Touch Technology Brief

Technology Comparison: Resistive and Surface Capacitive

Introduction

As touch screen usage increases, it is important to understand the differences between each technology. Touch screens are used in a variety of markets which include retail, hospitality, industrial, medical, entertainment, amusement, gaming, transportation, government, education and training, health and fitness, and finance and banking applications. The wide range of user environments for these applications has created a wide variety of touch technologies, each with its unique characteristics, and application advantages and disadvantages. The most commonly used touch technologies include surface capacitive, surface acoustic wave (SAW), projected capacitive, bending wave, infrared (IR), and resistive. Overall, resistive technology is the most commonly used touch technology. In this technology brief, we will compare the differences between "resistive" and "surface capacitive" touch technologies.

How Resistive Technology Works?

Resistive technology works on the premise of voltage being applied to a conductive, uniformly resistive surface or set of surface layers to create a voltage gradient across them. The top surface layer is separated from the bottom layer with insulating dots (also known as spacer dots). When the top sheet is pressed so that it makes contact with the bottom layer, an electrical connection is made between the layers, in effect closing an electrical switch with the voltage measurement on the sensing layer directly correlating to where the sensor is touched. The gradient is applied either in a horizontal or a vertical direction to acquire the X or Y coordinates of the touchdown and repeats for the other direction, requiring two measurements. The controller in the system correlates the voltage measurement to the location coordinates of the touchdown.

There are a number of different methods to create the gradient across the resistive layers and to measure the voltages. The most common are known as 4-wire and 5-wire resistive implementations. 7-wire and 8-wire resistive technology are variations designed to resolve potential limitations in 4-wire and 5-wire resistive technology. Each implementation has advantages compared to the others, with 4-wire being typically used for smaller, portable products like PDAs, while 5-wire is primarily used in larger and more public applications like POS terminals.

Given the theory of operation of resistive touchscreens, stylus or gloved input is an obvious advantage over other technologies. Any object that depresses the top surface to make contact with the bottom surface will induce a touch event. This flexibility is a benefit in some markets where user input methods can vary greatly but can also be a detriment in markets that cannot tolerate unintended touches, such as medical and gaming.

How Surface Capacitive Technology Works?

Surface capacitive technology works on the basis of a person or conductive stylus creating a path for an electrical alternating current to flow from the surface of a touch screen to ground. Specifically, the human body has inherent impedance ranging from about 20k to 300kΩ, which is much less than the inherent leakage impedance of the system from the touch screen to ground. As a result, when the touch screen is touched, current will flow through the finger, through the person's body impedance, then through a body-to-ground impedance and back to the system ground. The touch current that flows is very small—in the range of 20 to 500 µA. This current exceeds the touch threshold set by the controller and the position of the touchdown location is precisely calculated as being inversely proportional to the distance from the contact point to the corner.

The theory of operation for surface capacitive touchscreens explains why a bare finger or conductive stylus is needed for touch operation. A stylus or object that does not capacitively couple to the surface will not be detected by the electronics. This ability to only process intended touches means that accidental objects, insects, or debris hitting the screen are ignored, and makes surface capacitive a strong solution for markets that demand reliable and accurate touch response.

Construction

Surface capacitive and resistive touch sensors vary significantly in their construction (figures 1A and 1B). Resistive touch sensors are built using an ITO (indium tin-oxide) coated glass or PET that has similar stack-up on top with a conductive coating on the underside to create an electrical contact with the ITO on the bottom layer during a touch event. These two layers are kept separated by dielectric spacer dots which keeps the layers from shorting. An optional hard coat is applied to the front surface to increase the durability of the top layer and maintain the integrity of the sensor.

Surface capacitive touch sensors are made with one sheet of glass that is coated with a conductive coating and a linearization pattern. On top of these layers, 3M applies a protective hard coat with anti-glare properties and a scratch resistant top coat for additional protection against sharp objects scratching the screen.

