DEVELOPMENT OF SOFTWARE AND HARDWARE FOR AN INTELLIGENT LI-ION BATTERY CHARGE CONTROLLER BASED ON THE ATMEGA48PA-PU MICROCONTROLLER

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ANNOTATION

This article discusses the basic methods and means of organizing the correct operation of lithium-ion batteries and shows the main stages of developing software and hardware for an intelligent charge controller for lithium-ion batteries based on the Atmega8 microcontroller.

Key words: lithium-ion batteries, microcontroller, ATmega48PA-PU, controller, charging, discharging, chip

INTRODUCTION

Currently, lithium-based batteries are very widely used in various fields of technology [1, 2]. Various types of such batteries are used almost everywhere - from cell phones and mobile computer equipment to high-power power supplies for vehicles such as electric vehicles, unmanned aerial vehicles and underwater vehicles [3]. The most widely used are the so-called lithium-ion and lithium-polymer batteries (these are traditional names; although essentially all lithium batteries are lithium-ion, now lithium-ion is usually understood as batteries of early developments with liquid or gel electrolyte, other names are related with the material or design of the electrolyte or electrode) [4]. In addition to the two named types, a large number of other lithium-based batteries are also known (for example, lithium-iron phosphate batteries are commercially produced for use in transport [5]), but it is these two subclasses that significantly exceed all others in terms of the scale of their production and have much in common both in terms of output parameters, as well as in charge and discharge processes. Therefore, further under the short name "lithium" we will mean precisely these two varieties, although much of what modern technology provides to ensure high-quality charge-discharge of batteries is also applicable to other types. and in the processes of charge and discharge. Therefore, further under the short name "lithium" we will mean precisely these two varieties, although much of what modern technology provides to ensure high-quality charge-discharge of batteries is also applicable to other types. and in the processes of charge and discharge. Therefore, further under the short name "lithium" we will mean precisely these two varieties, although much of what modern technology provides to ensure high-quality charge-discharge of batteries is also applicable to other types.

The advantages of lithium batteries are obvious: they have a large specific energy capacity (150-250 W•h/kg versus 40-80 W•h/kg for their main competitors -

nickel-cadmium or nickel-metal hydride batteries), withstand high pulse discharge currents - 20 -40C, have low self-discharge (1%/month versus 20%/month for nickel-cadmium). A serious advantage of lithium batteries is the absence of a “memory effect”, as well as the high value of electromotive force (EMF) of a single cell (3.6 V versus 1.2 V for nickel-cadmium batteries).

However, there are some technical problems that accompany the operation of lithium batteries. First of all, this relates to the sensitivity of these batteries to deep discharge and excessive overcharging. Overheating or mechanical damage to battery cells is also unacceptable. Failure to comply with these conditions sometimes results in batteries catching fire or exploding. Although in recent years certain types of lithium batteries have appeared that have increased resistance to mechanical damage (for example, lithium-sulfur batteries [6]), they are not yet mass-produced, and the problem still persists.

In many cases, power supplies are not single battery cells, but sets of such cells (sections) connected in series into batteries having the required voltage. Mass production of multi-section batteries with from 2 to 6 sections has been established on the largest scale. For certain applications, multi-section batteries with several dozen sections are produced. The peculiarities of the electrochemical processes occurring in battery cells lead to the fact that over time the cells begin to differ from each other in energy capacity and internal resistance, which leads to imbalance - uneven distribution of voltage across sections. Subsequently, if special measures are not taken, this can lead to at least a decrease in the efficiency of battery use (underutilization of its capacity),

To comply with the safe modes of charging and discharging batteries (batteries), it is necessary to supply them with special electronic devices that provide control and equalization of voltages in individual sections. This is especially true for high-energy batteries with cell capacities over 5 Ah.

Devices for monitoring and controlling the processes of charge-discharge in a battery are built, as a rule, on the basis of microcontrollers and specialized microcircuits. These devices can be built into the battery itself, or into external service units, such as chargers. In stand-alone computers, the charge-discharge control of the battery is assigned to a special power management subsystem. This article will consider the stages of development of such a controller to ensure the smooth operation and charge of lithium-ion batteries.

