LED Display Screen Design and Proteus Simulation Based on Single-Chip Microcomputer

Ding Yanchuang
School of mechanical Engineering
Dalian Jiaotong University
Dalian, China
E-mail: dyc2004@126.com

Guo Jinying
2School of mechanical Engineering
Dalian Jiaotong University
Dalian, China
E-mail: guojinying_1027@sina.com

Abstract—This paper designs a LED display system controlled by AT89C52 MCU (Microcomputer Controller Unit). The AT89C52 controls the external circuit formed by 74HC154 and 74HC595 in order to display characters, Chinese characters and figures. DS1302 is used to control the real time display. Language C is applied to compile program in Keil uVision3 programming environment. The display system is simulated through Proteus software. In Proteus environment, the schematic diagram is drawn. Through stimulation, it achieves real-time display, static display and dynamic display of Chinese characters. It has switch keys to change display state of details. Through the actual simulation, the biggest controllable screen size of the AT89C52 MCU is 64×32. The AT89C52 controls the entire screen display of Chinese characters of 16×16 dot matrix, a total of eight characters. And the key function can be extended.

Keywords—LED display; AT89C52; Proteus; dynamic scanning

I. INTRODUCTION

Energy-saving issue attracts everyone’s attention. Thus the products that focus on energy conservation get more recognition. LED (Light Emitting Diode-LED) display produced in the 1970s when it was simply used to display number and text. With the diversification of Led colors and enhancement of brightness, full color outdoors LED display became a reality at the end of the 20th century. The LED of our country appeared in the 1970s and its industrial production in the 1980s. The development of information and advertising industry brings about the emergence of LED display screen. LED display screens are mainly used in advertising window, train stations, banks and other places. It gets more and more widely used. Its own characteristics could make it occupy a market in the display screen industry in the future.

In the design of LED display, the hardest part is hardware debug. In order to solve the signal interference, insufficient solder in hardware connection, component damage and a series of debugging problems, the EDA (Electronic Design Automation-EDA) utility software Proteus that the UK Labcenter electronics company researched can be used to realize the entire hardware system schematic drawing and simulation[1].

Proteus simulation environment includes ISIS and ARES. In the ISIS environment, electronic circuit can be directly stimulated in the stage of schematic. It also provides virtual machines, simulation of the input signal which makes a convenient simulation. ARES is mainly used for PCB (Printed Circuit Board-PCB) design. The device library provides schematic device and its package. It can design printed circuit board in this environment.

Proteus simulation system currently supports MCU (Micro Controller Unit-MCU) with ARM7, 8051/52 series, AVR series, PIC 10/12/16/18 series, HC11 series and the MSP430 [2]. It can observe the direct result of hardware debug with proteus simulation. It has the characters such as intuitive, convenient, cost savings, high efficiency and so on.

II. THE DESIGN OF LED DISPLAY

LED display system is formed by MCU, LED screen display circuit, external circuit and the program for control the system. LED screen display circuit includes LED panel and the driving circuit of row and column. The external function circuit includes key controlling circuit and real-time clock circuit. Display function can be achieved as follows: numbers, characters, Chinese characters, static display of monochrome pictures, and dynamic display. Dynamic display includes the whole display content moving up and left. The shift method is controlled by keys, and also by automatic cycle. The system of real-time clock display provides seconds, minutes, hours, day, date, month, and year information. The overall block diagram of LED display screen is shown in Fig. 1.

![Figure 1. The overall block diagram of LED display screen](image-url)
III. HARDWARE DESIGN OF LED DISPLAY

A. Design of Row Driving Circuit

The core of LED display system is the control circuit. The control circuit includes driving circuit, clock circuit and the smallest MCU system which consists of AT89C52 MCU, Crystal oscillator circuit and reset circuit. Row driving chip is 74HC154, 4-to-16 line decoder/demultiplexer, active LOW outputs. P2.0–P2.3 port of AT89C52 connect to A0–A3 of 74HC154 decoder. According to the operating principle of the decoder, when the MCU system controls its P2 port output 0x00–0x0F, the 74HC154 respectively output LOW level from Y0 to Y15. And then the first line to the sixteenth line of display screen is selected. The P2.4 port of MCU connects to the first 74HC154 decoder’s (1~16 line controller) enable pins, meanwhile connects to the second one enable pins (17~32 line controller) through inverters. That realizes line scanning method. When scanning from the first line to the sixteenth line, the P2.4 port’s output is jump from 0 to 1. And enable the second 74HC154: the seventeenth line is output. This method achieves scan of low-half LED display. The row driving circuit diagram is shown in Fig. 2.

