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Design of High-Precision Infrared Multi-Touch Screen Based on the EFM32

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Abstract: Due to the low accuracy of traditional infrared multi-touch screen, it's difficult to ascertain the touch point. Putting forward a design scheme based on ARM Cortex-M3 kernel EFM32 processor of high precision infrared multi-touch screen. Using tracking scanning area algorithm after accessed electricity for the first time to scan, it greatly improved the scanning efficiency and response speed. Based on the infrared characteristic difference, putting forward a data fitting algorithm, employing the subtraction relationship between the covering area and sampling value to curve fitting, concluding the infrared sampling value of subtraction characteristic curve, establishing a sampling value differential data tables, at last ensuring the precise location of touch point. Besides, practices have proved that the accuracy of the infrared touch screen can up to 0.5 mm. The design uses standard USB port which connected to the PC can also be widely used in various terminals. *Copyright © 2014 IFSA Publishing, S. L.*

Keywords: Infrared touch screen, High precision, Efm32, Regional tracking, Data fitting.

1. Introductions

With the deepening of social information degree and the development of digital multi-media technology, the human-computer interaction technology become complex, the amount of dealing data become bigger and bigger, as a result, it puts forward higher requirements on human-computer interaction equipment. Especially the demand in precision and response speed are higher [1-3]. However, due to the restriction of the principle of infrared touch screen itself and some technical flaw in the traditional infrared touch screen, most of the existing infrared touch screens have the problem of low accuracy and slow response speed [4, 5]. In this paper, for the common problem of the above two traditional infrared touch screen, proposing effective solutions and erected on a platform framework for the entire system based on the ARM Cortex-M3 processor core EFM32, on the other side, proposing multiple effective algorithms. After designed by the hardware and software, the accuracy and response speed of the infrared multi-touch screen system are improved, the overall system performance are strengthened so that the system can meet all kinds of high requirements.

2. The Overall Framework of the System

Infrared touch screen is constructed by a display screen which installed a rectangular circuit board frame around it and on the four sides of the rectangular circuit board are corresponding installed infrared emission and receiver tube [6]. The structure shown in Fig. 1, where the white is the infrared emission tube, black is the infrared receiver tube; the dashed arrows indicate the spread direction of the infrared lights.

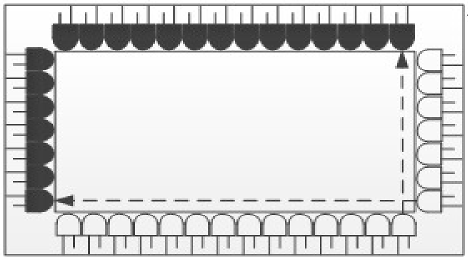

Fig. 1. Infrared touch screen structure.

Through the circuit drive, the infrared emission infrared light, the position corresponding to the infrared receiver receives the light signal, when the user touches the screen, the light in the horizontal and vertical will be sheltered by the finger. The changes of the infrared lights received by the infrared receiver tubes will cause electrical signal as the output the photoelectric detection circuit changed, through the comparative analysis of the electrical signal can determine the touch point position [7]. Any infrared light opaque objects can block its transmission and thus implement the touch positioning [8]. This design framework is based on the ARM Cortex-M3 core processor EFM32TG110. It separately drive infrared emission and receiver tube and then analysis and process of the received signal from the infrared receiver, finally, deliver the calculated position information to the host computer via the USB port. Fig. 2 shows the overall framework of the system.

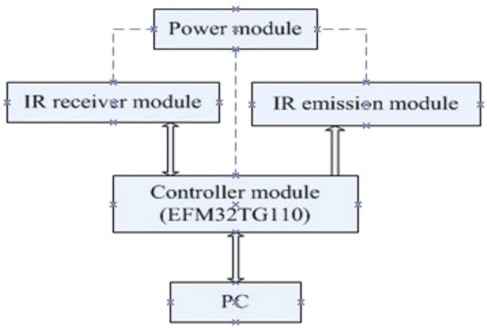

Fig. 2. The frame diagram of the system.

