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Design of Digital Frequency Meter Based on MCU

Yali He

Zhoukou Normal University, Zhoukou, Henan, 466001, China

Abstract

This article designs a digital cymometer with STC89C52 as the control core. The system is mainly composed of a main control module, an amplifying module composed of a triode, a processing module composed of a Schmitt trigger 74HC14, a frequency dividing module, an LCD display module, etc. The system can realize the frequency measurement of sine wave, rectangular wave and triangle wave in the range of 1Hz~20MHz. This design was simulated using Proteus software and downloaded to the development board for hardware testing. The simulation and test results show that the design has achieved the predetermined functions, and has the characteristics of high cost performance and accurate measurement.

Keywords

Digital frequency meter; STC89C52 single chip microcomputer; Proteus simulation.

1. Introduction

Digital frequency meter is an indispensable measuring instrument in scientific research and production fields such as computer, communication equipment, audio and video. It is a digital measuring instrument that displays the frequency of the measured signal with decimal numbers. Its basic function is to measure sine signals, square wave signals and various other physical quantities that change per unit time. In the process of designing, installing and debugging analog and digital circuits, because of its use of decimal number display, the measurement is rapid, the accuracy is high, and the display is intuitive, so a frequency meter is often used.

The digital cymometer designed in this article will use timing and counting methods to measure frequency, and use a 1602A LCD display to dynamically display 6 digits. The measurement range is sine wave, square wave, and triangle wave from 1Hz-10kHz, and the time base width is 1us, 10us, 100us, and 1ms. The single-chip microcomputer is used to realize the automatic measurement function.

The basic design principle is a measuring device that directly displays the frequency of the measured signal with decimal numbers. It uses the method of measuring period to automatically measure the frequency of sine waves, square waves, and triangle waves.

2. Overall Design

The design is based on the STC89C52 single-chip microcomputer as the platform. The STC89C52 single-chip microcomputer can collect and analyze the frequency. It can measure the frequency of periodic signals such as 1HZ to 10MHZ sine wave, triangle wave, and square wave signal, and can display the frequency and period of the measured signal in On the LCD screen. Through the LCD screen, the user can clearly see the current input frequency of the master. Therefore, according to the functions to be realized by the design, the hardware system can be divided into five modules in total, namely, the module, the display module, the amplification module, the frequency division module, and the processing module.

Main control module: This system selects STC89C52 single-chip microcomputer as the main control element, and finally realizes the counting and display of the counting control signal of the frequency division test.

Display module: This design uses LCD liquid crystal display, which has powerful functions and can display a large number of texts and graphics. The display is diverse and clearly visible. For this design, an LCD1602 liquid crystal display is enough, and the price is acceptable. More interface lines, but it will bring a lot of convenience to debugging.

Amplification module: The amplifying circuit is mainly used to amplify the signal to be measured, which can reduce the requirements for the amplitude of the signal to be measured. This design uses a triode or a field effect tube as the amplifying circuit. The original parts needed for the triode amplifying circuit are relatively simple and easy to purchase, and the circuit is relatively mature, the price of the triode is also very low, and the performance of the triode circuit is superior, which is low-cost as an amplifying circuit choose.

Frequency division module: Consider the external counting of the single-chip microcomputer. When using a 12MHz clock, the maximum counting rate is 500kHz. The maximum frequency measured by this design is 4MHz, so an external frequency division is required. The frequency divider circuit is used to expand the frequency measurement range of the single-chip microcomputer, and realize the use of a unified signal for the frequency measurement of the single-chip microcomputer, which makes the frequency measurement of the single-chip microcomputer easier to implement, and at the same time reduces the frequency measurement error of the system.

Processing module: The processing circuit converts the measured non-square wave signal into a square wave signal, which is convenient for measurement.

The overall design of the system: The system takes the single-chip microcomputer as the control core, and initializes the system. It mainly completes the control of functions such as liquid crystal display, frequency measurement, amplification, processing and filtering, and plays a role in the overall control and coordination of the work between various modules. As shown in Figure 1, the system mainly consists of a triode amplifier circuit, a processing circuit, a frequency divider circuit, a liquid crystal display and a main control module single-chip microcomputer.

