WHITE PAPER

UPGRADING USER INTERFACES (UI) ON HOME APPLIANCE PRODUCTS: **TECHNICAL SOLUTIONS AND ENGINEERING CHALLENGES**

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creating connections for life

Advanced user interfaces (UI) signify premium products to buyers of home appliances. Growing demand for computerized displays and touch controls in a highly competitive market has put pressure on home appliance developers to upgrade from conventional controls to digital interfaces and displays. This trend has become more pronounced in recent years, driven by the growing popularity of smart home devices and the internet of things (IoT).

To satisfy these consumer expectations, manufacturers are turning to a handful of digital technologies that provide customers with a sleek contemporary style, easier cleaning, and programmable features. These solutions typically involve components such as touchscreens, sensors and wireless connectivity. While these approaches provide a wealth of new benefits for end users, they also present significant engineering challenges.

When designing an improved user experience on a product, appliance makers often find that programming the firmware and the finer points of interface design lie outside their wheelhouse of expertise.

While many design engineers can envision the capabilities of a digital interface, they may be uncertain about the surface material selection, microcontroller configuration and space requirements for such an integration.

The Evolution of User Interface Solutions

A user interface is the point at which a person interacts with a machine. On the simplest level, a UI consists of a button, switch or dial that changes the product's mode of operation and displays important information.

These simple types of switches and variable controls have been part of home appliances for decades. The industry now views mechanical solutions as problematic particularly in kitchen environments. Buttons and knobs can break off with repeated, everyday use. Gaps between the mechanism and the control panel invite liquids or grease that over time degrade the electrical performance.

Different technologies devoted to UI aim to avoid these problems. These solutions might include components like printed electronics (PE), capacitive switch designs, flexible printed circuits (FPC) and LCD displays with backlighting.

This white paper surveys the current design options for home appliance product engineers who want to upgrade their designs to incorporate more advanced user interfaces. The report will outline some of the common issues in design development and the outlook for new technologies in this space.

Design Options for Appliance UI

Membrane Switches

Membrane switches are one of the first innovative approaches to UI and they are still a solution that holds strong in the world of appliances.

A basic membrane switch has a dome that, when compressed, triggers the contact closure. These switches can vary in their tactility and can also include embedded LEDs.

The membrane provides a smooth, easy-to-clean surface. Membrane panels are printed with graphics which suggest buttons, but since there are no openings around them, the approach avoids the ingress problems of traditional push buttons.

While still common on products today, membrane switches have new competition with the arrival of newer technologies that offer their own unique advantages.

Metal Domes

Another variation of membrane control includes the addition of a metal dome switch.

In this construction, the touchable location has a steel dome underneath that requires force to actuate and provides tactile feedback upon pressing.

Domes are selected based on the amount of actuation force required. The buttons often have a plastic or rubber keypad that overlays the dome and can protrude through a front panel.

This technology was popular in earlier cell phone keypads before the advent of the touchscreen. Straightforward structures that also resist water ingress, metal dome interfaces are still in use on smaller home devices, such as TV remote controls.

Capacitive Touch

The UI method in the forefront of design in premium appliances is called **capacitive touch**.

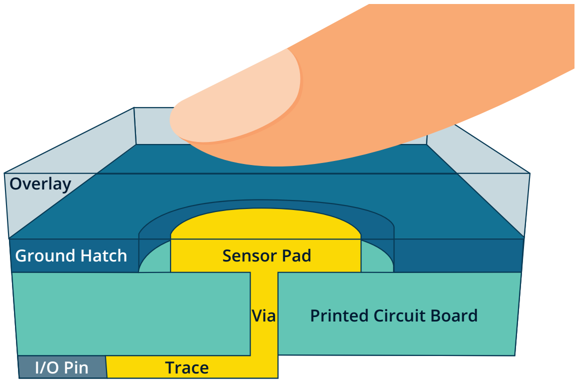
Consumers have become accustomed to the user interface of tablets and smart phones which use a capacitive touch overlay in front of an LCD screen. Capacitive touch surfaces do not need to involve an LCD screen behind them. Often in appliances, the surfaces can simply have backlit icons or graphics. The active area beneath these icons responds to being touched by a fingertip and so operates much like a button or switch.

