Czech Technical University in Prague

FACULTY OF ELECTRICAL ENGINEERING

Department of Microelectronics

Bachelor Thesis

Design of a battery detection system based on single-chip microcomputer

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Recommended information sources

1）Battery Management Systems: Design by Modelling, H.J. Bergveld, ISBN-13: 978-1402008320

2) Modern Battery Engineering: A Comprehensive Introduction, ISBN-13: 978-9811215988

Declaration:

“I hereby declare that this bachelor’s thesis is the product of my own independent work and that I have clearly stated all information sources used in the thesis according to Methodological Instruction No. 1/2009 – “On maintaining ethical principles when working on a university final project, CTU in Prague“.

Date Signature“

ABSTRACT

In the type of battery, the role of battery is relatively large, the storage of electric energy, itself is the conversion of chemical energy. The negative part is filled sponge lead plate, and the positive part is lead dioxide plate. Dilute sulfuric acid is used to realize electrolyte. When charging, there will be a reaction. In this process, energy conversion can be completed. In the process of charging and discharging, it is necessary to define the actual situation of voltage, current and other data, which is also to guarantee the value and meet the design requirements of the system.

The core part of the system is AT89 C 51 single chip microcomputer, which is mainly composed of 8K bytes fast write programmable / erasable read-only memory and other parts. The characteristics of the single chip microcomputer mainly include: high integration, very fast speed , and the overall power consumption is also relatively low, especially suitable for multi-path acquisition data control system. In this system, it is mainly used to detect the voltage of the battery, and to design the module. Among the detected data, it can be displayed and stored on LCD.

Key words： single chip microcomputer; battery; detection system; AT89C51

ABSTRAKTNÍ

U typu baterie je role baterie relativně velká, akumulace elektrické energie, sama o sobě je přeměna chemické energie. Záporná část je naplněná olověná deska s houbou a pozitivní část je deska s oxidem olovnatým. K realizaci elektrolytu se používá zředěná kyselina sírov á. Při nabíjení dojde k reakci. V tomto procesu lze dokončit přeměnu energie. V procesu nabí jení a vybíjení je nutné definovat skutečnou situaci napětí, proudu a dalších údajů, což má také zaručit hodnotu a splnit konstrukční požadavky systému.

Jádrovou součástí systému je jednočipový mikropočítač AT89 C 51, který se skládá hlavně z 8K bajtů rychlého zápisu programovatelné / vymazatelné paměti jen pro čtení a dal ších částí. Mezi vlastnosti jednočipového mikropočítače patří zejména: vysoká integrace, velmi vysoká rychlost a celková spotřeba energie je také relativně nízká, což je zvláště vhodné pro systém řízení sběrných dat s více cestami. V tomto systému se používá hlavně k detekci napětí baterie ak návrhu modulu. Mezi detekovanými daty je lze zobrazit a uložit na LCD.

Klíčová slova: jednočipový mikropočítač; baterie; detekční systém; AT89C51

Table of Contents

1 Introduction

Storage batteries are relatively convenient mainstream power sources, so they are fully utilized in industries such as electricity. In general cases, they usually need to be connected by series or parallel to get higher current or voltage in load. Similar to the bucket effect, the overall efficiency of the battery pack depends on the performance of ‘the worst battery' among them, so we hope to find and fix the problem in time to extend the life of the battery pack. Moreover, the battery is a chemical device, and the reaction that occurs in the battery is secretive. Therefore, the battery pack is necessary to implement monitoring while operating.

1.1 Significance of this research

The battery is a chemical power source. Since the birth of the battery, it has been widely used due to its flexibility and mobility. Lithium batteries are the most common in daily life. The advantages and disadvantages of lithium batteries can be roughly divided into the following points.

Advantages

1) High energy density.

Energy density is about 6-7 times that of lead-acid batteries. It also means more energy contain in small volume and low weight which makes better new energy vehicles (electric vehicle and hybrid vehicle).

2) Long-life period.

In general case lithium batteries have a lifespan of about 6 years and 10,000 charge and discharge times.

3) The rated voltage is high.

The single working voltage of the lithium battery is 3.7V or 3.2V, which is approximately equal to the series voltage of 3 nickel-cadmium or nickel-metal hydride rechargeable batteries, which is convenient to form a battery power pack.

4) With high power tolerance.

Among them, the lithium iron phosphate lithium-ion battery used in electric vehicles can reach 15-30C charge and discharge capacity, which is convenient for high-intensity start-up acceleration

5) The self-discharge rate is very low.

This is one of the most prominent advantages of the battery. Currently, it can generally achieve less than 1% per month, which is less than 1/20 of that of Ni-MH batteries.

6) Operation temperature

The normal working temperature is between -20-60 degrees, and the full performance working temperature is around 0-40 degrees.

Disadvantage

1） Safety.

When the lithium battery is overcharged, the internal pressure increases and there is a risk of explosion.

2） Price.

Compared with other storage batteries, it has a higher production cost.

As an important part of external power supply, the battery's safety and performance are particularly important. Therefore, it is necessary to detect and protect the battery.

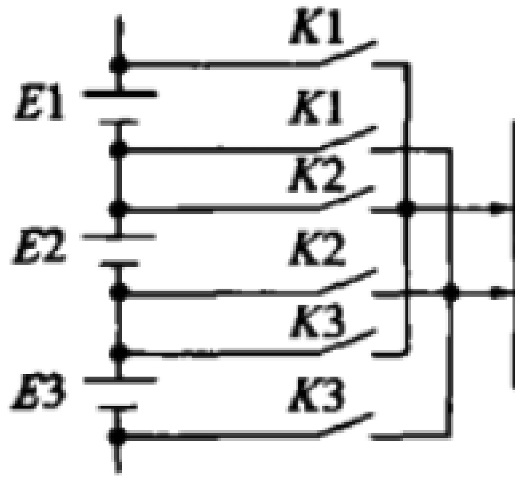
1.2 Method introduction

1.2.1 main parameters & measuring objects

For battery monitoring, current and voltage are mainly required as reference values to evaluate the battery's working status and performance.

1） Voltage

For the voltage measurement of a single battery, you can directly use a voltmeter in parallel with both ends of the battery for measurement. Similarly, when measuring a single cell in a series battery pack, this method could be used.



signal conditioning circuit at right side

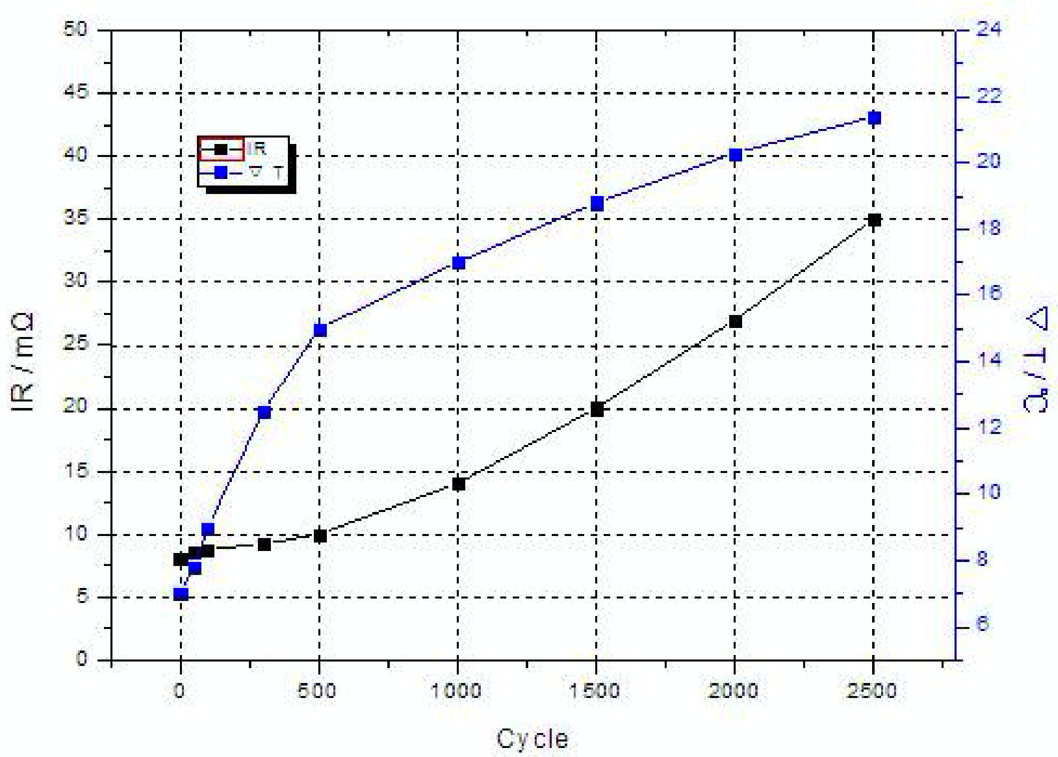
When measuring a certain battery, close the switches at both ends of the battery to connect the battery to the measurement circuit, and keep the other switches off.

When the number of batteries is larger, the number of switches (relays) is larger, and the overall volume is larger.