INTELLIGENT LI-ION BATTERY CHARGE CONTROLLER ON TP4056 CHIP

The lithium-ion battery charge controller was developed based on the Atmega48 microcontroller and the TP4056 chip.

The ATmega48PA-PU microcontroller is a popular chip from Atmel's AVR ATmega family of microcontrollers. The pin locations of the ATmega48 microcontroller are shown in Figure 1.

The ATmega48PA-PU is designed as a DIP chip with standard pin spacing, which means it can be easily installed on a breadboard.

To flash the microcontroller firmware, you will need a programmer such as AVRISP mkII. You can also use the Arduino board as a programmer, with the ArduinoISP sketch installed on it, which is standard and available with the Arduino IDE.

For compiling C++ programs, there are freely distributed tools: avr-gcc (Linux, MacOS) and WinAVR (Windows).

To make the chip work you need a stable power supply, which can be obtained through a voltage regulator.

The chip has an internal oscillator that allows the microcontroller to operate at a clock frequency of 8 MHz. A higher frequency can be set by connecting a quartz resonator to the microcircuit.

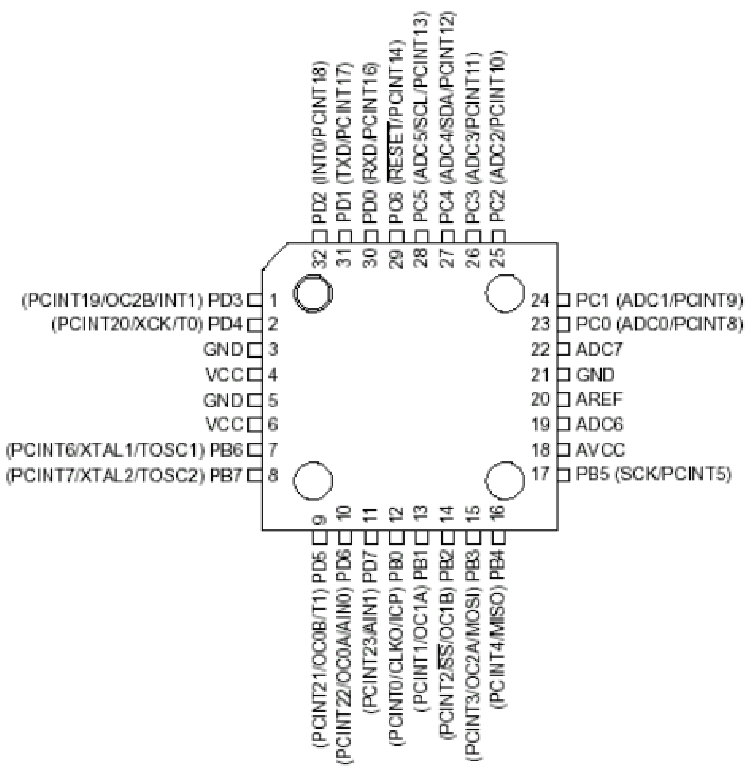

Figure -1 – Atmega48 microcontroller pinout

Characteristics

- Clock frequency: 0 - 20 MHz
- Flash memory size: 4 KB
- SRAM size: 512 bytes

- EEPROM size: 256 bytes
- Supply voltage: 1.8 – 5.5 V
- Current consumption in operating mode: 0.2 mA (1 MHz, 1.8 V)
- Sleep current consumption: 0.75 μA (1 MHz, 1.8 V)
- Number of timers/counters: 2 eight-bit, 1 sixteen-bit
- Total number of ports: 23
- Number of PWM outputs: 6
- Number of ADC channels (analogue inputs): 6
- Number of hardware USARTs (Serial): 1
- Number of hardware SPIs: 1 Master/Slave
- Number of hardware I²C/SPI: 1
- ADC resolution: 10 bits

The TP4056 (TC4056A) chip is a full-fledged linear CC/CV charge controller for Li-Ion batteries that requires a minimum number of external components for its operation. The maximum charge current is 1A, the charge voltage is 4.2V, there is an input for connecting a battery overheat sensor. The connection diagram of this microcircuit is shown in the figure.