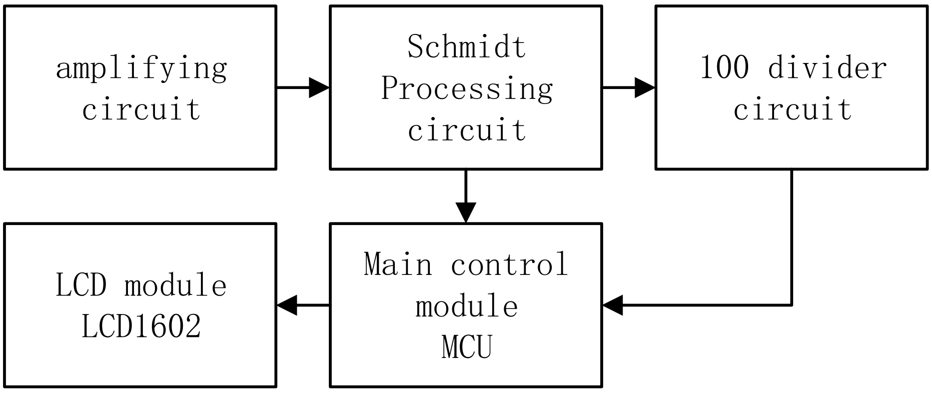


Figure 1. System structure block diagram

3. System Hardware Circuit Design

3.1. Minimal System Design of Single Chip Microcomputer

Figure 2 below is the circuit diagram of the minimum system of the single-chip microcomputer. The minimum system of the single-chip microcomputer is composed of the single-chip microcomputer, the clock circuit, and the reset circuit.

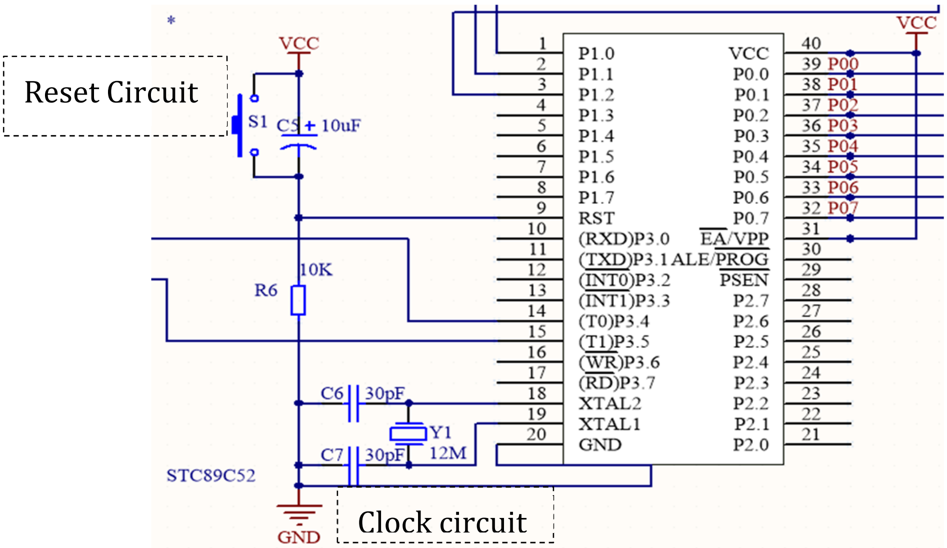


Figure 2. The minimum system circuit diagram of MCU

Because there is a gain inverting amplifier inside the microcontroller, it can form an oscillator. In normal use, the 18-pin XTAL1 and 19-pin XTAL2 can be connected to a quartz crystal and two start-up capacitors to form a self-excited oscillator to provide a clock cycle for the microcontroller. This design chooses 11.0592M quartz crystal oscillator, two 30pF starting capacitors, as shown in Figure 2.

The minimum system of the single-chip microcomputer adopts two reset methods of manual button reset and power-on automatic reset to realize the reset operation of the system. The power-on reset automatically performs the reset operation after the single-chip microcomputer is powered on. Manual reset is to realize the reset of the one-chip computer through the reset button during the operation of the one-chip computer, as shown in Figure 2.

3.2. LCD Liquid Crystal Display Circuit Design

Because some parameters need to be displayed in this design, LCD1602 is used as an interface display. Some related parameters can be displayed.

