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Design of LCD touchscreen controller based on MCU

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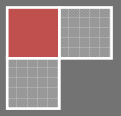
ABSTRACT

As a modern product the most commonly used in industry, family and office, LCD touchscreen has experiences a price decline because of the development and breakthrough on key technology. The LCD touchscreen has already replaced the traditional cathode-ray-tube-CRT monitor. Due to its portability, miniaturization and low power display technologies,LCD touch screen has become the overlord of the application areas such as families, hospitals, government agencies, and also has become a standard product. MCU refers to the technology to integrate most of the IC components in a microcomputer system into a single chip. It requests a lower development environment and has rich software resources. Generally, its product development only needs a PC and a programmer. Besides, it has a highly reliable application system, a standard system configuration and its function control has a lower cost but a higher performance. This study is based on the MCU of AT89C51 and uses the ADADS7843 proprietary controller to finish LCD touch-screen display system design. First, the essay will introduce the basic principle and design method of MCU, ADS7843 and four-wire resistive touch screen. Then the minimum system hardware interface framework design will be completed. The assembly language will be used in the software design to realize functions, including Chinese character display, scroll, move and touch.

KEYWORDS

LCD touchscreen, CRT monitor, MCU, AT89C51, ADS7843.



INTRODUCTION

LCD touchscreen generally uses the program that the touchscreen is installed on the screen. In order to realize the connection control between the touch screen andthe display screen, it is general to use a microprocessor to control the screen via the touchscreen and to achieve the desired function. It usually uses the LCD control light transmission technology for the realization of color. Its display principle generally includes reflective method and transmissive method. The LCD touchscreen is both easy and direct, and can replace the traditional vintage keyboard output. Therefore, its application in electronics, information industries and families has been widely concerned[1]. This study is based on the MCU of AT89C51 and uses the ADADS7843 proprietary controller to finish LCD touch-screen display system design.

HARDWARE STRUCTURE AND PRINCIPLES

Four-wire resistive touch screen

With the development of hardware and software technology, touchscreen has been widely used and become more closely related to people's life. Generally, touchscreen includes the following categories: resistivetouchscreen, capacitivetouchscreen, infra-redtouchscreen, vectortouchscreen, pressure-sensitivetouchscreen and surface acoustic wavetouchscreen[2]. Vector pressure sensing technology has basically no longer been used; Infra-redtouchscreen is prone to damages, produces light interference and surface distortion, but it is cheaper; capacitive screen is advanced in its designing good theory, but its image distortion problem is hard to be solved so far; resistive screen can position accurately, but its price is quite high and is vulnerable; surface acoustic wave screen overcomes the weakness of other touchscreens, and it is clear and suitable for all kinds of usage conditions, but its downside is if there is dust or water droplets on the screen surface, it would make the touchscreen running slow or even does not work.

The research design adopted the most popular four-wire resistive touchscreen[3], which has the most extensive application and popularization among all resistive touchscreens. The touchscreen is comprised of the lower lines (glass or film material) conductive ITO layersand upper lines (film) conductive ITO layers. It has an insulating dot in the middle. When the touch-screen surface when there is no pressure, the upper and lower lines are in the open circuitstate. Once pressure is applied to the surface of the touch screen, the upper and lower lines will be conducting. And Controllers applied driving voltage in the x directionthrough line conductive ITO layers. The probe on the conductive ITO layer of upper lines will detect the voltage in the X direction and thus deduce the contact point on the X coordinate.

ADS7843

ADS7843 is a four-wire resistive touchscreen controller, which is a synchronous serial interface 12-bit sampling ADC. Its power consumption is 750uW under the 125KHz throughput speed and 2.7V voltage, while it is only 0.5uW in off mode. With features of low power consumption and high data rate, ADS7843 is widely used in small, battery-powered handheld device. ADS7843 uses ADS7843 the SSOP-16 pin package with a temperature range between -40℃ to +80℃. ADS7843 has two auxiliary inputs (1N3, and 1N4) that can be set to 8-bit or 12-bit modes.

