Controller ICs take multitouch screens beyond smartphones

Margery Conner - April 19, 2012

Since EDN last surveyed touchscreens (Reference 1), they have become firmly entrenched in smartphones and are making their way into the lower-cost “feature phones” from vendors eager to attain some of the cachet of more expensive phones. Tablets such as the iPad and, more recently, the Kindle Fire also are helping to make touchscreens commonplace. As users become familiar with interactive, infinitely changeable touchscreens in their consumer electronics, they expect the same level of interactivity in other nontraditional uses for touchscreens, such as automobiles, medical electronics, and industrial devices.

Touchscreens have been around for decades, and they typically employ resistive-touchscreen technology. With resistive touchscreens, a user’s finger physically deforms the top layer of the screen, causing the resistive sensor to make contact below the finger. The resistive sensors are in a grid of X and Y traces, separated by a thin, transparent insulator.

Note the use of the word “press.” A press is a different action from a touch or a swipe. Resistive touchscreens have limited capabilities in their response to multitouch gestures, such as pinches, zooms, swipes, and scrolls. Users who have become accustomed to navigating their smartphones and tablets with these gestures become frustrated with simple touchscreens that lack these features. Touchscreens that can respond to complex multitouch gestures generally rely on capacitive sensing.

Capacitive-sense-touchscreen technology generally comes in self-capacitance and mutual-capacitance flavors, although other types, such as projected capacitance, exist. Self-capacitance sensors comprise a series of thin lines of indium-titanium oxide, a transparent, conductive material in an XY grid with an insulating layer between the X and the Y traces. Touching an area in the grid changes the parasitic capacitance of the sensors to ground. However, this approach can’t handle multiple-finger touches because the sensor can’t distinguish between multiple fingers along the same grid line. Mutual capacitance senses the change in the capacitor at the small intersection of the X and the Y lines. Because the area of the intersection is small, the capacitance is also small, but it is precise and can measure multiple-finger placements.

There are pros and cons to each approach. Although self-capacitance sensors generally cannot distinguish between multiple simultaneous finger actions, they also generate a stronger electromagnetic field that can detect objects even if the objects don’t actually touch the screen. Mutual-capacitance touchscreens can detect and track the touch of multiple fingers, but the fingers must touch the screen because the electromagnetic field from the tiny capacitors formed by the
The need for close contact between the finger and the touchscreen can be a problem when the user is wearing gloves. This restriction on the part of capacitive touchscreens causes a shift in favor of resistive screens. Resistive technology also has an advantage in liquid applications or in humid climates in which moisture affects the behavior of the electromagnetic field. Cypress’ TrueTouch controller technology seeks to overcome these hurdles by combining both self- and mutual-capacitance techniques (Reference 2).

Both self-capacitance and mutual capacitance require the same XY sensor grid. In self-capacitance, the controller must drive both the X and the Y lines. In mutual capacitance, the controller transmits into the X lines and receives on the Y lines. Because the TrueTouch controller IC uses Cypress’ PSoC (programmable-system-on-chip) core, the controller can dynamically configure its I/O pins and turn the transmitters into receivers on the fly. Thus, the controller can sense in both modes—self- and mutual capacitance—whenever the controller scans the sensor’s grid panel. Combining self-capacitance sensing with mutual capacitance allows for multitouch capability even with hands wearing thick ski gloves. This ability raises the question of how safe touchscreens in automobiles are (see sidebar “Q&A on auto safety and touchscreens with JD Power”).

Touchscreens in cars, at 10 in. or more diagonally, are usually larger than smartphone touchscreens, which are typically about 4 in. Atmel’s MaxTouch line of touchscreen controllers includes the mXT768E and mXT540E automotive-qualified controllers for 5- to 10-in. touchscreens in center-stack displays, navigation systems, and back-seat entertainment systems. Conventional controllers for capacitive touchscreens require a shield layer within the multilayer touchscreen to prevent noise coupling from the LCD. Atmel claims that the MaxTouch devices offer a signal-to-noise ratio of 80-t-1, eliminating the need for a shield layer and enabling a single-layer sensor design for lower-cost, thinner stacks (Figure 1). A high SNR also enables detection of touches from a finger in a thin glove. In general, the technology can sense touch from gloves as thick as 1.5 mm, such as leather, wool, or cotton gloves.

