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Tech Briefs / Emerging Technologies

Touch technology for today and tomorrow

Introducing the cPad™ to Toshiba notebooks

Toshiba, a leading notebook manufacturer, has a history of adapting and introducing the latest technologies to its products. This year is no exception as Toshiba is the first manufacturer to introduce the cPad™ from Synaptics into its notebooks such as the Satellite 5100. This device allows users to perform standard cursor navigation with touch pad functionality, as well as use touch screen technology for interactive computing.

With the cPad™ users can control the cursor on the notebook's primary display, easily launch applications — such as Microsoft Word® or PowerPoint® — via an auxiliary button, and run cPad's own applications on its own display. These applications include a calculator, sticky notes, date and time display, multimedia control for audio visual playback, signature input, and even a customizable background.

For example, a user can directly input numbers and functions by interacting with the cPad's 240 x 160 display. Signing documents can be accomplished by writing with one's finger across the screen. This means users can give letters a more "personal touch," as well as multi-task more effectively with the secondary display.

To better understand this new device and its benefits, this article takes a look at the cPad™ in the context of touch technology

Topics include:

- Introduction to touch technology
- Touch technologies: A definition and overview
- Understanding how the cPad™ projected capacitive technology works
- Sensing the cPad™ difference: Enhanced usability
- Summary of benefits for Toshiba notebook users
- Future Outlook: Development in haptics
- Conclusion: The world at one’s fingertips

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Introducing touch technology

Whether one is navigating one's way through an airport using a touch screen information kiosk or navigating the web using a touch pad for cursor control, touch technology has become a part of daily life. ATM machines, kiosks, touch displays, smart phones, computer-based training (CBT), PDAs (typically using a stylus), notebooks and tablet PCs all make use of this technology.

It is so prevalent that we might be tempted to think that it has been around for quite some time. However, touch technology is a relatively recent technology that first made its appearance in the form of touch screens. Developed by Dr Samuel Hurst in the 1970s, these screens allow users to interact with technology intuitively and easily by touching the screen directly with one finger or by using an input device, typically in the form of a pen.

TouchPads are an even more recent technology, having first appeared in notebook computers in 1994. Originally TouchPads intended to provide integrated cursor control in a notebook computer to eliminate the need for an external mouse. TouchPads have proven so popular that USB models for use with workstations have also been introduced.

Unlike the mouse, whose use is restricted to computers, the TouchPad™ works with a number of devices and applications. For instance, recently cars were introduced that incorporate a TouchPad™ at the centre of the steering wheel, enabling the driver to "blindly write" on the screen to activate GPS navigation or phone service others while driving.

In the future, touch technology will offer users a more symbiotic experience, allowing people to feel as if they are actually handling objects. While such developments are still in progress and may not be realised for several years, there are several important technologies already implemented today. The cPad™, as will be seen, introduces a number of enhancements and refinements in the field.

Touch technologies: A definition and overview

Touch technology involves detecting, measuring and processing the user's touch input. Today, there are four basic kinds of touch technology: **resistive, surface wave, scanning infrared** and **capacitive.**

Each method uses a different method to detect and measure the user’s touch and, as such, is suitable for different applications.

- **Resistive** – this approach responds to pressure on the surface of the screen; a finger, gloved hand, or stylus can be used; suitable for PDAs, such as Toshiba's Pocket PCs e310 or e740.
- **Surface wave** – uses ultrasonic waves that pass over touch screen pane; a finger or soft-tipped stylus can be used; suitable for information kiosks or CBT.

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- **Scanning infrared** – makes use of miniature IR LEDs (light-emitting diodes) to create a grid of invisible light; a finger gloved hand or stylus can be used; found in industrial, medical, military and manufacturing equipment.
- **Capacitive** – responds to disturbances in an electrical field that are created when the user touches the surface of the screen with a hand or finger.
- **Surface Capacitance** requires direct finger contact, a thin latex glove, or special conductive stylus
- **Projected Capacitance** allows gloved or direct finger input; used for kiosks and ATMs

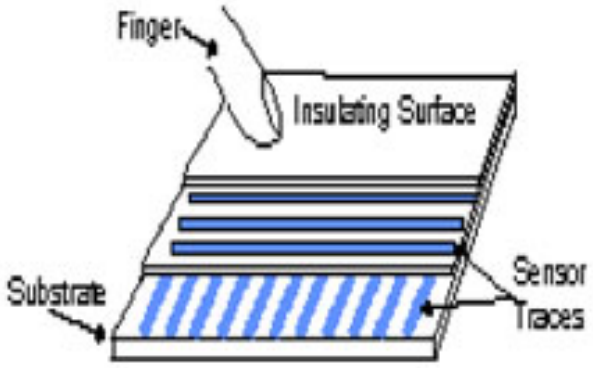
Whatever method of input or detection is used, information about the "touch event" is transmitted to a controller for processing. The controller calculates the X- and Y-coordinates (location) of the user's input and forwards this information to the operating system/software application for processing.

