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Self Capacitive Sensing Brings Touch to Large-Screen Products


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The widespread adoption of projected capacitive (p-cap) touch sensing has contributed to one of the largest consumer electronics revolutions in recent years. As devices such as smartphones and tablets have proliferated, so a durable, sensitive touch-enabled user interface has become an almost mandatory feature for product designers in every field.

The vast majority of these devices are now based around a p-cap sensor, driving a phenomenal growth rate in this part of the touchscreen sector. Figures from leading industry analyst DisplaySearch show that, though still relatively new, p-cap has rapidly risen to become the most widely used touch sensing technology in the global market, overtaking the long established and increasingly commoditized resistive sensing technology.

This fast uptake has been driven by a compelling feature set, including an effectively unlimited lifespan conferred by a resistant all-glass surface, edge-to-edge design capability (with no requirement for bezels) and high levels of sensitivity. However, as original equipment manufacturers (OEMs) seek to incorporate touch interactivity with a similar style and performance outside the portable consumer domain, there becomes a realization that touch screens which satisfy different set of design criteria are required.

Two choices of technology

OEMs can choose between two distinct types of p-cap touch sensing methodologies. The most common now, is mutual capacitance. This uses two separate conductive layers, one of which contains the sensing cells through which the position of the touch event can be identified, while the other has the driving cells through which an electrical signal passes. The cells are usually interlocking and each is connected to the control electronics. When the screen is touched, there is an alteration of the charge held within the local electric field, reducing the **mutual** capacitance built up between the two layers. This alteration is picked up by the cells in the sensing layer. Detection algorithms within the controller electronics determine the individual cells with the greatest change in charge, and output a corresponding X-Y co-ordinate to the host system.

The second “flavor” of p-cap sensing uses the principle of self-capacitance. In contrast to mutual capacitance, this technique employs a separated X-Y grid of open ended conductive lines connected to a controller containing the detection algorithms. The charge held on the lines is altered by human body capacitance, as the user’s finger comes closer to the touchscreen surface. The X and Y lines with the peak change in charge are detected and the touch co-ordinate is output to the PC.

TPK 2007

There are a number of reasons behind the adoption of the mutual capacitance approach in consumer electronics. The technology is particularly capable of providing multi-touch functionality assuming sufficient cell density and controller IC power is available. The high density of individually connected cells makes it possible to gather and interpret the large amounts of touch data required to separate multiple independent touches.

However, conventional mutual capacitive screens can suffer major drawbacks when a designer attempts to move to larger form factors. In order to accurately track multiple touch points, the controller must capture data from each of the small individual cells. The bigger the screen, the larger the amount of information that need to be captured. Eventually the size of the data set becomes overwhelming. In practical terms once the touch display size reaches 15 inches (approx. 380 mm), the number of cell intersections that must be connected to and monitored by the controller becomes a major challenge. The increased complexity in the control electronics and connectivity also adds to the bill of materials and increases the required integration time and effort.

For those weighing between mutual and self-capacitive techniques, practical manufacturing issues also take on increasing importance as display size grows. Mutual capacitance solutions are generally based on a matrix of cells made of Indium Tin Oxide (ITO), a conductive, near-transparent material that is deposited and patterned on glass or film using a semiconductor-style photolithographic manufacturing process. ITO is widely used in applications requiring mass produced, small touch displays (such as portable consumer electronic devices), where the volume-friendly production process is a plus. However, if volumes are lower (and this often goes hand in hand with larger screen sizes such as those used in public, self-service applications for example), the relative inflexibility of the ITO process and the high one-off cost of photo masks become more problematic.

Finally, in addition to manufacturing complexity and cost, there is a question of touch performance to be considered. For all its benefits, ITO has a relatively high resistivity. This means that as the display area increases, and the distance between cell and controller grows, the signal to noise ratio decreases rapidly, resulting in progressively lower touch sensitivity and in the worst case an inoperable device.

A self-capacitive alternative

Zytronic's proprietary Projected Capacitive Technology (PCT™) is a self-capacitive system that has been proven in deployments all over the world in the last 10 years, particularly in situations where larger screen size is required. Based on an X-Y matrix of micro-fine capacitors, embedded within a laminated glass substrate, PCT uses frequency modulation to detect minute capacitance changes within the conductive tracks.