Features and Benefits

With these construction differences, each technology detects touch differently and offer different features and benefits that help meet many of the touch market requirements. One key feature is light transmission (figure 2). The construction of surface capacitive sensors allows for increased light transmission by having limited transition layers to reflect light away from the user. The second key feature is durability and reliability in the user environment (figure 3). When constructed with a protective hard coat, a surface capacitive touch sensor surface is extremely durable. In addition, having no mechanical motion from flexible layers during a touch event offers increased reliability of touch durability in heavy-use environments. However, if the application requires stylus or glove input flexibility, this mechanical movement is what allows for resistive to meet the input needs of such applications. The second major component of a touch system is the touch electronics. Electronics that ensure repeatable and reliable touch performance in demanding environments are important. When choosing a touch technology, it is very important to ensure that it is paired with electronics that meet the needs of the application. Both resistive and surface capacitive technologies offer fast touch response, however, depending on the mode of operation, each can offer a premium or standard solution. Most resistive touch sensors operate in a "voltage sensing method" that can create inaccuracies when processing touch from measurements taken at different points

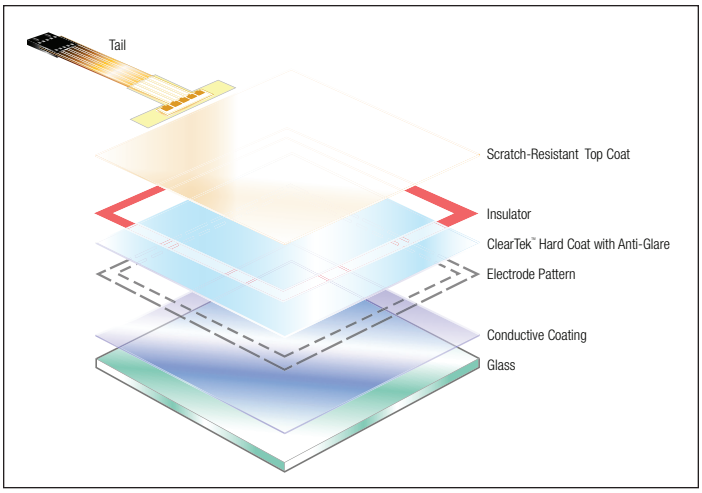

Figure 1A: 3M surface capacitive technology has six manufacturing layers

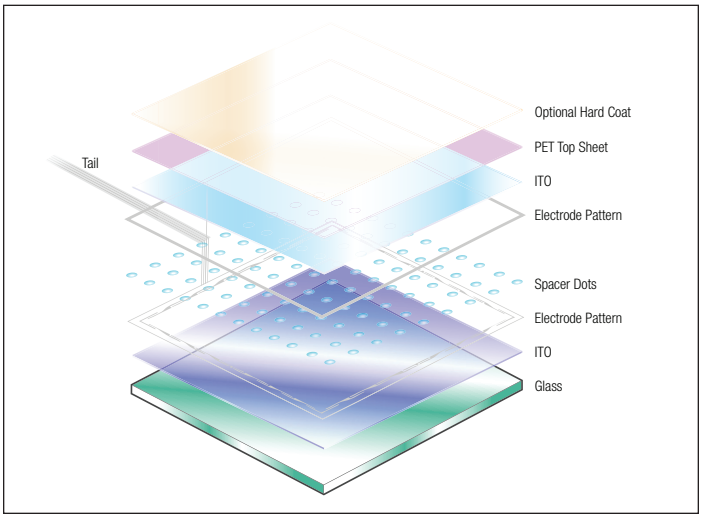

Figure 1B: 5-wire resistive can have up eight layers, plus an air gap

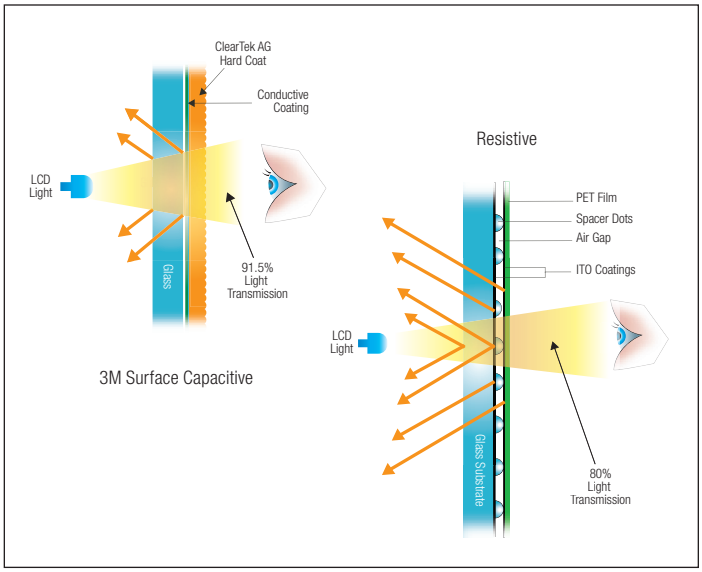

Figure 2: 3M surface capacitive technology offers increased light transmission due to less light index changes.