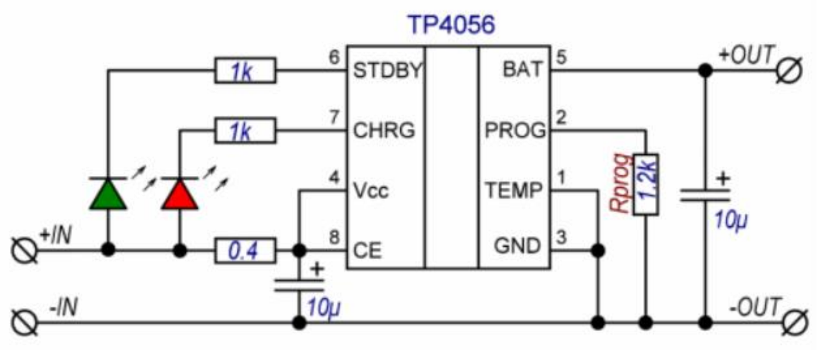

Figure 2 - TP4056 chip connection diagram

Table-1 - Characteristics of the TP4056 chip

Model	TP4056/ TC4056A
Input voltage	4...8 V
Charge current	50...1000mA
Charge completion voltage	4.2V
Frame	SOP-8
Operating temperature range	-40...+85°C

Based on these components, a general circuit diagram of the controller was assembled (Fig. 3) and software was developed in the C language. Block diagram of this program is shown in Figure 4.