As shown in Figure 3. The P0 port of STC89C52 is used as a data connection terminal. Use P1.2, P1.1, and P1.0 to connect to EN, R/W, and RS of LCD respectively. Among them, EN is the chip selection signal triggered by the falling edge, R/W is the read/write signal, and RS is the register selection signal.

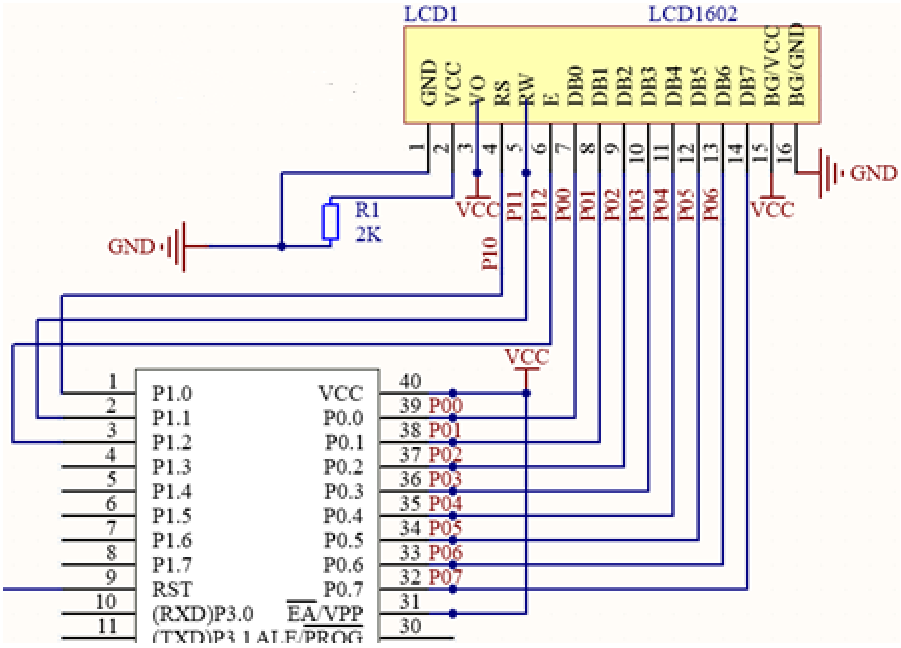


Figure 3. LCD1602 and STC89C52 interface circuit

3.3. Triode Amplifier Circuit Design

Since the single-chip microcomputer can only read digital signals, when the input signal is relatively small, the single-chip microcomputer can not read directly, so this design uses a first-level transistor amplifier circuit to amplify the input signal, but the amplification factor will eventually be limited by the transistor The current amplification factor. Therefore, the final magnification will be limited to hundreds of times. Because here only the input periodic signal needs to be amplified to a large enough size, the square wave can be formed by the processing circuit. Therefore, the magnification here does not need to be very precise, and the amplified waveform has cut-off distortion. It will not cause the measurement result. As shown in Figure 4.

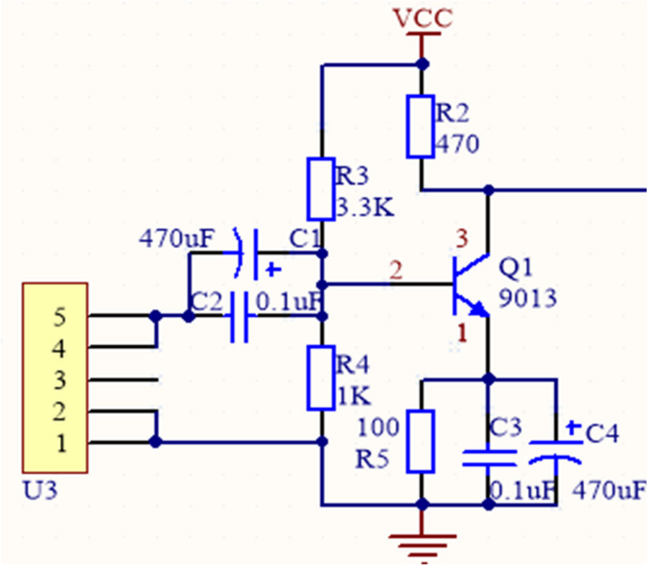


Figure 4. Transistor amplifier circuit

3.4. Signal Processing Module

Since the signal output by the triode amplifier circuit is not a standard square wave signal, there are problems such as the rising edge is not steep enough, and the waveform is similar to a sine wave. In order to better collect the signal from the single-chip microcomputer, a Schmitt trigger

74HC14 is used to amplify the triode. The signal output by the circuit is shaped. The circuit diagram is shown as in Figure 5.