The operating voltage of the circuit is between 2.7V and 5.25V, and the reference voltage is between 1V and 5V. Reference voltage of the circuit determines the input range of the converter, and each number of the output data represents the analog voltage, which is equal to the voltage divided by 4096. Average reference input current is determined by the ADS7843 conversion rate. It is highly precise, and is hardly limited by environment, which can be used in all kinds of places[4]. Basic supply voltageof ADS7843 is between 2.7 and 5V. It has a 12-bit serial interface chips inside. TABLE 1 shows the ADS7843 pin function description

TABLE 1 : ADS7843 pin function description

PIN number	PIN name	Function description
1,10	+Vcc	Power supply 2.7~5V
2, 3	X+,Y+	Touchscreen positive electrode, the internal A/D channels
4,5	X^-,Y^-	Touchscreen negative electrode
6	GND	Ground
7,8	IN3, IN4	Two subsidiary A/D input channels
9	V_{REF}	A/D converter reference voltage input
11	PENIRQ	Interrupt output to external pull-up resistors (10KΩ or 100KΩ)
12,14,16	DOUT, DIN, DCLK	Serial interface pins, at the falling edge of when the clock declines, data output; when it rises, data input
13	BUSY	Busy state, active low electrical level
15	$\overline{CS}$	Chip select

AT89C51

AT89C51 microcontroller is alow-voltage and high-performance CMOS8-bit microprocessor with 4K-byte FPEROM-flash programmable and erasable read only memory, also called as MCU. The device uses the ATMEL high density non-volatile memory technology and it is compatible with thethe industry standard instruction setMCS-51 and the output pin. Due to the versatile 8-bit CPU and Flash memory on a single chip, the AT89C51 of ATMELis an efficient micro-controller for many embedded control systems and provides a flexible and inexpensive solution. Figure 1 shows AT89C51 microcontroller pin chart

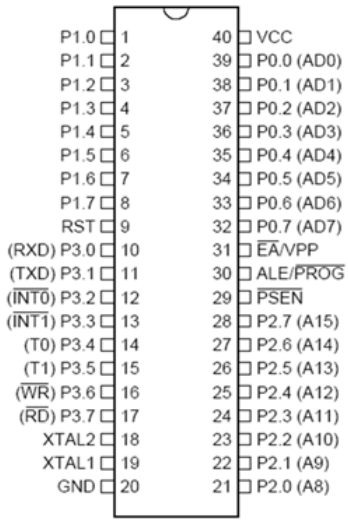


Figure 1 : AT89C51 microcontroller pin chart

AT89C51 consists of An 8-bit CPU, a interrupt and control system, the internal oscillator and clock circuit, a system bus, a serial communications port, Two 16-bit timers/counters, stack and instruction set (111 instructions), and a 4K bytes internal program memory (ROM). As it is shown in the Figure 2 below:

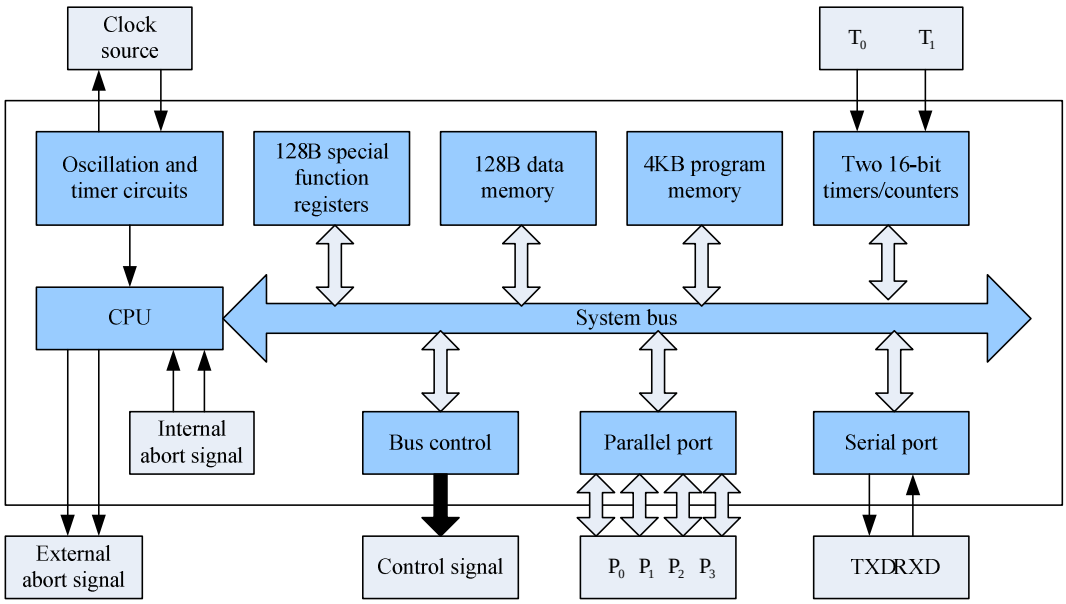


TABLE 2 : Structure of AT89C51

DESIGN

Hardware design framework

This study is based on the MCU of AT89C51 and uses the ADADS7843 proprietary controller to finish LCD touch-screen display system design. Hardware needed includes a reset circuit, a clock circuit, LCD screen, a touchscreen, power, communication interfaces and other modules[5]. The concrete framework is shown in Figure 3 below.

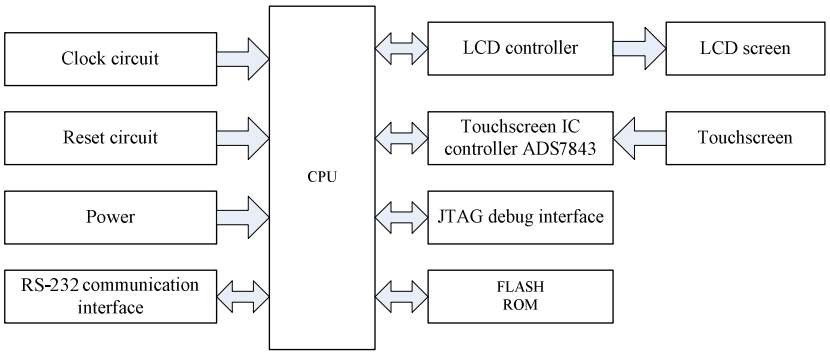


Figure 3 : Hardware design framework

Four-wire resistive touch screen state recognition

The hardware structure of the four-wire resistive touchscreen usually consists of insulation layer (glass substrate) and two layers of transparent resistive layer. According to the features of AT89C51, the speed touch cannot be detected, so the sign meaning should be determined by samples obtained by analyzing touch gestures[6]. These common gestures are shown in TABLE 2 and the pressure data is shown in TABLE 3.

TABLE 2 : Touch Screen Gestures

Gestures	Pressure value Z		
Click	Without pressure to within pressure	Within pressure to without pressure	
Slide	Without pressure to within pressure	Keep the pressure to move the coordinates	Within pressure to without pressure
Long press	Without pressure to within pressure	Maintain the same pressure coordinates	Within pressure to without pressure

TABLE 3 : Pressure change

State	Pressure value Z
Press	Without pressure to within pressure
Popup	Within pressure to without pressure
Hold	State within pressure
Idle	State without pressure

The orientation between touchscreen and LCD

In order to reduce the measurement error of touchscreen, ADS7843 touchscreen controllers operate by measuring the differential reference voltage to achieve a point-to-point correspondence between LCD and four-wire resistive touchscreen and to reduce operational errors and difficulties of program and debug. However, regarding the measurement error problem of the touch screen edge, the exact correspondence between LCD and four-wire resistive touchscreen can be achieved and the control functions of LCD and touchscreen can be realized too[7-8].

The design connects ADS7843 touch screen controller and AT89C51 microcontroller by SPI interface. Once a touch gesture is detected, ADS7843 touchscreen controller will send an interrupt request to AT89C51 microcontroller. Then AT89C51 microcontroller completes the interrupt request, converts the results by SPI interface and determines the specific touch point coordinates.

