International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May 2013
ISSN 2229-5518

Resistive Touch Screen Controller Implementation on ARM7 CPU

Padma Prasada, Sukesh Rao M, *E & C Dept, NMAMIT, Nitte, India*

Abstract – Today, many fields are adopting touch screens or touch panels for applications with human/machinery or human/computer interfaces. ARM Microcontrollers are hot selling chips in the present embedded market, this paper presents the concepts and methods for the interfacing of Resistive Touch–Screen panel with host ARM7 CPU. Software programming algorithm and their implementation are also portrayed. The implementation methods give special consideration to analog power–down strategies, efficient analog to digital conversion and optimize the touch sensor algorithm.

We begin by looking at the theory of operation of a resistive touch screen. Techniques are presented for improving accuracy and minimizing errors; the operation of the Pen Interrupt is explored. The designed system is capable to determine the Touch position in terms of X-Y coordinate values. In this approach LPC2103 microcontroller from Philips Semiconductor Pvt Ltd, based on ARM7TDMI-S core is used as host controller. The ARM7TDMI-S CPU features 8 A/D channels, 32 general purpose I/O and several power saving modes. Using Cross ware Embedded development Studio, the entire software programming is done in C–language.

Index Terms— ARM7TDMI – S Core, Resistive touch sensor, Touch Screen Controller, UART, hyper Terminal.

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1 Introduction

The paper aims in implementing a Resistive Touch Screen Controller on an ARM7TDMI-S CPU. Touch screens emerged from academics and corporate research labs in the second half of the 1960s. One of the first places where they gained some visibility was in the terminal of a computer–assisted learning terminal that came out in 1972 as part of the PLATO project. The popularity of smart phones, PDAs, portable game consoles and many types of information appliances is driving the demand for, and the acceptance of, touch screens [9].

To interface Resistive Touch Screen with a microcontroller, it requires a microcontroller with inbuilt Analog-to-Digital converter having two or more channels. This is needed because; the touch screen will provide data in terms of an analog voltage level on two different pins, using which position of Touch can be determined. Also, ADC input pins of the microcontroller should be configurable as General Purpose I/O (GPIO). The ARM7TDMI-S fulfils this requirements as it posses' inbuilt Analog-to-Digital converter with 8-channels, and more importantly these pins can also be configurable as General purpose I/O pins. In this proposed system prototype we are using LPC2103 microcontroller from Philips Semiconductors. It is based on 32-bit microcontroller ARM7TDMI-S CPU.

The LPC2103 microcontrollers are based on a 32–bit ARM7TDMI–S CPU with real time emulation that combines the microcontroller with 32kb of embedded high speed flash memory. Due their tiny size and low power consumption, LPC2103 are ideal for applications where miniaturization is a key requirement. Hence it is used as host controller in this project, accepts input from resistive touch screen, which is processed by this host controller and, determines the Touch position on resistive touch screen. Here UART is being used for the testing of measured Touch position, obtained in terms of X-Y coordinates are passed to windows hyper terminal and tested.

The rest of this paper is organized as follows: section II describes the construction and basic working principle of Resistive touch Screen. Section III gives the system configuration of proposed device. Section IV exposes the hardware design and interfacing techniques. In section V, software implementation method and workflow of the system is portrayed. Section VI shows the implementation result and Section VII concludes this paper.

2 Resistive Touch Screen Panel Basics

Of all the kinds of touch screens available, Resistive touch Screen are easy to interface, cheap and they have fair sensitivity. The cross section of a resistive touch screen is shown in Figure 1. The construction is simple, two sheets of glass are brought together to form a sandwich. The two sheets are coated with a resistive substance, usually a metal compound called Indium Tin Oxide (ITO). The ITO is thinly and uniformly sputtered onto both the glass and the PET layer. Nearly invisible bumps called spacer dots are then added to the bottom layer and on top of the resistive ITO coating.