A key attribute of this technology is its high sensitivity. It can detect a touch through very thick overlays, protective glass and even heavily gloved hands and therefore has an unsurpassed level of Z-axis sensitivity and control. This makes it eminently suitable for industrial and public access applications, and even for outdoor use. Because PCT requires unique detection algorithms running within the control electronics, Zytronic has also developed its own touch controller hardware and firmware, designed specifically to work with its PCT sensors. The latest controller will output two separate touch co-ordinates, making it capable of supporting most gesture recognition and multi-touch software.

Two variants of PCT sensors are currently available. An ITO-based solution suits higher volume applications that require a rugged interface with a relatively small screen size, such as white goods and industrial vehicle telematics. Although this senses in the self-capacitive style, it uses the same basic manufacturing processes as mutual capacitive sensors designed for consumer electronic applications. For large format and lower volume applications, a solution based on copper is offered. Here, the capacitive matrix within the sensors is made of 10 micron diameter copper electrodes. One advantage of this material is its extremely low resistivity (10 times less than ITO) allowing touch detection without noticeable degradation of sensitivity, even on screens larger than 80 inches. Another advantage of using copper electrodes is that they can be deposited directly onto the rear glass surface without the need for photo masks – this means that new designs can be quickly created, tested and manufactured with minimal effort.

Furthermore, the ductility of copper means it can also be applied onto curved planes. Microsoft ® Corporation made good use of this capability when developing a touchscreen for its Envisioning Lab (at the corporation's global headquarters in Redmond, WA). A wrap-around ZYBRID® touch sensor was supplied for its conceptual 10 display multi-monitor workstation, called the Spatial Desk, operated through a single PCT touch-enabled surface and used to demonstrate the latest Microsoft technologies to key customers.

Figure 1: PCT-based touchscreen applied to Microsoft's Spatial Desk

With a choice of materials and of mutual or self-capacitive sensing p-cap methodologies, OEM interface designers have a toolkit at their disposal that allows them to create a touch screen for any application, depending upon factors such as the deployment environment, touch performance, physical screen size and volume required.

An example of an unusual application solved by p-cap sensing occurred when advanced user interface specialist Sunvision Technology was asked to create interactive dining tables for exclusive Taipei restaurant Mojo. For this project, it was necessary to make the wooden tables touch sensitive. This required a technology with extremely high levels of Z-axis sensitivity and the capability to detect touch through the wooden surface of the dining table. With this challenging brief, Sunvision chose to embed Zytronic's 22-inch ZYBRID PCT sensors behind each table top, linking each to a computer-controlled projector mounted above the table presenting interactive menus on the touch-enabled surface. With the touch sensors hidden from view, when coupled with software specifically written for Mojo by Sunvision, diners are now able to interact with projected images, scrolling through dining options, placing orders, playing games and messaging diners at other tables.

Figure 2: PCT brings multi-touch table service to Mojo restaurant

The ability of PCT to enable far larger screens than can be realized using conventional mutual capacitance alternatives is demonstrated by its increasing use by digital signage specialists such as Infinitus. Here a 65-inch version of the ultra-rugged ZYTOUCH® product was specified for the iMotion® high-definition digital signage systems designed for use in outdoor, public environments (such as ski resorts, plazas and amusement parks).

Figure 3: Zytronic touch sensors specified by Infinitus for large format digital signage application

Design engineers in a broad range of markets outside of consumer electronics, are increasingly keen to adopt similar levels of touch interactivity already enjoyed in the latest hand held tablets and smart phones. In the process, the limitations of conventional mutual capacitance techniques become apparent. The nature of the materials used and their manufacturing processes (with resulting economies of scale) normally employed in the production of mutual capacitive p-cap screens mean they will probably remain best suited to small format, high volume designs.

In more demanding, ruggedized applications, which require volume flexibility and large form-factors, alternative approaches are essential. As a result, p-cap sensors derived from advanced self capacitance sensing such as PCT are likely to remain at the forefront of such applications as industrial controls, self-service terminals and medical devices. This technology is already delivering touch interaction in products that simply would not have been possible using other methodologies and has the potential to enable further innovation in the future.

The continued improvement in p-cap controller ICs coupled with sensor developments using printable conductive inks and nano-materials are likely to extend the capability and use of this versatile touch technology family further still.

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