Understanding how the cPad's™ projected capacitive technology works

The cPad's capacitive touch sensing technology works using an electrical phenomenon called projected capacitance.

Whenever two electrically charged objects come near to one another without touching, their electric fields interact to form capacitance. In the case of the cPad™, projected capacitance forms between the user's finger and the electrodes in the sensor grid laminated to the LCD surface. This "touch event" is detected, precisely measured, and passed on to the system for processing.

To better understand how this touch sensing technology works, let's examine the construction of the capacitive used in cPad™:



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Insulating surface: A thin layer of clear polyester that protects the underlying sensor traces. The texture is coated with a special texture that maximizes clarity but also provides texture to improve finger movement and to reduce smudging from fingerprints.

Laminated sensor grid: These traces that form the sensor grid are made from a nearly transparent metal called Indium Tin Oxide (ITO) and run horizontally and vertically through the sensor. To reduce the visibility of the grid, the traces are specially designed to tile the entire surface yet minimally overlap at the crossings. To prevent the grid's horizontal y-axis and vertical x-axis from shorting out where they cross, the horizontal and vertical wires are located on two different layers. Each trace is an electrode that connects to the touch controller chip. These traces sense and detect the user's finger: information about x and y coordinates is passed to the touch controller chip.

Bottom Substrate: Another thin layer of clear polyester that separates the sensor grid from the underlying LCD. A clear adhesive is used to secure the capacitive sensor to the LCD.

When the user interacts with the cPad™, the following processes occur:

- **User's input:** The user initiates the touch event by interacting with the sensor grid through the insulating front glass layer.
- **Capacitance:** Electrodes on the sensor grid capture information about the amount of capacitance on the x- and y-axes.
- **Measurement:** Circuits on the touch controller chip measure the capacitance on each sensor electrode. This is equivalent to determining how hard the finger is pressing on, but it cannot tell where on the electrode the finger is located.
- **Location:** The location of the user's finger on the grid is calculated by looking at the distribution and amount of capacitance on all the electrodes. By examining this distribution of capacitance, the touch controller can determine the position of the finger. The points where the largest amount of capacitance on the x-axis and y-axis are mapped together pinpoint the location of the user's input. By comparing the amount of capacitance on adjacent electrodes (a process referred to as "interpolation"), a more precise location is determined.
- **Processing:** The touch controller board processes the information (about the pressure/location of the touch input) and passes it to the computer.
- **System Response:** Operating System/Application Software responds to the user's input.

Sensing the cPad™ difference: Enhanced usability

The cPad™ has a very high degree of sensing accuracy: it can locate the position of a finger to a resolution of less than a tenth of a millimeter. This precision is enhanced though a number of refinements:

- **Interpolation:** The cPad™ can mathematically compare the capacitances on several electrodes to locate the finger much more accurately. This means that although the

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electrodes are spaced about 17 millimeters apart, the screen can interpolate finger position to less than 0.1 millimeters.

- **Design of the Sensor Grid:** The unique patent-pending grid design provides maximum coverage over the sensor surface yet minimizes the visibility of the grid.
- **Special Processing Algorithms:** Based on the capacitive sensing algorithms found in over 40 million notebook computers, the cPad™ incorporates patented algorithms to suppress unwanted noise and other artifacts so only your finger is detected. Furthermore, special palm rejection software is included to suppress cPad™ activity if your palm accidental touches the cPad™ during typing.

Summary of benefits for Toshiba notebook users

By incorporating the cPad™ into its notebooks, Toshiba offers customers the latest technology advances for easier and more intuitive computing. The following are some of the major benefits for users:

- **Durability:** This solid-state technology does not use physical switches that must flex and rub throughout their useful lifetime. Moreover, the capacitive sensing operates even under a highly durable surface, such as polycarbonate. This device is rated as having 1 million uses.
- **Suitable for compact designs and devices:** The size and shape of the sensor surface and the controller can be customized for different applications, offering a flexible solution for various notebook designs.
- **Low-power requirements**
- **Easy-to-use:** does not require calibration.
- **Ergonomics:** this very thin technology is 6.1mm at maximum thickness.
- **Light:** very light, weighing 28.8 grams.
- **Robust:** unaffected by traces of moisture, grease or dust on the user's hand
- **Works in a variety of climate-conditions:** operating conditions support 0°C to 60°C and 5%-85% humidity; can be stored at temperatures ranging from -20°C to 65°C; not affected by swings in temperature and humidity.
- **Designed to respond to the human touch:** Unlike other technologies that respond best to a stylus or other input device, this technology is more sensitive to the human finger with a resolution of 1000 dpi (dots per inch) as compared to 300 dpi or less in resistive screens.