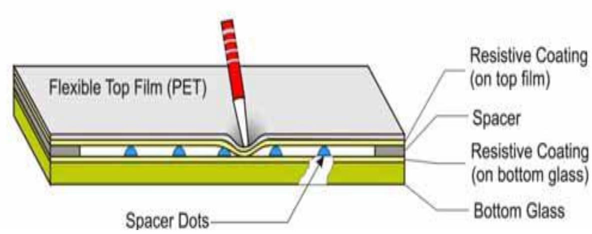

Figure 1.Cross section of a resistive Touch Screen

The bumps keep the PET film from sagging, causing an accidental or false touch. The buss bars and traces are made of silver ink; connect the ITO layer to the flex tail [1] [6]. When the PET film is pressed down, the two resistive surfaces meet and position of this touch point can be read by a touch screen controller circuit. In this paper we present the implementation of resistive touch screen controller on an ARM7TDMI-S CPU.

International Journal of Scientific & Engineering Research Volume 4, Issue 4, February -2013
ISSN 2229-5518

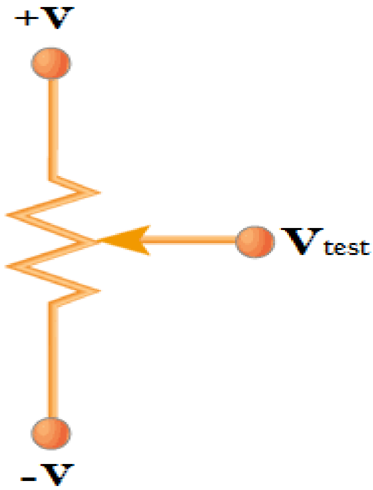

Figure 2. Equivalent Circuit

An equivalent resistive circuit is shown in Figure 2. A touch screen controller applies the V sources to the ends of one of the conductive layers, while the other conductive layer on the opposite sheet of glass, plays the role of the potentiometer wiper. The Vtest value read by the touch screen controller depends on where the glass is touched and the conductive surfaces come into contact. The controller then translates the voltage reading into binary voltage level representing, for example the X-coordinate of the point where the screen is being touched. The voltage potential is then applied to the second surface's end-points and the first surface plays the role of the wiper, yielding a value that represents the Y-coordinate.

3 SYSTEM CONFIGURATION AND ARCHITECTURE

The proposed system consist a 4–wire resistive touch screen, host controller i.e. ARM7TDMI–S CPU. As user writes over touch screen, resistive touch screen produces corresponding touch position dependent analog voltage. Resistive touch screen is controlled and driven by ARM7TDMI–S CPU; it receives analog voltage output from resistive touch screen, and converts it into corresponding machine understandable digital voltage signal to identify the touch point on the touch screen. Its functional block diagram is represented in Figure 3.

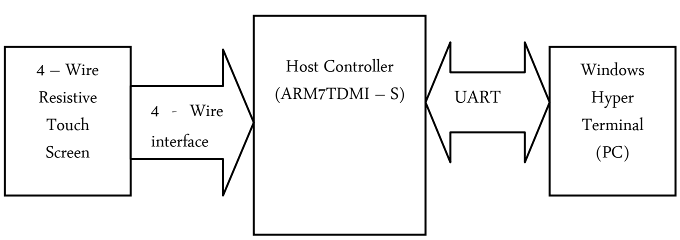

Figure 3.Block diagram of proposed system

The Universal Asynchronous Receiver/Transmitter (UART) Controller is the key component of the serial communication subsystem of a computer. The UART takes bytes of data and transmits the individual bits in a sequential fashion. At the destination, a second UART re-assembles the bits into complete bytes. The CPU passes converted signal levels, representing touch coordinates into windows hyper terminal via UART serial communication for testing our design prototype.

4 HARDWARE DESIGN AND INTERFACE TECHNIQUE

In an embedded system development power consumption is a critical issue to be considered. In our approach, we give special consideration to analog power-down strategies like deactivating unused on-chip peripherals of host controller, and implementation of efficient analog to digital conversion.