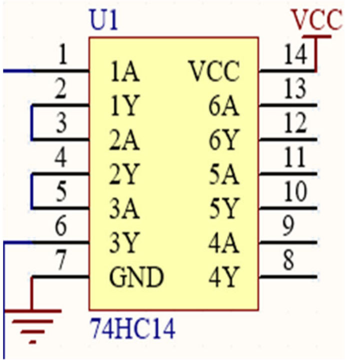


Figure 5. Schmitt trigger circuit schematic diagram

3.5. Frequency Dividing Circuit Design

Due to the limited operating speed of the single-chip microcomputer, it takes 1 machine cycle for the single-chip microcomputer to run a basic instruction, that is, 12 clock cycles, which is converted into a time of 1us. Therefore, when the frequency is too high, the single-chip microcomputer cannot convert the frequency very accurately. To solve this problem, this design includes a counter with a divider of 100. When the frequency is higher than 200KHZ, the one-chip computer calculates the signal after frequency division. When the frequency is lower than 200KHZ, calculate the signal before frequency division. This combination of high and low can expand the measurement frequency of the single-chip microcomputer. Finally, the actual corresponding frequency is converted and displayed on the liquid crystal. Among them the circuit diagram is shown as in Figure 6.

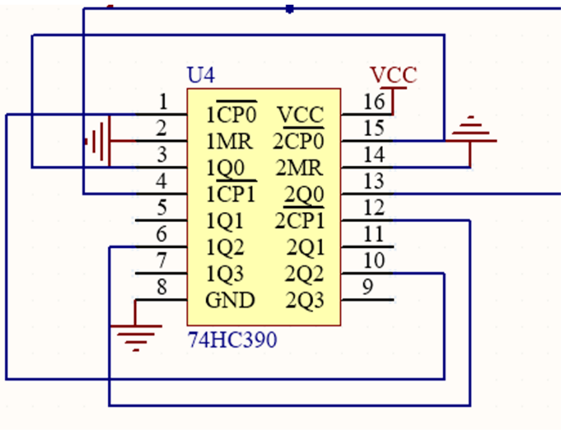


Figure 6. 74HC390 frequency dividing circuit schematic diagram

4. System Software Design

After the single-chip microcomputer is powered on, first perform initialization, set the initial value of the variable to 0, and then start the timer to count the input signal divided by 100 within 1s. When the measured frequency is greater than 200KHZ, the single-chip microcomputer will display the current measurement frequency Sum period, and then perform the next count. When the measured frequency is less than 200KHZ, the microcontroller will re-acquire the data before the frequency, display the measured data, and then enter the next count. The system workflow is shown in Figure 7 below.

