Touch Sensor Technology for Hand-held and Mobile devices

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A touch screen sensor is generally a clear glass panel with a touch responsive surface. The touch sensor/panel is placed over a display screen so that the responsive area of the panel covers the viewable area of the screen.

The sensor normally has an electrical current or signal going through it and touching the screen causes a voltage or signal change.

This voltage change is used to determine the location of the touch on the screen.
Do you think Touch Sensors are gifts of 21st century ??

First Touch Sensor was developed in 1971 by Doctor Sam Hurst (Prof. at the University of Kentucky)

This sensor was called the "Elograph" and was patented by The University of Kentucky Research Foundation.

In 1974, the first true touch screen incorporating a transparent surface came on the scene developed by Dr. Sam Hurst
HISTORY

- Touch Sensors have been used extensively in industries since 1970’s because they have simple user interface, are easy to use and have a less response time.

- With the improvement in technology and advent of hand-held devices, Touch Sensors can now be integrated into small devices such as Mobile phones, i-pods, finger print scanners, gaming PDA’s etc.
Why are Touch Sensors used??

- Touch sensors are mostly used in the devices where space is at a premium. They provide a friendly user interface which is not only easy to use but also attractive.

- Touch sensors are completely sealable which helps to create a device resistant to water spills and dusts to a larger extent.

- Touch sensors provide fast response which eliminates the delay caused by mechanical buttons in general devices.
Types Of Touch Sensors

- Capacitive
- Resistive
- Surface Acoustic Wave
- Infrared
- Optical

We will describe touch sensors and their working using particular devices which are presently in use and are very common.
Application of Touch Sensors...

Mobile Devices

Hand-Held Devices
Mobile Devices

- Touch Sensors represents a significant breakthrough in Mobile devices, enabling lighter, smaller and thinner handsets.

- Touch Sensors are very easy to use, power efficient, compact and can be integrated easily in Mobile Devices.
I-Phone uses capacitive touch sensors.

- Instead of a physical keypad, I-phone uses virtual buttons and controls that appears on its screen.

- Once we touch the screen, the featureless rectangle becomes an interactive surface and the inputs are read and interpreted using capacitive touch sensors.
Capacitive Touch Sensors consist of an all-glass touch screen with a transparent metallic conductive coating, as seen in the figure.
Capacitive touch-screens use a layer of capacitive material to hold an electrical charge; touching the screen changes the amount of charge at a specific point of contact.
When a finger touches the touch screen it draws a minute amount of current at the point of contact, creating a voltage drop.

This happens because the tissue of the human body contains conductive electrolytes covered by a layer of skin which is a lossy dielectric. It is this conductive property of fingers that makes capacitive touch sensing possible.
Capacitive Touch Sensors...

- An electrode pattern is printed along the edges of the screen which is responsible for creating a low voltage field over the conductive layer.
Capacitive Touch Sensors...

Most of the electric field lines in this system are concentrated directly between the plates of capacitors but some field lines spills over into the area outside the plates, and these are called fringing fields. These fringing fields should be directed into an active sensing area accessible to a user.
Capacitive Touch Sensors...

- The current flow from each corner is proportional to the distance from the touch point. By measuring the distance the exact location of contact can be computed.
Capacitive Touch Sensors...

Touch strength can be increased by
1. Pressing harder
2. Increasing area of touched surface
3. Increasing capacitance

When D is decreased
1. Capacitance is increased
2. Touch strength is increased
Problems with Capacitive Sensors...

- Most of the time, these systems are good at detecting the location of exactly one touch. If we try to touch the screen in several places at once, the results can be erratic.

- Some sensors simply disregard all touches after the first one. The main reasons for the same are:
  
  - Many systems detect changes along an axis or in a specific direction instead of each point on the screen.
  - Some screens rely on system-wide averages to determine touch locations.
  - Some systems take measurements by first establishing a baseline. When we touch the screen, we create a new baseline. Adding another touch causes the system to take a measurement using the wrong baseline as a starting point.
Then how i-Phone uses multiple touch?

