White Paper

Touch Screens
for military applications

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1 General

Barco has used a whole range of touch technologies in its display range as an optional feature and is continuing to do so. Every technology has its specific signature and is applicable for a certain application/market. With the need for more and more touch area and applications, it becomes more than ever important to define the best appropriate technology for the use in a rugged and harsh environment.
Next paragraphs will list the different technologies, their features and the use of it with some of Barco's monitors.

2 Analog Resistive (AR)

This is the most known touch screen technology. Basically, it is a sensor consisting of two opposing layers, each coated with a transparent resistive material called Indium Tin Oxide (ITO). The inner layer has a glass substrate, whereas the outer layer is a flexible hard-coated polyester film.
Those two layers are separated by a pattern of very small transparent insulating dots. Along the edges, there are bus bars that make an electrical connection to the surface of the ITO, spanning the desired axis.
When a user touches the upper flexible layer, the two layers come into electrical contact, so measurements can be made to determine where on the touch screen the user has touched. Typically, this is done by applying a linear voltage gradient (typically 5V) across the touch screen layers. The voltage can be measured to determine where on the touch screen the touch has occurred.

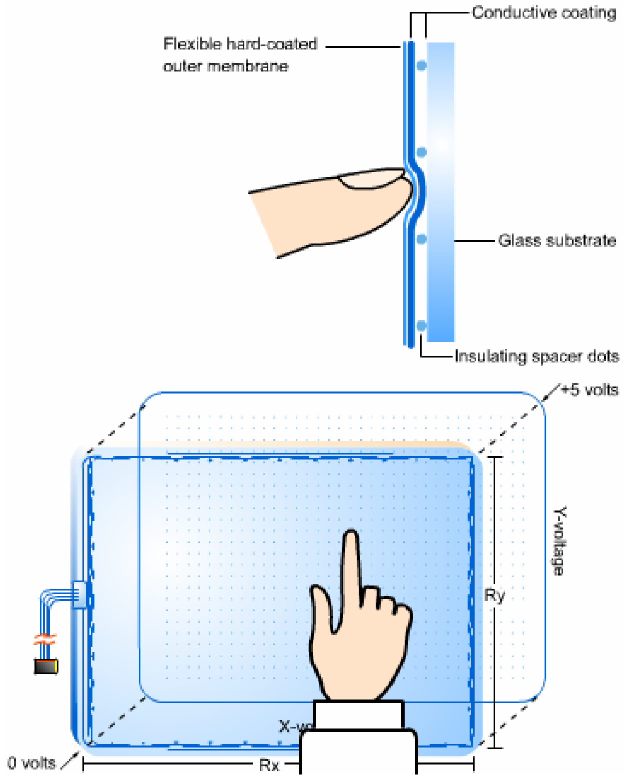

Figure 1: Analog Resistive

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There are several methods within the Analog Resistive technology to measure the correct coordinates, of which 5-wire and 8-wire have been used in Barco recently.
5-wire has the voltage gradient on only one layer (the robust inner glass layer), so that drift is essentially ruled out if the outer polyester layer degrades over time.
The 8-wire method has a better precision compared to 5-wire, because the sense line are directly located on the bus bars at the edge of the ITO coating. However, these lines are both on the outer and inner layer, so wearing out can be an issue.

Some issues related to this technology:

- As the outer layer is made out of polyester, there are environmental consequences in humidity and temperature:
    - Pillowing (layer coming off its substrate)
    - Moisture in the cavity, creating false electrical connections, therefore wrong touch coordinates
- Not scratch resistant
- Wearing after a time, because mechanical contact is needed between the two ITO layers.
- A lot of reflecting surfaces in the optical path adds up to the total reflectivity, decreasing the perceived contrast in higher ambient environments.

The newest products of RFD251 and MRFD251 use the 8-wire Analog Resistive touch screen.
There is no implementation foreseen in future Barco Rugged Displays.

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3 RUGGED ANALOG RESISTIVE

By applying a scratch resistant outer surface layer (4H hardness) instead of a polyester layer, the regular analog resistive touch screen becomes more protected. Technology wise, this is the same as normal analog resistive. Only the environmental issues have been mostly eliminated, so humidity and temperature is not an issue anymore and this is scratch resistant.