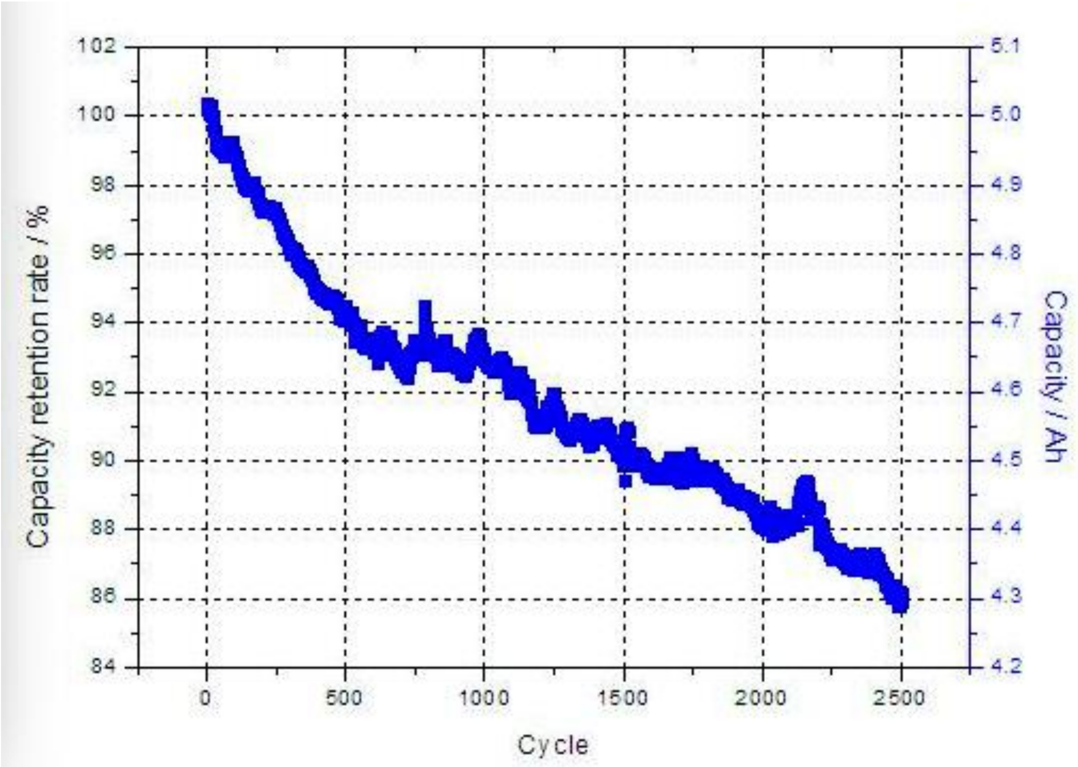
A common method is to use the V/F converter as a similar A/D converter, but this method will have a delay in comparison in time. Different parameters of the internal RC circuit will have different effects on the accuracy of the measurement results.

2） Current

The current is related to the internal resistance of the storage battery. And the temperature changes also come with the change of internal resistance.



This figure shows the internal resistance and temperature changes during aging of the storage battery. The internal resistance of the battery is proportional to the temperature, so both the internal resistance and the temperature can be used to monitor the aging of the battery.



This chart shows the change in battery capacity during the cycle of rechargeable batteries. Combining the above information, it can be known that the aging (decrease in capacity) of the storage battery is accompanied by an increase in internal resistance and an increase in temperature.

1.2.2 method

The battery pack is measured by analog signal, and the signal is easily disturbed during transmission. When the internal resistance of the battery is measured by the discharge method, the line voltage drop is obvious due to the large discharge current. Due to the uncertainty of field wiring, accurate compensation cannot be achieved, resulting in a decrease in measurement accuracy, and temperature measurement is more difficult to achieve. So generally only measure current and voltage as reference values.

To implement the multi-parameter measurements, to improve the monitoring accuracy by using a centralized control method. I plan to use a multi-processor system with a master-slave structure. Each battery has its own measurement control circuit, which is controlled by the host. Each control circuit needs to include a microcontroller, measurement module, and communication module.

2 Overall system design

As for the battery monitoring system, its biggest role is to detect the battery's operating conditions, avoid battery discharge transitions, excessive temperature, etc., and in the event of a failure, it can also provide early warning. Through system monitoring, make full use of the battery's power storage capacity to extend the battery's use time. Based on system requirements, complete data collection and other operations, and obtain battery-related data information. After the final acquisition is completed, it needs to be transferred to the single-chip microcomputer, and arithmetic processing is performed. After that, operate on the LCD, etc., and detect signals such as the chip of the DS2438 battery. On this basis, it can ensure that the telecommunications union and the keyboard connected to it can be used normally and set a certain numerical standard to complete the alarm, and then show the situation of data switching. After the parameter value exceeds the set numerical standard, the system will send out an alarm prompt. A hardware watchdog circuit is added to the design for protection. The structure diagram is shown in Figure 2.1.

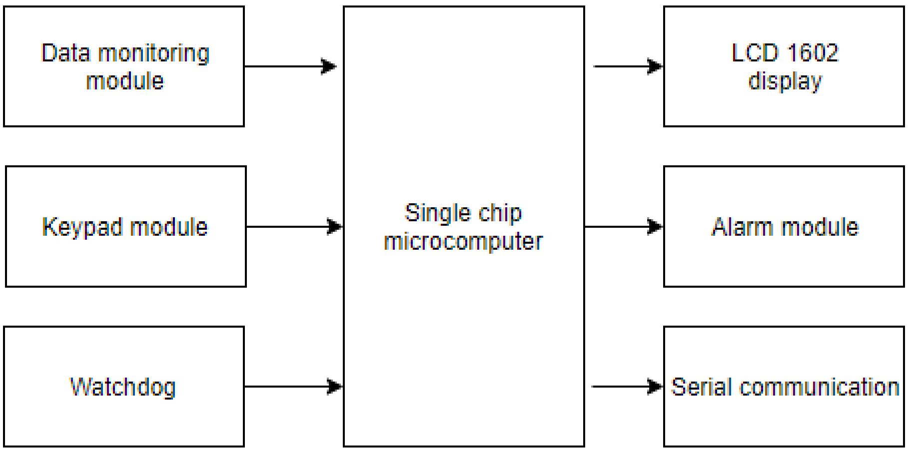


Figure 2-1 System block diagram

The functions of this design module mainly include:

1) For the data detection module circuit, it is necessary to collect the signal values such as the voltage of the single cell in the battery, and transmit the obtained data to the single-chip microcomputer.

2) Click the button to switch the content of the maximum and minimum values of the numerical alarm.

3) 89C51 single-chip microcomputer arranges the hexadecimal signal, and then automatically generates the control mode signal.

4) The LCD display circuit can obtain values such as temperature.

5) For the alarm output unit, if the finally detected value exceeds the maximum and minimum values, then an audible and visual alarm will appear.

6) For the serial communication interface, it is necessary to complete the connection processing with the host computer.

7) For the watchdog circuit, the main purpose of its design is to protect the microcontroller system.

3 Hardware design

In the process of designing a 12V battery system, it is necessary to integrate the measurement cost and the complexity of the circuit to avoid the use of high cost and more complex circuits. For the main controller, the CMOS 8-bit microcontroller AT89C51 is mainly used, which consumes less energy and has high performance. For the signal acquisition part, the battery is mainly used, and the detection of the chip DS2438 is completed by this battery. Its chip structure is a single bus structure, which can effectively simplify the complexity of the circuit. For work, choose +5V power supply, the source of its power is the battery cell voltage and other equipment. The system uses a 1602 character display. For the alarm device, light-emitting diodes and buzzers are mainly used, and the operator can set the specific value of the alarm to realize the switching between the data. The chip model used in the system is X25045. In the system, the main function of the single-chip microcomputer is to obtain the corresponding data, and then the data can be directly serialized with the interface circuit, and sent to the PC to display the obtained data parameter value. Therefore, in the hardware system, there are five main modules included, and the hardware circuit is specifically designed below.

3.1 The smallest single-chip system

In the AT89C51 microcontroller, its chip contains many functions of the computer. The smallest single-chip microcomputer system is the simplest circuit including power supply and other parts. The specific wiring diagram is shown in Figure 3.1. The smallest system of the single-chip microcomputer can maintain the operation of the entire single-chip microcomputer, reduce the number of components, and simplify the system design.

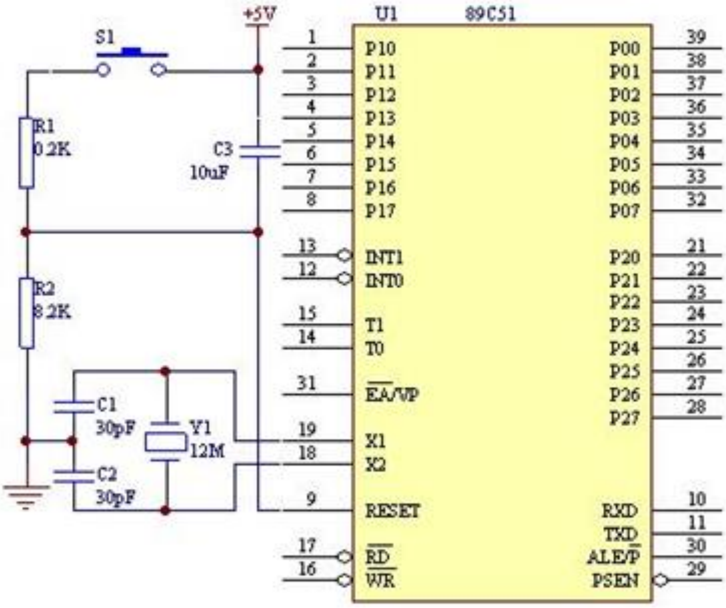


Figure 3-1 Minimum system wiring diagram

3.1.1 Introduction to Microprocessor

The microcontroller model is AT89C51. This model of the controller contains an 8-bit CPU, and the amount of data memory RAM/SFR can reach 256 bytes. The model of the program memory is Flash ROM, which is a 4K large memory. There are parallel I/O ports P0-P3 and other parts. Comparing this controller with 8051, its energy-saving type is stronger. The specific package pin diagram is shown in Figure 3.2.

