Design of the control system for full-color LED display Based on MSP430 MCU

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Abstract

The LED display incorporate the micro electronic technique, computer technology and information processing as a whole, it becomes the most preponderant of a new generation of display media with the advantages of bright in color, high dynamic range, high brightness and long operating life, etc. The LED display has been widely used in the bank, securities trading, highway signs, airport and advertising, etc. According to the display color, the LED display screen is divided into monochrome screen, double color display and full color display.

With the diversification of the LED display's color and the ceaseless rise of the display demands, the LED display's drive circuit and control technology also get the corresponding progress and development. The earliest monochrome screen just displaying Chinese characters, simple character or digital, so the requirements of the controller are relatively low. With the widely used of the double color LED display, the performance of its controller will also increase. In recent years, the full color LED display with three primary colors of red, green, blue and grayscale display effect has been highly attention with its rich and colorful display effect. Every true color pixel includes three son pixels of red, green, blue, using the space colour mixture to realize the multicolor.

The dynamic scanning control system of LED full-color display is designed based on

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MSP430 microcontroller technology of the low power consumption. The gray control technology of this system used the new method of pulse width modulation (PWM) and 19 games show principle are combining. This method in meet 256 level grayscale display conditions, improves the efficiency of the LED light device, and enhances the administrative levels feels of the image. Drive circuit used 1/8 scanning constant current drive mode, and make full use of the single chip microcomputer I/O mouth resources to complete the control. The system supports text, pictures display of 256 grayscale full-color LED screen.

Keywords: Low power consumption, Full-color LED display, Gray control, Drive circuit

Introduction:

The LED display incorporate the micro electronic technique, computer technology and information processing as a whole, it becomes the most preponderant of a new generation of display media with the advantages of bright in color, high dynamic range, high brightness and long operating life, etc[1]. The LED display has been widely used in the bank, securities trading, highway signs, airport and advertising, etc[2, 3]. From the point of the LED screen's display color, the LED display screen is divided into monochrome display screen, double colors display screen and full color display screen. We can choose the different display according to the requirements of the display effect and the applications[4].

With the diversification of LED display color and the unceasing enhancement of the display requirements, the drive circuit and control technology also get the corresponding progress and development. The earliest monochromatic displays generally display the Chinese characters, simple characters or Numbers, so the requirement for the controller is also low. Hou Kun and others use the MCS - 51 single chip as the central controller to achieve the above functions to the LED monochrome displays[5]. With the widely application of the double color LED display, the controller's performance is enhanced. Ding Yu, Zhu Gengjun adopted double single chip microcomputer with two RAM to complete the control of the diverse double color display to display the Chinese character[6]. In recent years, the full-color LED display with red, green and blue tri-phosphor and gray scale display is concerned with its rich and colorful display effects, every full-color pixel include red, green and blue three sub pixels, using mixed color space to realize multicolor[7]. At the same time, the full-color LED display on the performance of the control system is also put forward higher request[8]. For full color LED display control: someone with ARM microprocessor as the core, on the control of programmable logic device FPGA, he has completed the data transmission and update of the display, refreshing the dynamic image, circulation scanning display, and other functions; Others used Atmega128 to realize the display control of the full color LED screen[9]. This paper use the MSP430 series MCU as the core controller, communicating with the PC through the RS232 chip to complete the display control of the full color LED display screen.

1 System Scheme Selection

1.1 The Choice of the Main Controller

The full-color LED display control system designed in this paper is mainly used in companies, institutions of image display and announcement of chamber indoor or outdoor. The content of this kind of propaganda way is relatively fixed or can real-time display. So it requires that the controller has both the functions of offline display relatively fixed content and can satisfy the requirement of higher refresh rate to achieve the demand of real-time display. Therefore, relative to choose other embedded control system, the selection of ultra low power 16-bit single chip MSP430F149 as main controller of the system has the following advantages:

(1) Low power consumption. MSP430 series SCM is an ultra low power microcontroller [10]. From the CPU kernel structure to on-chip peripherals, as well as the whole chip manufacturing is carried out based on the principle of ultra low power consumption. The power supply voltage of MSP430 series MCU is the low voltage from 1.8 V to 3.6 V, which is on the same level with the working voltage of the ARM, but the working voltage of MC51 series MCU is normally from 2.7 V to 6.0 V. In activity pattern, the MSP430 series MCU consumes 250 $\mu A/MIPS$, but the traditional MC51 microcontroller is about 10 to 20 $mA/MIPS$. The leakage current of the MSP430 single chip microcomputer input port is maximum 50 nA, which is far less than other

series MCU's 1 ~ 10 μA . As can be seen from the above comparison , MSP430 single chip microcomputer for the whole LED display system's energy saving electricity design has played a decisive role.