- An APPLE i-PHONE does not use the exact type of sensors described earlier.

- For providing Touch commands that require multiple touches, the i-Phone uses a new arrangement of existing technology but in a different pattern.

- The touch-sensitive screen includes a layer of capacitive material arranged according to a coordinate system.
Then how i-Phone uses multiple touch?

- The circuitry can sense changes at each point along the grid. In other words, every point on the grid generates its own signal when touched and relays that signal to the processor.
- This allows the device to determine the location and movement of simultaneous touches in multiple locations.

- The iPhone's screen detects touch through one of two methods: Mutual capacitance or Self capacitance.
Multiple Touch – Mutual Capacitance

- The intentional capacitance that occurs between two charge-holding objects or conductors, in which the current pass through one into the other is mutual capacitance.

- i-Phone touch sensor has Driving lines carrying current, and sensing lines, detect this current at nodes.

- Sensing line and the driving lines are closely spaced together, the air or material separating them acts as a dielectric, and the lines act as capacitor plates.
Multiple Touch – Self Capacitance

- i-Phone self capacitance has a transparent electrode layer which detects any change in capacitance using the capacitive sensing circuit.

- The capacitive sensing circuit is connected to each electrode which enables the determination of the exact location of touch.
Disadvantages of Capacitive Touch Sensor

- Capacitive Touch Sensors can only detect a touch by a conducting object and hence cannot be used with stylus or with gloves.

- In the presence of high electric fields, charges can develop over the capacitive touch sensor and may result in false detection.

- These drawbacks can be overcome by using a resistive Touch Sensor
Mobile Devices
Resistive Touch Sensors...
Resistive touch screens consist of a glass or acrylic panel that is coated with electrically conductive and resistive layers made with indium tin oxide (ITO).

The thin layers are separated by very small invisible spacers called microdots.

The total resistance of each layer varies from vendor to vendor, but typical screens are in the 100 to 900-ohm range.
When contact is made on the surface of the touch screen, the two sheets are pressed together.

To Measure the Y-coordinate of point of contact, voltage is applied across the screen in Y direction.

The contact of layers creates a voltage divider which is sensed by sensors in X direction and the Y coordinate is determined.

The complete process is repeated with the X direction being driven, and reading is taken from Y electrodes to determine the X coordinate.
Disadvantages of Resistive Touch Sensor

- Resistive touch Sensors are not very clear. Modern resistive touch sensors can achieve 80% Clarity.

- The layers of resistive touch sensor can be damaged by very sharp objects.

- Addition of Resistive touch sensors reduce the brightness, color saturation and contrast of the display and hence a strong backlighting is required to compensate for transmission losses. This, in turn, increases the current consumption and the power consumption.
Surface acoustic wave (SAW) technology uses ultrasonic waves that pass over the touch screen panel.

When the front surface of the touch screen is touched, a portion of the mechanical wave is absorbed, thus changing the received signal.

The signal is then compared to a stored reference signal, the change is recognized, and the coordinate is calculated.

This process happens independently for both the X and Y-axes.
## Comparisons...