Touch screen controller is the key to this design. Currently there are variety of microcontrollers are available in market. Considering price, speed and flexibility and other factors, a high cost-effective chip LPC2103 based on ARM7TDMI-S CPU of Philips Semiconductors Pvt Ltd is used. LPC2103 includes an 8 analog to digital conversion channels with conversion time as low as 2.44u Sec, which is key requirement to implement touch screen controller, and also 32 general purpose input / output ports along with, multiple serial interfaces including UARTs, I^2C buses, SPI and SSP [7].

Resistive touch screens are easy to interface, cost effective and they have fair sensitivity. Resistive Touch screens are simple transducers. This touch screen has a resistive layers in both X and Y directions. According to the position of the touch, their X coordinate and Y coordinate resistance changes. So, what we have to do is we have to determine the X and Y coordinates resistance to get the position of the touch in terms of X and Y coordinates. Figure 4 gives the simple structure of resistive Touch Screen.

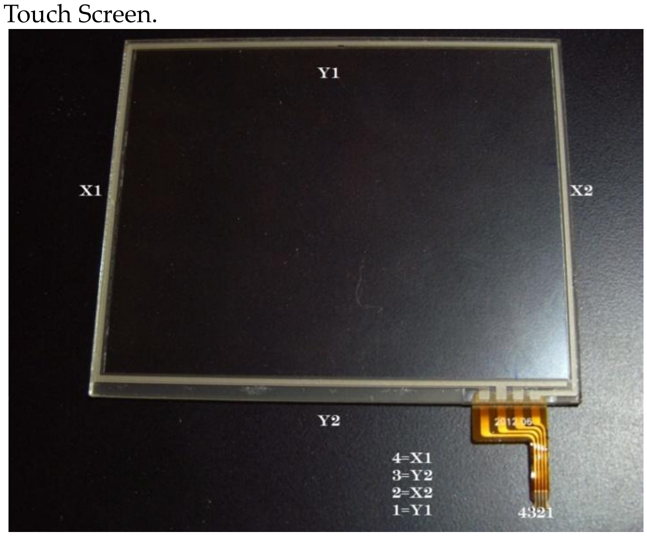

Figure 4. Four-wire Resistive Touch Screen

To interface resistive Touch screen with a host microcontroller, we need a microcontroller with inbuilt Analog-to-Digital converter. ARM7TDMI-S CPU provides eight Analog-to-Digital converter channels, out of this two channels are utilized for this purpose. To read the position of the touch, we have to first read touch position sequentially i.e. first read X

International Journal of Scientific & Engineering Research Volume 4, Issue 4, February -2013
ISSN 2229-5518

position and then read Y position. To do this, we connected X1 and Y2 pins of Touch screen to ADC multiplexed GPIO pins of LP2103, i.e. P0.22 and P0.23 respectively. And X2 and Y1 pins of Touch screen to simple GPIO pins of LPC2103, i.e. P0.20 and P0.22 respectively. TABLE I gives detailed 4-Wire Resistive Touch Screen interfacing configuration with the ARM7TDMI-S CPU

TABLE I Resistive Touch Screen Interfacing Configuration

ARM7TDMI-S Port Pins	Resistive Touch Screen Pins	Pin Assignment for X-Position	Pin Assignment for Y-Position
P0.20	Y1	No Connection	+3.3volts
P0.21	X2	Ground	No Connection
P0.22	Y2	ADC Input	Ground
P0.23	X1	+3.3volts	ADC Input

RS232 is standard defined for serial communication; this standard defines the signal level requirements at transmitter and receiver. Therefore to make it compatible with the TTL output an interface IC is required. The interface IC should convert the TTL logic to RS232 standard and vice versa. MAX232 is one such IC which is used for this conversion. ARM7TDMI-S is available with inbuilt UART ports. Hence the Receive/Transmit pins of ARM7TDMI-S CPU is connected to T1in and R1out pins of MAX232. In this way Development board is connected to windows hyper terminal. Implementation method and workflow of implementation will be discussed in next section.

