Technology Comparison: Surface Acoustic Wave, Optical and Bending Wave Technology

Introduction
As touchscreen usage increases and new applications emerge, it is important to understand the differences between touchscreen technologies. Touchscreens are used in a variety of markets which include retail, hospitality, industrial, medical, entertainment, amusement, gaming, transportation, government, and education and training. The range of user environments for these applications has created a wide variety of touch technologies, each with unique characteristics contributing to application advantages and disadvantages. With the proliferation of low-cost, large-format displays, many customers are demanding to make these displays interactive. Typically large-format displays range from 32 inches up to 82 inches. Public displays are intended for out-of-home viewing by multiple people. Touchscreen manufacturers have responded to meet this need in different ways. Some have chosen to develop purpose-built technologies specifically designed for large-format displays, while others have scaled up existing technologies to accommodate these larger sizes. The most commonly used large-format touch technologies include surface acoustic wave (SAW), projected capacitive (embedded wire), bending wave (3M’s DST), infrared beam (IR), and optical (camera based). In this technology brief, we will compare the differences between surface acoustic wave, optical and 3M DST touch technologies.

Surface Acoustic Wave Technology
Surface Acoustic Wave (SAW) technology determines touch locations by measuring the attenuation of mechanical waves across the surface of the glass substrate. The basic principles of surface wave technology are that the surface wave energy can be attenuated by an energy (sound) absorbing material touching the surface, and that the direction of the surface wave energy can be changed or directed by patterns or ridges with specific orientation. The pattern can be printed on or etched into the glass and is placed on all four sides of the screen. A typical SAW touchscreen is made of transducers, receivers, and reflector patterns on glass to create mechanical waves that travel across the screen. The transducers generate acoustic energy that is coupled to the glass substrate and reflected by patterns to create the X, Y grid (FIGURE 1). The receivers receive the transmitted acoustic waves after they travel across the screen. A finger touching the screen causes signal attenuation to the portion of the wave under the finger and a coordinate can be determined by measuring when the attenuated portion of the wave is received.

Advantages and Disadvantages
Acoustic absorbing contaminants can cause SAW screens to perform with decreased sensitivity or create performance issues with the touchscreen.

Advancements have been made to “map around” on-screen contaminants, but the biggest challenges remain with contaminants near or in the reflector patterns of the touchscreen. Because liquids can also absorb acoustic energy, moving liquids across the screen can create reported touch coordinates or false/unintended touch responses (FIGURE 2).

Figure 1: How Surface Acoustic Wave technology works.

Figure 2: How contaminants can affect SAW touchscreens.
Optical Camera Technology

Large-format optical systems use two infrared cameras mounted typically in the top corners to scan the surface of the touchscreen. The cameras are scanning the surface to detect breaks or touch points on the surface. The system calculates touch based on the positional locations observed by both cameras. In order to increase the ability of the cameras to resolve detection points, many manufacturers incorporate passive reflector materials around the perimeter of the screen. Another implementation of 2-camera systems use an active perimeter to flood the screen with infrared (from LED light guides or wave guides around the perimeter) to enhance the camera’s ability to detect the touch points on the screen (FIGURE 3).

Advantages and Disadvantages

The cameras are using this increased contrast with the IR to help avoid the effects of ambient light on the system. High levels (direct sunlight) of ambient light can affect the systems performance and result in missed touch or unintended touches. Direct sunlight on the camera lens can disrupt the camera’s ability to accurately detect touch response.

Optical-based technology is also subject to the affects of on-screen contaminants. If the camera view is blocked by an object or contaminant on the touch surface then the screen may not be able to resolve touch points elsewhere on the screen, especially in the vicinity of the obstruction. Optical systems currently do not have the same ability to “map” around the object on the screen as SAW technology can (FIGURE 4).

Bending Wave Technology

Dispersive Signal Technology (DST), 3M’s proprietary implementation of bending wave technology, works by analyzing the bending waves which propagate within the glass substrate of the touch substrate. Bending waves are created when a user touches or performs a drag/draw on the glass surface. A bending wave propagates through the substrate much like waves propagate outward from a contact point in a pond. As the waves reach the corners of the touchscreen, piezoelectric sensors convert the mechanical energy of the bending wave into electrical signals. The electrical signals are analyzed by a 3M proprietary algorithm running on the DSP-based controller board and a precise touch location can be determined (FIGURE 5). Each touch location and draw events are calculated real time on the 3M Controller and requires no host PC process to analyze or determine the touch location.

Advantages and Disadvantages

Because the bending wave travels within the glass substrate, objects or hands resting on the screen or on-screen contaminants do not affect the bending wave and therefore, do not affect the performance of the touchscreen. 3M DST can be activated by bare finger, fingernail, stylus, and pen or basically anything that create the bending wave in the glass substrate (FIGURE 6).
The two primary limitations of 3M DST is size and substrate. 3M offers DST for display sizes ranging from 32 to 47 inches, which uses a 2.2mm chemically-strengthened substrate. While larger sizes are theoretically possible, 47 inches is the largest commercially available size.