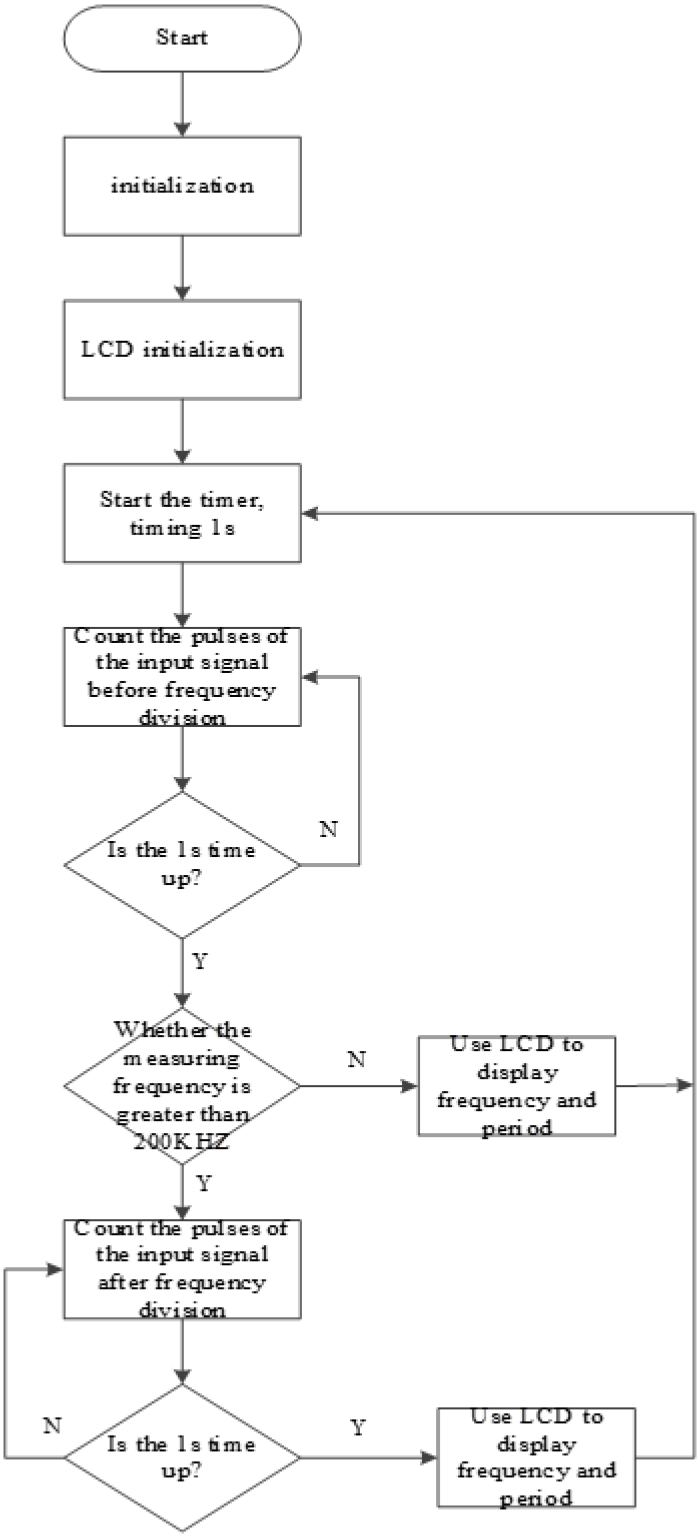
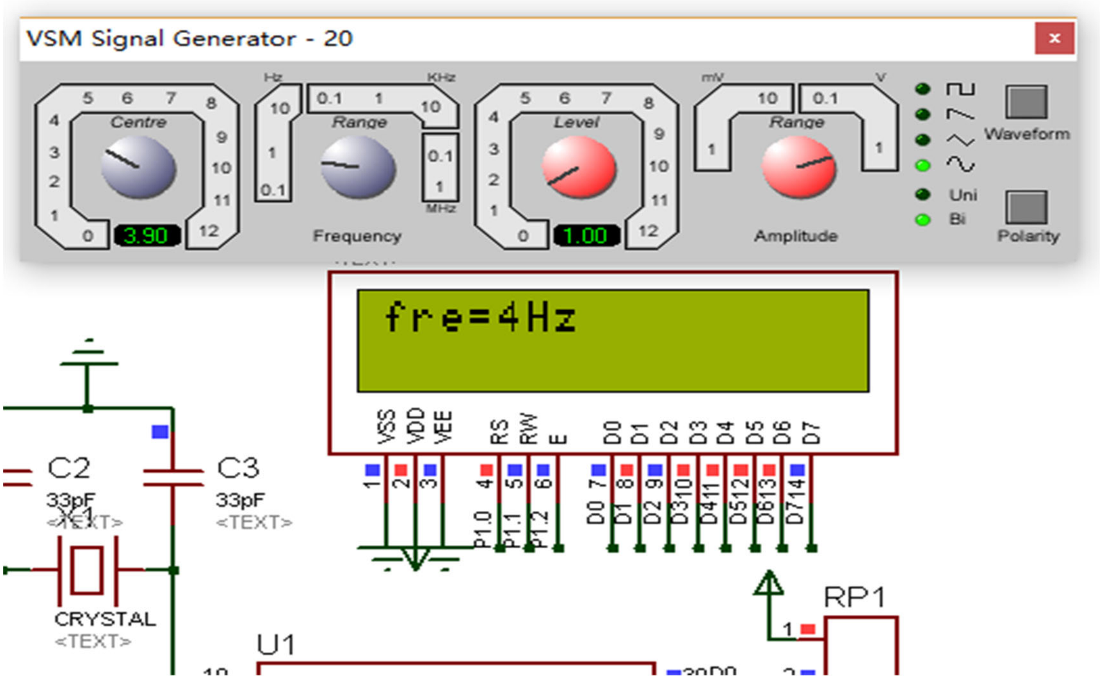


