# Design and Simulation of Digital Voltmeter Based on Single Chip Computer

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**Abstract:** Pure hardware digital voltmeter has complex structure, low measurement accuracy and high price. In daily use, it has a high frequency of use, resulting in frequent damage to the multimeter and high failure rate, which brings a lot of inconvenience to the use and maintenance. In order to design a high precision digital voltmeter, the method of combining AT89C52 single chip computer with ADC0809 A/D conversion is adopted. Through Proteus simulation experiment, we get the measurement effect that the ordinary hardware digital voltmeter cannot achieve. The experimental results show that the digital voltmeter has the advantages of simple structure, high measurement accuracy and low failure rate.

## 1. Introduction

Analog voltmeter has a high precision and has a wide market. Now many engineers are still using analog voltmeter. It is true that analog voltmeters are accurate in displaying measured values, but there are also problems. Analog voltmeter adopts pointer type, which is magnetoelectric or electromagnetic structure, so its response speed is slow [1]. However, in today's society with rapid development, the demand for high-speed signal processing is increasing. Because of the slow response speed of analog voltmeter, it is no longer suitable for high-speed signal field, but will be replaced by digital voltmeter. But the accuracy of digital voltmeter is not very high because of sampling error. At present, however, the error can be reduced by technical means. Its accuracy is as accurate or even higher as that of analog voltmeter. It is obvious that digital voltmeter will replace analog voltmeter in the future. Nowadays, more and more digital measuring instruments appear, but their principles are different from those of digital voltmeters. Therefore, it is of great practical significance to study digital voltmeters. In the actual measurement of electric quantity, voltage, current and frequency are the most basic three measured objects. Voltage measurement is the most frequent. With the continuous development of electronic technology, high-precision voltage measurement becomes inevitable. Therefore, digital voltmeter has become an indispensable measuring tool. Because of the characteristics of accurate and convenient reading, high accuracy, high sensitivity, high resolution, small error and fast measurement speed, digital measuring instrument is popular with users [2].

## 2. Overall Design Scheme of Digital Voltmeter Based on Single Chip Computer

The measured voltage is converted from analog value to digital value by A/D converter, which is output to LCD screen under the logic control of MCU. A simple digital voltmeter is designed with AT89C52 chip and ADC 0809 A/D conversion chip. It can measure the analog DC voltage from 0V to 20V, and display it by LCD1602. The measurement error is about 0.01 V. The analog voltage input of ADC0809 chip is 0V~20V, and the corresponding digital quantity is generated and transmitted to the AT89C52 chip through its output channel D0~D7 [3]. A/D conversion is mainly accomplished by ADC0809 chip, which is mainly responsible for converting the collected analog data to the corresponding digital data and then transferring it to the data processing module. Data processing is completed by AT89C52 single chip computer, which is responsible for processing the digital data transmitted by ADC0809 and producing the corresponding display code to the display module for display. The range conversion module is mainly composed of relays and voltage dividers. Resistance is composed of single-chip computer to control the relay switching attenuation multiple to achieve

range conversion. The display module is mainly composed of LCD1602, which can display the measured voltage in real time. Because the development of single-chip computer is mature, many application circuits can be assembled by the combination of software and hardware of single-chip computer system. The principle of this scheme is a reference voltage source of analog-to-digital converter chip. The measured voltage input terminal inputs the reference voltage and the measured voltage respectively. The analog-to-digital converter chip converts the analog voltage signals collected by the measured voltage input terminal into corresponding digital signals, and then programs the software of the single-chip computer system so that the single-chip computer system can collect these digital signals according to the specified time sequence, and calculates the value of the measured voltage through a certain algorithm. Finally, the calculated measured voltage value is sent to the display circuit module in a certain time sequence for display [4].

## 3. Selection and Design of Digital Voltmeter Hardware Based on Single Chip Computer

### 3.1 Selection of Single Chip Computer.

AT89C52 is a low-power, high-performance CMOS 8-bit microcontroller. The chip contains 4 K Bytes ISP (In-system programmable) Flash read-only program memory which can be erased 1000 times repeatedly. The device is manufactured by ATMEL's high-density, non-volatile storage technology. It is compatible with standard MCS-51 instruction system and 80C51 pin structure. The chip is integrated with a general-purpose 8-bit central processor and ISP Flash memory sheet. AT89C52 is a powerful microcomputer, which can provide cost-effective solutions for many embedded control applications. Flash on chip allows program memory to be programmed in the system and is also suitable for conventional programmers. On a single chip, AT89C52 is widely used in many embedded control applications because of its smart 8-bit CPU and system programmable Flash.