Construction

Surface acoustic wave touchscreen construction is typically 2-5mm glass substrate with two transducers and two receivers mounted on the front side of the glass. In addition, reflector patterns that direct the acoustic energy are typically etched or printed around the perimeter of the front surface of the glass. During the design phase considerations for integration accommodations need to be made to protect the transducers and provide a gap above the transducer to ensure proper operation. Having both the reflector patterns and transducer mounted on the front surface eliminates the option of creating the flat front surface (FFS) industrial design. Border width is an issue with today’s narrow border LCD displays. Existing SAW designs have border widths of 22.9mm and 24.4mm, which are wider than the LCD border of many displays.

Optical touchscreen construction is substrate independent but is typically acrylic or glass with two surface-mounted cameras on the front side of the glass. In addition, a perimeter light guide or reflector pattern is located on the front side of the substrate. Having the camera and reflector patterns mounted on the front surface eliminates the option of creating a flat front surface industrial design. The border widths on the typical 42-inch optical system are 20mm on three sides and 40mm on the top. The top border is designed to allow the cameras to recess above the standard border to improve performance and eliminate “blind spots” for the camera. Many of today’s display do not have integration space to accommodate such wide border widths.
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3M Dispersive Signal touchscreen construction is 2.2 mm chemically-strengthened glass substrate, with four piezoelectric sensors attached in the corners on the back side of the glass. The Integration stack up consists of the glass substrate, and rear mounted VHB which creates a total stack height to approximately 4.4mm. This height is less than half that of typical SAW and Camera technologies. The second critical integration challenge is border width. The existing narrow border DST has border widths of 10.32mm, allowing DST to be easily integrated into most displays.

Features and Benefits
Since each of these technologies has unique operation and construction characteristics, each technology detects touch differently and offers features and benefits to help meet many touch market requirements. In demanding, heavy-use environments, a key touchscreen feature is contaminant resistance. Since 3M DST does not rely on an active front surface as both SAW and optical technologies do, it excels in meeting this requirement. Also, with the piezoelectric sensors located on the back side of the glass, the front side is flat and easy to integrate a suitable sealing gasket for user applications.

The second key feature is flexibility in the user integration. 3M DST has a low integration profile (only 4.4mm) and narrow border widths (10.32mm) so it can be easily integrated into a wide range of commercially available displays.

Summary and Recommendations
Understanding the available touch technologies is very important in selecting which best meets the needs of your specific application. The main benefit of the optical technology is that it can support two fingers on the screen and scale to large sizes. 3M DST and SAW are capable of simulated gesture functionality, such as flick, swipe, zoom, pan, etc. The drawback to active surface technologies, such as SAW and Optical, is that because the first surface is active, performance can be affected by contaminants on the screen.

3M DST’s unique method of detecting touch does not require an active surface, so it is unaffected by on-screen contaminants. This allows customers “orientation flexibility” when installing DST-equipped displays. They can be positioned in almost any orientation, such as portrait, landscape or horizontal (in table tops). 3M DST also allows objects to be resting on the surface of the touchscreen for table top applications.

**Product Specification Comparison (for typical 42-inch systems)**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Optical</th>
<th>SAW</th>
<th>3M DST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Touch Versatility</td>
<td>Requires stylus greater than 3mm</td>
<td>Requires sound absorbing stylus</td>
<td>Stylus independent</td>
</tr>
<tr>
<td>Touch Response Time</td>
<td>9-22ms</td>
<td>10ms</td>
<td>Less than 20ms</td>
</tr>
<tr>
<td>Accuracy</td>
<td>±2mm on 90%</td>
<td>Standard deviation less than 7.68mm</td>
<td>Better than 99%</td>
</tr>
<tr>
<td>Surface Contaminants</td>
<td>No Specification</td>
<td>No Specification</td>
<td>Unaffected by surface contaminants</td>
</tr>
<tr>
<td>Optics</td>
<td>Substrate independent</td>
<td>Anti-glare / Anti-reflective</td>
<td>Anti-glare standard</td>
</tr>
<tr>
<td>Transmission</td>
<td>88-89%</td>
<td>92%</td>
<td>92%</td>
</tr>
<tr>
<td>Ease of Integration</td>
<td>Requires 9-15mm height</td>
<td>Requires greater than 9mm height</td>
<td>Requires less than 6mm height</td>
</tr>
<tr>
<td>Installation</td>
<td>Requires different orientation</td>
<td>Requires different orientation</td>
<td>Can be mounted in any orientation</td>
</tr>
<tr>
<td>Multi-touch</td>
<td>Two finger and gestures</td>
<td>Gestures only</td>
<td>Gestures only</td>
</tr>
<tr>
<td>Warranty</td>
<td>1 year</td>
<td>5 year</td>
<td>3 years</td>
</tr>
</tbody>
</table>

The passive first surface of DST allows flexibility in installing the units in any orientation portrait, landscape, or table top without the need for new designs or additional calibration. When using active technologies such as Optical and SAW it is beneficial to have the camera and transducer oriented at the top of the screen to avoid contaminant build up along the edges.