B. Design of Column Driving Circuit

P1.0–P1.2 ports of MCU are used to control the column driving chip MC74HC595. 74HC595 is shift register with an 8-bit serial in, serial or parallel out with output latches 3 states. Its control clock and shift clock are separate that brings convenience for controlling. Each character is composed by dot matrix of 16 rows and 16 columns: each character of national standard Chinese character library is represent by 256 dots matrix [3]. The font software generates code of dot matrix which is hexadecimal number of 8 bit a group. In this design row scan is used, so the horizontal font code is taken. Using 74HC595 to control the column data send out. When using 74HC595 to control each characters code display, P1.0 port of MCU will send 8 bit serial data from the first column to the eighth column, which is high after the previous low in this transmission. P1.2 port of MCU outputs shift clock. When P1.0 port outputs a bit data, the electrical level of P1.2 port changes from low to high once, then the content of shift register 74HC595 will move one bit from the high to the low once. When the ninth bit data is sent to SDI port of 74HC595, the 74HC595’s SDO port will serially output the first bit in the shift register to the eighth bit of the next 74HC595 chip, and the new incoming data is sent to the eighth in the first chip. After the end of the data preparation from the 1st column to the 64th column, P1.1 port generates a rising edge pulse which sends to the LCHCLK port of 74HC595. Firstly putting 74HC595 chip in cascade connection, then connecting the parallel output clock pins in series and these clock pins are controlled by P1.1 port. Therefore, when the output clock is valid, every 74HC595’s column data output at the same time. Then to achieve displays this whole row by selecting the homologous row. Continuing to do the steps, it can realize a row scan. As long as the entire screen of the scan rate is higher than 50 times per seconds, people could see static images. The 74HC595 column driving circuit is shown in Fig. 3.

C. Design of Functional Circuit

Besides the above function, the design also has real time display and the key function to switch the display modes. P3.0–P3.3 ports individually connect to four buttons which control static display, moving up display, moving left display and automatic cycle display. The automatic cycle display is from the static, moving up to moving left circle shows. The function is realized by programming of key scan.

DS1302 chip is used to control real time clock. The time information such as second, minute, hour, day, date, month, and year is displayed in LED display screen. A 3.6V button battery is connected to the eighth pin of DS1302, which ensures DS1302 continuous operation while LED display system does not work [4]. Three data wires are used to control DS1302 in order to achieve synchronous serial communication. The P3.6 port of MCU controls serial clock SCLK pin, P3.7 port controls the DS1302’s REST/ RST pin, and P3.5 connects to data line I/O. According to the operating principle of DS1302, MCU reads and writes the data, then sends to display in LED panel. The function circuit and the MCU system diagram are shown in Fig. 4.
IV. SOFTWARE DESIGN

Using C language to write the program, the program is compiled in Keil uVision3 development environment. The program uses modular design, which is as follows: time delay function, 74HC595 performance function, DS1302 control function, data display function and the main function. The modular design of LED display program is convenient for writing and changing.

Fig.5 is the main function block diagram. It mainly realizes the overall initialization, DS1302 initialization and key scan. When the main function is programmed, sub function should be placed before the main function, or declared in advance. Key scan includes four function keys, which respectively accomplish the moving up, left, cyclic and static display.

Fig.6 is DS1302 initialization function block diagram. The function realizes DS1302 internal variable initialization, prohibiting write protection, sending the address of write and read data, and reading date/ time for display in LED screen. When reading or writing data, it needs to close the write protect. And after reading or writing data, it can open the write protect.

V. PROTEUS SIMULATION

Simulation in Proteus can control the display size of 8×8, 16×16, and 64×16 and so on. Through the actual simulation, the smallest size of LED panel is 8×8. In order to keep the screen without flickering, the biggest size is 64×32. If the display size increases, the screen will produce flickering phenomenon. The reason is that the frame updating frequency is lower than the frequency of human vision persistence.

The control circuits, driving circuit and functional circuit in Proteus are consistent with the Protel schematic. In the Proteus development environment, the LED panel is 64×32 jointed by LED 8×8 modules. Part of the electrical connections is used by Label.

Through the actual simulation, it can realize Chinese characters, numbers and characters display, and also can switch display mode by buttons. In the static display, the eight characters are displayed in the screen at the same time, every characters is in the form of 16×16 code. The dynamic display is include four state displays, which include moving up, left, static, and three states cycle display. It also realizes real-time
clock display. The Proteus simulation diagram is shown in Fig. 7.

Figure 7. Proteus simulation diagram

VI. CONCLUSION

This design introduces the circuit and control principle of the LED display screen in detail. Adopting AT89C52 as controller, 74HC154 as row driving circuit and 74HC595 as column driving circuit, modular programming through language C, Proteus software as simulation environment, It can display eight Chinese characters or characters and real time, and control display models by buttons. It can achieve the display contents moving up, left, static, and automatic cycle display. The design mainly reflects modular programming ideas. So when the system adds or deletes hardware or software without the need, it is changed little. Using Proteus simulation, it brings convenience to design. Through simulation, the maximum controllable LED panel is $64 \times 32$ by AT89C52.

REFERENCES