Capacitive touch is an increasingly popular interface option that can provide an intuitive and interactive experience for users. Like familiar personal touchscreen devices, users can operate devices using this technology by touching and swiping their fingers on the surface of the product, such as directly on the cooktop surface glass.

Consumers are increasingly gravitating toward capacitive touch surfaces, especially on high-end appliances. Capacitive touch surfaces do not have a mechanical moving component that could potentially wear out over time. A capacitive touch user interface does, however, require a number of design trade-offs and robust user testing. These should be considered before upgrading high-end appliances to this method of UI.

A capacitive touch user interface is typically activated through the simple touch of a finger. Rather than relying on pressure to close a membrane or steel dome, the presence of a finger induces a change to the capacitance. That change is detected by a microcontroller that requires firmware. Because of the requirement to write firmware, a capacitive touch user interface typically involves a more intensive design process.

Besides the programming of firmware to perform user commands, designers also need to consider various aspects of ergonomics and aesthetics of a custom UI: the backlighting quality, legibility of readouts and symbols, sensitivity of touch and sound alerts, among others.



UI Challenges

Despite this evolution, many manufacturers may still struggle to implement these solutions effectively. Good UI design requires some background knowledge of practices that have worked well in past products. Some problematic issues in interface technology continually resurface.

This is where product design and development consultants with expertise in UI can provide valuable guidance and support to design teams looking to upgrade user controls. With a deep understanding of the technical and engineering challenges involved, an experienced development partner can help manufacturers to identify the best solutions for their products and ensure successful commercialization.

Differentiating Triggers

Take a popular example of a touch-control surface, the glass-top electric range. Traditional capacitive touch senses the presence of an object but is not able to interpret what caused the capacitance change. This lack of specificity can mean a cat walking across the stovetop could accidentally turn on the elements.

Similarly, for a surface prone to getting splashed by liquid, spills could be the means of change in capacitance, leading to features turning on or off without intention.

Certain design choices in the sensor arrangement and firmware can eliminate the possibility of a capacitive switch triggering unexpectedly.

Surface Materials

Not all surface materials support traditional capacitive touch solutions. Stainless steel, a fashionable kitchen appliance finish, is not compatible with capacitive touch. Manufacturers can approximate the look and feel of stainless steel in a plastic panel, but for those who wish to use true stainless steel — or other unique materials as their touch surfaces — alternative technologies to capacitive touch may be necessary.

Legibility and Backlighting

A set of best practices in flexible hybrid electronics has emerged to optimize the combination of backlit graphics and capacitive touch.

The design of a capacitive touch region on a backlit area of a surface is often achieved with a transparent conductive ink called PEDOT. On a clear polyester substrate, silver and PEDOT inks are used to create printed electronic foils, which sit between the graphic and the LEDs that reside behind the graphic. The PEDOT ink minimally effects the transmission of light from behind the foil up to the graphic, providing crisp backlit images.

Haptic Feedback

Some people love the feeling of the way a tactile button clicks. A touch on a glass does not have the satisfying click that signals a physical contact has been made like in mechanical controls or even to some extent membrane or metal dome buttons, but some efforts have been made to simulate this effect.

This new feature is referred to as **haptic feedback**. For example, a device may vibrate slightly when pressed, giving the user a tactile response. Haptic feedback technology can be incorporated into the circuits of the capacitive user interface.

