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Five-Wire Resistive Analog Touch Screens for Hand-Held Applications

Hand-held devices are no longer a "disposable device." As hand-helds become an accepted tool for mainstream business, the demands placed on the touchscreen for reliability and optics have become increasingly important.

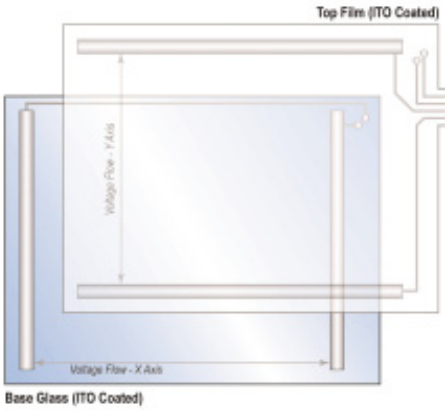
Resistive analog four-wire touch screens have long been a successful touch screen user interface for hand-held devices, however mainstream industrial businesses such as, warehousing, inventory control, retail, hospitality and medical applications have placed new demands on the interface pushing four-wire resistive technology beyond its physical limit. This has prompted manufacturers to develop new and more rugged resistive touch screens for these harsh environment applications.

Resistive Analog Four-Wire Technology Construction and Functionality

The four-wire consists of two opposing electrically conductive elements. The conductive material is typically ITO (Indium Tin Oxide) because of its transparent nature. There are two different ways to construct a four-wire touch screen. One, using two flexible conductive films laminated to a glass or plastic backing. Two, using a flexible top conductive layer laminated to a conductive piece of glass. Most hand-held PDA constructions are built using the film/glass construction method.

Electrical Functionality of the Four-Wire:

The X and Y axis data points are derived using both conductive planes. In the first phase of data collection, the top conductive layer is electrically charged and the bottom conductive layer acts as the feedback sending raw voltage of the touch point to the electronics, deriving one-half of the full touch coordinate. In the second phase, the bottom layer is electrically charged and the top layer serves to send the voltage information to the electronics, completing the X and Y coordinate signal. Typically low-cost four-wire constructions built with a film/film type are rated at 100,000 activations and higher cost four-wire film/glass constructions are rated at 1 million activations.



Four-wire construction: X- and Y-axis on two layers

Reliability is the Key Limitation of a Four-Wire Touch Screen

In four-wire touch screens, accuracy is affected with environmental changes, primarily shifts in humidity and temperature. The top film represents the X- or Y- axis depending on the design. It is important that the resistance value remain stable on both axis after initial calibration. Because the top layer is made with polyester, this top sheet will expand and contract with changing conditions, thereby causing changes to the initial resistance values. This change results in what is known in the industry as "drift" to the touch point location, which diminishes the touch screen reliability. In addition, frequent flexing of the top layer upon single locations (such as, on and off icons) can cause mechanical damage to the conductive coatings. This fracturing of the conductive coating changes the resistance values as well, and results in the need for frequent field recalibration or complete and permanent electrical failure of the touch screen.

The benefits of a four-wire are its widespread usage, which has helped keep the cost low and prompted numerous chip manu-

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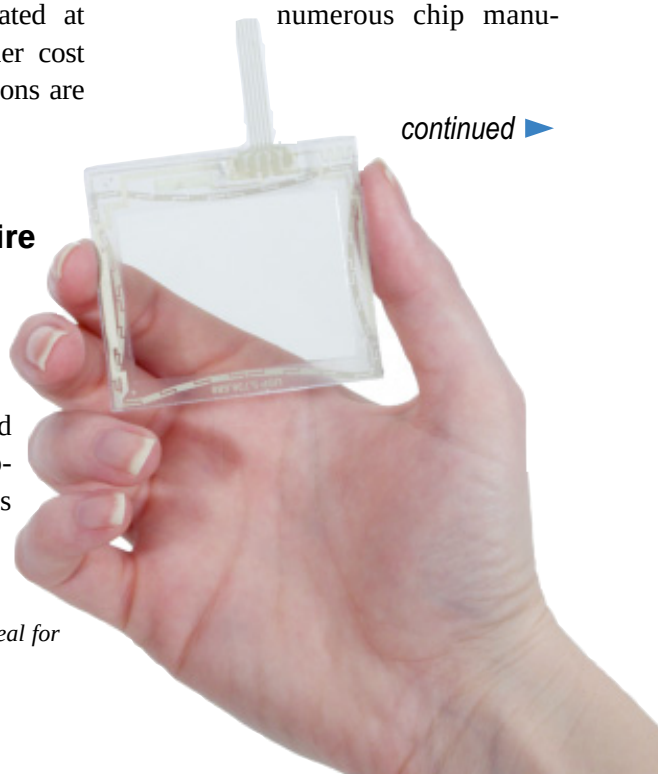


