

# **An Advanced Touch Screen Controller: A Critical Component To The Success of Tablet PC**

by Fred Hwang

A touch screen is an input device; more specifically it is a pointing device. Because it is overlaid on the display's front surface of a PC, Notebook, or Tablet, it takes less desk space than a keyboard. Directly tapping a touch screen is much more convenient than moving a mouse cursor then clicking. The traditional usage or applications of touch screens are when the monitor display and/or keyboard space is limited. Some other popular applications are when complicated commands need to be simplified or broken down by pieces of command icons/buttons. The drawback of using a touch screen is that it can not be used too long at one time, due to arm fatigue. A touch screen is not a keyboard emulator, it is not meant for massive data entry. Therefore the majority of current applications are meant only for a few taps. The popular commercial examples are these: point of sales, restaurant order entries, public information inquiry, museum exhibition, ticking booth, etc. The popular end-user examples are PDA, e-Book, etc.

A tablet is a digitizer, a pen-based pointing device; more specifically, a drawing device. The tablet stylus pen senses a great degree of the pressure levels and generates special inking and drawing effect for the artist; and a handy "eraser" at the end of the stylus lets one delete text or portions of images with a swipe. Comparing to a mouse, the tablet is a very good device for the graphical applications. The hand writing is a basic function of a tablet device. Since Microsoft has introduced a state of the art Windows XP and a Windows XP Tablet PC Edition operating systems, more and more people have put their attentions on the Tablet PC. The tablet becomes a hot and noticeable device. More of less, there are some other similar products are coming up, such as WritingPad, Notepad PC, WebPad, SmartPad, etc.

The original design of a tablet was to be used on top of a desk, not easy to be designed underlying to a LCD panel. The technology of using EMR (Electro-Magnetic Resonance) can have interference from the LCD's metal frame. A special error correction algorithm has applied to correct these side effects.

The original design of a touch screen was to be used in a targeted area that is slightly larger than a finger tip. The traditional touch screen was meant for use in a larger touch area but unsuited for the Tablet PC environment. The most important issue to the successful acceptance of Tablet PC by the general public is the development of an advanced touch screen, which has the characteristics of low power, high resolution, low cost, user friendly and reliable. The author of this paper has just developed one. Before describing his new design, a status of Tablet PC is given below.

The Tablet PC has different kinds of models: the convertible model that converts a notebook PC into a tablet PC; the pure tablet model that is ultra-slim and lightweight; the docking model that allows you dock or undock for grab-and-go; the screen rotation model that makes the display screen orientation changeable between portrait and landscape view. From a user's viewing angle, the Tablet PCs are actually a cross laptops and notebooks in size and allow digital pen and ink input like a PDA. As far as viewing angle from a PC manufacturer, the Tablet PCs have a new input device, the tablet, which has to put into the design.

According to the Microsoft XP Tablet PC Edition System Requirements, posted on June 21, 2002, web address <http://www.microsoft.com/windowsxp/tabletpc/productinfo/sysreq.asp> the Tablet PC-specific requirements are:

□ **An electromagnetic digitizer:**

The electromagnetic digitizer is a special panel that sits behind the screen and communicates with a special pen. Because of the digitizer's high resolution, handwriting recognition is more accurate and ink looks more realistic. Unlike a resistive-touch screen, the digitizer makes it possible to rest your hand on the screen while writing.

□ **Optimized power states:**

Tablet PCs have the ability to resume from standby in about 5 seconds.

□ **Screen rotation:**

Tablet PCs support rotating the screen between portrait and landscape views without restarting. With the push of a button, the screen rotates from one orientation to the other.

□ **Surprise undocking:**

Tablet PCs support "grab and go," the ability to undock from a docking station without having to notify your system.

□ **Legacy-free hardware:**

Tablet PCs do not include external serial or parallel ports. USB ports are provided.

□ **A hardware button for logging on to Windows:**

Tablet PCs provide quick and secure logon procedures using a single CTRL+ALT+DEL button.

Summary for the above requirements, a resistive touch screen can be used as a substitution to the tablet, if:

1. A touch screen controller provides high resolution to make handwriting recognition more accurate and ink more realistic.
2. A touch screen panel has built in so much dense spacer dots that make it possible to rest your hand on the screen while writing.
3. A touch screen controller resume from standby is faster than 5 seconds.
4. A touch screen controller supports the screen rotating without restarting.
5. A touch screen controller supports "grab and go" undocking operation.
6. A touch screen controller uses a USB port that is provided by a Tablet PC.

Such dreamed touch screen panels and the touch screen controllers are developed in our Lab. Touch Screens based on 4-wire analog resistive and pressure sensitive design are existing products. Many manufacturers are available. The price of a touch screen panel is low and very competitive to a tablet. The spacer dots, an insulator that is in tiny size and separates two conductive and transparent touch-screen layers, are controllable in manufacturing to its density. When higher dense spacer dots are applied, the sharper tip is required penetrating of making a touch of the two layers. These dense spacer dots are providing of hand rest on the screen while writing.

Hi-Tech Instruments HTIUSB001 controller is a USB microcontroller. The chip interfaces with two (2) 12-bit ADCs to provide 4096 x 4096 very high resolutions in both the X and Y direction. The

chip has a special and proprietary firmware algorithm that smoothes the hand-writing trace. The high resolution combined with the smooth hand-writing trace make handwriting recognition more accurate and ink more realistic. The controller resumes from standby much faster than 5 seconds, actually is in 2 usec. The controller takes a command to do the X-Y coordinates rotating that meets the screen rotating references without restarting.