Future outlook: Developments in haptics

Generally, the field of research and development for touch technology is referred to as haptics; its etymology comes from the Greek meaning "to touch." This includes not only the ability to input information by touching the device, but also a more symbiotic experience. The technology provides digital information about shapes and textures, enabling people to feel as if they were handling objects directly.

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Overall, haptics promises to enrich the user's 3D experience. Simulations and virtual environments will take the user to places that were never possible before.

Emerging applications and devices under development today can be grouped into the following areas, including:

- Entertainment and fashion
- TouchPads and touch input
- Medical technology
- Exploration
- Virtual museums
- Learning and gaming simulations

Entertainment and fashion
The most recent touch technology in the consumer market is the Levi's musical jacket, which includes a capacitive keyboard woven into silk organza and a MIDI synthesizer that play music. The keyboard is mass-produced using ordinary embroidery techniques and conductive thread. Flexible and durable, this keyboard is also responsive to the touch, sensing increased capacitance of the electrode when touched. For wearable computing, touch technology promises enhanced usability and intuitive interaction with computing and entertainment devices.

Goodbye to the mouse: Hello to the Touchpad™ of the future
Some experts predict that the mouse may well become an "extinct species" of technology as touch pads of various kinds are adopted. The surface of the keyboard could allow for cursor control as well as gestural inputs that normally require a series of mouse clicks at present. For example, by pulling a thumb and finger together, the user could nip or cut a piece of text. "Drag and drop" could also be done by touching an object to select it, moving one finger across the surface and tapping at the place where one wanted to drop the object. Prototypes of such keyboards are currently under development.

Toshiba has developed a prototype motion processor that offers an alternative means of communicating with your appliances and computing devices. Using scanning infrared touch technology, the motion processor detects gestures and translates them into commands.

Medical technology
Scientists around the world are working on tools that allow people to feel the shape and texture of objects using touch technology. For instance, Takuya Nojima of Tokyo University is working on a Smart-tool that senses the difference between various kinds of liquid (such as oil and water) and tissues. The user can actually feel the change in resistance and texture when moving through liquid and physical entities. Incorporated into a scalpel, this technology could be used for training surgeons or used to aid difficult surgical procedures. When the scalpel is close to vital organs, such as the heart, it can sense them and push back against the surgeon's hand. Similar technology is also being developed for dentistry, allowing students to practice their art on teeth. They can feel what it is like to drill a tooth before handling real patients.

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Exploring our world and space
Robot explorers could be equipped with the ability to transmit touch information, enabling the scientist at the other end to use a touch device to feel and, perhaps even remotely control the device, so that one could pick up and touch various objects. For deep sea exploration or exploration in space, the ability to touch objects that might otherwise not easily be obtained means that users can learn more about earth and other worlds far away.

Virtual museums
Similarly, online museums could enhance the visitor's experience by allowing individuals to not only look at the object and rotate it on the screen, but also to pick it up and feel its surfaces, weight and texture. For the museum visitor, this will open up an experience that is not currently allowed. Museum visitors will be allowed to touch the paintings, artifacts, sculptures, and other objects in the museum.

Learning and gaming simulations
Video games or simulations of the future will work through a series of bracelets on arms and legs, together with a headset. A computer will track the user's motion and provide feedback on one's technique or play. With the addition of haptics, one could play virtual ping pong or learn a martial art and feel the experience. This means feeling the ball hit the paddle or feeling the impact of being hit in combat. So, one could learn new skills and practice. For people who do not have room for a ping pong table in their house or for those who simply want to master their skills in a new sport, this technology offers a new learning and play environment.

Conclusion: The world at one's fingertips

From the mouse to the touch pad, it has become increasingly easier for users to interact with computers and other devices. The cPad™ is the latest technological innovation, enabling notebook users to interact with a small touch screen and TouchPad™. In the future, touch technology promises to transform daily life, including fashion, medical training and care, education, leisure and exploration of the world. Touch technology may well allow users to more fully feel sense and experience the world, virtual realities, and distant planets.

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