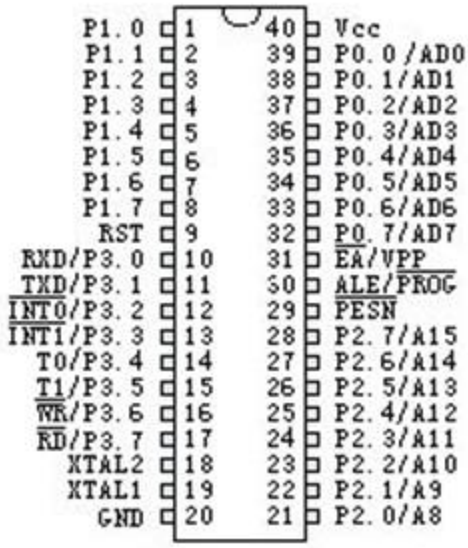


Figure 3-2 AT89C51 package diagram

3.1.2 Reset circuit

This part of the circuit mainly realizes circuit reset by combining the two reset methods of power-on and manual. If it is in the charged state, the capacitor C is charged and the position of the RST terminal realizes a positive pulse to complete the reset. The power supply time is less than 1ms, and the power-on reset can be realized. Manual reset, directly control switch S.

3.1.3 Oscillation circuit

In order to be able to meet the corresponding requirements, in the oscillator circuit, the 12MHz crystal and the fine-tuning capacitor are integrated with each other, and connected to the middle of the pins XTAL1 and XTAL2 by means of an external connection.

3.2 Signal acquisition unit

In this unit, mainly for the research of the detection chip, select the DS2438 model, the detection voltage and other parameter values. Through DS2438 chip, can collect the corresponding signal parameter, and input the parameter into SRAM/EEPROM. For 51 single-chip microcomputers, you can complete the data read operation according to the specific command content, and organize the data. However, in the process of software programming, the difficulty coefficient is relatively large.

3.2.1 Introduction to DS2438 Chip

The chip is a more intelligent chip, and can complete the battery detection. In the device, in order to be able to quickly process the battery status, real-time monitoring is required. The function of this device is relatively strong, and the volume is very small and so on.

1) The pin diagram and function of DS2438

Its appearance and pin arrangement machine functions are shown in Figure 3-3 and Table 3-1 respectively.

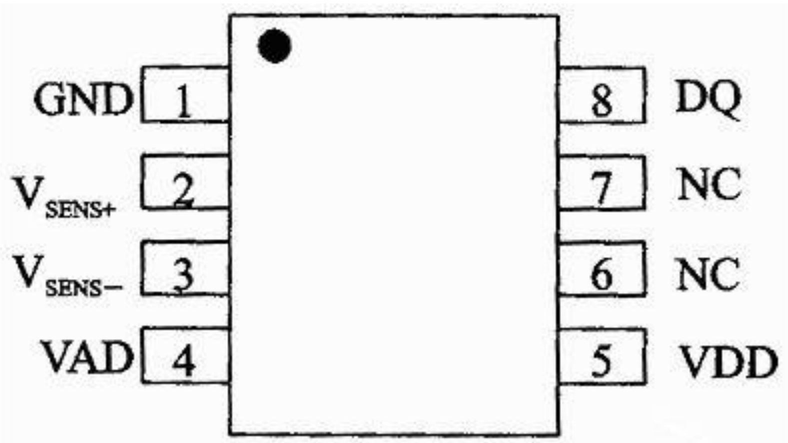


Figure 3-3 DS2438 Package

Table 3-1 DS2438 pin functions

Pin number	Pin name	function
1	GND	grounded
2	VSENS+	Battery measurement current input (+)
3	VSENS-	Battery measurement current output (-)
4	VAD	Universal voltage A/D input terminal
5	VDD	Power supply voltage (2.4 ~ 10V)
6，7	NC	-
8	DQ	Data input and output, single bus

2) DS2438 internal structure block diagram

DS2438 is an integrated chip, the structure diagram is 3-4:

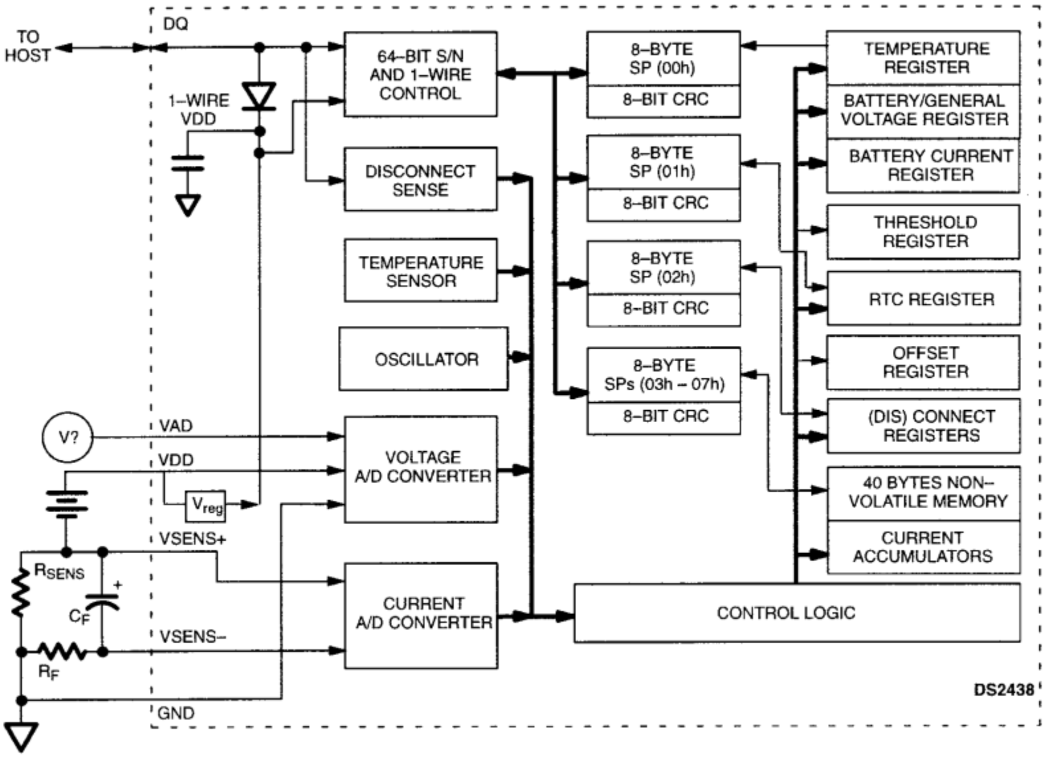


Figure 3-4 Block diagram of the internal structure of DS2438

As can be seen from the above figure, its structure mainly includes single bus interface, temperature sensor and other parts. In addition, during the input process of the voltage A/D converter, its programming is mainly to complete the input through the VDD power terminal, etc., so as to meet the input and detection requirements of the VDD power terminal.

3.2.2 DS2438 storage space

1) DS2438 storage structure

The storage space has 8 pages, and the number of bytes contained in each page is 8. In this storage space, the data access mode mainly includes RAM and SRAMIEEPROM. RAM, that is, high-speed temporary storage, is mainly used to save the communication data of a single bus and ensure that the stored data can be consistent. Enter the data into the RAM of the DS2438. After confirming the data, you need to use the ROM to issue a copy command and complete the data storage. Part of the special function is covered in the space, which is on page 0 as a storage unit.

2) DS2438 register

The chip is mainly mapped in the memory, and all operations can also be completed in the register.

3.2.3 Data acquisition board circuit

The circuit structure of the signal acquisition board is as follows, and the circuit diagram is scaled 3-5.

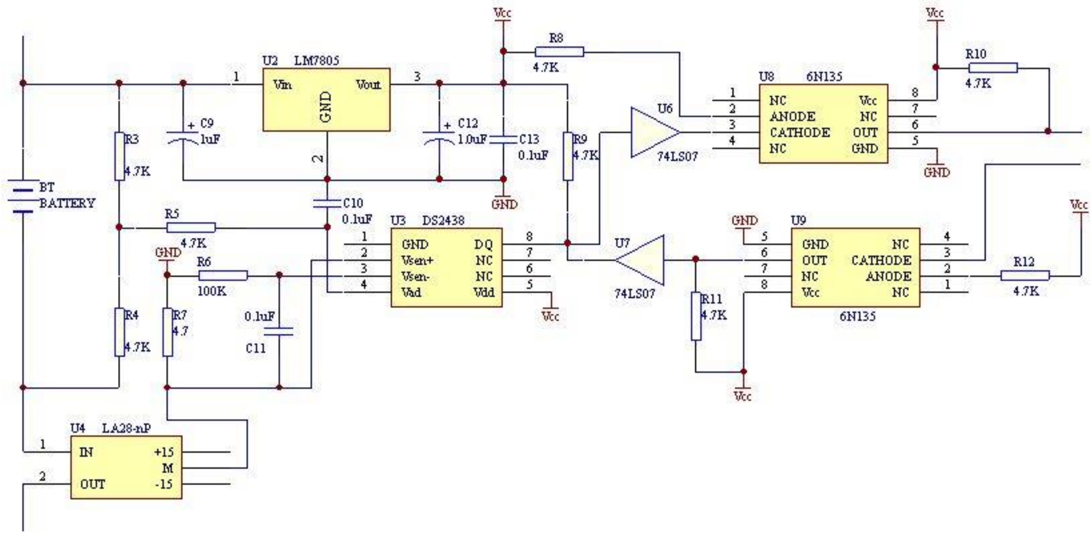


Figure 3-5 Signal acquisition module

1) +5V working power supply circuit

The battery needs to be processed by the LM7805 chip to complete the operation of voltage stabilization and filtering. The voltage generated by it is 5V, which is regarded as the running electric energy of the acquisition board. The circuit diagram of this part is shown in Figure 3-6.