3. The Design of Regional Tracking Canning Algorithm

Because the response is slow, traditional infrared touch screen will produce a phenomenon of disconnection or trialing which affect the normal use. Whereas the response speed of infrared touch screen depends on the scanning speed [9, 10]. The traditional infrared touch screen has a low scanning speed, so we put forward a regional tracking scan algorithm. That is after the first time to scan and assure the touch point position, using a scanning method that gradually narrowing the scanning area, and ultimately achieve a small area tracking scanning without lost touch points and greatly improve the scanning rate at the same time. Regional track scan mode shows as the Fig. 3. After the first time of full scan, we can obtain the touch point A(X, Y), the second time scan will using point A as the center and the radius is RX1 (RY1), similarly the third time scan will use point A as the center and the radius is RX2 (RY2), the final scan radius is RX2 (RY2), thus achieved the regional track scanning.

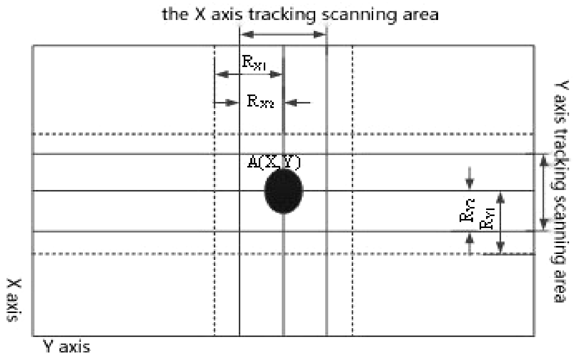

Fig. 3. Regional track diagram scanning algorithm.

4. The Design of Data Fitting Algorithm

Traditional infrared touch screen can only discern whether the infrared tube is covered or not, so the number of infrared tube determined the resolution of the infrared touch screen. Use the Φ5 mm infrared tube, for example, for a screen which the size is 121.5 cm × 68.5 cm and the width is 55 inch, infrared screen of tube array is 243×137, also, the resolution of the touch screen is 243×137. So the method of enhancing resolution only increase the number of infrared tube or reduce the volume of the infrared pipe, which give higher requirements of the cost and production technology. But this design through collect the analog signals of the infrared receiver tube, according to relationship between the signal difference and the shaded area to calculate the shaded area of the infrared tube. As a result, we can through a look-up table to get the corresponding position which is blocked, thus can precisely position and greatly improve the resolution of the infrared touch screen at the same time.

4.1. Theoretical Calculations

At first, analyzes the relationship between the degree of keep out area and the block. The head of the infrared tube is a Φ5 mm circle. The relationship between the blocked position x and blocked area S shown as in Fig. 4.

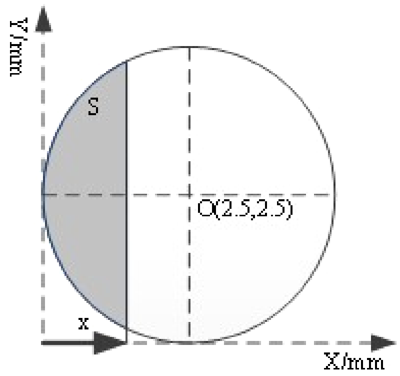

Fig. 4. Relationship between location x and shaded area S.

Establish a rectangular coordinate system as shown in the above. The center of the circle is O (2.5, 2.5), the equation of the circle is:

$$(x-2.5)^2+(y-2.5)^2=2.5^2, \quad (1)$$

By the formula (1) can be obtained the shaded area S is:

$$S = 2\int_0^x (\sqrt{5x - x^2} + 2.5)dx, \quad (2)$$

So we can obtain the curves between blocking position and blocking area shown in Fig. 5.