Figure 7. System work flow chart

5. System Simulation

The design results were jointly debugged in the environment of Proteus and Keil. After the Keil software is debugged correctly, a HEX hexadecimal file is generated, and the HEX file should be placed under the same target as the source file. Then load the HEX file into the microcontroller, and input the pulse frequency into the simulation software, then the pulse frequency can be measured.



VSM Signal Generator - 20

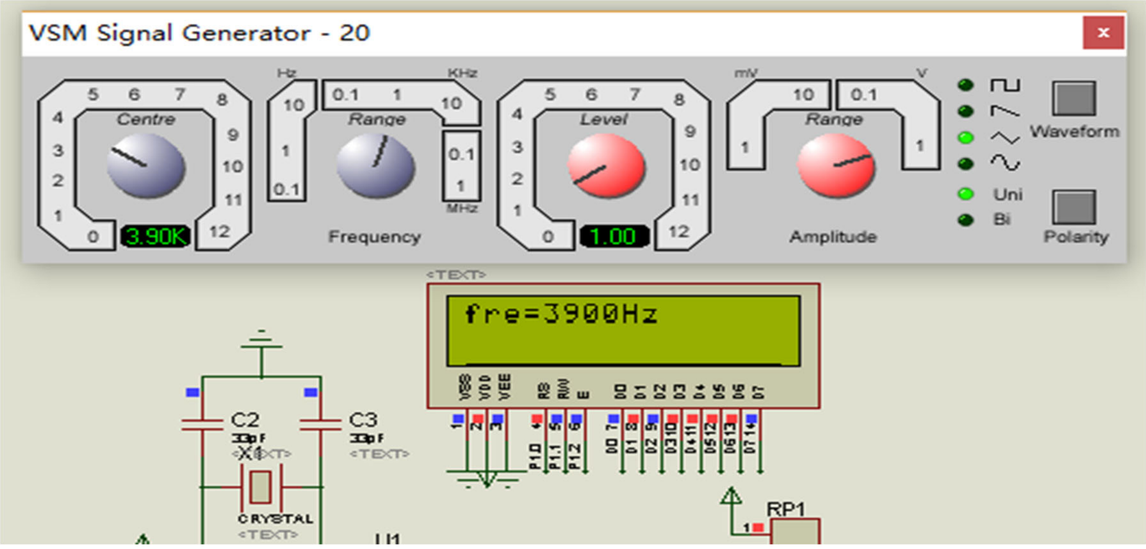
Centre: 3.90

Level: 1.00

fre=4Hz

Figure 8. Simulation diagram of sine wave frequency measurement

As shown in Figure 8, the simulation is carried out in the Proteus environment. Given the actual signal 3.9HZ, in the case of a sine wave, the simulation result is 4HZ. The difference between the actual and the simulation is 0.1HZ, and the error is 0.025%.