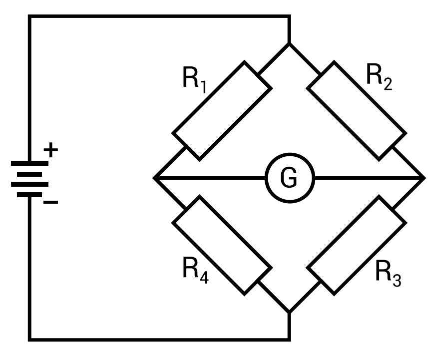
What's Next for UI

Recent innovations in the UI space have looked beyond capacitive touch to address some of the common challenges and limitations. For instance, all three of the following developments are attempts to make touch-sensitive controls work on a true metal surface.

Strain Gauges

Strain gauges are devices that are used to measure changes in strain or deformation of an object. They work by converting the deformation of the object into an electrical signal that can be measured and analyzed. New developments have created sensors so sensitive they can detect a few micrometers of physical deflection.

Strain gauges can be used to create electronic touch interfaces by attaching them to a flexible material such as a thin film. This can be mounted behind a true metal surface. When touched or pressed with some force, it deforms and changes the resistance of the strain gauge, which generates an electrical signal. This signal can be amplified, processed and interpreted by a microcontroller or other electronic circuitry to detect and respond to touch or pressure.

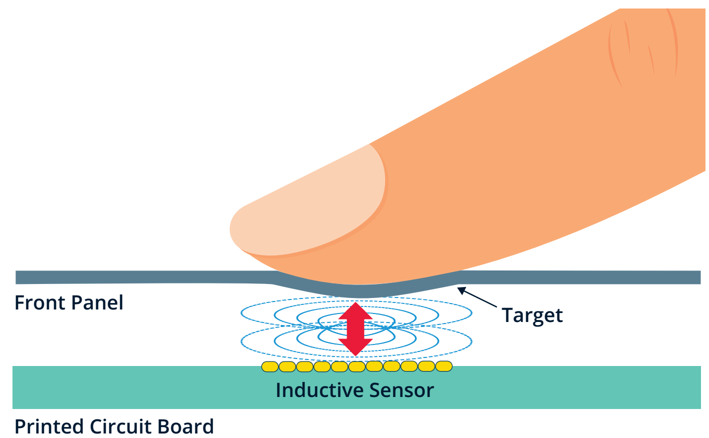


Extremely sensitive strain gauge detectors use a printed-electronics version of the wheatstone bridge arrangement of resistors.

Resistive sensors in the form of a wheatstone bridge can be printed on polyester for compact and economical touch control. This printed electronic can be mounted behind a rigid touch surface that will sense a force.

Inductive Touch

An inductive sensor responds to changes in a magnetic field. Similar to a strain gauge, this type of sensor is placed behind a front panel that deflects the target. This style of sensor brings touch commands to metal surfaces and so would operate on stainless steel appliances. It is also sensitive to pressure changes, making the technique less prone to accidental triggering.



Ultrasonic

Pushing against the bounds of spatial limitation are ultrasonic touch sensors. These sensors don't rely on pressure (like inductive touch) or presence (like capacitive touch).

In ultrasonic control mechanisms, a small chip emits ultrasound frequencies—like those used for prenatal views—that are projected across the entire surface area. When a finger touches the surface, the device can sense that something has interfered with the sound wave propagation and pinpoint the location.

Ultrasonic gives the capability to put touch controls on any type of metal and in addition the ability to separate the electronics a fair distance from the point of contact. Controls could be placed on a very thick slab of steel or aluminum, for instance.

Collaboration with UI Experts

Upgrading home appliance UI to an unfamiliar technology is a complex and challenging process, but one that is essential for manufacturers to remain competitive in an increasingly demanding market.

With a range of design techniques and innovative approaches available, manufacturers have many opportunities to improve their products and provide greater value to their customers. By working alongside a design and development organization fluent in the styles and engineering of advanced UI, appliance manufacturers can ensure a successful product implementation.

Choosing a team with decades of experience will jumpstart the process, eliminate rounds of painful trial and error, and equip your project with best-in-class reliability testing and production techniques.

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