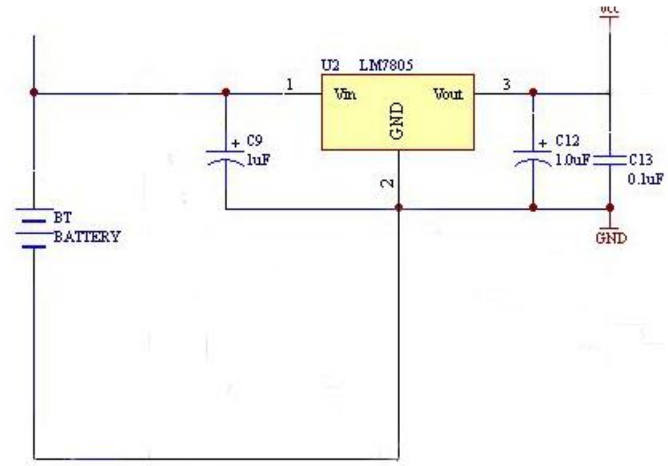


Figure 3-6 Working power supply circuit

2) Voltage acquisition circuit

According to Figure 3-7, the circuit composition of its voltage collection. And when its voltage is 12.8V, the battery starts to float, the voltage will reach 16V, and the value of the chip voltage will be between 0-10V. In this case, resistors R3 and R4 need to be used to reduce the pressure. After that, you need to use R5 and C10 filter circuits to complete the filtering, and then input it into the VAD. After DS2438 receives the voltage conversion command, the ADC converter will complete the conversion of the VAD pin voltage, the time is basically 2 ms, and the final result is directly stored in the voltage register. If the single-chip microcomputer commands it to read, the final detected data will be transmitted and processed using the DQ terminal in the DS2438 chip. It is guaranteed that its resolution is in the state of 0.01V. Therefore, the voltage formula of the battery is [value in voltage register * 0.01 *(1+R3/R4)] that its unit is V.

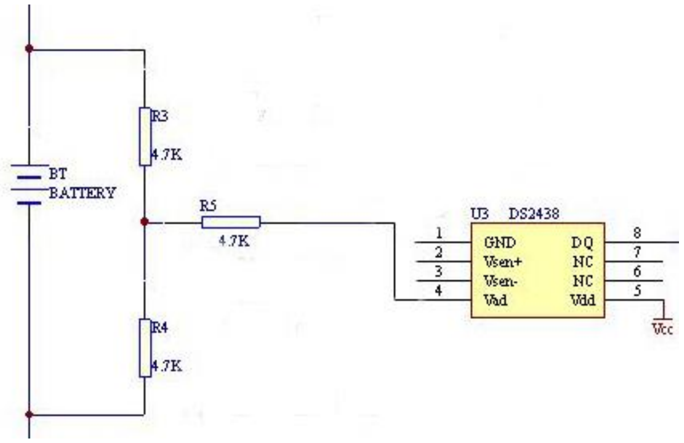


Figure 3-7 Voltage acquisition circuit

3) Current acquisition circuit

According to the display of 3-8, it can be seen that when the battery pack is connected in series, the current when it passes through each battery is the same, and a collection board can be used to complete the current measurement. Among them, it is necessary to measure the voltage across the external sensing resistor to measure the current. The external sensing resistor R7 is connected between the ground and the Vsens+ pin. In addition, the low-pass filter circuit of R6 and C11 are connected to the Vsens- terminal. In this way, the interference of peak current can be avoided. The value is equal to 100kΩ, and the value of C11 is equal to 0.1μF.

The input voltage based on the two pins of Vsens+ and Vsens- should be controlled within the range, so the value of the current that can be measured is relatively small, but the current in a battery pack is usually from dozens of amperes to dozens of amperes, which is undergoing conversion In this case, a current sensor is required. In this article, the multi-range current sensor LA-28NP is used in the process of building the system. The device is developed by LAM. Different wiring methods can be used to set different current values. The range is controlled within 5A-25A. The edge current value is defined as 25mA, making the value of resistor R7 equal to 4.7 ohms. The formula for calculating the actual current is as follows:

Real current = ±(k * |values in current register|)/R7 * 4096

In the above formula, the change of the transformer is represented by K, and the sign bit of the current register is determined by ±.

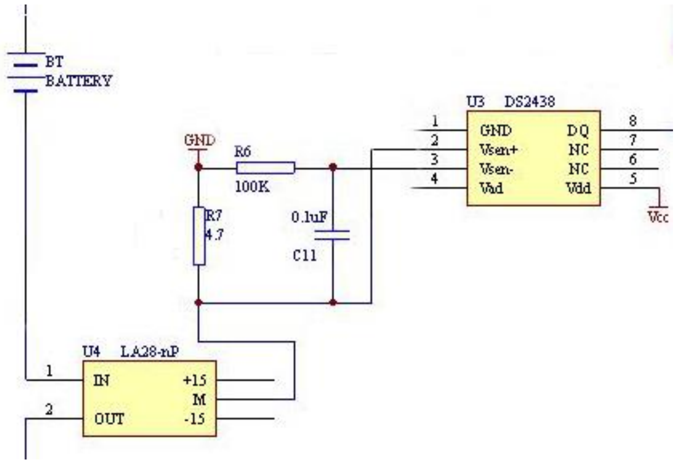


Figure 3-8 Current acquisition circuit

4) DS2438 and MCU communication circuit

The single-chip microcomputer has an 8-bit microprocessor. The core is the single-chip microcomputer, and the other part is the DS2438, which is connected to the bus through signal lines. On the one hand, it can transmit data in both directions, and on the other hand, it can transmit clocks. As shown in Figure 3.9, the bus can connect multiple measurement and control targets. And this technology has advantages such as easy maintenance. When transmitting, its rate is as high as 110 bytes per second. Before the expansion, the maximum distance of the bus is 600 meters. After expansion, the distance of the bus can be increased to 2500 meters.

Because the monitoring boards do not share the same ground, the medium-speed photocoupler 6N135 needs to be used to isolate the signal receiving and sending process. Based on the DS2438 can not turn on the photocoupler, and the output current is weak, a line driver 74LS07 is added. DQ indicates that the data output of the DS2438 can form an open-drain, and a resistor R9 is added. When the signal propagates, the ability to resist interference is very strong, so the accuracy is guaranteed while measuring. In the actual operation process, each detection board can monitor the power of different batteries in the battery pack at the same time.

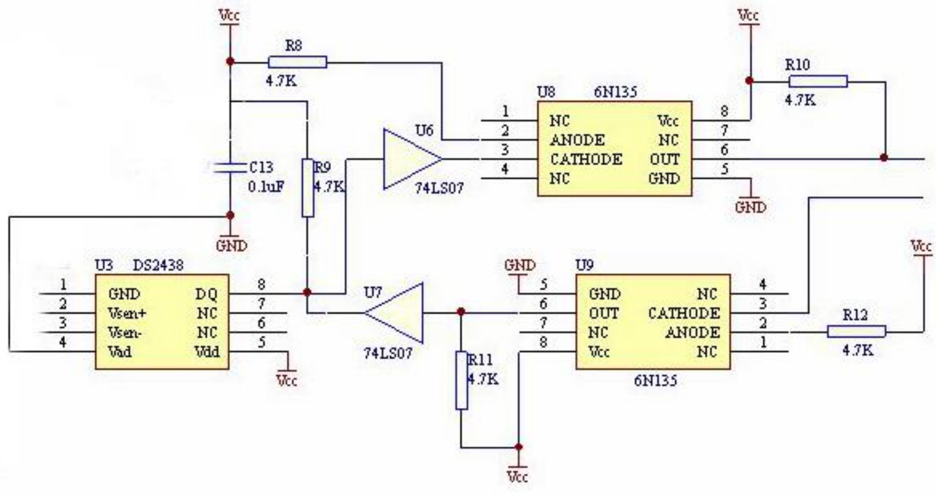


Figure 3-9 DS2438 and MCU communication circuit

3.3 Display circuit design

Host computer display and liquid crystal display are the two main display methods used in the research process of this article. This time I chose the 1602 display, which can clearly see the remaining power and other data. Moreover, the UART serial port is connected to the upper computer. According to the basic needs of users and displayed on the upper computer to realize human-computer interaction. When the tested battery status exceeds the specified range, the intelligent system will issue an alarm by itself and prompt the user to complete the corresponding operation. The following will focus on the related content of these two display modes.

3.3.1 1602 LCD display

The LCD1602 liquid crystal display can display two lines of content, and the number of characters in each line is 16. The types of LCD monitors on the market are basically HD44780 chips, but there is no difference in the way of operation. Therefore, this type of liquid crystal chip has a higher market share.

The LCD screen provides 16 connection pins to the outside, and its interface circuit is shown in Figure 3.10:

Pin 1: This pin is directly connected to the ground.

Pin 2: Connect a 5V power supply to provide an internal power supply.

Pin 3: Through this pin, the contrast can be effectively adjusted, which is negatively related to the voltage at both ends.

Pin 4: Register port, which can provide users with choices. When it is provided with high potential, it functions as a data register; otherwise, it provides an instruction register.

Pin 5: Read and write control port inside the chip, read operation is high, write operation is low.

Pin 6: This port is used as a line enable terminal. The high potential reads data from the storage space, and a negative jump occurs to complete the operation of the instruction.

Pins 7 to 14: data pins capable of bidirectional transmission with the main control chip.

Pin 15-16: The positive and negative poles of the backlight power supply of the display screen.