(2) Powerful processing ability and rich on-chip peripheral modules. MSP430 adopts the reduced instruction set can execute one instruction in one clock cycle (the traditional MC51 to execute one instruction need 12 clock cycles).

(3) Low cost . In this design, the processing capabilities of MSP430 MCU are comparable to ARM, but its cost is only a quarter of the ARM. When the requirement of an LED display's area is not too big (a few square meters), the cost saving is obvious.

1.2 The drive way of the drive circuit

The drive way of the driver circuit is 1/8 scan constant current.

1/8 scan driver: that is eight line LED tube share a line drive. the LED light on and off is controlled by the line control signal, the data transmission and the gray scale control is realized by the column control signal

Constant current driver: due to the forward characteristic of the LED device is steep, and the dispersivity of the device, make the forward current of the devices is not the same under the same supply voltage and current limiting resistance, thereby leading to the differences of the intensity of light. If proceeding constant current drive to the LED device, as long as the constant current values are the same, it is close to the luminous intensity, thus the constant current drive is adopted.

1.3 The choice of LED chip

As a new type of solid-state light source, LED has many potential advantages, such as energy saving, environmental protection, long service life,etc[11]. The LED is the most critical components for LED full-color display. The stand or fall of LED's performance influence the screen display effect and the evaluation to the display of the audience directly, and LED accounts for the largest share of the display screen's overall cost accounts, ranging from 30% to 70%. In recent years, surface mounted LED (SMD LED) full color screen has become a hot spot of LED large screen display. This design chooses the LED of SMT type and the pixel spacing is 6 mm, using for indoor and outdoor full color display screen has the outstanding advantages: the visual angle can be achieved 120° above, the luminance reached more than 12000 cd/m^2.

2 The composition of the system

2.1 The system chart

The PC as upper computer through the RS232 communication interface transmit the data display and control signal to the MSP430F149 MCU, the MSP430F149 as the core controller of the system to control the drive circuit formed with the integrated chip to complete the display of LED dot matrix scanning process. The principle block diagram is as follows:

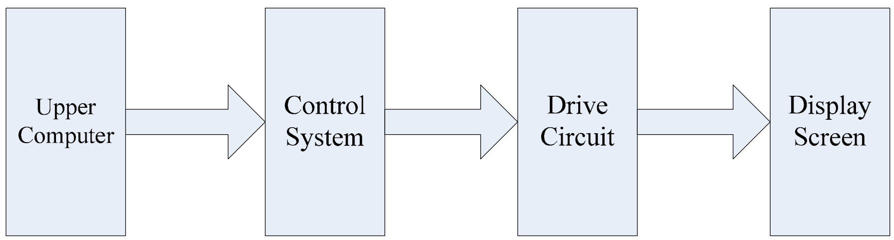

Figure 1 LED full color display module system schematic diagram

2.2 The structure framework of MSP430F149

The MSP430F14X structure framework mainly including: CPU, ROM, RAM, oscillator and system clock, A/D converter, the JTAG port, timer (Timer A and Timer), hardware multiplier, I/O port, watchdog and serial port. MSP430F14X series in each model have some difference, according to the need of the design, this paper selects MSP430F149 to control the LED display.

