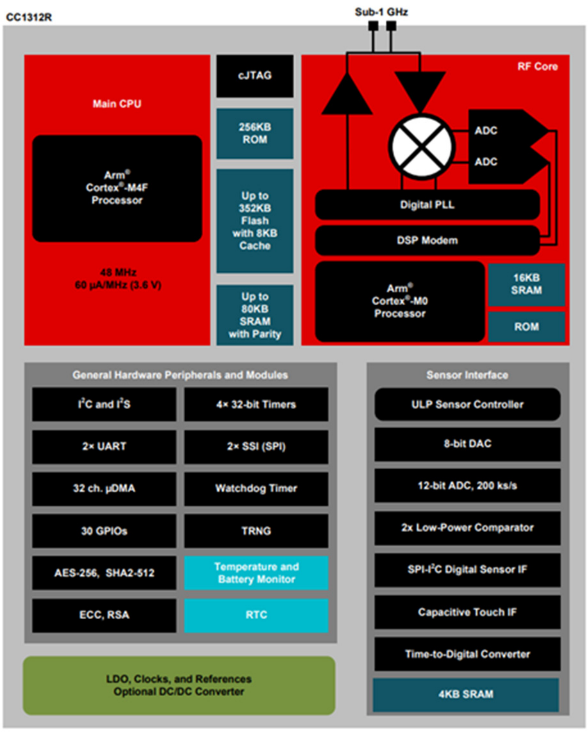

Figure 1. CC1312R module diagram

1.2 Measurement Methods

In this design, the ADC (analog to digital converter) module that comes with the microcontroller is used to test the battery voltage using the classic ADC voltage measurement method[7]. An ADC samples an analog signal to provide a quantized digital code representing the input signal. The digital output code is processed and the result is reported to an operator who uses this information to make

ISSN: 2414-1895 DOI: 10.6919/ICJE.202306_9(6).0024

decisions and take action. It is therefore important to correctly relate the digital codes to the analog signals they represent.

The ADC input voltage is related to the output code by a simple relationship, as shown in Equation 1:

$$V_{IN}(V)=OutputCode*LSB\ Size \quad (1)$$

Where V_{IN} (V) is the input voltage to the ADC, and the output code is the digital output code of the ADC in decimal format (, LSB size is the least significant bit in the ADC code. Equation 1 is a general formula that can be used for any ADC. If the output of the ADC It doesn't matter if the code is in binary or two's complement format, as long as the binary number is properly converted to its decimal equivalent. Once the ADC conversion is complete, multiply the decimal value of the output code by the LSB size to calculate the input voltage. Knowing the LSB size is the key to converting between code and voltage. Equation 2 determines the LSB size:

$$LSB_{Size}(V/Code)=\frac{FSR}{2^N} \quad (2)$$

Where FSR is the full-scale input range of the ADC proportional to the reference voltage, and N is the number of bits in the ADC output code. 2N is equal to the total number of ADC codes. The LSB size is equal to the full-scale input range (FSR) divided by the total number of ADC codes. This is equivalent to the step size per code needed to cover the entire input range. Figure 2 shows the step function of a 3-bit ADC, which maps the input voltage to the output code.

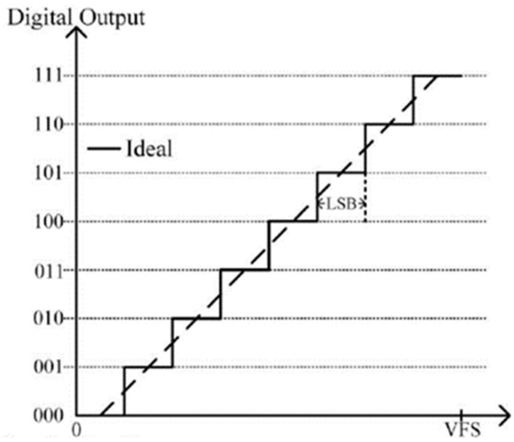

Figure 2. The step function of the three-bit ADC

During the working process of the battery, the voltage will decrease with the decrease of the battery capacity, but the rate of decrease of the voltage is usually very slow. When the battery capacity is reduced below 20%, the rate of decrease of the voltage value will suddenly drop rapidly. Using this feature, the battery voltage drop rate is used as the standard for judging the battery power. When the voltage drop rate reaches a certain threshold, a signal is sent, and the signal is sent to the terminal display through the wireless radio frequency unit.