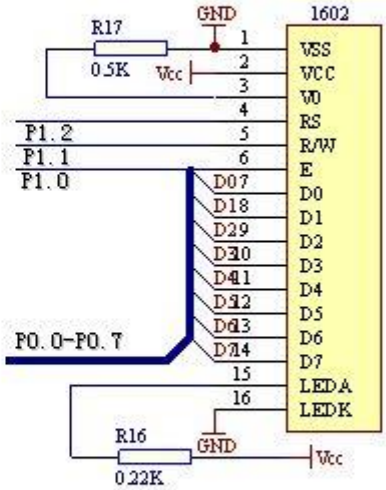


Figure 3-10 1602 and MCU wiring diagram

3.3.2 Host computer display

Use the serial port line to display the information data, so the communication should be completed on the upper computer and the single-chip computer through the interface. At this stage, communication methods include parallel and serial communication methods. Generally speaking, twenty-five leads need to be installed. But the two-way communication only needs to install the serial input RXD and other leads. The RS-232C standard stipulates that any level is within the range of +3 ~ +15V, and the logic "0" level is negative logic level. Any level within the range of -3 ~ -15V means logic "1". Level, there is a certain difference between CMOS and TTL levels. In computer interface chips and interface circuits, it is usually CMOS or TTL level, so in the communication process, it is necessary to convert the level through the MAX232 chip, and on this basis, it provides convenience for matching the level of the RS-232C standard. Because the MAX232 chip's drive capability is relatively strong, there is no need to add additional drive circuits. Figure 3-11 shows the hardware interface circuit using the MAX232 interface.

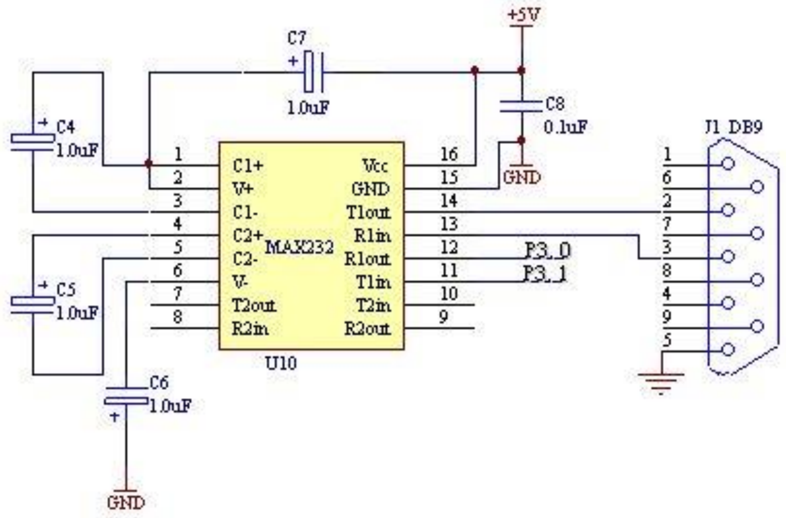


Figure 3-11 Serial communication interface circuit

3.4 Keypad and sound and light alarm circuit

The application of the entire BMS system needs to cooperate with other modules to achieve more functions, such as controlling the temperature of the battery pack through a fan to make it work at full performance. When the SOC is too high or too low, the circuit should be cut off to ensure safety and battery life. But because of limited personal ability and time, I chose to make a matrix keyboard to temporarily replace the corresponding function expansion.

3.4.1 Keypad circuit design

The specific function of the keyboard is to be able to transmit commands and complete the entry of related data, etc., which is a very effective means of manual intervention calculation. Normally, the keyboard is composed of keys arranged according to certain rules, and each case belongs to a kind of switch element. It is the ability to complete the connection or disconnection of electrical energy in the machine. There are two types of keyboards: independent or matrix. All the keys of the independent keyboard must be connected to the I/O port line to ensure that one keyboard fails and will not affect other keys. It is widely used in environments with fewer keys. The other is a matrix keyboard. Based on the basic design requirements, the author chooses a 4×3 keyboard. The internal structure of the keyboard is shown in the figure below.

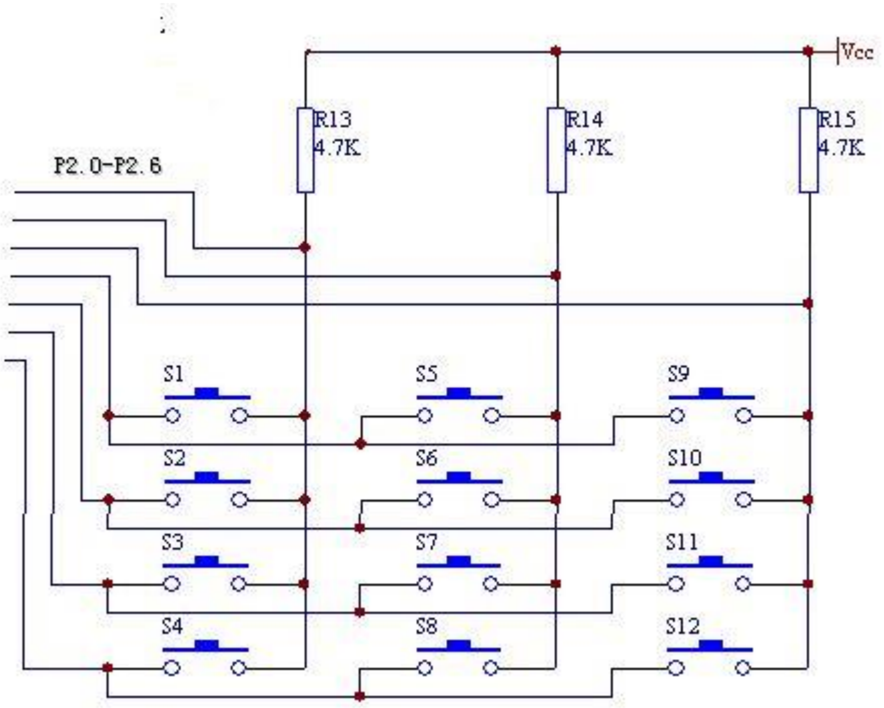


Figure 3-12 Keyboard circuit

The column line shown in the above figure is connected to +5V in resistance. If the key is not closed in the keyboard, then all the lines and columns in the figure are in a disconnected state, and the column line is at a high level. If any key in the keyboard is in the closed state, the row and column lines of the key will malfunction. If the connection between the input port of the microcomputer and the column line is completed in this case, it needs to be controlled by the computer to ensure that the output of the line P2.3 is low, and the other three routes are all at high power. level. And you can understand the alignment status through the input port. If P2.0-2.2 are all high level, then the meaning is that there is no closed key in the row line P2.3, and the final row line is low power, but there will be some high-level states, but, In the low-level part, the key at the intersection of the column line and the row line P2.3 is always closed; if there is no key closure in P2.3, adjust the row line P2.4 to low level, then The key positions of the remaining row lines are all high. Use the way you want to check the P2.4 line to see if there is a closed key. After that, check whether there is a key closure in the remaining row lines in a certain order. The above inspection method is one scan of the keyboard, and this method is often used by people in the process of keyboard recognition. To analyze the application principle of this method, you need to first judge the key position. If a key is pressed in the keyboard, you need to judge the position of the key, then extract the corresponding key code value, and finally refer to the key code value standard Select the corresponding function program.

3.4.2 Sound and light alarm circuit

The sound and light alarm is a relatively important device. Its function is mainly reflected in the detection of battery parameters. During the specific detection process, if a certain party is found to be faulty, it will use sound and light to send out an alarm to reduce battery damage. And the probability of accidents. The circuit is shown in Figure 3-13.

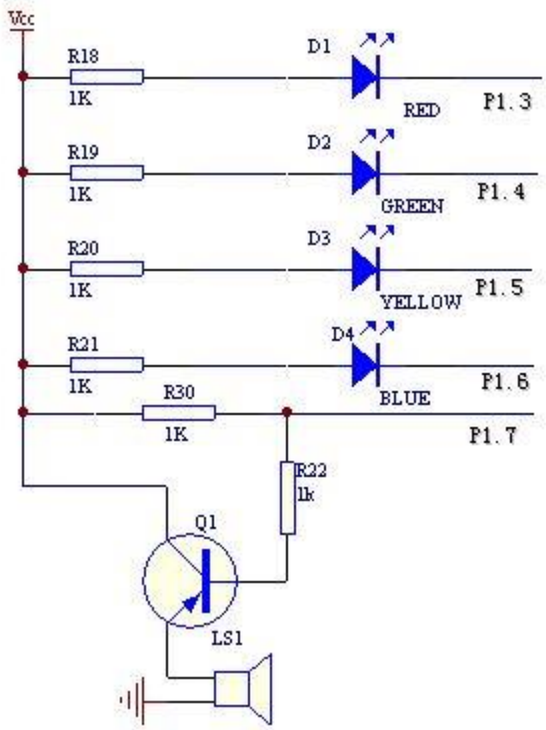


Figure 3-13 Sound and light alarm circuit

When designing the sound and light alarm device in this subject, 4 kinds of LED indicators are specially designed, namely red, blue, yellow, and green. In a sense, the I/O drive capability of the microcontroller itself is relatively poor. In order to ensure the stability of the drive, it is also necessary to add a transistor, or PNP, to the buzzer drive to ensure the buzzer's output. The voice is loud and loud. After the output of the single-chip microcomputer is low, the buzzer will sound, thereby reducing the probability of false alarms. Based on design flexibility and dynamic considerations, the author designed a dynamic flashing diode. When the red diode flashes, the voltage value exceeds the standard; the green indicator flashes, the current exceeds the standard; the yellow light flashes, and the temperature is not up to the standard. The blue light flashes and the remaining capacity is not up to standard. When the above data is abnormal, an alarm will appear.

4 Software Design

After the hardware circuit design is completed, it needs to be debugged. However, in the hardware and equipment, there is no software to control, then the system is flawed. If it is in the monitoring system, to complete the design of the software, it is necessary to meet the requirements of the small area.

