

Touch Panel Types and Technology

Overview

As the main user interaction portal, touch panels greatly contribute to perception of quality and overall usability of a mobile device. Through persistent innovation, these components have grown in capability and complexity. Many touch panel manufacturers continue to seek out new technologies and improve existing ones in an ongoing commitment to meet the growing needs of customers in new and innovative applications and environments.

This document describes the role touch panels play in today's enterprise mobile computers, and introduces the different types of touch panels, how they are designed, and how they function. It also discusses the benefits and limitations of each type of touch panel, in terms of providing users with intuitive user interfaces and environmental flexibility.

Touch Panel Types

Long before the mass deployment of consumer smart phones, the use of touch panels became popular to control enterprise digital assistants (EDAs). Referred to as “touch panels”, “touch screens”, or “digitizers”, these components are all part of the group of sensors that translate the position of an input in a physical reference space to an input in a digital space.

These sensors are often transparent and integrated with a LCD display to create the touch user interface (touch UI) now present everywhere—from automobiles to home thermostats. The types of touch panels present on today's products can be separated into two groups: resistive and capacitive.

Resistive Touch Panels

Resistive touch sensing technology has been established for a relatively long time. This type of touch panel is commonly used for its simplicity of construction, durability, and environmental flexibility. As the name would suggest, a resistive touch panel senses position by converting physical compression of the touch panel to changes in resistivity.

DESIGN AND FUNCTIONALITY

A resistive touch panel is constructed from two films, which are separated by an air gap. Both films have electrically conductive surfaces that face each other. Each of the conductive surfaces detects position in one orientation; for example, the top film may detect vertical position and the bottom film may detect horizontal position.

When an input force is applied to the touch panel, the top film collapses inward beyond the air gap to make a physical contact with the bottom conductive surface. The resulting electrical connection changes the resistance value across both the upper and lower conductive surfaces. A microcontroller within the device measures this new resistance value as a change in voltage, which corresponds to a new vertical and horizontal position. The measurement of the upper and lower conductive surfaces occurs many times a second to track input, such as a stylus, as it is moved across the touch panel.

RESISTIVE TOUCH PANEL LIMITATIONS

Micro-Cracking and Mechanical Wear

Since a resistive touch panel relies on physical movement of the top film to create an electrical connection, this type of touch panel is susceptible to mechanical wear. This mechanical wear occurs because every physical movement of the top film causes small micro-cracks in the conductive surface.

Once these micro-cracks grow large enough to disrupt the electrical connection between top and bottom films, the touch panel may develop inoperable regions, or appear to respond in a location that is different than what was activated. Resistive touch panels exhibiting these symptoms have physically worn out.

Micro-Cracking Dependencies

The causes and timeframe of the formation of these cracks depend on many factors, including:

- The force used to compress the films (sometimes called activation force)
- The temperature conditions during compression
- The geometry of the object used to compress the films (stylus, finger, or other object), as described below:

A common root cause of accelerated micro-cracking, is the use of a ball point pen to activate a resistive touch panel.

- The tip of a common ball point pen consists of a steel ball with an approximate diameter of 0.5 mm. This steel ball is both harder and smaller than the tip of a mobile computer stylus, which is made of plastic and has a diameter around 1.6 mm.
- When a small diameter instrument, such as a ball point pen, is used, even typical activation forces (250-450 grams) can result in large stresses in the conductive layer. This high stress leads to the accelerated formation of micro-cracks.
- Additional damage is done as the hard steel ball also leaves scratches in the comparatively softer top film of the touch panel.

RESISTIVE TOUCH PANEL BENEFITS

The benefits that contribute to the continued relevance of resistive touch panels include the following:

- Their ability to sense user input despite changing environmental conditions. The reliance on physical contact with, and subsequent compression of, the top film creates a sensor which is difficult to inadvertently activate. Rain drops, snow, or other precipitation do not produce enough force to compress the top film of the touch panel; therefore, these environmental conditions do not affect operation.

- The dependence on physical contact allows the touch panel to be activated by users wearing any type of gloves that allow for adequate force to be applied to compress the top film.