1.3 Soft Design

According to the design requirements, combined with the hardware circuit, when the analog signal is input, the resistor divider is used, and the final sampling input voltage is only one-half of the actual input voltage. It should be noted that the output results are displayed on the LCD screen, and there are certain requirements for the display frequency[8]. When writing the program, the display subroutine should also be considered.

The design flow chart is shown in Figure 3:

When writing the specific work program, the designer designs the jump instruction according to the actual situation of the voltage measurement system to form a "self-protection" to avoid unreasonable damage to the single-chip system caused by unexpected situations. When the CPU receives the

ISSN: 2414-1895 DOI: 10.6919/ICJE.202306_9(6).0024

interrupt request signal and responds, the CPU pushes the current content into the stack for protection, and then transfers to the corresponding interrupt service routine.

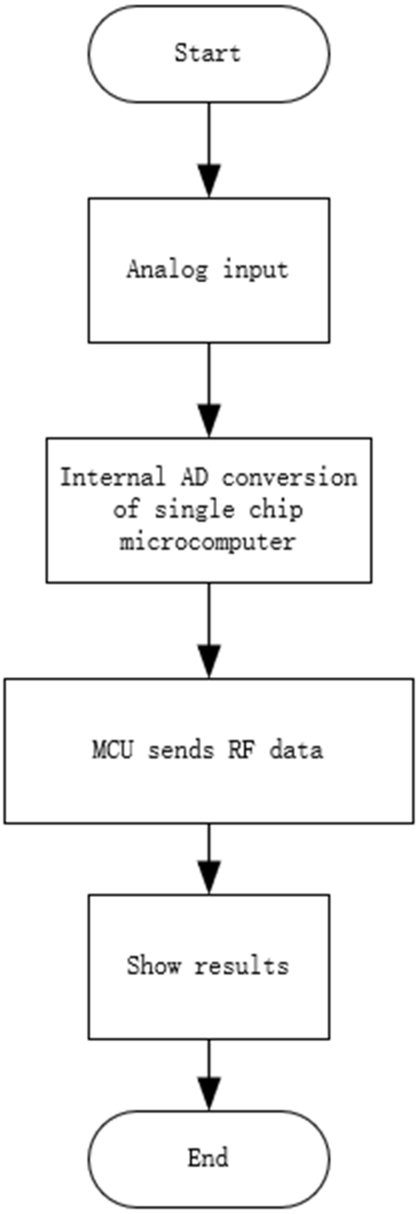

Figure 3. Operation flow chart

Code example:

```
int32_t adc_v(void)
{
    uint8_t   adcCode{3};
    adcCode{0} = readByte();
    adcCode{1} = readByte();
    adcCode{2} = readByte();
    return (int32_t) ((adcCode[0] & 0x80)?(0xFF):(0X00)<<24) |
                                        ((adcCode[0] & 0xFF)   << 16) |
                                        ((adcCode[1] & 0xFF)   << 8)   |
                                        ((adcCode[2] & 0xFF)   << 0)   |
```

ISSN: 2414-1895 DOI: 10.6919/ICJE.202306_9(6).0024

```
}
int32_t outputCode = adc_v();
double    voltage = (double) outputCode * LSb_size;
```

2. Pratical Testing

In order to verify the reliability of the battery power detection device designed in this paper, the three parts of the lithium battery, power detection module, and display terminal will be built for system monitoring. When the terminal battery voltage is observed, the multimeter will be used to measure the battery voltage, and the results will be analyzed. For comparison, test system stability.

The battery used in this test is the ER17335 lithium battery produced by Guangxi Ruiyi New Energy Company, the nominal voltage of the battery is 3.6V, the recommended maximum continuous discharge current is 100mA, the maximum pulse current is 200mA, and the working temperature range is -60 ℃~+85℃, it has the advantages of stable high working voltage, long storage life and wide working temperature range. Therefore, it is widely used in intelligent instruments and meters, wireless alarm and remote tracking monitoring systems, real-time clocks and other equipment.