Primarily, the words on the screen should be determined in line with the horizontal and vertical lines. Second, the touch point value between touchscreen and LCD will be calculated to effectively find out the coordinates range of the touch point. The formula below can help to find out the pixels between LCD and the touch point on touchscreen:

In the formula above: x and y are the contact point measurements. (Xmin,Ymin) and (Xmax,Ymax) represent minimum coordinate contact valueand maximum coordinate contact valuerespectively.

Software design

The software of the control system design uses assembly language. As a coding language closest to the computer language, the assembly language is totally different from other advanced languages. Its main feature is that it can be fully correspondent to machine language. Assembly language is a low-level computer programming language. As for “low-level”, rather than its features and complexity, it means the language appeared early in the history of computers and is still widely

used in the field of computer, which is the basis of most other languages. Furthermore, it is a machine-oriented language, that is, it is closely related to computer hardware and the operation. Assembly language has direct access to any hardware related memory or I/O port, can maximize hardware capabilities and is not restricted by compilers. As the growth of software size, requirements about the efficiency and speed of software increase as well and assembly language is gradually replaced by other high-level languages. However, assembly language cannot be completely replaced.

The software design goes as follows: after the hardware system is charged, the softwaresystem will be initialized for LCD can displays pictures properly. Specific operation includes LCD parameters (number and frequency, etc). The initialization process goes as follows Figure 4:

```
INIT:MOV DPTR, #8100H:    #8100H   Command port address
MOV A,#40H
MOVX @DPTR,A;             Send command code to command port address
MOV A,#30H
MOV DPTR,#8000H:                 #8000H Data port address
MOVX @DPTR,A;             Send parameters to data port address
MOV A,#07H;               Sets the cursor width into 8
MOVX @DPTR,A
MOV A,#07H;               Sets the cursor height into 8
MOVX @DPTR,A
MOV A,#27H;               According to LCD need, set the number of bytes in each row
MOVX @DPTR,A
……
```

Figure 4 : Hardware initialization program

After the initialization is complete, the LCD monitor display properties and the cursor pointer parameters will be set up. Then the screen clearance will be conducted by Clear screen subroutines. After all these, the display subroutine can displays words and pictures on the LCD monitor. The main process is shown below Figure 5:

```
DRAW:MOV  DPTR,#8100H
MOV  A,#46H
MOVX  @DPTR,A
MOV  DPTR,#8000H
MOV  A,CURL
MOVX  @DPTR,A
MOV  A,CURH
MOVX  @DPTR,A
MOV  DPTR,#8100H
MOV  A,#42H
MOVX  @DPTR,A
MOV  COUNT1，#00H
LOOP:MOV DPTR,#CTAB
MOV  A,COUNT 1
MOVC  A,@A+DPTR
MOV  DPTR,#8000H
MOVX  @DPTR,A
INC  COUNT1
MOV  A,COUNT1
CJNE  A,#NUM,LOOP
……
```

Figure 5 : The main process

After the display of footage, when the user touches the screen, INTO will turn into low electric level and send interrupt signals. AT89C51 microcontrollercan determine the specific touch coordinatesthrough the terminal services program[9] and convert it to a bitmap data, sending to the LCD screen. Then the touchscreen operation is completed.

CONCLUSION

The study completes the LCD touchscreen design by AT89C51, ADS7843 and four-wire resistive touchscreen. The touchscreen has a high stability, low cost, clear output and is easy to operate. Besides, its high maintainabilitycan meet actual demands in a better way. More functions can be realized by the usage of the internal flash memory and the CPU with A/D conversion functions to make system more simplified and convenient.

As computers have become the major source of information, touchscreen has been given considerable attention from more and more system designers, due to its advantages, including convenience, durability, fast response and small size. In order to meet the actual requirements of production, the development of LCD touchscreen focuses specialization, multimedia and stereo and the big screen, offering users more convenient access to a variety of information. Meanwhile, in order to enable people to obtain more intuitiveinformation, LCD touchscreen uses many transmission modes, such as text, images, music, narration, animations and video, which brings great convenience to people's lives. It is no doubt that touch-screen will play an important role in the popularization of computer technology.

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