2.3 Design of driver circuit

This display module has a total LED dot of 16 line 32 columns. The constituent part of the display module mainly has 2 pieces of 08 port, 2 slices of 245 bus driver chip, 2 slices of 138 decoder, 12 slices of 5020 columns display driver chip, 8 slices of 4953 line display driver chip. The module is divided into up and down two parts according to the eight line scan driver mode, the drive circuit block diagram is as follows:

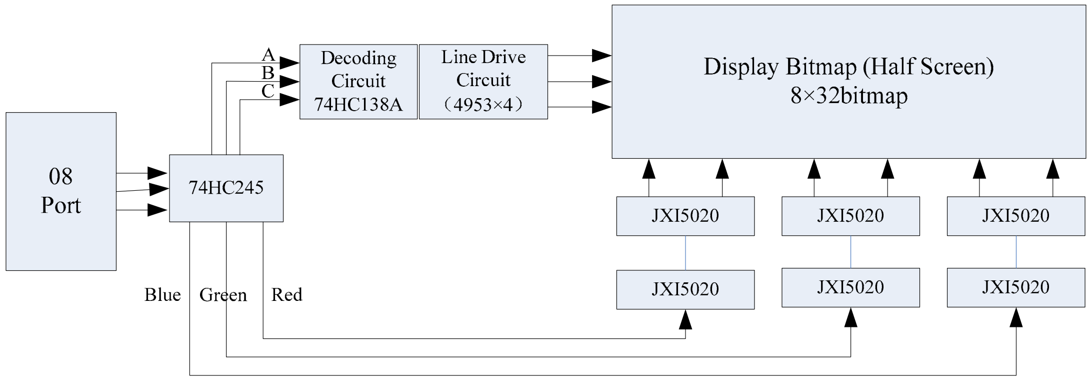

Figure 2 A half screen circuit frame diagram

3 Grey control and the realization of the hardware interface

3.1 The realization of the gray control

For the true color LED screen control system generally requires at least 256 level gray scale. This paper according to the human visual inertia, using the method of pulse width modulation (PWM) to realize the average current of the flow through the LED brightness control. Namely through to control the LED pulse duty ratios to realize the brightness control.

Assume an n bit binary number $D=[d_0,d_1,\cdots,d_{n-1}]$ means the Display of gray level, so for the same pixel color (red, green or blue) through n field, corresponding $d_0,d_1,\cdots,d_{n-1}$ with $d_0/2^0,d_1/2^1,\cdots,d_{n-1}/2^{n-1}$ cycle respectively. When the n field circulate fast enough (less than 18*ms*), shows the average effect of n field, namely the 2^n grey level.

Define T for every display time. It is composed of LED conduction time and turn off time, namely:

$$\text{Total time} = \text{conduction time} + \text{shut off time} \tag{2.1}$$

If you want to achieve level 256 grayscale display, the former conduction time is 2 times of the next conduction time. As shown in figure 3:

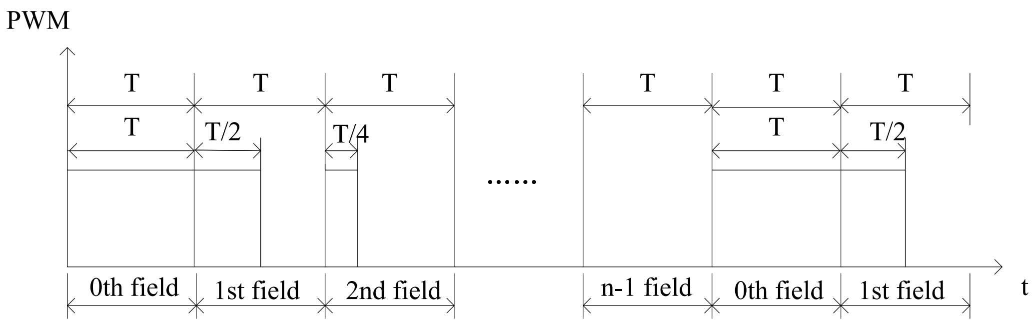

Figure 3 The relationship between the lead time and the display session

From the analysis of figure 3:

$$\text{Conduction time} = T\sum_{i=0}^{n-1}\frac{d_i}{2^i} \tag{2.2}$$

$$\text{Total time} = nT \tag{2.3}$$

The LED luminous efficiency is η = conduction time/total time. When the digit is 8, we can expand each conduction time to 2 times under the condition that each display time is 2 times of the next. As shown in the following table:

Table 1 The relationship between each conduction time and the total time

Each Conduction Time								Conduction Time	Total Time
0th field	1st field	2nd field	3rd field	4th field	5th field	6th field	7th field		
1T	T/2	T/4	T/8	T/16	T/32	T/64	T/128	≈2T	8T
2T	1T	T/2	T/4	T/8	T/16	T/32	T/64	≈4T	9T
4T	2T	1T	T/2	T/4	T/8	T/16	T/32	≈8T	12T
8T	4T	2T	1T	T/2	T/4	T/8	T/16	≈16T	19T
16T	8T	4T	2T	1T	T/2	T/4	T/8	≈32T	34T
………..									
128T	64T	32T	16T	8T	4T	2T	1T	≈255T	255T

The upper table shows that, when the total time is 8T, 9T, 12T, 19T and 34T, the luminous efficiency η is 25%, 44.44%, 66.67%, 84.21% and 94.12% separately. We can determine the total time of field according to the size of the LED display, the refresh rate and the number of gray levels. This experiment chooses a total time of 19 fields, that is the" principle of 19 fields". In this experiment, the 8 bits of data points will be displayed by 19 fields separately.

The realization of the gray-scale control is mainly by the PC transmits the contents which are programmed to MSP430 single chip microcomputer through the serial port. The task of column driver chip 5020is to finish receiving, latch and display of the data. LED display is controlled by serial mode. One bit of the serial data under the CLK signal was outputted by the P2 port of the single chip microcomputer, inputted from the SDI, removed from the SDO, the LE signals are used to latch into the data. The CLK clock shifts the displayed data from SDI one by one, until the very end LED of the cascade. The LE signal shows the pins which are stored in the controller, and then continue to the next set of data as a cycle. The PWM waveform is determined by the OE signal of line controller.

3.2 Interface connection of SCM and drive circuit

The line control signal of full color LED display is finished by P4 and P5 port of the single chip microcomputer. The PC transmit the red data to the column controller through P3.0 and P3.3 port; P3.1 and P3.4 port are responsible for green data transmission, P3.2 and P3.5 port are responsible for blue data transmission; P5.5 port output the shift clock pulse signal in the process of columns data transmission; When a bit of column data transfer has been completed, the P1.1 port sends the data latching signal to LAT side to complete data latches. The implementation of the MCU and driving circuit interface, as shown in figure 4.

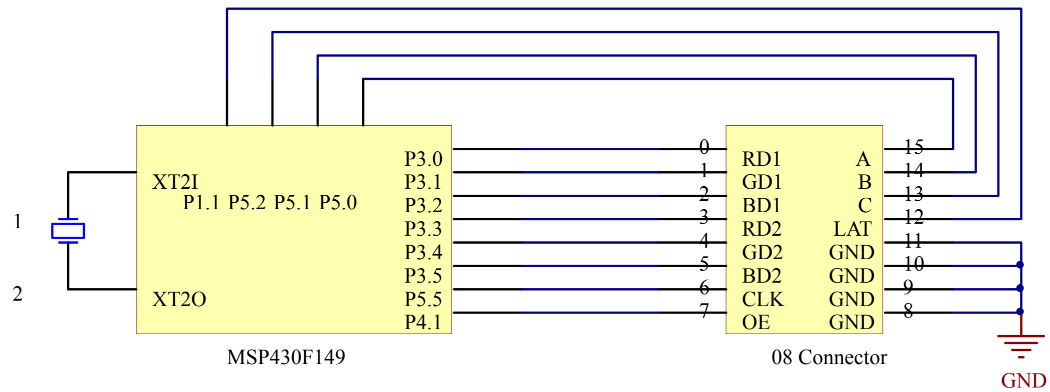

Figure 4 The implementation of the MCU and driving circuit interface

4 Conclusions

Compared with traditional single-chip LED screen control system, this system under the condition of without any increase in costs can support information on full-color display of 256 level; By adopting the method of pulse width modulation (PWM) and 19 fields display principle to control the display of grayscale, the contrast is more obvious, the image is more distinct and expressive and the luminous efficiency of LED is enhance from 25% to 84.21% compared with the 8 fields display principle; The hardware connection of single-chip computer and drive circuit realize the flicker free dynamic scanning display of full color LED display screen.

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