1) Easy to **MAINTAIN**. Under normal circumstances, the software system designed and developed should be easy to understand. When errors are found, the methods of correction and modification should be as simple and convenient as possible. Because the detection and monitoring system is very complicated, in a relatively short period of time, the designer cannot achieve an error-free understanding of the entire system, and it is impossible to complete the design and debugging of the software at one time. There are many problems in the software operation. It was discovered in the process of software development. Therefore, when compiling software, it must be easy to understand and maintain.
2) **REAL-TIME**. In the detection and control system, the most common requirement is real-time. In response to the external occurrence time, the system must respond in a timely manner, and then provide the processing method and results in the shortest time.
3) **TESTABLE**. Testing the testability of the monitoring system software mainly includes two aspects: first, the formulation of test criteria should be simple and rapid to test the software; second, after the software is designed, it must first be run in a simulated environment. Then carry out static analysis and dynamic simulation operation, and put it into actual operation after confirming that there is no error.
4) **ACCURARY**. This is very important for the detection control system. There is a lot of calculation work in the system, and the control result will be directly affected by the accuracy and correctness of the algorithm. Therefore, the algorithm and the number of bits must meet the requirements when selecting the algorithm.
5) **RELIABLE**. Reliability is a very important indicator when testing control software. Reliability has two main requirements: during trial operation, even if there are changes in its parameters, it is necessary to ensure the stability of the software operation. Means it can still get the correct finally result. In a relatively harsh working environment, once the impact is greater, the software can run stably, which is very important for the detection and control system.

4.1 Development language and development environment

The compilation languages frequently used are assembly and C language. In the process of this design, the programming language used is assembly language.

When designing the microcontroller, the basic language used is assembly language. Using this programming language, developers can easily manage the hardware devices in the operating system. For assembly language, the design is usually completed by numbers, etc. This language has relatively low requirements for understanding and other aspects, and it is easy to remember. In the process of compiling, it can also correspond to machine language, and can also make up for the inconvenience of machine language memory, query, and modification. Programming refers to describing the problems that need to be solved step by step in a language that can be recognized by the computer. Unlike other microcomputers, the single-chip microcomputer has its own system software, and all the single-chip microcomputers need the user to set the program. . At present, many single-chip computers have realized programming in a high-level language environment, but the assembly language itself has many advantages that some high-level languages cannot match. For example, compact program structure, occupying only a small part of memory and CPU resources; close connection with the internal hardware of the computer, which can give full play to the role of the hardware; short program, super-fast execution speed; super real-time It can play a very good role in real-time detection and control system [9].

Usually, when using assembly language to design, the first thing to do is to analyze the problem to be solved, then determine the design idea and process, draw the specific flowchart clearly, and then complete the compilation. The last step, which is very critical, is to complete the system debugging. In the design here, these will not be reflected in turn.

In this design, the software mainly uses the system developed by WAVE, and the entire system contains many sub-modules. The functions of the software part are as follows: restore the system to the initial state, and design functions such as battery voltage and current.

In order to be able to realize the above-mentioned functions, it needs to be realized through the main program, measurement, and other modules, and the details are as follows.

4.2 Main program module

After completing the system design, it must be initialized. Clarify the settings of the flag bit and other parts and need to check whether the alarm value is set. If an interruption occurs after the system is initialized, then it is necessary to implement a keyboard scan and avoid the interruption of the timer. The specific frame diagram is shown in Figure 4-1.

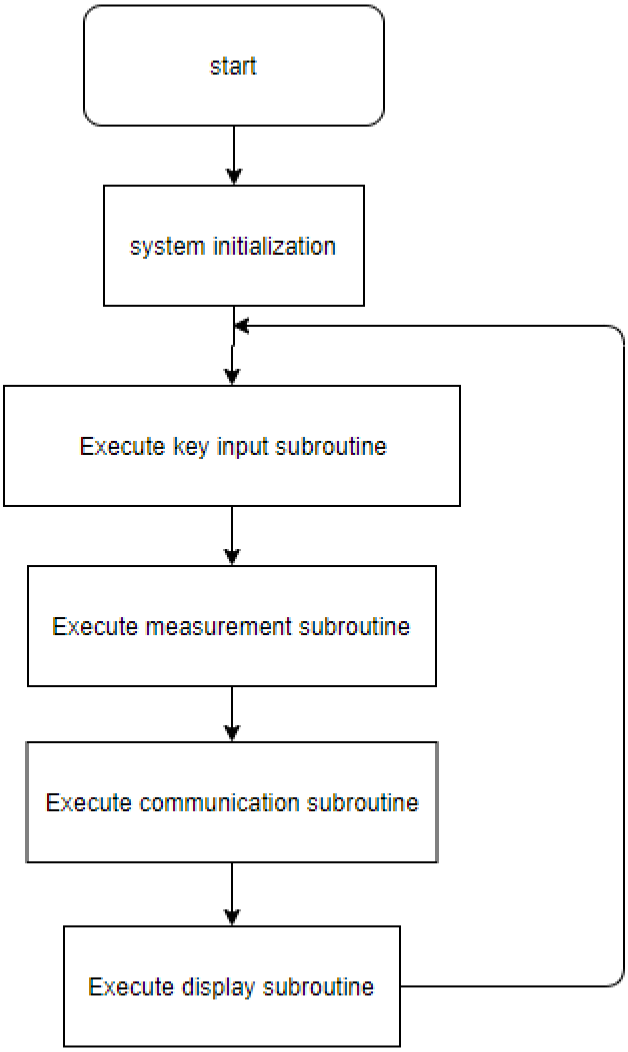


Figure 4-1 Main program flow diagram

4.2.1 Communication between DS2438 and MCU

If the communication between the host and the single-bus device is completed based on the sequence of initialization, then the flowchart is shown in Figure 4.2.

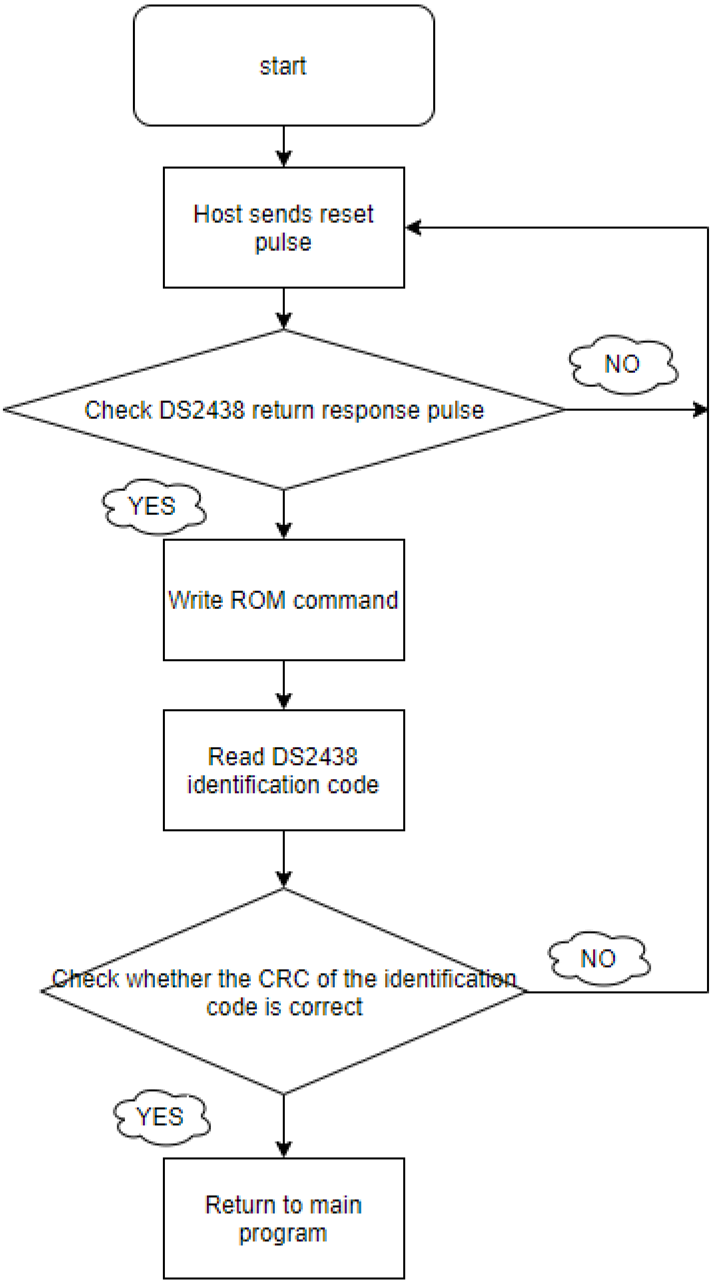


Figure 4-2 Communication flow chart between single-chip microcomputer and DS2438

The whole process of single bus communication mainly includes parts such as transmitting data. In this circuit, the timing signals include reset and other types of signals. When sending byte commands, it can directly adjust various types of timing signals. When designing, it is necessary to ensure that the duration of the execution of the command can be lower than the minimum duration of the timing signal. After the byte data is read and written, it is necessary to transmit control and other types of instructions. And in the process of data communication, the microcontroller is operated as a single-bus device. The usual process is: initialize the device, send ROM commands and RAM commands, and finally, need to complete the exchange of data.

4.2.2 The system detects the various parameters of the battery

1) Measurement of voltage, current, and temperature parameters

For DS2438, the specific parameter values of its various data are mainly stored in registers. Through the single-chip microcomputer, specific data information and related collection work are obtained. In the following Figures 4-3 and 4-4, the sampling flowchart of current, voltage, and temperature.

