The Apple iPhone's Impact on the Touch-Panel Industry

by Geoff Walker

The Apple iPhone (Fig. 1) is arguably the most talked about consumer-electronics device that has yet to hit the market, even though according to most media reports it will not be available to the public until June 11. While the world will be watching to see if Apple's latest gizmo attains the same status as its iPod, display-industry professionals will be watching for a different reason – simply put, if the iPhone succeeds, it could have a significant impact on the touch-panel industry.

How big will the impact be? Apple's sales goal is 10 million iPhones in 2008, or roughly 1% of the total cell-phone market. Cost estimates for the iPhone's touch screen have ranged from $3 to $30, so let us split the difference and say $15. Ten million touch screens at $15 each is $150 million, or 15% of the $1 billion transparent touch market. That is larger than the combined value of all surface-acoustic-wave (SAW), infrared, optical, bending-wave (APR), and projected-capacitive touch screens sold worldwide in 2006! In fact, it is 750% of the estimated 2006 worldwide sales of projected-capacitive touch screens – the technology used in the iPhone.

The iPhone's Touch Screen

Until the product is actually available, the best source of information on the iPhone's touch screen is Apple's patent applications. The most relevant one is #2006-0097991, dated May 11, 2006 and entitled "Multipoint Touch Screen."

The patent describes two different implementations of projected-capacitive touch technology. The first, which Apple calls "self capacitance," is a simple passive array of 24×36 sensing electrodes in a single plane. This is commonly known as a "matrix" touch panel, and it is commonly used in applications such as industrial control panels, membrane keyboards, and other situations where a limited number of well-defined areas on a surface need to be made touch sensitive. Since it is basically a low-resolution architecture, it is not regularly applied to displays.

The second implementation of projected-capacitive touch technology described in Apple's patent application is a more traditional structure consisting of two sets of parallel rows of transparent conductors, one on each side of a substrate, perpendicular to each other. Apple calls this implementation "mutual capacitance." From a sensor point of view, it is essentially the same concept as Touch International's ExtremeTouch™ product.

Figure 2 shows a simplified view of Apple's implementation. A single drive line is excited with an ac signal of appropriate amplitude and frequency, and then

Fig 1: The Apple iPhone.

short subjects

the capacitance at each intersection (node) between the driven line and each sense line is measured simultaneously. A multiplexer outputs the measured values in a serial data stream and then the sequence starts over again with the next drive line.

The key difference between Touch International's implementation and Apple's implementation is in the firmware. Touch International's current firmware only processes and outputs one touch at a time, while Apple's firmware processes and outputs up to 15 simultaneous touches. (In the patent application, Apple describes the 15 points as "ten fingers, two palms, and three others.")

How Touch Is Used in the iPhone
There are six fundamental touch-vocabulary elements (gestures) in the iPhone user interface (UI):
- Single tap to select or activate something.
- Double tap to change the display format.
- Drag and drop to move something.
- A stroke ("swipe" or "flick") up/down/left/right to scroll.
- "Pinching" two fingers together to shrink something.
- "Spreading" (un-pinching) two fingers apart to enlarge something.

These elements work consistently everywhere throughout the iPhone's UI. For example, spreading two fingers apart zooms in on an on-screen photo or enlarges text/e-mail messages.

The scrolling stroke is particularly interesting in that the stroke speed controls the scrolling speed. But in a typical Apple touch (pun intended), scrolling does not simply stop instantly like it does in Windows; it keeps going for a moment and then decelerates to a smooth stop, simulating the physics of a real object. It's a minor detail, but it is illustrative of the incredible level of detailed thought that has gone into the iPhone's UI.

Pinching and spreading are the only touch-vocabulary elements that make use of multi-touch (multiple simultaneous touches). If the user is doing a pinch gesture, the array of data points output by Apple's firmware contains two sets of touch coordinates that are moving toward each other over time.