<table>
<thead>
<tr>
<th>Type</th>
<th>Resistive</th>
<th>Acoustic Wave:</th>
<th>Capacitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activation:</td>
<td>Pressure sensitive</td>
<td>Wave absorption</td>
<td>Human body electricity</td>
</tr>
<tr>
<td>Antiglare protection:</td>
<td>Minimal</td>
<td>Medium</td>
<td>Clear, Light-Etch, Etched</td>
</tr>
<tr>
<td>Clarity:</td>
<td>Medium</td>
<td>Best</td>
<td>Minimal, Medium, Best</td>
</tr>
<tr>
<td>Damaged by:</td>
<td>Very sharp objects</td>
<td>Glass - breakable</td>
<td>Glass coating wears out</td>
</tr>
<tr>
<td>Can handle dirt:</td>
<td>Good</td>
<td>Poor</td>
<td>Best</td>
</tr>
<tr>
<td>Made with:</td>
<td>Hardened acrylic plastic</td>
<td>Glass with coatings</td>
<td>Glass with coatings</td>
</tr>
<tr>
<td>Works with:</td>
<td>Finger, glove, stylus</td>
<td>Finger, glove, soft stylus</td>
<td>Finger</td>
</tr>
<tr>
<td>Durability (MTBF):</td>
<td>15 million touches</td>
<td>30 million touches</td>
<td>60 million touches</td>
</tr>
<tr>
<td>Resolution:</td>
<td>1 million touch points</td>
<td>1 million touch points</td>
<td>1 million touch points</td>
</tr>
<tr>
<td>Warranty:</td>
<td>1 Year</td>
<td>3 Years</td>
<td>5 Years</td>
</tr>
<tr>
<td>SUMMARY:</td>
<td>Best Price</td>
<td>Best Clarity</td>
<td>Most Durable</td>
</tr>
</tbody>
</table>
i-Pod also uses capacitive touch sensors.

- Instead of a physical keypad, I-pod uses Click wheel a touch sensitive ring used to navigate through all of iPod's menus.

- It provides two ways to input commands: by sliding a finger around the wheel and by pressing buttons located under and in the middle of the wheel.
There is a membrane embedded with metallic channels under the plastic cover of the click wheel.

At the points where the channels intersect, a positional address is created, like coordinates on a graph.

The metal channels that form the grid conduct electricity. When a finger gets close to the grid, the current tries to flow to the finger to complete the circuit.

The piece of nonconductive plastic the Click Wheel cover acts as insulator, so the charge builds up at the point of the grid that's closest to the finger causing change in capacitance.
Determining the speed of touch...

- The change in capacitance is measured by a click wheel controller chip which sends a signal to the microprocessor on sensing change in capacitance.

- The greater the change in capacitance at a particular point, the closer the finger must be to that point.

- As the finger is moved around the wheel, the charge builds-up and moves around the wheel with the finger.
The faster the finger moves around the wheel, more compacted stream of signals are sent, as the microprocessor receives the signals, it performs the corresponding action.

When the finger stops moving around the wheel, the controller stops detecting changes in capacitance and stops sending signals to the microprocessor and corresponding action is stopped.
Scanners generate an image of the ridges and valleys that make up a fingerprint.

A capacitive touch sensor is used to generate the image.

The scanner device reads the sensor output and determines whether it is characteristic of a ridge or a valley.

Because it requires a real fingerprint-type shape, rather than the pattern of light, this makes the system harder to trick.
A basic touch screen has three main components: a touch sensor, a controller, and a software driver. Working of the sensors has been discussed and now lets see the controller devices which are used as an interface between the embedded board and the sensor.

A high resolution analog to-digital converter (ADC) is used in the controller chips to convert the sensed analog voltage to a digital code.

Analog interface circuit are not used because the capacitive sensor may be affected by subtle noise, crosstalk, and coupling.
An Atmel Corp low-cost touch sensor IC - AT42QT1040 is available in a 3mm x 3mm x 0.85mm 20 pin package, making it suitable for use in mobile phones and other handheld devices where PCB space is at a premium.

The AT42QT1040 draws only 31µA from a 1.8Vdc supply, allowing capacitive sensing to be added with minimal impact on battery lifetime.

Similar to AT42QT1040 there are a number of cheap and small IC’s available which can be used with standard Touch Sensors to the micro-controller to provide a reliable interface.
Trade off...

- Though the Touch sensors help in optimizing the premium space of handheld devices, the device drains more power to provide better clarity.

- Touch Sensors are durable in terms of life span but require more care while handling.

- Even though the Touch sensors are attractive and easy to use but one has to pay higher price to avail this luxury.
Conclusion...

- The Touch Sensor Technology is being developed for future purposes of mass use at cheaper prices. An example is an e-book reader and notes keeper which can display pages and allows the users to make notes, highlight line using stylus.

- This is useful for kids for learning as the interface is lively and allows instant access to different books. And also this can save them from heavy school Bags!!
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Thank You