An elegant-looking touchscreen design imparts a cool factor that is nearly as important to consumers as the touchscreen’s performance, and industrial design decrees that, for smartphones, thinner is always better. Cypress’ SLIM (single-layer-independent-multitouch) technology makes for a thinner screen because the sensor is one layer rather than two. For conventional two-layer stackups,
manufacturers build the sensors on two layers: the X lines and the Y lines in separate layers with an insulator between them. This XY grid is expensive because of the cost of ITO, which is effectively a transparent metal and costs about $1 per diagonal inch of screen.

Cypress has created a proprietary pattern that allows the routing of both the X and the Y sensors on the same surface in one layer with no jumpers or vias (**Figure 2**). John Carey, director of marketing for TrueTouch controllers at Cypress, claims that SLIM makes for the thinnest and lowest-cost touchscreen sensor and works for screens as large as 4.5 in. diagonally. The company does not reveal what the pattern is; customers work with Cypress’ licensed-partner touchscreen suppliers.

Even with the decrease in prices for multitouch touchscreens, they are still about 10 times more expensive than resistive screens, which have a large installed base. For applications in which cost is dominant yet that still require some form of multitouch, Freescale offers the Xtrinsic CRTouch, which enables the retrofitting of resistive touchscreens to recognize slides, two-finger pinches for zooming in and out, and multifinger rotations on standard resistive touchscreens. The chip uses proprietary algorithms and dedicated analog hardware, as well as on-chip state machines. The controller chip also manages as many as four capacitive touchpads for realizing keypads, rotary dials, and linear sliders. As a part of Freescale’s Ready Play offerings, the CRTouch chip offers turnkey software integration with both Android and Linux operating systems. The chip also offers configurable screen resolution and optional calibration and pressure detection for stylus inputs to resistive touchscreens.

Partially to reduce costs, Amazon used infrared touch sensors on the Kindle Touch. The Touch reader has a black-and-white e-ink display that benefits from the lack of an ITO layer between it and the viewer. The screen instead relies on infrared sensors in the bezel that detect when a finger breaks the IR beam. The display can respond to multitouch pinching motions, which it uses to cue zoom or shrink on PDFs, but is incapable of the more elaborate multitouch gestures of smartphones (**Reference 3**).

As touchscreens move into applications such as automobiles, instrumentation, and medical devices, these devices’ user interfaces can become infinitely adjustable and updatable. The placement of physical control knobs and dials has always been important for test-and-measurement-equipment designers, with focus groups spending inordinate amounts of time deciding which button should go where.

A catchphrase for spectrum-analyzer designers in the past was “tune, boom, zoom,” in which tune was the center frequency; boom was the reference level, or amplitude; and zoom was the span of the signal under measurement. The equipment designer’s goal was to make tune, boom, and zoom as fast and as accessible as possible. For example, burying the center frequency, the reference level, and the span buttons in some menu structure would be a bad idea. Instead, those three buttons are
usually fairly prominent on a spectrum analyzer’s front panel. Loyal customers are often reluctant to accept front-panel changes. Now, equipment designers can allow customers to customize the control panel to suit their own preferences.

In an attempt to mimic the sensory environment of the real world, haptics technology is also dropping in price and may make its first inroad through the game market. Sensory feedback from the touchscreen can make for a richer experience in gaming; in automotive or instrumentation touchscreens, it can free the operator from watching the touchscreen for a visual cue that the system has noted and reacted to an action (see sidebar “Haptics 101”).

Looking to the future, much larger control surfaces than touchscreens will soon enter the market. Self- and mutual-capacitance sensing becomes less practical with screens larger than 10 in., yet some devices need the physical impact of a larger surface. For example, the SmithsonMartin’s Emulator DVS DJ System is a transparent mixing desk that allows the audience to see the DJ through the mixing panel (Figure 3). The transparent screen has a projector below it, which displays the buttons, knobs, and sliders that the DJ sees through the screen. The audience can also see the DJ through the transparent screen. Cameras in the corners can track finger movement, enabling the display.

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References