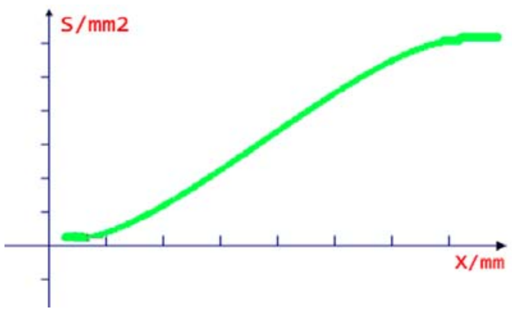

Fig. 5. The relationship curve between sheltered location x and shaded area S.

Thus, according to equation (2) and Fig. 5, we can establish the relational data sheet between sheltered area and blocked position.

4.2. The Actual Measurement and Difference Calibration

Measure and record the blocking area and sample values for multiple infrared tubes, the keep out area and the sampling value differential relation graph is shown in Fig. 6.

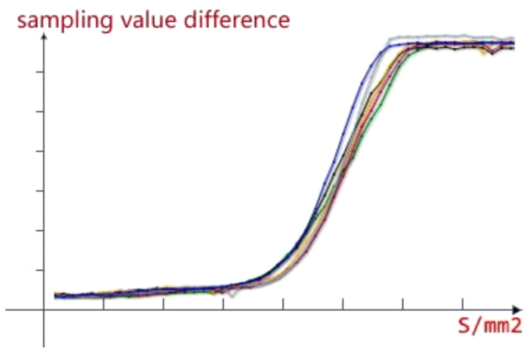

Fig. 6. The keep out area and the sampling value differential relation graph.

As shown in Fig. 6, since the parameter difference between each infrared receiving tube, each block area and the sampling value difference curve are inconsistent, and then need data fitting. The proposed function model is

$$H_i(S) = a_i * h(S) + b_i, \quad (3)$$

The coefficient of a_i and b_i are used to represent each individual differences of infrared receiving tube. The actual curve of h(x) can be obtained through extensive testing about the occlusion area of infrared receiving tube and its sampling curve, then get each infrared receiving tube's characteristic parameters of a_i and b_i, the data table about the relationship between each block area of the infrared receiving tube and corresponding sampling value difference can also be established. The accurate block position can be obtained by twice look-up table after getting the sampling value differential. Schematic diagram is shown in Fig. 7.

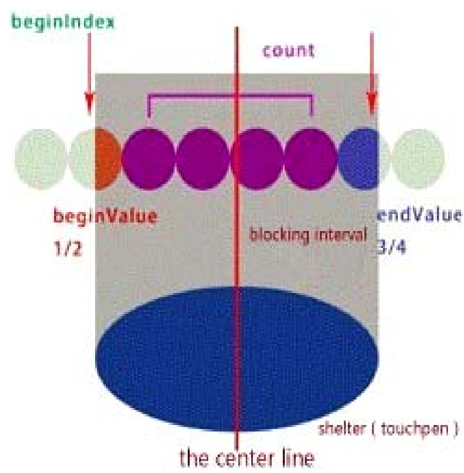

Fig. 7. Sampling value differential fixed-point schematic diagram.

5. The Infrared Emission and Received Circuit Design

5.1. The Infrared Emission Circuit Design

The function of the infrared emission circuit is driving the infrared emission tube in a certain sequence. Because IR3893C/HO has many advantages, such as high transmission power, big transmission angle, narrow emission spectra etc., so choosing it as the infrared emission tube from the company called EVERLIGHT in the design. The driver chip of infrared emission tube used SN74HC138D, because of its high speed, low power consumption. Considering the infrared tubes need a larger driver current and the performance parameters of the IR3893C/HO and SN74HC138D, this design increases a transistor amplifier circuit between SN74HC138D and IR3893C/HO to increase the driving current. The circuit connection diagram between SN74HC138D and infrared emission tube as shown in Fig. 8.