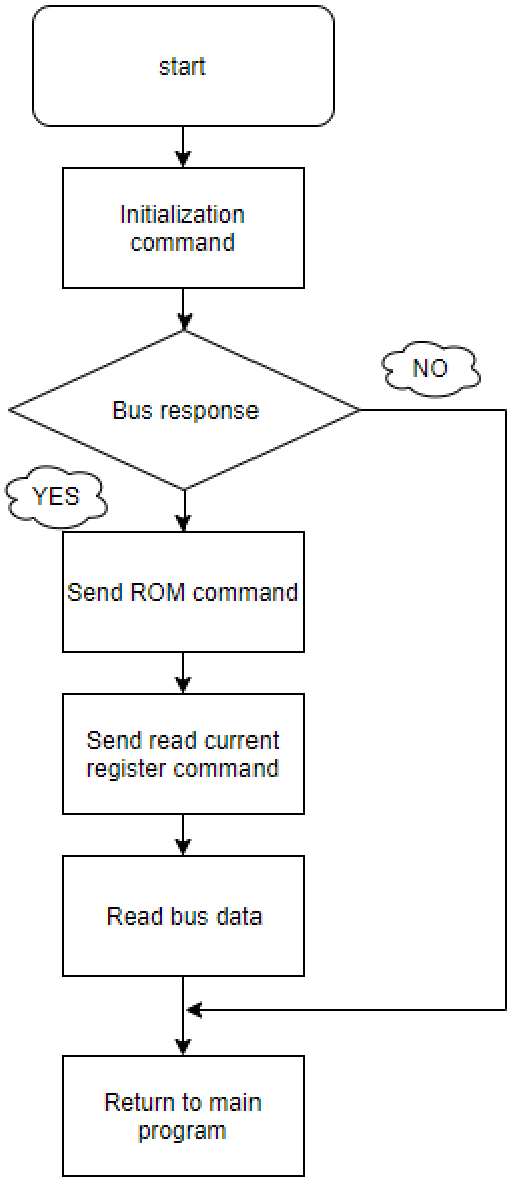


Figure 4-3 Current sampling flow chart

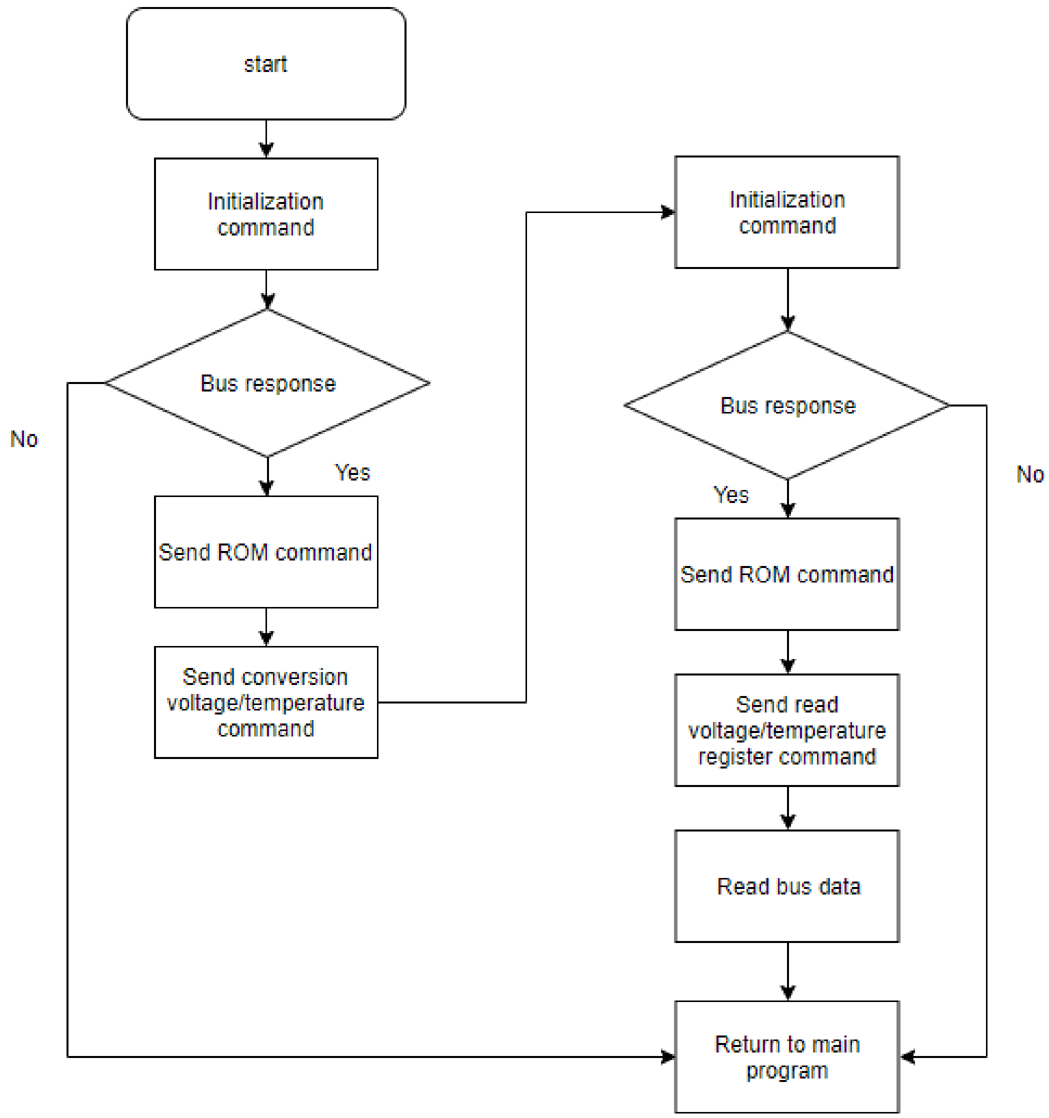


Figure 4-4 Voltage/temperature sampling flow chart

It can be seen from the above flowchart that in the process of collecting current, voltage, and temperature, the specific processes are not the same. This is also because, in the process of completing current sampling, it is necessary to maintain the speed of 36.41 times/sec to complete the collection of current data. However, under normal circumstances, the voltage and temperature are not automatically obtained. After the command conversion of the voltage and temperature is completed by the single-chip microcomputer, the voltage and temperature data can be accurately read through the register.

2) Remaining capacitance detection

In order to obtain the remaining battery capacity, it is necessary to use the state of charge to show the battery capacity, that is, the SOC, which is also a relatively important parameter value for the remaining capacity state of the battery. In addition, the SOC cannot be obtained through detection during this process, and its value needs to be calculated through the accumulated value of the current integral in the register, and then it can be obtained. In DS2438, use ICA to detect the remaining power. If the ICA changes, it will be modified after the detection is completed, and the net accumulated value of the incoming and outgoing current will be stored. In this process, there is no need to implement management and control, just use the microcontroller to obtain the ICA register value. After that, the read value is substituted into the formula, and finally, the specific value of the remaining power can be obtained, which is ICA/(2048*RSENS). The specific process of remaining battery detection is shown in Figure 4 -5.

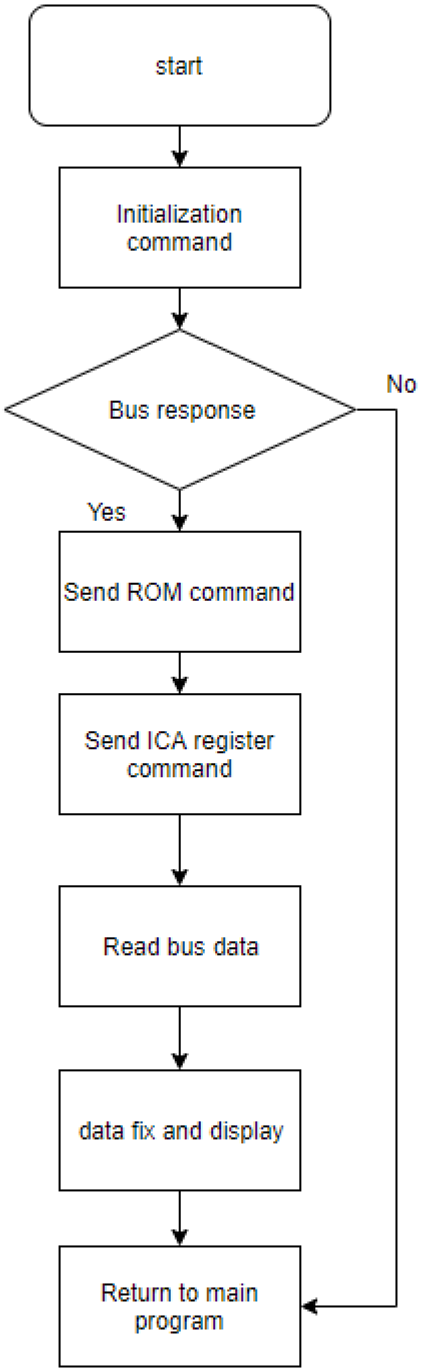


Figure 4-5 Flow chart of remaining battery detection

By reading the register value, reading errors can be avoided. However, it is necessary to detect whether the DS2438 has modified the contents stored in the register, which requires an accurate judgment of the status or the status of the bit.