This 2.4" five-wire touchscreen is ideal for hand-held phone applications.

facturers to make electronics accessible and economical.

Alternative Five-Wire Resistive Technology for Hand-Held Devices

Resistive analog five-wire touch screens are the most reliable resistive analog on the market today, but have never had the ability to be incorporated in a hand-held device until now. Five-wire has been the resistive analog solution for tough environment applications such as industrial control modules, POS applications and Kiosks for nearly 20 years, but has been limited to diagonal sizes of 6.4" or larger. This diagonal limitation prevented the technology from consideration in hand-held applications, which are typically 3.9" in diagonal or smaller.

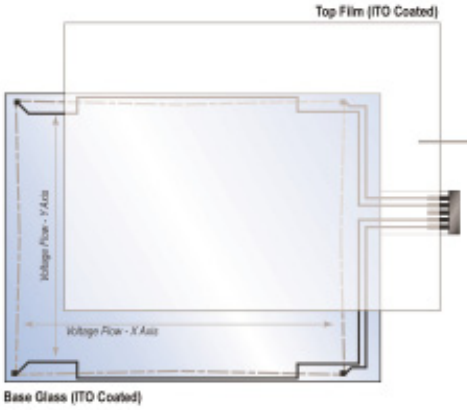
The following information describes five-wire construction, functionality and its ability to now be incorporated into hand-held devices.

Five-Wire Construction and Functionality

The mechanical layers that make up a five-wire construction are similar to that of a film/glass constructed four-wire.

The key difference between four-wire and five-wire is how they perform electrically. The four-wire must use two layers to create X- and Y-axis measurements. In contrast, the five-wire utilizes the stable substrate of glass for both X- and Y- axis measurements.

Five-wire operates by supplying five volts to ground and toggling in both directions, thus supplying the necessary X- and Y- axis measurements. The sense line or 5th wire is the top film substrate. When the top layer is depressed making contact with the base layer it picks up the voltage data and carries it to the electronics. Because the top film is working only as a pick up layer it can tolerate resistance changes without impacting the reliability of the touch points accuracy from the base layer. It is for this reason; the five-wire is able to withstand temperature, humidity and mechanical stresses. As a result, five-wire manufacturers are able to specify their touch screens at 35 million activations. Three companies currently manufacture five-wire resistive analog touch screens, The Bergquist Company, EloTouchsystems and 3M Touchsystems.



Five-wire construction: X- and Y-axis on base layer of glass

Barriers which prevented Five-Wire from being used in hand held applications

Although the five-wire has proven itself in the market to be reliable resistive analog solution for rugged applications, there were significant barriers that prevented its usage in hand-held devices. These barriers included the inability to linearize diagonals under 6.4", external electronic correction (NovRam), higher power draw, its' wider perimeter and limited electronic accessibility in the marketplace.

To help break down these barriers, The Bergquist Company has developed five-wire drop in sizes for hand held devices and has recently introduced a 2.4" diagonal for phone applications. The success of these smaller diagonals resides in Bergquists' patented linearity resistor network. This pattern is able to linearize small diagonals as well as off-ratio sizes (aspect ratio of 6:19). Off-ratio sizes are not only used in hand-held applications, but are of particular interest to the automotive industry where GPS and entertainment applications need the off-ratio dimensions. This linearization is first order, so no external correction electronics are necessary. In addition, Bergquist has taken the power draw of a typical five-wire down from 100 mA to 21 mA making it a practical solution for power sensitive hand held devices.