As there are still several reflective layers in the optical path, the reflectivity remains very high. However, improvements can be made by applying special optical filters to minimize the reflections of the total touch screen assembly to less than 1%. For the technologically challenged readers, Barco will add a circular polarizer and a retarder to change the polarization of the incoming ambient light such that it will be not seen as reflection, see **Figure 2** for more information.

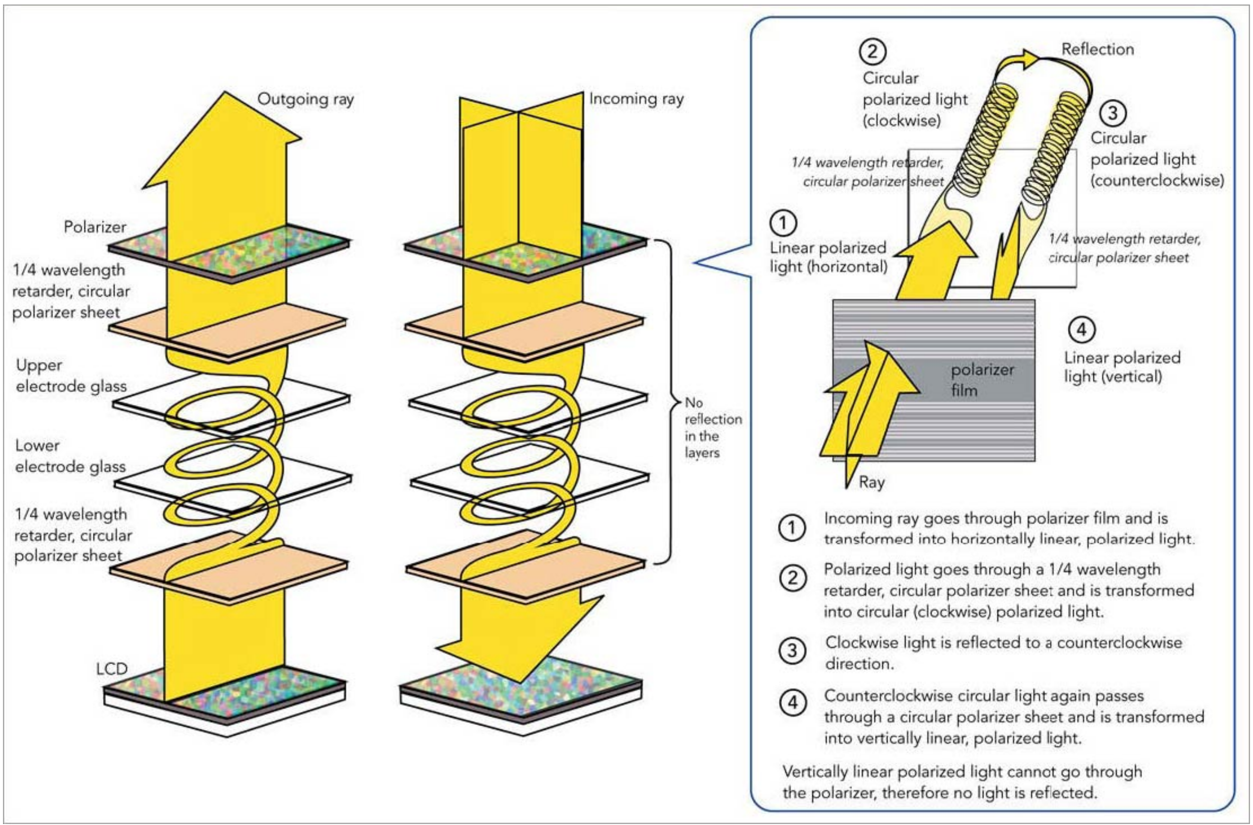

Figure 2: Circular Polarizer and retarder to minimize reflection

Barco uses the basic rugged analog resistive touch screen in its MRDS243HB product (not with the extra circular polarizer yet).
The ThinX concept will also make use of this technology with added optical filters for reduced reflectivity.