Capacitive Touch Panels

The force-based activation scheme used by resistive touch panels is robust and allows for environmental flexibility, but does not allow for multiple touch inputs. The (projective) capacitive touch panel was developed to enable multi-touch inputs and as a result creates a more intuitive user interface. Gesture-based inputs, such as pinch-to-zoom, reduce the number of steps needed to perform device interactions and simplify the user interface. This simplification for the end user comes at the cost of increased complexity, both at the touch panel hardware and control software levels.

DESIGN AND FUNCTIONALITY

A capacitive touch panel is a non-contact sensor that uses changes in capacitance to measure input position. The touch panel consists of two main subcomponents: the sensor and the cover glass. Structurally, the sensor may be constructed on glass or flexible polymer films; for illustrative purposes this document only describes touch panels that use film sensors.

Like a resistive touch sensor, the capacitive sensor consists of two films. Each film senses input in a single orientation; either along the horizontal or vertical axis. For a single orientation, the conductive surface of the film is etched to create a grid pattern of conductive cells. Each cell projects an electrostatic field above the surface of the sensor. As a conductive object, such as a human finger, is brought into the projected electrostatic field, some charge is capacitively coupled to the object. A microcontroller then measures the new capacitance as a change in voltage, which is then converted to a position on the touch panel, and ultimately the display.

Microcontroller Integrated Circuit and Firmware

Since this technique measures each conductive cell independently, many times a second, all capacitive touch panels require a specialized microcontroller IC. The firmware run by this IC can control many details of the touch panel function. This includes the distance away from the sensor that a conductive object will be registered as a touch (sensitivity), the size of the object that will register as a touch (resolution), and the frequency that the position will be updated. Uniquely tuned firmware and ICs interact with the mobile device OS in different ways; therefore, changes to these items commonly necessitate OS driver updates.

CAPACITIVE TOUCH PANEL LIMITATIONS

The most difficult failure mode to prevent on capacitive touch panels is damage due to point impacts. Point impacts occur in a variety of ways, but most often when a device is dropped to an uneven surface, such as gravel or asphalt.

When a device is dropped face down, small protrusions on the landing surface contact the touch panel. Since such protrusions have a very small contact area, the local stress on the touch panel can reach levels high enough to crack even chemically strengthened glass. These types of failures can be mitigated through device design, but remain a primary contributor to overall capacitive touch panel damage.

CAPACITIVE TOUCH PANEL BENEFITS

Performance Optimization

The sensor pattern design, controller IC, and controller firmware all contribute to the overall performance characteristics of touch panels. These factors can be tuned to allow the touch panel to perform in various environments, such as in rain or when the input object is not conductive (a gloved hand). Tuning presents a complex optimization problem whereby performance can be improved, but not always made flawless. Touch panels can be specifically optimized for known customer environments to maximize flexibility.

Within this area of ongoing innovation by touch panel suppliers, new products will leverage the best possible solutions to accommodate their customers' needs.

Mechanical Strength and Resilience

While the sensor itself provides the functional aspect of a capacitive touch panel, the cover glass offers the structure and mechanical resilience. The cover glass is often twice as thick as the sensor, although in some industrial applications, it is even greater. The sensor and cover glass are typically laminated together using optically clear adhesive (OCA), which gives the sensor uniform mechanical strength.

The strength of cover glass has improved in the last decade with the introduction of "chemically strengthened" glass. This type of glass increases the touch panel's ability to bend without breaking and also resists scratching. Bending strength is an important property when developing a product, which needs to survive drops from various heights.

During drops, the structure of a product deforms, causing the touch panel to bend; touch panels constructed from chemically strengthened glass can withstand larger amounts of bending without developing cracks in the cover glass. Additionally, chemical strengthened glass possesses a greater surface hardness compared to non-strengthened glass; this results in a comparatively higher degree of scratch resistance. Many manufacturers of chemically strengthened glass exist, but Corning Gorilla Glass is currently considered the most resilient.

Conclusion

Manufacturers continue to select the type of touch panel used on new products based on the voice of their customers. The current trends point toward a customer need for intuitive user interfaces and environmental flexibility. These needs have driven the capacitive touch panel (which allows water rejection and gloved operation) to dominate the current product roadmap. Consequently, integration of resistive touch panels has declined, although they continue to serve a niche role for devices that utilize low complexity user interfaces.