In the design, a plurality of infrared emission tubes driven by combinational circuits which composed of SN74HC164D and SN74HC138D. An infrared emission tube block is composed of eight infrared emission tubes. In each block, eight emission tubes cathode together is controlled by an output port of SN74HC164D, within the group of eight emission tubes anode respectively controlled by an output port of SN74HC138D, meanwhile the signals of all the output ports of the SN74HC164D amplified by the transistor circuit as an enable signal of SN74HC138D, which makes a SN74HC164D and a SN74HC138D can control 64 infrared transmitting tubes at the same time ,also can independently control anyone of the 64 infrared transmitting tubes. As shown in Fig. 9 is the circuit connection diagram.

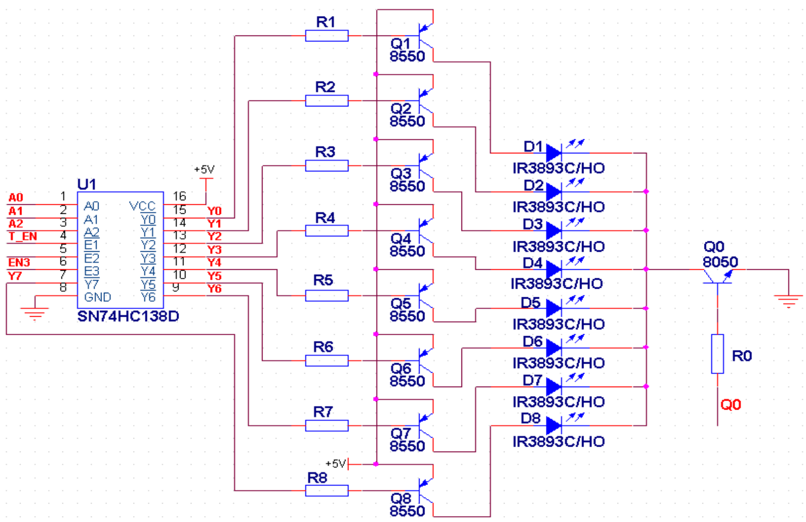

Fig. 8. The circuit diagram of infrared emission tube drive.

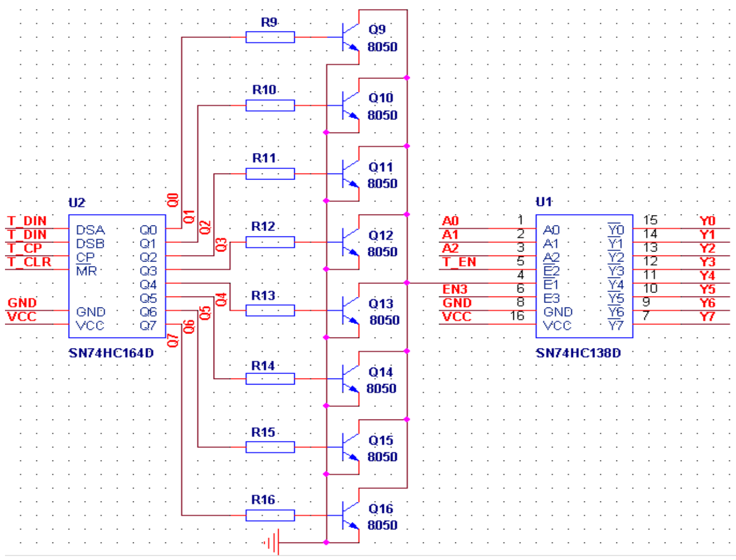

Fig. 9. Infrared emission tube cascade circuit.

5.2. The Infrared Receiver Circuit Design

According to luminescent performance and physical parameters, this design use the EVERLIGHT company's PD3894-6B/L3 as the infrared receiver tube. It has a high light conversion efficiency, good linearity, fast switching speed, etc.74HC4051D which has high switching speed, all ports are compatible with the various modes of operating voltage, and low crosstalk between each port, so the design choose 74HC4051D as a control chip to control infrared receiver on or off. In the infrared receiver tube 74HC4051D and receiver tube is connected with the circuit diagram as shown in Fig. 10.