4 Surface Acoustic Wave (SAW)

This technology is based on the absorption of ultrasonic acoustic waves traveling across the surface of the glass layer. These waves travel both in the X and Y direction, to get the correct coordinates after measurement.
For every axis, there are 2 transducers (piezoelectric devices that transform an electrical signal from the controller into an ultrasonic vibration and vice versa). One is transmitting the waves across one axis, where reflectors spread it out over the glass substrate. Reflectors on the parallel side pick up those acoustic waves and guide them into the receiver transducer.

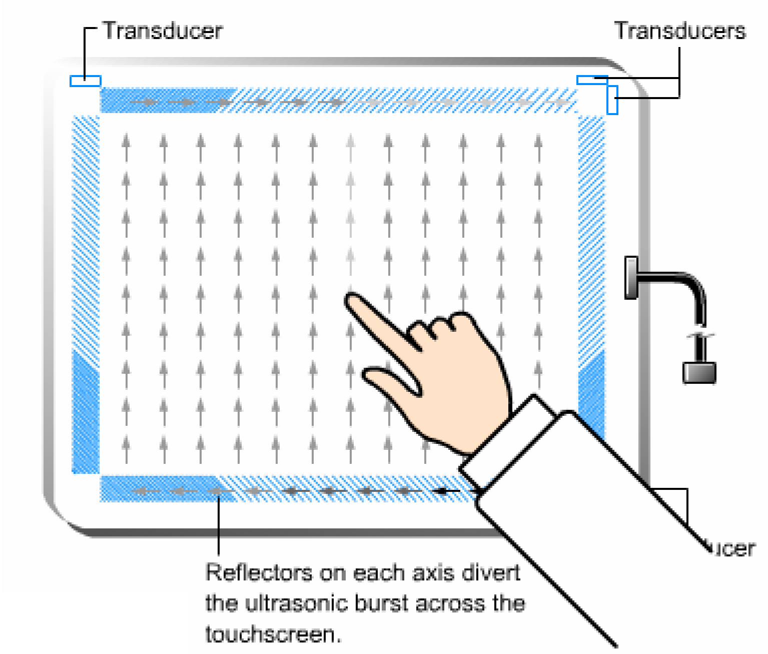

Figure 3: Surface Acoustic Wave

Some advantages to this technology, due to the glass top surface:

- Superior image clarity
- Better resolution
- Higher transmission of light
- Higher durability (no layers that can be worn out)

Some issues related to this technology:

- Touch input has to be a sound absorbing stylus
  - Finger
  - Gloved hand
  - Soft-tip stylus
- Activation by water droplets
- Need to have a clean surface to operate
- No IP65 at the front
- Higher maintenance when used in dirty and dusty environments
- Big borders needed (to hide the reflectors under the bezel)

These touch screens are used in the MRFD family of displays, more specifically in the MRFD243, the MRFD248 and the MRFD354.
There is no implementation foreseen in future Barco Rugged Displays.

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5 Surface Capacitive

A capacitive touch screen contains an ITO coating on the outside of the glass where a continuous electrical current (under low voltage) is conducted across the surface. This creates a certain uniform electrical field (capacitance) as seen by the detectors in all four corners. If a finger or other stylus touches the surface, electrical current is drawn from the sensors, which detects this and calculates the coordinates.

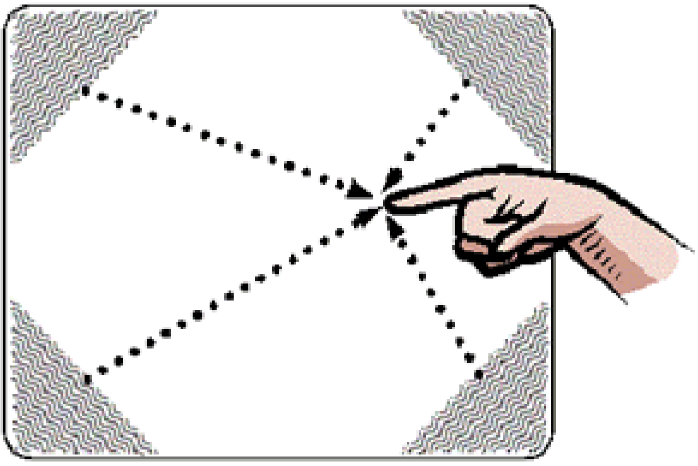

Figure 4: Surface Capacitive

This system also has a few drawbacks:

- There is a wear issue with the surface ITO layer
- EMC performance is adversely affected because of the small AC current in the surface ITO layer
- No metal bezels can be used
- Recalibration needed

Due to these issues, there is no implementation foreseen into Barco’s rugged LCD displays.