A touch screen used in an operating system needs more features than used in an application. In the traditional touch screen applications, emulating a mouse left-button clicking is sufficient for the entire operation. Besides those requirements were described above, while in a Tablet PC operating system, a touch screen needs not just left-button clicking, but also needs features of dragging, right-button drop-down menu, double-clicking (left-button), higher accuracy, and high resolution for handwriting recognition. Almost all these features are performed by the controller, not by the touch screen panel. The touch screen controller plays more important role than a touch screen panel at this point. The requirements for a touch screen controller being able to use under Tablet PC are listed below:

Select	Emulating mouse left-button down click. The cursor shall move once and become steady. The particular situation is at Start menu item selection.
Open	Emulating mouse left-button up condition. The cursor shall be steady. The particular situation is at Start menu item selection.
Drag	Emulating mouse left-button down click and cursor movement. At the moment of stylus lifting (emulating mouse left-button up condition) the cursor shall be steady. The particular situation is in Windows Explorer, the dragging file(s) into a correct destination has to be successfully executed.
Drop-down menu	Emulating mouse right-button click. The operating system itself and many applications support right-button click to have a drop-down menu for selecting items. There shall be a hardware easy-to-use mechanism that switches the tap operation from generating a left-button click to a right-button click momentarily.
Double-tap	Emulating mouse left-button double-click. The cursor shall move once and become steady. The time interval between two taps shall be about 0.2 second. The shorter time interval the harder double-tap can achieve. The longer time interval the slower handwriting performs. The particular situation is in Windows Explorer, a file shall be easily and successfully opened.
Handwriting	The trace of handwriting shall be smooth. The smoother the trace the higher recognition rate gets. The trace smoothie includes: horizontal line, vertical line, inclined line, arch ratio and gradient. Without losing the details, the trace shall have no jump-spike at meddle, no saw-tooth like line, no jump-stroke at end. Handwriting recognition shall be performed well not just for English (continued curved writing) but also other language writing, such as Asia language (stroke by stoke writing). Handwriting shall also have fast response and lost no details.
Accuracy	In the Tablet PC operating system, a great deal of times there are targeted area or buttons are so small to touch. Because commonly used display resolution on the market are at least 1024 x 768 and above. The touch screen has circuitry resistance effective loss plus the active area of the touchable screen is smaller than the actual screen size measured from the edges. The touchable resolution is actually much less than the resolution it suppose gets from the ADC conversion. Therefore the touch screen controller shall use at least or higher than 12-bit ADCs, to provide a “wished” 4096 x 4096 resolution.
Linearity	The analog resistive touch screen panel has only 4 wires go to the controller. The circuit

	is so simply that only two (2) wires per each layer has. In normally condition, the separated layers act like an open circuit. When a touch is occurred, the layers are closed. At the touch point, a divided resistance per each layer is formed to have a relative voltage potential. The relative voltage is proportional to the location of the screen and is converted by a X or Y ADC respectively into digits representation. These converted digits are representative for the coordinates and are linear to the touch locations. However, these digits are not 1-to-1 relationship to the display pixel coordinates. For an example, the pixel coordinate is from 0 to 1023 while the touch location converted digits are from 18 to 3828. If a linear relationship is used for calculation of converting touch location digits into pixel coordinates, depends upon the decimal deficiency is used, then there always be tolerance. This problem is commonly seen by the traditional controller design. The center area may look more accurate than to the side areas; or the area closer to the origin look more accurate than to the area far from the origin. A special mathematical method shall use to overcome this phenomenon.
Power	The less power consumption the better level system achieves. The controller shall support the standby and suspend modes. The wake up time shall be short. The current shall be drawn only when there is touch occurred; when there is no touch occurred the current shall be drawn conservatively.

To a traditional touch screen application, the controller design is simple and no need to consider all the criteria's mentioned above. To a touch screen that is going to use in a Tablet PC, the controller has to have all the solutions to all those requirements. Sometimes, the cursor shall only move once and become steady for emulating a click; on the contrary, while in handwriting, we want the cursor moves the faster the better. Another example, at the second touch of the double-tapping, we need the cursor steady; on the contrary, while in writing a dot for an English i letter, we want the cursor moves in fast motion. A good controller design must be able to distinguish from a simple tap motion into all its different meaningful reacts. They are complicated and challenged tasks, but Hi-Tech Instruments has done them all. With all these features, the HTIUSB001 controller should satisfy the requirements of the Tablet PCs.

The comparison features between a tablet and a touch screen from Hi-Tech are:

<b>Task</b>	<b>Touch Screen</b>	<b>Tablet</b>
left-click , drag, double-click, pull-down, handwriting	Yes	Yes
Pen input	Any pressure media, finger or stylus	EMR special pen with buttons
Right-click	Yes, touch with a short steady hold	Yes, a button on the pen
Cost	Estimated 1/8 price to the tablet	Expensive
Assemble integration	Easy	Complicated
Design integration	Retrofit various LCD sizes	Only available on the fixed sizes
Interface	USB	Serial (RS232)
Hand rest	Yes	Yes
Power consumption	Better, less current drawn @no touch	Worse, EM radiation occurs always
Response time	Fast, ADC only	Slow, scan+transmit+receive & ADC
Inking effect <sup>1</sup>	No	Yes, various pressure applied on pen tip
Eraser button <sup>2</sup>	No	Yes, a button on the pen

Note 1: is a good feature for an artist on drawing. Does handwriting really need this?  
Note 2: can be achieved via software menu selection.

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