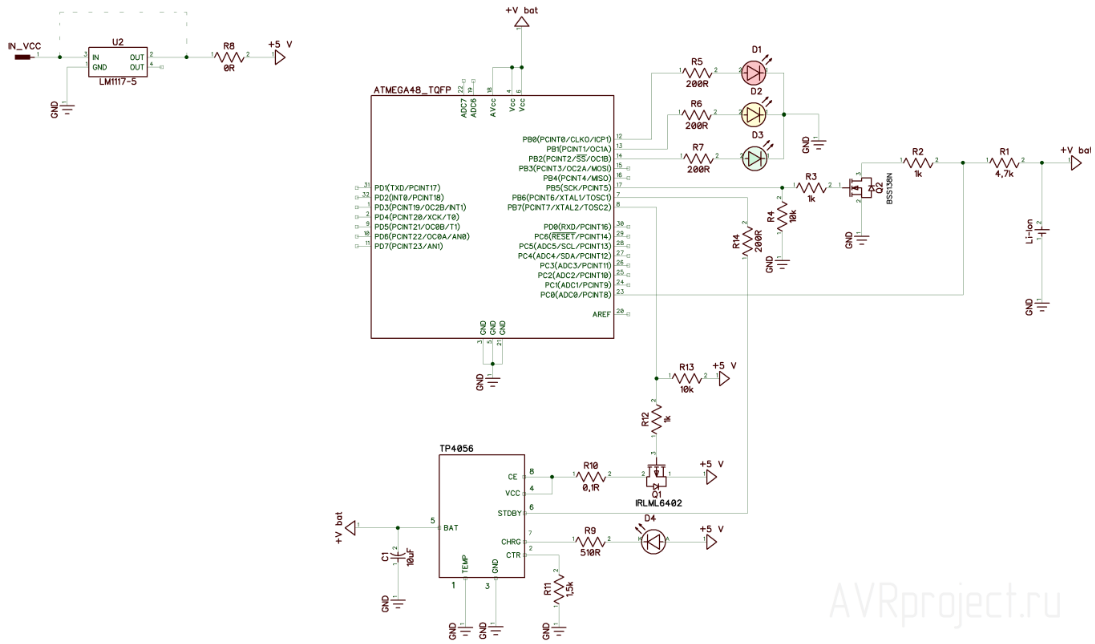

Figure 3 – General diagram of the controller

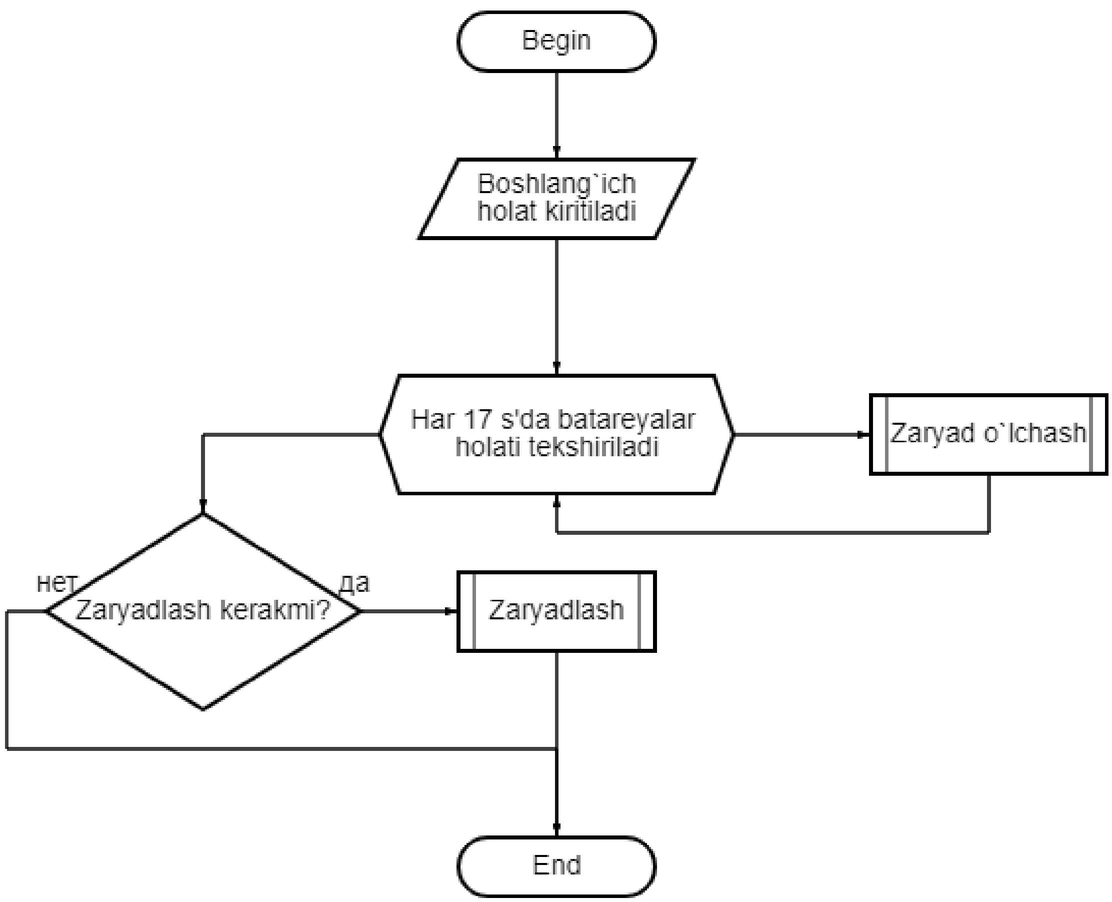

Figure 4 – Block – software diagram

DEVICE OPERATION LOGIC

The microcontroller occasionally (about every 17 seconds) wakes up, measures the voltage on the battery and goes back to sleep. The remaining charge on the battery is visually displayed by three LEDs: if the voltage is above 3.6 volts, the green LED (D3) flashes, if the voltage is from 3.6 to 3.3 volts, the yellow LED (D2) flashes. If the voltage is below 3.3 volts, the red LED (D1) starts flashing. If the battery is discharged to 3.2 volts or less, charging on the TP4056 chip is switched on, which is turned on by transistor Q1.

In order to reduce battery consumption on the resistor divider R1-R2, a field-effect transistor Q2 is used. Before measuring the voltage, we open the transistor - we close the divider to the ground, we measure the voltage - we close the transistor, thus eliminating unnecessary waste of energy.

An input voltage of 5 volts, required to recharge the battery, is supplied to the V input connector. If you plan to apply more voltage there, the board provides a place for the LM1117-5 stabilizer in the SOT-223 package.

CONCLUSION

Managing the charge-discharge processes of lithium batteries is a rather complex and responsible task. However, today it has been greatly facilitated due to the presence on the market of a large number of different microcircuits, modules and finished products that are designed specifically to solve this technical problem. In this article, the task was set to develop software and hardware of a controller for charging lithium-ion batteries and the task was completed.

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