5 IMPLEMENTATION METHOD AND WORKFLOW

The 4-Wire Resistive Touch Screen is interfaced to ARM7TDMI-S CPU as explained in previous section. Used two ADC multiplexed General Purpose Input / output pins for reading X and Y Touch position coordinates and two simple General Purpose input / Output pins for driving power signals.

As stated earlier, first we have to read X position of the Touch, for that, pin X1 of Touch Screen is programmed as Logic HIGH (+3.3volts) and Configured X2 as logic LOW (ground). Resistive Touch Screen contains a resistive layer in both directions. So, when we apply Logic HIGH and Logic LOW to its pins, it will create a voltage gradient in X direction. Voltage on the X channel will vary according to the Touch position. We measure this voltage to determine the X position. For this purpose, Y2 is connected to ADC input and Y1 is kept at HIGH impedance state. The value of ADC output will be relative value of the Touch.

After reading X position, now we have to read the Y position to determine the Touch position. To read Y position Y2 is programmed as Logic HIGH, Y2 as Logic LOW, and X1 as ADC input and X2 as HIGH impedance state. The entire procedure explained above must be repeated continuously to determine Touch position instantaneously.

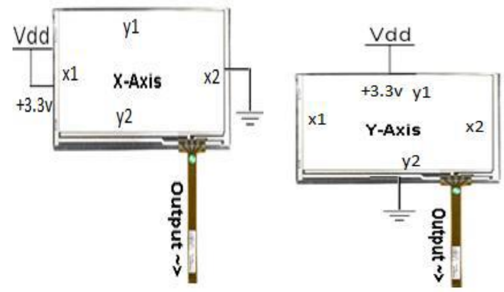

Figure 5.Configuration to read X and Y Touch position

The Pen Interrupt feature is implemented with a simple analog circuit, schematic is shown in Figure 6. By simply pulling-up the output pin of resistive Touch Screen to Vcc through series connected diode, a basic interrupt function can be implemented. While the Touch screen is untouched, the diode is not biased, and no current will flow. The voltage level at point A will be approximately Vcc.

When the Touch screen is pressed, the diode is forward biased and current flows to complete this current loop to ground. Now, the voltage at point A is pulled LOW. The low going voltage level at point A can be used as interrupt to host controller to perform analog-to-digital conversion [10].

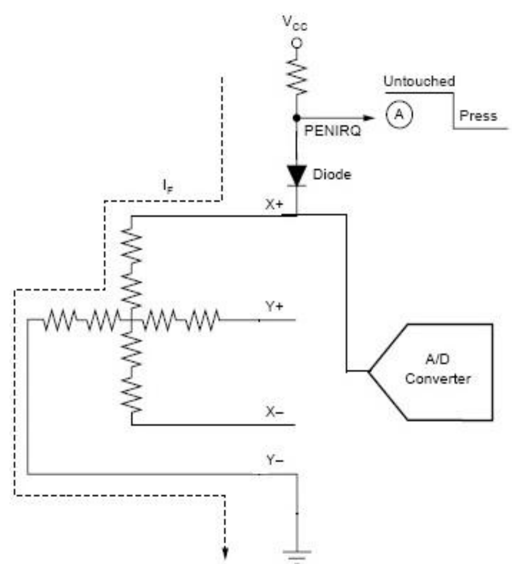

Figure 6.Schematic for PENIRQ generating technique

Figure 7 describes the work flow of driving and reading resistive touch Screen, to determine the Touch position coordi-

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ISSN 2229-5518

nates.