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6 PROJECTED CAPACITIVE

A projected capacitive touch screen uses embedded microfine wires within a glass laminate composite. Those wires are connected to an integrated controller board, which establishes an oscillation frequency for each wire. When a conducting stylus, such as a finger, touches the glass surface of the sensor, a change in capacitance occurs, which results in a measurable oscillation frequency change in the wires surrounding the contact point. The integrated controller then calculates the new capacitive values, this data is transferred to a host controller, and software is used to translate the sensor contact point to an absolute screen position.

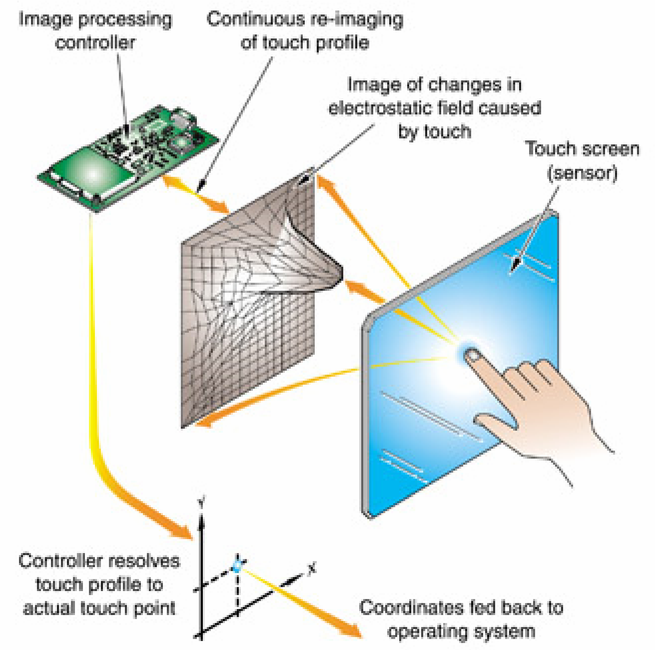

Figure 5: Projected Capacitive

Some drawbacks:

- EMC performance is adversely affected because of the oscillating electrical field
- Metal bezels should be avoided
- Possible optical interference with the wires and subpixels
- Only conducting stylus such as a finger

Due to these issues, there is no implementation foreseen into Barco's rugged LCD displays.

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7 INFRARED (IR)

Infrared touchscreens rely on the interruption of an IR light grid in front of the display screen. An opto-matrix frame is integrated into the display bezel that contains a row of LEDs and phototransistors (photoreceptors), each mounted on two opposite sides to create a grid of invisible light.

The opto-matrix frame is isolated from the outside environment by an IR transparent barrier. The IR controller sequentially pulses the LEDs to create a grid of IR light beams. When a stylus enters the grid, it obstructs the beams, causing one or more of the phototransistors to detect the absence of light and transmit a signal with the x and y coordinates.

Some issues related to this technology:

- The screen may react before it is physically touched, so ergonomically a problem, also with accidental touches.
- Issues with NVIS
- Reduced resolution at the borders
- Activated by water droplets, insects …