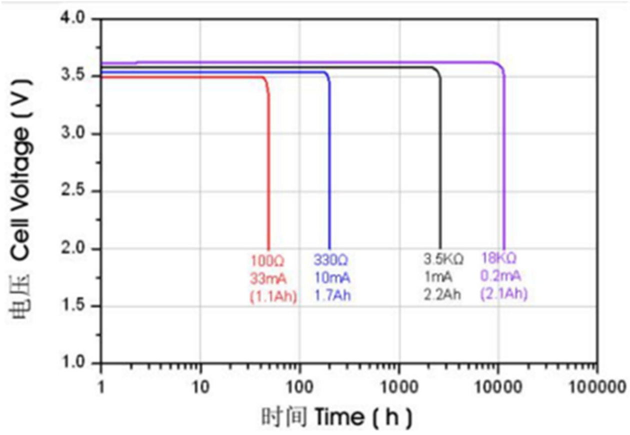

Figure 4. Changes in battery voltage

It can be seen from Figure 4 that the voltage of the battery is very stable. However, when the battery is about to run out, the voltage of the battery begins to drop sharply. This article designs the program using the characteristics of lithium batteries. The single-chip microcomputer uses the ADC method to measure the battery voltage, transmits the battery voltage to the single-chip microcomputer CPU, and calculates the rate of change of the voltage through the CPU. The user battery will be drained.

Table 1. Analysis of test results

Measurement Times	1	2	3	4	5	6
Display Data	2.502V	2.821V	3.012V	3.181V	3.418V	2.601V
Measurement Data	2.497V	2.804V	3.093V	3.200V	3.394V	2.603V

Error calculation:

Average value of display data=(2.502V+2.821V+3.012V+3.181V+3.418V+2.601V)/6=2.471

Average value of measured data=(2.497V+2.804V+3.093V+3.200V+3.394V+3.603V)/6=3.099

Value of difference= (2471-3099)/2471=0.25%

Therefore, it can be considered that the test results are relatively accurate within the allowable range of error.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202306_9(6).0024

3. Conclusion

This design selects the CC1312R single-chip microcomputer for the design, conducts in-depth research on the single-chip microcomputer, and is familiar with the working principle of the single-chip microcomputer. After completion, the accuracy of the design in this paper is demonstrated by comparing the experimental results with the multimeter measurement results. Mainly completed the following work:

Researched the basic unit and internal structure of the CC1312R single-chip microcomputer; explained the principle of analog-to-digital conversion (ADC) in depth, and showed some description codes; within range. The results show that the designed micro-power wireless battery power detection system can accurately calculate the battery voltage and complete the early warning function.

References

[1] Xiaozhou Chen: Application of Micro-power Wireless Communication Mode in Electric Meter Reading System[J]. Science and technology innovation 2016（24）:45-46.

[2] Lan Su, Geng Zhang, Yang Wang et al. Feng, et al. Application of improved micro-power wireless communication in power system[J]. Electrical application,2013,32(S2):303-306.

[3] China National Standardization Management Committee. Specifications of Crane Design (China Standardization Press, China 2008), p. 16-19.

[4] Wu Tianqi. Smart home electricity management and control based on power-line carrier communication [C]// International Conference on Machinery, Materials, Environment, Biotechnology and Computer. China: IEEE Press, 2016:1000-1003.

[5] CHEN J, YU J. Theoretical analysis on a new direct expansion solar assisted ejector-compression heat pump cycle for water heater[J]. Solar Energy,2017,142(1):299-307.

[6] R. LAZZARIN. Heat pumps and solar energy: A review with some in-sights in the future[J]. International Journal of Refrigeration,2020(116):146-160.

[7] Zheheng Liang, Jinbo Zhang, Yu Qiu, et al. Design and Simulation of Large-Scale Micropower Wireless Communication Network Channel[J]. Measurement and Testing Technology, 2020,47(11):87−90.

[8] Zhenming Yang, Kun Li, Chengtao Yang, et al. Research on System Architecture of Battery Intelligent Online Monitoring Device [J]. Electric Power Equipment Management, 2019(8):38-39.