Where OEMs were once bound to the touch screen manufacturer for their five-wire electronics solutions this is no longer the case. Companies like Burr-Brown, Texas Instruments and Hampshire Company have made the electronics simple and accessible with "off the shelf", inexpensive electronic chip solutions for five-wire.

The heavily patented five-wire was also once seen as a barrier for acceptance of the technology. OEMs were concerned about locking themselves into a technology where there was limited competition. The Bergquist Company's approach is to enable the market in a threefold man-

ner; One, by manufacturing the touch screens themselves, two contracting the manufacturing with existing four-wire manufacturers and three, licensing arrangements.

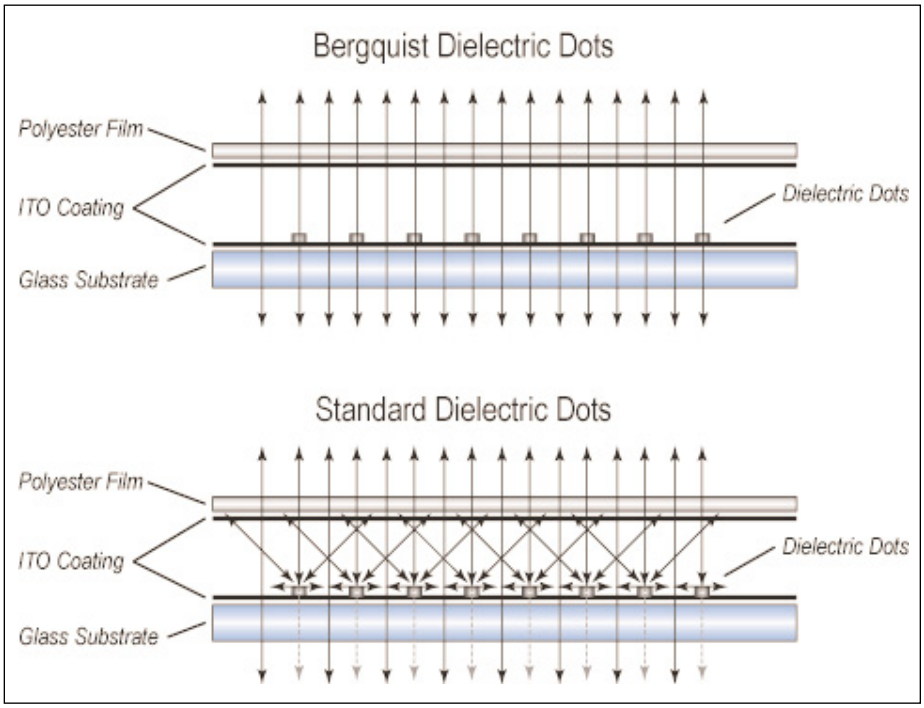
Five- Wire Optics

Resistive touch screen manufacturers are continuously working on improvements to enhance the optical performance of the touch screen. The five-wire is uniquely suited for improvements in this area because the top conductive film does not require as many manufacturing-processing steps to complete. Five-wire can use nearly any conductive film, including polarized, anti-reflective, high contrast, gloss and matte film offerings. This flexibility keeps five-wire manufacturers consistently on the leading edge of optical performance.

Bergquist has taken their optical performance a step further by significantly reducing the scattering of light within the touch screen itself. This is accomplished using a dot separator treatment that is closely color indexed to the conductive coating and change the direction of light. Instead of scattering light, the dot separators allow the light to pass through the substrates.

Manufacturers of hand-held devices are expanding into applications well beyond what was once considered the disposable consumer market. These include such rugged applications as, warehouse management, courier services, hospitality, retail, inventory control, healthcare and sales automation. These applications require not only durability, but optics that can enhance the display in all lighting conditions indoors and out. Expect to see more five-wire touch screens filling these applications.

Five-wire touchscreens range from as small as 2.4" to as large as 23". (Shown are 7" off-ratio, 3.9" and 2.4" sizes)



Bergquist's patented dielectric dots (top) allow the light to pass through reducing the scattering of light. Standard dielectric dots (bottom) bounce light from both conductive layers causing the "veiling light phenomenon" — light scattering.