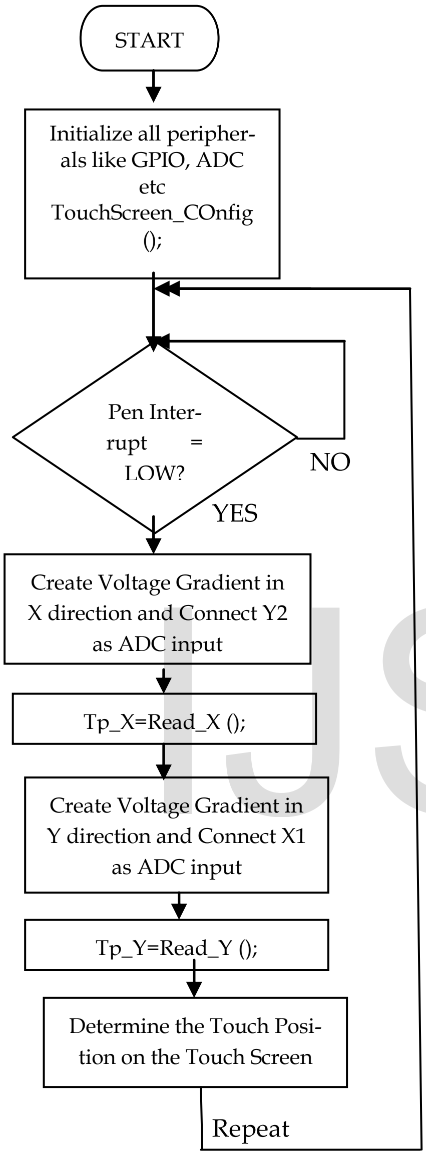

Figure 7.Touch Screen reading work flow

6 EXPERIMENTAL RESULT

Implementation is successfully carried out on ARM7TDMI-S CPU using Crossware Embedded Development Studio. Crossware's Embedded Development Studio leverages the features of windows to provide a development environment that allows the programmer to concentrate on the primary task of software development. Windows hyper terminal is being used in this approach to test the design prototype. Figure 8 shows the output values obtained on hyper terminal for touch event with its coordinate values and untouch event represented as Zero's .

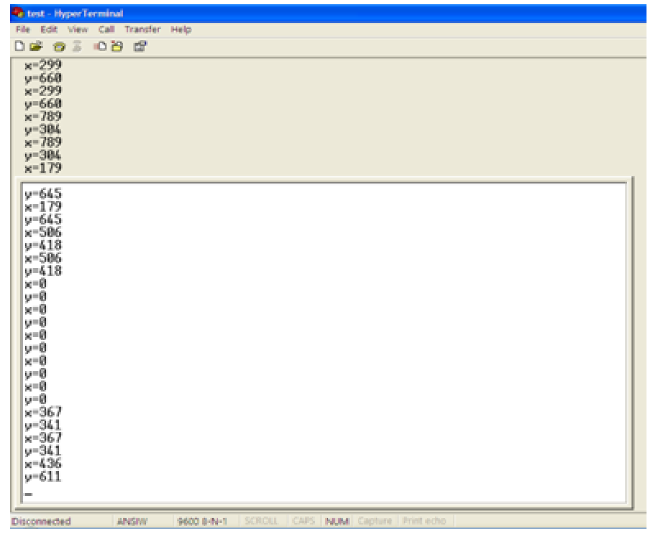

Figure 8. Windows hyper terminal

7 CONCLUSION

The 4-Wire Resistive Touch Screen interfacing with ARM7TDMI-S CPU is designed, implemented and tested. We use windows hyper Terminal for testing the touch coordinates values obtained as a function of Touch on a Resistive Touch Screen. Measurements are made by applying voltage gradient across one of the layer and measuring the voltage on the other layer. This measurement is made twice, once with the gradient across the ridged layer and the measurement taken from the flexible layer and again with the gradient applied to the flexible layer and the measurement taken from the ridged layer.

The resistance of the bus bars and the connection circuitry introduces an error (offset) in the voltage measurement. These offsets can also drift, with changes in temperature, humidity and time. So calibrating the screen periodically is to be done or can utilize 8-wire Touch Screen. And non-linear response exists when the contact between the two layers is not good. The nonlinearity exists mainly when the level pressure is not enough.

A real-life equivalent of the system prototype presented in this paper can be developed with minimal development cost and relatively low operational cost.

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