The design achieves the control of multiple infrared receiving tubes by using 74HC164D to control eight 74HC4051D chips. Each eight infrared receiver tubes make up an infrared receiver tube block. Each block within eight infrared receiver tubes cathode connected together and then connected to a 5 V power supply terminal, a capacitor and two resistors are added to between the group of 8 launch tube anode and the control chip which forms a π type filter circuit, a preliminary filtering on the received optical signal. All of this greatly enhanced the light interference ability of the whole system. As shown in Fig. 11 is the circuit connection diagram.

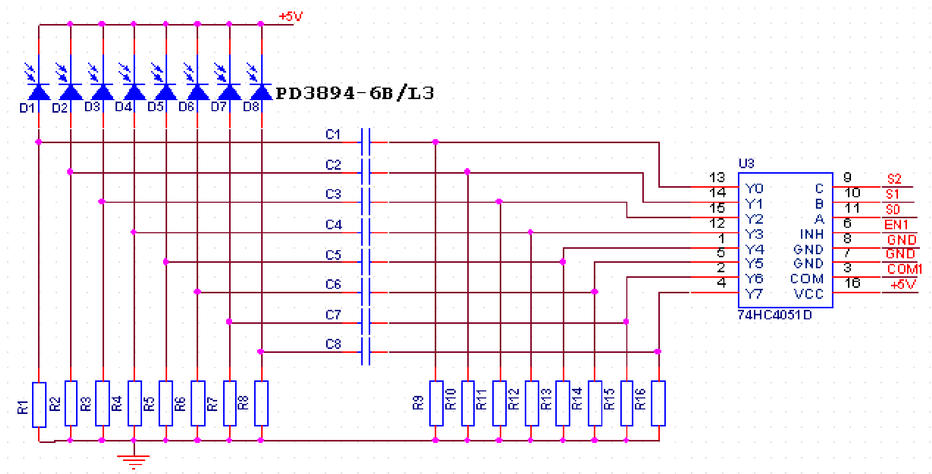

Fig. 10. The Circuit Diagram of Infrared Receiver Tube Driver.

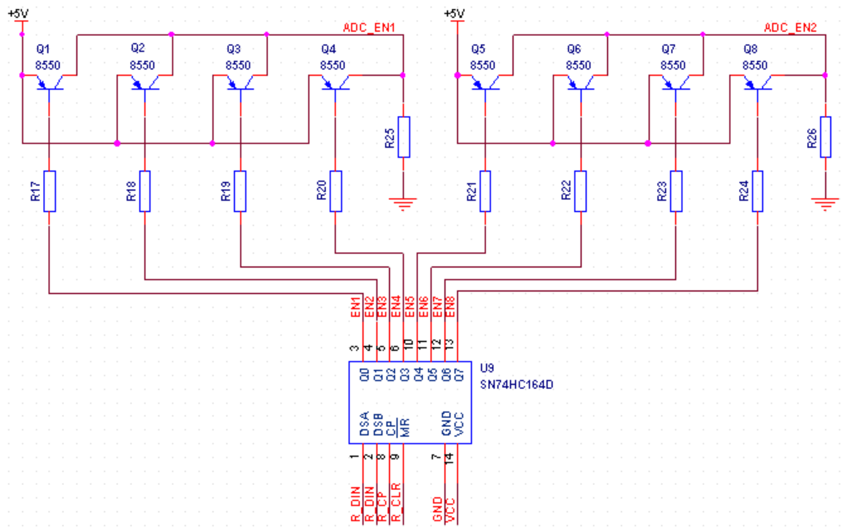

Fig. 11. Infrared Receiver Tube Cascade Circuit.

6. Conclusion

This paper presents design of high-precision infrared multi-touch screen system which based on ARM, giving the various design aspects, proposing regional tracking scanning mode, elaborating data fitting algorithm. This design has many advantages, such as simple hardware circuit, low demand for infrared tubes' installation and technical, easy to implement, etc. Practices have proved the accuracy of the infrared touch screen can be up to 0.5 mm, it solves the traditional infrared multi-touch screen slow response speed and low accuracy cannot normally used in the occasions with high requirements, and taking the widely application of the future system into account, the design using a standard USB interface to communicate with the host computer.

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