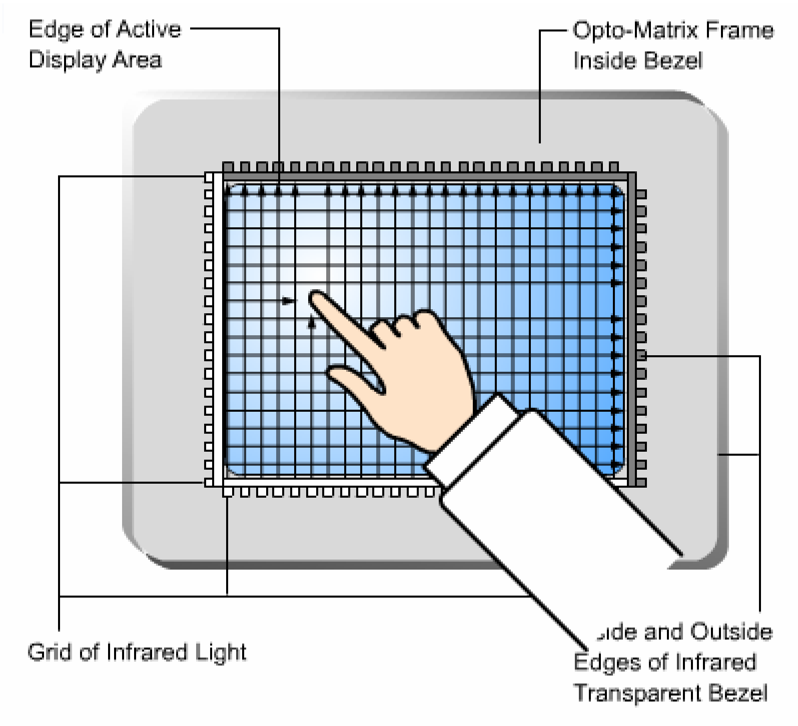

Figure 6: Infrared

These touch screens are used in the MPRD138HB as an option.
There is no implementation foreseen in future Barco Rugged Displays.

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8 ACOUSTIC PULSE RECOGNITION (APR)

The APR assembly consists of a glass display overlay with four piezoelectric transducers mounted on the back surface. These transducers are positioned on two diagonally opposite corners out of the visible area and connected to a controller.
The impact when the screen is touched or the friction caused while dragging between a stylus and the glass, creates an acoustic wave. This wave radiates away from the touch point, making its way to the four transducers which produce then an electrical signal proportional to the waves. The controller card then converts and compares these signals digitally to a stored profile, so the touch location can be determined. Ambient sounds are rejected.

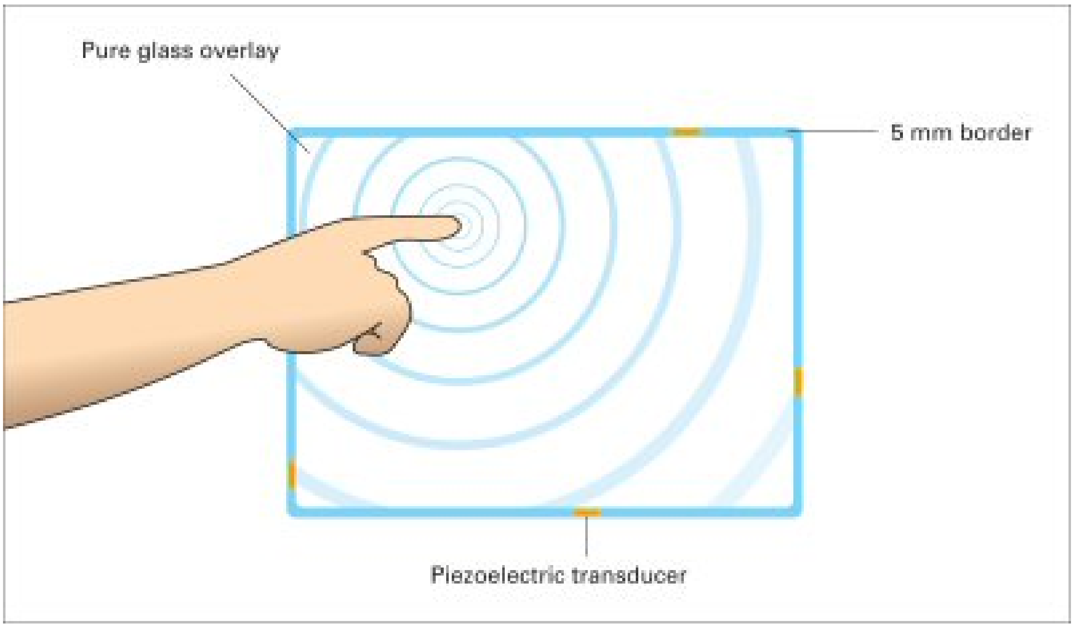

Figure 7: Acoustic Pulse Recognition

There are some advantages related to this technology:

- The overlay can be chosen so light transmission and reflectivity can be optimal
- Any stylus is accepted
- Good drag performance

The only main drawback is the unknown effect of vibration and shock in the rugged environments, so this is not used in Barco

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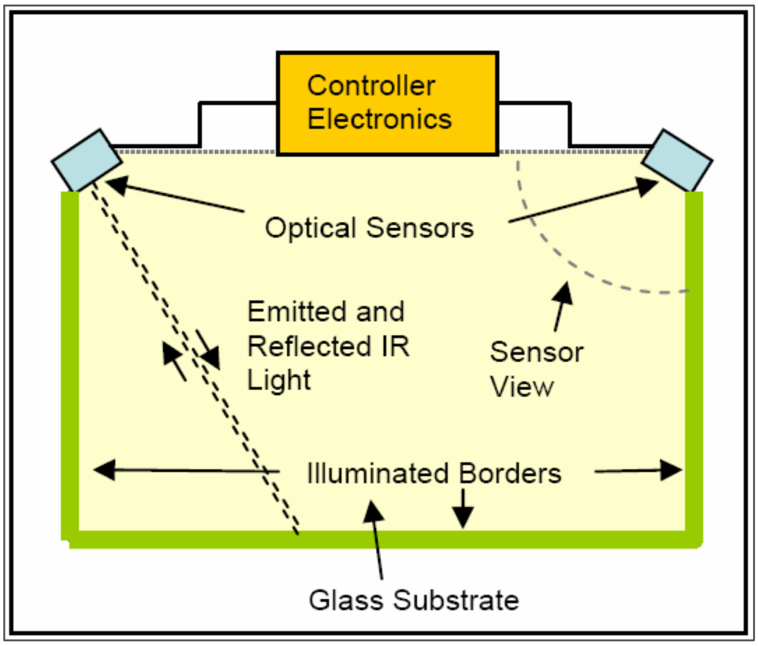
9 Optical Touch - NextWindow

An optical NextWindow touch screen consists of a plain sheet of glass, or other flat substrate, with two or more line-scanning optical sensors located at the corners of the substrate. Infrared light is distributed evenly across the surface of the substrate via a passive method with illuminated borders on the three facing edges. When a finger or other object touches the substrate, it blocks the light seen by the optical sensors. Electronics analyze the resulting optical information and use triangulation to calculate the point of touch.

The next figure shows a system-level overview of the optical touch screen. Key elements are:

- The substrate
- Lighting subsystem
- Optical subsystem
- Controller electronics.



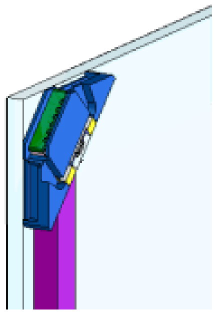


Figure 8: Optical Touch

Note: Barco's own addition is that optical sensors and LEDs are actually located at the bottom. This is because otherwise water can block the illuminated border, reducing the sensor view.

The substrate can be any flat material, so Barco chooses its own ruggedized front filter (chemically strengthened glass with AR coating).

The lighting subsystem consists of infrared (IR) light-emitting diodes (LEDs), providing illuminated borders located along the left, top and right edges of the substrate. In operation, the lighting subsystem distributes infrared across the substrate through the use of illuminated borders. The optical sensor subsystem consists of two optical sensors located in the lower left and right corners of the substrate.

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Each optical sensor views the entire substrate in a 90-degree sweep. When no touch is present, the two optical sensors see a relatively uniform level of light across the substrate. When a finger or other object touches the substrate, it blocks the light from the illuminated borders, causing the optical sensors to see a silhouette (shadow) of the object. The controller electronics processes information from the optical sensors and calculates the touch point location.

The optical subsystem consist of line-scanning optical sensors. Line-scanning optical sensors are used in a wide variety of applications, including bar-code readers, flat-bed scanners, industrial inspection equipment and dimension-measuring systems. A line-scanning optical sensor consists of a single row of pixels aligned parallel to the touch-screen surface, a lens to focus the image and a driver control circuit. Each optical sensor has 512 pixels. A single scan of all 512 pixels takes about one millisecond. Both optical sensors scan simultaneously in order to avoid skew effects while the touch point is moving (i.e., during dragging). This is one of many factors that help ensure excellent dragging performance.