### 3.2 Selection of Monitor.

Ordinary LED digital tube can only be used to display numbers. If you want to display English, Chinese characters or images, you must use liquid crystal display. The English name of LCD is Liquid Crystal Display, short for LCD. As a display device, LCD has the advantages of small size, light weight and low power consumption, so LCD has become an ideal display for various portable electronic products, such as electronic watches, displays on calculators and so on. According to the display content of LCD, it can be divided into three types: segment LCD, character LCD and dot matrix LCD. Among them, character LCD is an ideal substitute for LED digital tube because of its low cost, rich display content, beautiful appearance and convenient use. When INTR becomes low level, CS is set low first, then RD is set low. After RD is set low at least through time, the data on the data output port reaches a stable state. At this time, the data on the data output port is read directly. After reading the data, RD is raised immediately, and then CS is raised. INTR is changed automatically without human interference.

### 3.3 Selection of Conversion Chip.

ADC0809 is an 8-bit ADC0809 which belongs to a continuous progressive A/D converter. ADC0809 is a single channel analog input, 8-digit digital output function A/D converter, conversion time is 100us, analog input voltage range is 0V~5V, with reference voltage input, including a clock generator, without zero adjustment.

### 3.4 Circuit Design.

AT89C52 is a low-voltage, high-performance CMOS 8-bit microcontroller produced by ATMEL Company in the United States. The chip contains 8KB Flash Read-Only Program Memory which can be erased repeatedly and 128 bytes Random Access Data Memory. The device is manufactured with ATMEL's high-density, non-volatile storage technology, compatible with the standard MCS-51 instruction system, and flexibly applied to various control fields. The minimum system circuit of AT89C52 is composed of four parts: control circuit, reset circuit, crystal oscillator circuit and power

circuit. The main control circuit is mainly composed of AT89C52 chip. In the circuit, U1 is AT89C52, P4 is pull-up resistance of P0, and C5 is decoupling capacitor of MCU.

AT89C52 MCU needs to reset when it starts running or when it crashes, so that CPU and other functional components are in a certain initial state, and work from this state. The reset signal produced by the reset circuit (high level effective) is fed into the internal reset circuit by RST pins, and the reset signal of AT89C52 single chip computer is reset. The reset signal should last more than two machine cycles (24 clock cycles), so that the AT89C52 single chip computer can be reset reliably. The working principle of reset circuit: the potential of RST pin is equal to that of VCC at the instant of power-on. RST pin is high level. With the decrease of charging current of capacitor C6, the potential of RST pin decreases continuously. Its charging time constant is T=R9*C6=100ms. This time constant is enough for RST pin to complete reset operation in the time of maintaining high level. When the single chip computer is in operation, press the reset key S1 and release it. It can also keep the RST pin of the single chip computer at a high level for a period of time, thus realizing the manual reset of AT89C52 single chip computer.

XTAL1 and XTAL2 are the input terminals of in-chip oscillation circuit. These terminals are used to connect external quartz crystal and fine-tuning capacitor, i.e. to connect the timing feedback loop of OSC in AT89C52 single chip computer. After the crystal oscillation is started, a sine wave of about 3V should be output at the XTAL2 end so that the OSC circuit in the chip can self-oscillate at the same frequency as the crystal oscillation. Usually, the output clock frequency FOSC of OSC is 6MHZ-16MHZ, and the typical value is 12MHZ or 11.059MHZ. Capacitors C5 and C6 help the crystal oscillate, with a typical value of 30pf. The purpose of fine tuning FOSC can be achieved by adjusting them. In this system, the crystal oscillation is 12MHZ.

## 4. Program Design and Simulation of Digital Voltmeter Based on Single Chip Computer

### 4.1 Program Design of Digital Voltmeter Based on Single Chip Computer.

We divide the system program into initialization module, A/D conversion subroutine and display subroutine. The three program modules constitute the main program of the whole system software, and the program flow is shown in Figure 1.