VSM Signal Generator - 20

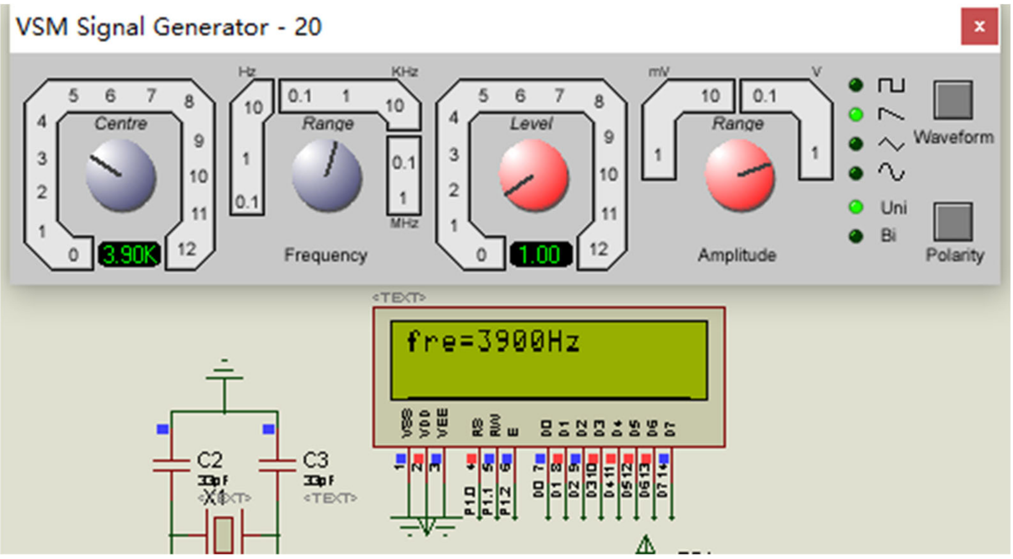
Centre: 3.90K

Level: 1.00

fre=3900Hz

Figure 9. Simulation diagram of Triangular wave frequency measurement

As shown in Figure 9, the simulation was carried out in the Proteus environment. Given the actual signal 3.90KHZ, in the case of a triangle wave, the simulation result is 3900HZ. The simulation result is the same as the actual signal, which meets the design requirements, with high accuracy and zero error.



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fre=3900Hz
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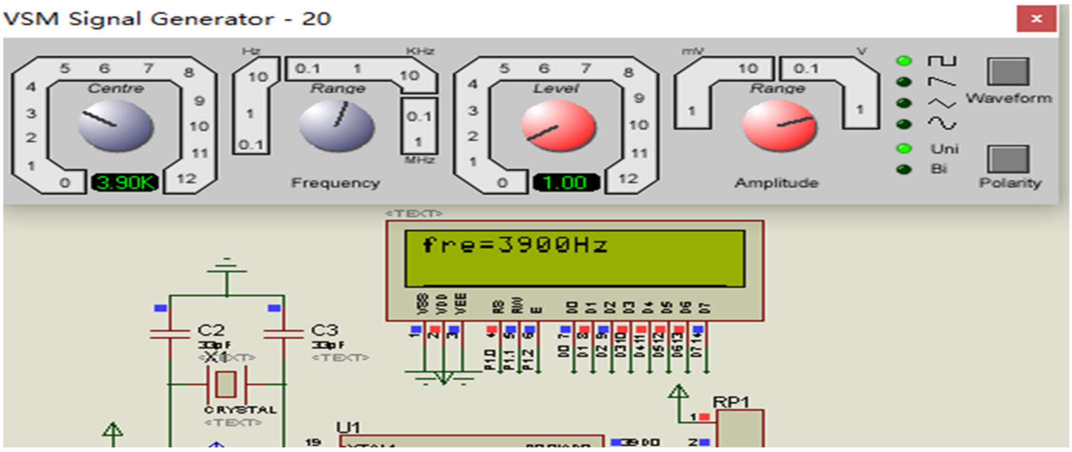
Figure 10. Sawtooth frequency measurement simulation diagram

As shown in Figure 10, the simulation was performed in the Proteus environment. Given the actual signal 3.90KHZ, in the case of sawtooth wave, the simulation result is 3900HZ. The simulation result is the same as the actual signal, which meets the design requirements, with high accuracy and zero error.



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fre=3900Hz
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Figure 11. The simulation diagram of rectangular wave frequency measurement

As shown in Figure 11, the simulation is carried out in the Proteus environment. Given the actual signal 3.90KHZ, in the case of a rectangular wave, the simulation result is 3900HZ. The simulation result is the same as the actual signal, which meets the design requirements, with high accuracy and zero error.

6. Conclusion

This paper mainly studies the hardware circuit design and software programming of the digital cymometer based on the single-chip microcomputer, and conducts circuit simulation. The simulation results show that the digital cymometer with the STC89C52 single-chip microcomputer as the core has stable performance, low cost, convenient function expansion, the design has good interactivity and certain application value.

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