4.3 Display circuit subroutine

4.3.1 1602 LCD display basic operation sequence

In 1602, there are mainly 4 kinds of operation timings

	RS	R/W	E	D0-D7
Read state	Low	High	High	State
Write cmd	Low	Low	High pulse	-
Read data	High	Low	High	Output
Write data	High	Low	High pulse	data

4.3.2 Display subroutine function and flow

For the display program flowchart part, the specific situation is shown in Figure 4-6:

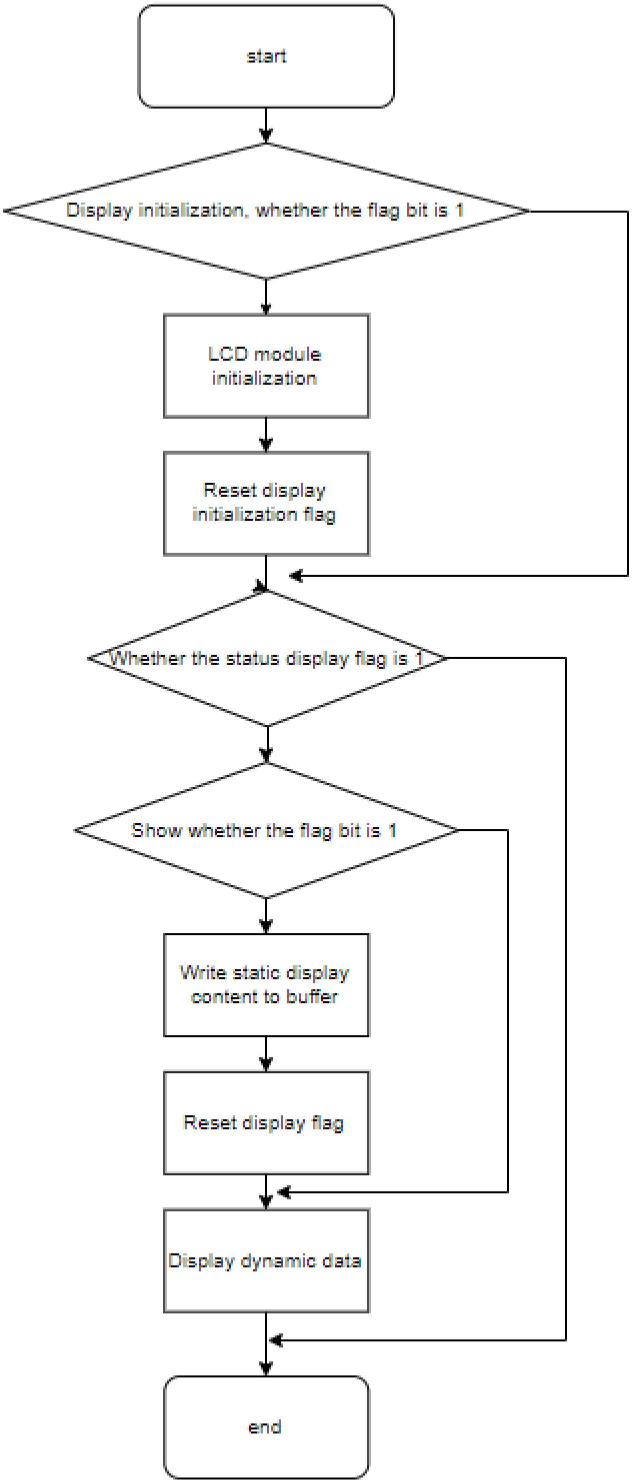


Figure 4-6 shows the flow diagram of the subroutine

In this system, the requirement for the LCD screen is to clearly display the battery voltage, current, and other information. These data need to be fixed on the display screen, and the data values of these items need to be updated on time. When the system enters the setting state, the corresponding information screen needs to be set at the bottom of the screen. If there is no corresponding operation when the system is in use, the actual situation of the first channel will be displayed. When observing the status of other circuits, you need to adjust it through the keyboard to show the circuit status and clarify the position of the mark. When an alarm condition occurs, an alarm symbol will be displayed at the upper right position of the screen.

5 System test

After the design is completed, it needs to be adjusted in accordance with the requirements of the program to close the loopholes and improve the system reliability. When debugging, you need to check the part first, and then check the whole. Each module is gradually adjusted and jointly debugged to ensure the effective operation of the control system.

5.1 Test steps

1. Hardware circuit detection: first check whether each pin of each module is connected correctly, check whether the reset circuit of the single-chip microcomputer and the crystal oscillator is working normally; check whether the components are soldered;

2. For software debugging, after the program is compiled and reviewed, the program can be placed on the microcontroller according to the results of the information prompt box, that is, the status of 0 error and 0 warning.

3. Online debugging: After the hardware circuit detection and software debugging pass, further overall debugging is carried out. The purpose of system joint debugging is to test whether the system can accurately complete operations such as data collection, single-chip data processing, and LCD1602 display. Whether it can meet the design requirements of the topic.

5.2 Hardware test

Based on the AT89C51 single-chip microcomputer chip, the system design is completed. Its main functions include the measurement of the battery voltage, current, and temperature, and transfer it to the single-chip microcomputer, and control the LCD display after program processing. And can give an alarm prompt according to the parameter value. For the above functions, the following aspects are mainly debugged:

1) After the single-chip microcomputer is reset, whether the working state of its circuit and crystal oscillator is normal or not.

2) Welding of components.

3) The change of pin voltage.

5.3 Software test

The programming language of the system is the same as the one-chip computer C51, which can be compiled or debugged in the Keli4 environment [20]. If it is software programming, then all modules need to complete the operations of nominal, debugging, device debugging, and online debugging. The most important one is the last step, which will affect the success of the system.

After the program is compiled and reviewed, if the result of the message prompt box is 0 error and 0 warning, then the program can be placed in the microcontroller. The code of the AT59C51 system can be downloaded through STC-ISP V35, and the computer serial port can be used to write its program to the single-chip microcomputer.

Step1 selects the AT89C51 microcontroller.

Step2: Press Open File to debug the program and form a HEX file.

Step3: Determine the COM port and baud rate.

Step4: Select the default value of the system.

Step5: Click Download and start the power supply of the MCU development board. In the next message, the prompt box will directly display that it is in the encrypted state, which means that the program has been downloaded.

5.4 System overall joint test

Before the overall joint test of the system, the simulation experiment can be carried out through the Proteus simulation software. The system simulation diagram is shown in Figure 5-1. The simulation consists of analog sensors, the minimum system of the single-chip microcomputer, AD analog-to-digital conversion, and LCD1602 display circuit.

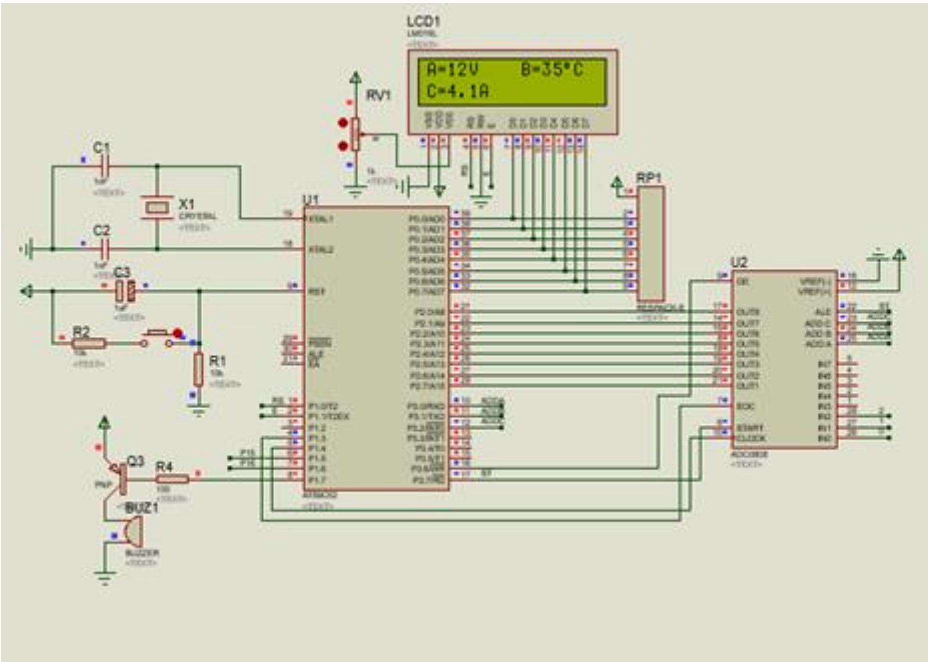


Figure 5-1 System simulation diagram

After the simulation experiment is completed, further overall debugging is carried out. The system joint debugging is to test whether the system can accurately complete operations from data acquisition, data conversion, data processing, and LCD1602 display.

After all the modules are built, power on to provide the sensor with a sensitive test signal, observe whether the LCD1602 display is correct. Complete the system joint test.

6 Conclusion

After this experience in designing an online battery system, I have gained a lot. The design of each content needs to consult a large number of literature materials, and then go through repeated inspections to ensure the success of the system design.

On the whole, the process of this design is very complicated: When designing the hardware circuit, you need to consider what kind of device to choose to enable the overall function of the system to be realized. When the process is completed, you must also consider the chip used. Appropriate or not; when programming the software, you need to consider the designed hardware circuit, and then comprehensively consider the programming method and the function of the chip. In addition, the practicability and feasibility of the entire design scheme cannot be ignored either.

In the process of this design, the control system is mainly realized by a single-chip microcomputer, and the circuits involved mainly include signal acquisition, keyboard input, interface with the host computer, LCD liquid crystal, holy light alarm and so on. For the controller part, it is mainly a single-chip microcomputer to complete the management, control and use the cooperation of programming software and circuits to detect various data of the battery. The data obtained is directly transmitted through the interface circuit on the position of the upper computer and is shown to the staff in the display. And through the automatic operation of the system, the parameters are output and displayed. If the obtained parameter value does not meet the pre-set alarm value. The system will give an audible and visual alarm. Through the above process, the working status of the battery can be well monitored.

In this design, the key content is to obtain the specific values of all the data of the battery, and the obtained data can be displayed on the display screen. For software design, it is mainly to complete the programming of DS2438, and when designing, the biggest problem encountered is the design problem of timing.

It was my original intention to build a vehicle BMS model, but with the in-depth study and perfect product design, huge difficulties appeared when making prototype products. Due to the limited time and the infinite knowledge, I realized that I lacked the ability to make prototypes, and because of the epidemic, the one-and-a-half-year study was particularly difficult. There were less teacher-student exchanges and lack of laboratory courses. , The confusion encountered in the process of self-learning. All these made me feel anxious when I was approaching graduation. Maybe I will continue to refine my design and make a prototype in the future.

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