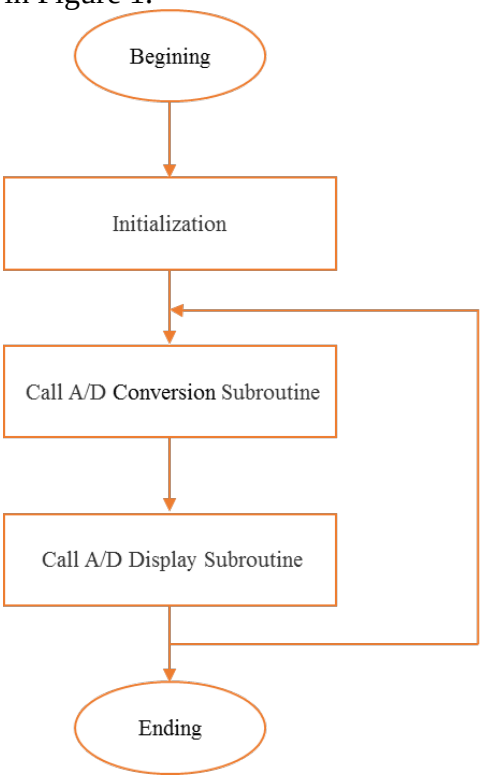


Figure 1. Main program of digital voltmeter based on single chip computer

Initialization is to set the initial working state of the internal components or extended chips of the microcontroller to be used. The main work of the initialization subroutine is to set the working mode of the timer, initial value preset, interrupt and open the timer, etc. A/D conversion subroutine is used to control the acquisition and measurement of the input module voltage signal, and the corresponding values are stored in the corresponding memory unit. A/D conversion subroutine is used to control the acquisition and measurement of the input module voltage signal, and the corresponding values are stored in the corresponding memory units. The display subroutine uses dynamic scanning to realize the display value of four-digit digital tube. When using dynamic scanning display mode, it is necessary to set appropriate scanning frequency to make the LED display more uniform and have enough brightness. The system uses 70 HZ scanning frequency and 10 ms interval to scan the LED dynamically. The display time of each LED is 1 ms, which can produce ideal display effect.

### 4.2 Simulation of Digital Voltmeter Based on Single Chip Computer.

We use C51 language to design waveform generation program, and use Proteus to carry out modular simulation. The simulation result of digital voltmeter is shown in Figure 2. Nine voltage values were randomly tested for the sample. The simulation results are very close to the actual input voltage. When the sliding rheostat connected to the AD converter is changed, the voltage of the analog voltage source changes, and the value of the voltage on the LCD is basically the same, the accuracy is ±0.1%. When the input voltage is 3.10V, the simulation result is 3.09V. The absolute error is 0.01 V, which meets the design requirements.

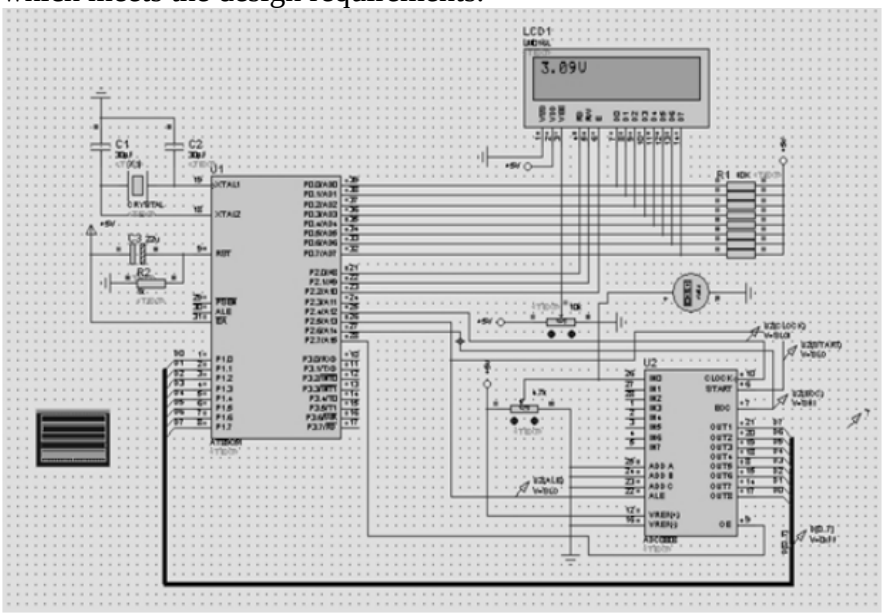


Figure 2. Result of Digital Voltmeter simulation

## 5. Conclusion

The digital voltmeter based on single chip computer has the advantages of simple structure, less external components, low price, strong practicability and high reliability. Therefore, in practical application, it is very convenient to measure digital voltage, with high measurement accuracy, accurate measurement voltage value, high stability, and can achieve the desired effect.

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