An example of what one optical sensor "sees" is shown in next figure. The vertical axis is light intensity; the horizontal axis is optical sensor pixel position. The very distinct dip in the curve at pixel 358 is the touch location; the dip is in effect the "shadow" of the touching finger. The flat portions of the curve at each side (the "shoulders") are safety margins that ensure the optical sensor in fact sees the entire surface of the substrate. The narrow peak in the middle of the curve is the point where the LED light source is reflected directly into the optical sensor.

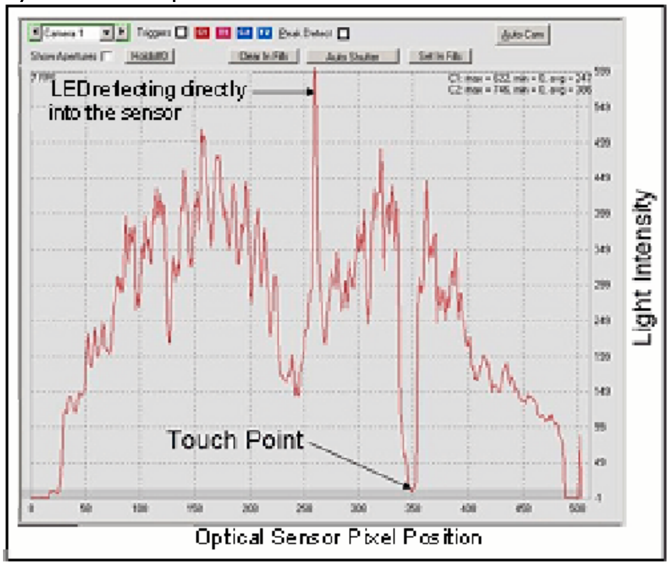

Figure 9: Optical Sensor "view"

The controller electronics then calculates the exact location of touch using trigonometric triangulation and sends the coordinates out to the user system via USB or RS-232. The USB is HID (Human Interface Device) compatible, meaning that the touch screen is actually a plug-and-play device without the need to load any drivers.

Touch detection starts by comparing the real-time (fast-changing) video signal to a reference (slow-changing) copy of the video signal. The reference signal sets a baseline that accounts for ambient light, shadows and other environmental conditions. When the fast-changing signal drops below a

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certain threshold percentage of the reference signal (i.e., when a finger or other object starts to block some of the light), the touch-detection process starts.
Once the touch-detection process has started, the velocity of the approaching finger (or other touch object) is determined. When the velocity reaches zero, a touch is registered, eliminating most of the pre-touch found on IR and optical touch screens.
A complication occurs when the touch point is very close to the top edge of the touch screen. The result is a slight decrease in accuracy in the X-dimension, mostly confined to the lower 10 mm of the touch screen. The accuracy in the Y-dimension is unaffected by this situation. If the typical accuracy in the X-dimension over most of the screen is +/-2 mm, the typical accuracy in the bottom 10 mm ranges from +/-3 mm in the corners up to +/-6 mm in the top center.

Some of the issues related to this technology:

- Issues with NVIS
- Activation by foreign objects (lots of water, insects)
- Bottom 10mm less accurate in X-dimension

Advantages are:

- Touch is unaffected by dirt on the surface.
- Any stylus input is accepted
- Small water droplets don’t create an activation.
- Fluent dragging functionality
- Choice of own front filter, so high optical quality (transmission, reflection…)

Currently this technology comes out as one of the best to be used in a rugged environment. The newest thinLITE family will be fitted with this technology.

10 CONCLUSION

As touch screen technology is constantly improving and changing, we need to evaluate from time to time to be able to implement these in rugged displays.
For the moment (Q1 2008), the Optical Touch technology from NextWindow looks to be the most promising technology to use in the newest thinLITE product family.
The Rugged AR touch screen with improved optical filters to reduce reflectivity is currently the best choice for the ThinX (in development).
The other touch technologies will be gradually phased out.

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