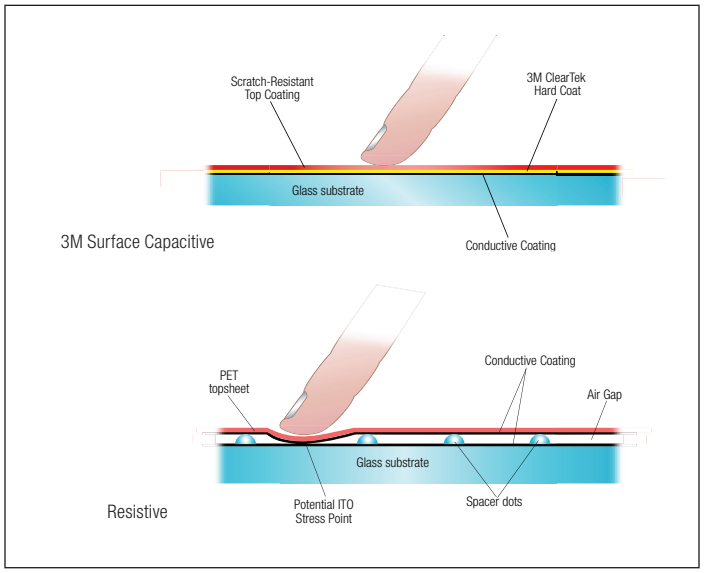

Figure 3: 3M surface capacitive with no moving parts increases long-term reliability and durability.

in time. Even with surface capacitive technology, some electronics solutions can offer touch performance similar to resistive electronics to qualify as a cost effective, low power solution. However, as sensor sizes increase, a "current driven method" for sensing touch location is preferred. With a current driven method, all four corners are measured simultaneously allowing for the most accurate possible touch response. Most controllers offering a voltage based sensing solution achieve greater than 98% accuracy, while most controllers offering a current driven method achieve greater than 99% accuracy.

Resistive touch sensors are offered in very small sizes, as small as less than 3 inches and up to 22 inches. Surface capacitive sensors are available from 4.3 inches up to 32 inches. Both technologies can be designed to meet the current LCD trends of wide format as well as traditional 4:3 formats.

Product Specification Comparison

Feature	Typical 5-wire Resistive	3M Surface Capacitive
Touch Reliability	Designed for 35 millions of touches*	Designed for greater than 200 million of touches
Touch Versatility	Finger, stylus, or gloved input	Finger only (virtually no inadvertent touches)
Touch Response (minimum)	15-24 milliseconds	5.4 milliseconds
Surface Characteristics		
Durability	Polyester surface (scratch/blemish prone)	Glass surface (with hard coat and top coat)
Scratch Resistance	3H-4H Pencil Hardness rating*	Exceeds 9H Pencil Hardness rating (max pencil hardness available) Mohs Hardness rating (mineral test used to determine hardness of different minerals – a pencil falls between 2 and 3 MoHS)**
Cleaning	Cleaning solutions for plastics	Cleaning solutions for coated glass
Display Optics	80-83% light transmission*	91.5% light transmission **
Ease of Integration	Sensor alignment is critical to avoid	Sensor alignment is not critical to integration constant touch due to bezel contact
Temperature		
Operating	-10°C to 50°C (typical)	-40° C to 70° C **
Storage	-40°C to 70°C (typical)	-50°C and 85°C **

* NOTE: Typical published specifications from leading 5-wire resistive manufacturers, but does not represent one unique product.
** Actual published specifications for 3M MicroTouch System SCT3250EX

Summary and Recommendations

Knowing the differences between touch technologies is very important in selecting which technology best meets the needs of your application. Resistive technology's differentiating feature is stylus independence since it allows for touch input with anything that will bend the top layer. Surface Capacitive's differentiating features are exceptional light transmission, robust surface durability, and long term reliability.

Since any touch overlay will reduce the light transmission of the LCD display to some degree, it's important to choose the touch technology with the best light transmission to provide the least degradation to the LCD image.

Since the device manufacturer or display integrator has little control of an application's environment or the cleaning and maintenance of the touch sensor, the superior durability of a glass surface and no moving mechanical parts helps ensure long term reliability of the touch system.

The largest markets for surface capacitive touch technology include casino gaming and financial ATMs. Both applications are public use devices that operate 24 hours per day, 7 days per week. With more than 20 years of repeatable, reliable touch performance in these markets, surface capacitive has been the technology of choice when durability and light transmission are important to the application.

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