However, if the user is holding the iPhone with one hand and doing a pinch gesture with the other hand, there is a good chance that there are more than just two fingers touching the screen. Since all the application software is totally under Apple's control (it is a closed system!), that means that the application software can process and eliminate any additional "undesirable" touch points reported by the touch screen. For any given application screen, there are a defined number of "active buttons" that must respond to a static touch. Other static touches such as those caused by the user's thumb as he or she holds the device can easily be ignored. If the application sees two touch points moving toward each other for some minimum duration and/or distance, then it can interpret the pair of touch points as a pinch gesture and take appropriate action while still ignoring all the other "undesirable" touch points. The touch screen's ability to process up to 15 simultaneous touches makes good sense in this context.

Conclusion
Is Apple's use of touch in the iPhone significant? I think the answer is yes. Certainly, Strategy Analytics, a market research and consulting firm, thinks so. In January 2007, they issued a report entitled "Apple iPhone: Catalyst for Capacitive Touch-Screen-Only Phones to Balloon to 115 Million Units within Two Years." That makes Apple's 10 million units look like chump change!

Actually, I think Apple's use of touch in the iPhone is significant in several ways: First, it is a major gamble in user-interface design. If it succeeds, it is likely to drive touch into more segments of the consumer-electronics industry and into even broader adoption generally. Second, it is the best implementation of a touch UI that I have ever seen. It sets the bar very high for all present and future competitors. And last but not least, it is a highly visible, high-volume application of projected-capacitive touch technology. As such, it is going to shake up the touch industry.

iPhone Competitors
 LG Prada KE850: capacitive touch screen
 Meizu M8: unknown touch screen
 Neo1973: unknown touch screen
 Neonode N2: optical touch screen

Sources for Additional Reading
 Apple iPhone website
  (www.apple.com/iphone)
 Wikipedia iPhone article
  (http://en.wikipedia.org/wiki/IPhone)

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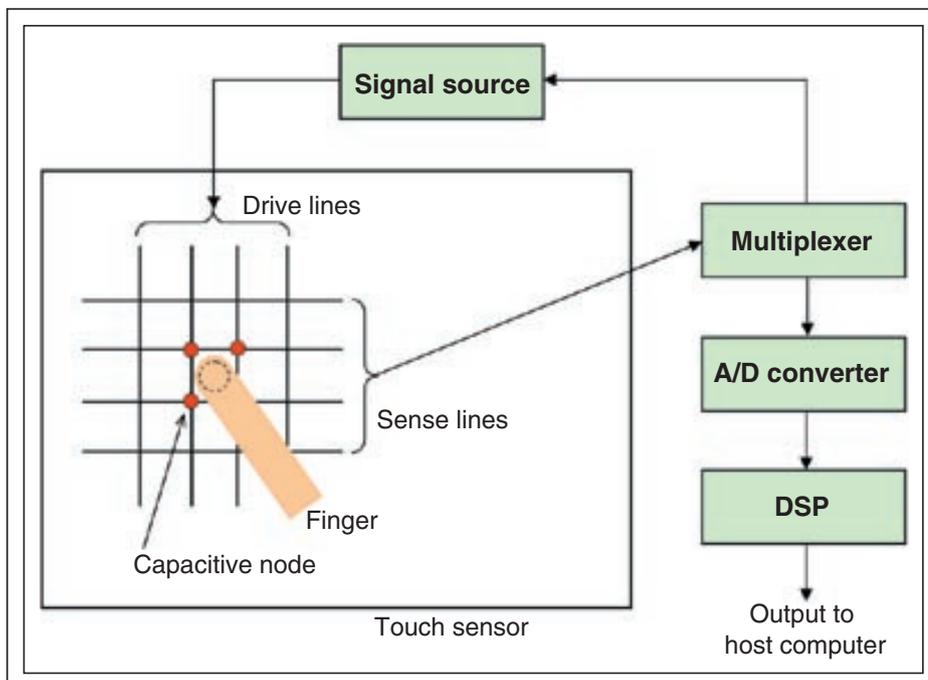

Fig. 2: A simplified view of Apple iPhone's projected-capacitive touch screen.