Frit and the Better Touch Screen

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Touch International's 5-wire touch screens are superior to the competition's 5-wire touch screens because of the use of frit instead of ordinary silver inks to make the edge circuitry. The purpose of this white paper is to describe what frit is and why it makes a better product. This paper assumes the reader has a good understanding of the construction of 4 and 5-wire touch panels, which are described in other Touch International documents.

The best resistive touch screens use "frit" for the conductors. Frit is a mixture of silver flakes and glass in a thicksotropic paste. The paste is applied to the ITO glass substrate with a stencil or silkscreen and then heated to a very high temperature. At a high temperature the glass beads and silver melt together, resulting in a very hard low resistance conductor.

The Hardened Frit has the Following Desirable Properties

- The frit has a very low electrical resistance, usually less than .001 ohms per square.
- Wires and flex cables can be soldered to the frit instead of heat stamped. This results in a durable, gas free connection that resists the negative impacts of aging.
- Frit bonds to the ITO making the conductor-to-ITO interface very low resistance.
- The hardness and good bond strength makes the conductor resistant to de-lamination when the other layers are adhered to the glass.
- Frit has low chemical reactivity, so touch screen borders can be made narrow. This is because other inks can be printed over the frit without causing electrical or chemical interaction.

Resistive Touch Screens and Frit

The two primary types of resistive touch screens are generally called 4-wire and 5-wire. Both types of touch screens use the same material construction, but the X-Y voltages (used to generate the coordinates) are measured in different ways. In the 4-wire touch screen the voltage change is measured on the bottom ITO layer for the X coordinate, and the upper ITO layer is used to measure the Y coordinate. On the 5-wire type, both the X and Y coordinate are taken from the rigid bottom layer. (Please refer to one of Touch Inter-national's other white papers which explain why 5-wire touch screens are superior to 4-wire.)

Electrical Differences between 4-Wire and 5-Wire

For 4-wire, the voltage drop caused by the uniform ITO resistance between two bus bars is used to generate the coordinate. As an example scenario, let's say 5 volts are applied on the connecting tail. The connecting tail passes through a heat seal bond to the silver ink on the ITO glass and arrives at the buss bar to ITO at 4.5 volts. Half a volt is lost in the resistance of the tail, heat seal bond, connecting silver, and ITO silver interface. The 4.5 volts will further drop across the ITO surface where it will be probed to generate a

coordinate, and then arrive at the other bus bar at 0.5 volts. This means the electrical half-way point, which is the middle of the coordinate range, will be at 2.0 volts instead of the theoretical 2.5 volts (half of the original 5 volts). The calibration phase, when the touch point is aligned to the display, will adjust the coordinates to the voltage loss. This is the so-called signal to noise ratio (4 volts of signal and 1 volt of noise). The upper plastic layer of a 4-wire type uses slightly different construction, and thus the signal to noise ratio might be different than the bottom layer.

In a 4-wire touch panel construction, the continuous silver buss bar delivers the same signal along the whole axis (side). In a 5-wire touch screen, the buss bar is created from discontinuous silver segments along the edge. This complex "pattern" uses signal switching to create the X-Y field on the bottom surface. The upper plastic-with-ITO layer is just a probe, which touches the rigid bottom layer to generate both X and Y coordinates. In generating a linear 5-wire touch screen, it is critical that the voltages to all of the corners be almost identical. If, for example, one corner gets 4.5 volts, and another corner 4.75 volts, the resulting coordinates will not be Cartesian (grid) but curved lines. Unbalanced corner voltage yields a touch screen, which will be unacceptably non-linear. (On some bigger 5-wire touch screens, especially those made with ink instead of frit, you may see a series of boxes in the edge trace that is an attempt to balance the resistance to each corner.)

More Durable Touch Screens

Making a superior touch screen, especially a 5-wire touch screen, is dependent upon frit. The first benefit is that the tail, which connects the electrical controller to the touch screen, can be soldered. A soldered tail is durable, meaning that it is very hard to pull off of the glass, and metal to metal, which means the electrical resistance is almost zero. If conventional and less expensive silver ink is used, the tail cannot be soldered because it would be burned off in the process. Instead of soldering with silver ink, a heat-seal process; applying heat and pressure to "glue" the tail to the touch screen is used. Not only is this tail more susceptible to being pulled off of the touch screen, but over time the conductive adhesive will increase resistance. Because of the way a 4-wire touch screen is made, one may calibrate out the change in the heat seal resistance, but it will not affect the linearity; a 5-wire will become non-linear over time if a heat-seal interface is used instead of solder.

The superior adhesion of frit to ITO glass contributes to the stability and accuracy of touch screens over time. Many of Touch International's military 4-wire touch screens use frit be-cause of the stability created when strong adhesives adhere the top ITO plastic layer to the bottom glass layer. Adhesion is done over the silver buss bars. In the case of silver ink, any mechanical force pulling on the top sheet can rip the silver ink off of either layer and ruin the touch screen. Frit is fused into ITO glass and is better bonded to the glass than to the adhesive, thus pulling the top sheet off of a frit touch screen will (ordinarily) have no negative impact. A fritted touch screen is undoubtedly the best choice, especially when a touch screen is sealed to a bezel.

Border Area and 5-Wire Touch Panels

5-wire touch screens are better than 4-wire, although historically 4-wire touch screens needed less space on the edge for the silver conductors. In the status quo 5-wire touch screens can have the same narrow border as 4-wire, because conductive inks can be printed over frit without causing changes in the electrical conductivity. Frit gives the user the ability to specify a better 5 wire panel and enjoy the same narrow border area of a 4 wire type.

Cost and Frit

Historically 5-wire touch screens have been more expensive than 4-wire types because of the additional cost of frit. The high temperature required to melt the frit also can affect the uniformity of the ITO. If the air inside the melting chamber is not carefully controlled, extra oxygen could cause the ITO to increase in resistance and extra nitrogen could lower the resistance. In the past, this change would sometimes not occur uniformly and patches of different resistances would be left and the touch surface would be ruined. Today, however, the frit curing process is under control so there is less cost difference between the two types of touch screens.