The Future of Mobile Touch

Walker Mobile, LLC

October 2, 2007
What was the most important event in touch in mobile displays in 2007?
Answer

The Apple iPhone

…and the iPod touch

Photos courtesy of Apple
Why?

1. The innovative user interface changed the perception of the value of touch

2. The hardware brought projected-capacitive touch from a niche into the mainstream
A Quick Trip Through
The Future Of Mobile Touch

- **The past:** Four-wire resistive touch
- **The future:** Projected-capacitive touch
  - Why did Apple choose it?
  - How does it work?
  - How is it implemented in the iPhone & iPod?
  - Who are the current suppliers?
  - What does the future look like?
The Past: 4-Wire Analog Resistive

- Dominant touch technology in mobile devices
  1. Lowest cost
  2. Readily available (50+ suppliers)
  3. Finger & stylus
  4. Other technologies aren’t suitable
     - Projected capacitive – few suppliers; niche positioning
     - Surface capacitive – too sensitive to EMI
     - Infrared – too much projection above touch surface
     - Surface acoustic wave (SAW) – too sensitive to contamination
     - Optical – doesn’t scale down to mobile size; too much projection
     - Bending wave – not available yet as a component
     - Force-sensing – not available yet; too sensitive to vibration
     - In-pixel – not available yet; light-sensing causes light loss

Photo courtesy of EELY (pre-iPhone)
Why did Apple choose projected capacitive?

1. It supports multi-touch (required by the iPhone’s user interface)
   - Only other current multi-touch technologies are IR & optical
2. It eliminates resistive’s two primary shortcomings
   - **Poor durability** – PET plastic top surface is easily damaged
   - **Low optical clarity** – 10% to 20% light loss
3. A high-capacity (30M units/year) supplier became available
   - TPK/Optera + Balda
4. It’s a proven technology
   - Signature-capture POS terminals, information kiosks, outdoor ATMs…

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**Omni 7100 MPD Payment Terminal from Verifone**

**ExtremeTouch from Touch International**
How The iPhone’s Projected-Capacitive Touch Works

Diagram showing the process of how the touch works:
- Drive lines and Sense lines
- Capacitive node
- Finger
- Controller
- Signal source
- Multiplexer
- A/D converter
- DSP
- Output to host computer
How The iPhone’s Multi-Touch Works

Raw data including noise → Filtered data → Gradient data

“10 fingers, 2 palms and 3 others”

Coordinates of touch regions

Images from Apple Patent Application #2006/0097991
iPhone Touchscreen

- Top surface (glass), sensor (glass) and LCD are laminated
- Back of LCD (Epson, Sharp, TMD)
- Touchscreen cable & circuit
- To sensor

Broadcom 1st-generation touchscreen controller
- NXP (Philips) ARM-7 DSP
- (Underside)
- Shield
- To digital mainboard
- To sensor
- To sensor

Photos courtesy of Portelligent (www.teardown.com)
iPod Touch Touchscreen

- Touch sensor (glass) & top surface (glass) (laminated)
- LCD (not laminated)
- LCD cable
- Touchscreen cable to mainboard (soldered)
- Broadcom 2nd-generation touch controller (may include DSP)
- Touchscreen & WLAN circuit boards (stacked)
- Touch sensor cables

Photos courtesy of iFixit
Projected-Capacitive ITO Sensor Suppliers

- Balda/TPK/Optera – Apple iPhone
- Synaptics – LG Prada phone
- Wintek – Apple iPod touch ®
- 3M Flex Capacitive – shipping 750K sensors/month (roll-to-roll production)
- Sharp – Apple iPhone
- Optrex – Apple iPhone ®
- Innolux – building $30M production facility (ship 1Q08?)
- Touch International – Verifone POS payment terminals
- N-trig (dual-mode touch & pen) – new Tablet PC (4Q)
- Others – e.g., Sony ® …

® = Rumor

Flex Capacitive photo courtesy of 3M
Projected-Capacitive Controller Suppliers

- Broadcom – Apple iPhone & iPod touch
- Synaptics – LG Prada phone
- Wintek – unknown
- Elan Microelectronics – unknown (Innolux acquiring? ® )
- Cypress (PSoC) – unknown
- Quantum (QProx) – unknown ®
- N-trig (dual-mode touch & pen) – new Tablet PC (4Q)

Synaptics’ next-generation phone concept “Onyx”

® = Rumor
## iSuppli’s Forecast (6/07)

### Total Market for Projected-Capacitive Touch

<table>
<thead>
<tr>
<th>Projected Capacitive Touch Application/Market</th>
<th>2007 K Units</th>
<th>%</th>
<th>2009 K Units</th>
<th>%</th>
<th>2012 K Units</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Phones</td>
<td>4,000</td>
<td>94.5</td>
<td>12,000</td>
<td>97.4</td>
<td>20,736</td>
<td>97.6</td>
</tr>
<tr>
<td>Retail</td>
<td>120</td>
<td>2.8</td>
<td>173</td>
<td>1.4</td>
<td>299</td>
<td>1.4</td>
</tr>
<tr>
<td>Industrial/Financial</td>
<td>35</td>
<td>0.9</td>
<td>46</td>
<td>0.4</td>
<td>69</td>
<td>0.3</td>
</tr>
<tr>
<td>Kiosk/POI</td>
<td>36</td>
<td>0.9</td>
<td>45</td>
<td>0.4</td>
<td>63</td>
<td>0.3</td>
</tr>
<tr>
<td>Medical/Healthcare</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>6</td>
<td>0.0</td>
</tr>
<tr>
<td>Other</td>
<td>40</td>
<td>0.9</td>
<td>48</td>
<td>0.4</td>
<td>64</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Total Projected Capacitive</strong></td>
<td><strong>4,232</strong></td>
<td><strong>100%</strong></td>
<td><strong>12,315</strong></td>
<td><strong>100%</strong></td>
<td><strong>21,237</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

### Touch Technologies in Mobile Phones

<table>
<thead>
<tr>
<th>Mobile Phone Touch Technology</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projected Capacitive (M units)</td>
<td>4.0</td>
<td>10.0</td>
<td>12.0</td>
<td>14.4</td>
<td>17.3</td>
<td>20.7</td>
</tr>
<tr>
<td>Resistive (M units)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other (M units)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **Projected Capacitive**
  - 1.5% market penetration
  - No impact outside of mobile phones

- **Resistive**
  - Resistive still dominant
  - 6.5% market penetration

Forecast from iSuppli’s “Touch Screens: The Right Touch for High Growth” report (2Q07)
In 2009...

- 187M total touch-screen mobile phones (16% of all phones)
  - 163M (87%) will have capacitive touch-screens
    - Of the 163M, 115M (~70%) will be touch-screen-only, while 48M (~30%) will have both a touch-screen and a keypad
  - 36% market penetration; 500M units (41% total)
  - 14% market penetration; 163M units (16% total)
  - Resistive insignificant
### Touch Technologies in Mobile Phones

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<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projected Capacitive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iPhone</td>
<td>3M</td>
<td>9M</td>
<td>18M</td>
</tr>
<tr>
<td>Top 5 OEMs</td>
<td>12M</td>
<td>25M</td>
<td>50M</td>
</tr>
<tr>
<td>Others</td>
<td>1M</td>
<td>2M</td>
<td>4M</td>
</tr>
<tr>
<td>Mobile Phones with Projected Capacitive</td>
<td>16M</td>
<td>36M</td>
<td>72M</td>
</tr>
<tr>
<td>Resistive</td>
<td>45M</td>
<td>50M</td>
<td>45M</td>
</tr>
<tr>
<td>Mobile Phones with Touch</td>
<td>61M</td>
<td>86M</td>
<td>117M</td>
</tr>
<tr>
<td>Percentage of Total Mobile Phones</td>
<td>5.8%</td>
<td>7.7%</td>
<td>9.9%</td>
</tr>
</tbody>
</table>

- **iSuppli** 12M (1%) vs. **Strategy Analytics** 163M (14%)
- **iSuppli** 68M vs. **Strategy Analytics** 187M (5.8% vs. 16%)
Why Just Mobile Phones?

- Walker Mobile predicts that projective-capacitive touch *will* penetrate other mobile devices (PND, PMP, PDA, MID, DSC, DVC, etc.)
  1. Rapidly increasing number of suppliers
     - Few barriers to entry
  2. Rapidly dropping cost
     - 3M’s 2-inch, 2-layer PET sensor = $2 to $6, depending on volume
  3. Substantial user benefits
     - Very high durability (depending on the cover material)
     - No optical loss (longer battery life, higher contrast)
     - Multi-touch (depending on the controller)

- User negatives
  - **No stylus**
  - ✓ This is the main reason resistive will maintain some market share, especially in Asia
In Closing…

- We’ve just barely scratched the surface of mobile touch
  - RPO’s optical waveguide infrared touch (SID 2007)
  - Sharp’s in-pixel light-sensing touch (sampling 9/07)
  - Samsung’s in-pixel capacitive-sensing touch
  - Haptics in mobile displays
  - Mobile SAW from Fujitsu Labs
  - ITO-replacement materials
  - Increasing use of glass-glass resistive touch
  - Solutions for increased outdoor readability (hot topic!)
  - New touch start-ups – Integritouch, SiMa Systems, Stantum
  - N-trig’s dual-mode pen & touch for Tablet PCs
  - And more…
Thank You!

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Appendix
Who Owns The IP?

- Does Apple own the IP on the use of projected capacitive with multi-touch on a mobile phone??
  - The media seems to thinks so, but Walker Mobile doesn’t!
    - The form of projected capacitive that Apple is using has been in production by multiple companies for at least five years
    - Multi-touch was invented in the 1980s; the “pinch” gesture was in use long before the iPhone existed on paper
  - The touch-screen & gesture patents for which Apple has applied (but hasn’t been granted yet) are largely a **PR exercise**
iPhone Touch Sensor Stack-Up

- Top glass (0.7 mm)
- Optically clear adhesive
- ITO traces in one direction
- Sensor glass (0.7 mm)
- ITO traces in other direction
- Optically clear adhesive
- LCD (2 x 0.3 mm glass)

Measurements courtesy of Portelligent