In this era of smart connectivity, even home appliances are getting in on the action. A broadening portfolio of electronics solutions and design strategies exist to help manufacturers innovate sleek and smart appliances. Next-generation capacitive technologies are empowering greater freedom and economical ways to incorporate enhanced features to make appliances more functional and fun for today’s tech-centric consumer homeowners.

**SOLID-STATE CAPACITIVE FLUID-LEVEL SENSING**

Fluid-level sensing is an essential technology in a range of modern appliances. Immersed mechanical systems have traditionally served this role in icemakers, dishwashers, washing machines, water filtration systems, and beverage dispenser tanks. The sensors, floats, and switches used in these systems are immersed in fluid, which can cause excess wear, corrosion, and even cross-contamination. Conventional mechanical fluid-sensing systems are limited to use with standard cylindrical or rectangular tank shapes in order to yield consistent measurements. The constant exposure to fluids tends to decrease mechanical accuracy over time and shorten sensor lifespan.

Appliance manufacturers seeking better design strategies can now use capacitive fluid-level sensors to overcome these challenges. Capacitive sensors ensure precise fluid-level measurements with greater accuracy and lower set-up costs, utilizing customized end-to-end solutions and easy-to-install calibration software. The technology provides greater design flexibility and more durable, efficient appliance operation than traditional mechanical systems. The same basic concept used to make smartphone screens responsive to the touch of a finger, capacitive fluid-level sensors easily mount to the outside of a container and can measure fluid or granular material through almost any non-metallic material. They can be custom designed and optimized for a range of appliance applications from beverage dispensers to dishwashers. Because they are solid-state with no moving parts and do not require immersion in a reservoir tank, capacitive fluid-level sensors deliver longer product life with more accurate measurements.

A traditional printed circuit board can be used for a capacitive fluid-level sensor mounted on a flat surface reservoir, while a thin polyester or polyimide flexible circuit is preferable to accommodate curved tank surfaces or space-constrained applications. The use of flexible circuits gives designers the choice to use unconventional shaped reservoir tanks to optimize available space. A capacitive fluid-level solution typically includes customized embedded software, which can be configured for auto-calibration for easy installation, or manual calibration to maximize the accuracy. A single capacitive fluid-level sensor may be used as a point sensor indicating the presence or absence of fluid at a given level on a tank. Alternatively, two sensors used in tandem at low and high levels can regulate fluid in a reservoir by triggering a refill, then turning flow off when at the desired level.

Output interfaces for capacitive fluid-level sensors may include USB, I2C, or discreet signals, depending on the application. Combined with a microprocessor, a sensor can wirelessly transmit signal data to a control unit. Capacitive fluid-level sensors provide an enabling technology as more appliances and home systems connect to user devices via the Internet of Things (IoT) to streamline maintenance functions, with alerts to replace a filter or add fluids, and enhanced features such as scheduling home tasks—or connecting directly to manufacturers for service FAQs and software updates.

**EYE-CATCHING, EFFICIENT, AND ECONOMICAL CAPACITIVE USER INTERFACES**

You know what they say about first impressions. Appliance shopping is no exception. Quality features and design create that first impression. Not surprisingly, capacitive touch screens are now outpacing mechanical interfaces—with cluttered buttons and switches—and resistive touch controls in home appliance designs. Capacitive technology provides overall higher reliability and more intuitive user interfaces. From a branding standpoint, many manufacturers are switching to capacitive touch screens to give consumers more “bang for the buck” with appealing, eye-catching touch screen designs. Custom capacitive touch screens can incorporate and combine multiple switch formats and layouts, including discrete switches, slide.
switches, rotary wheels, and combinations of tactile and non-tactile products.

Environmental factors are important considerations for design, material selection, and fabrication. While most homes maintain a relatively stable environment, appliances are affected by daily shifts in temperature and humidity, in addition to frequent use—and occasional misuse by consumer homeowners. The choice of PCB, polyimide, or polyester substrate will depend on the application. Each presents unique design challenges, manufacturing costs, and operational limitations in capacitive interfaces.

With capacitive touch-based applications becoming increasingly popular, the use of technologies built around conductive Indium Tin Oxide (ITO), with its inherent weaknesses (brittle, inflexible, and costly to pattern), has led to a search for alternative materials that offer high optical clarity, similar resistivity, and easy processing, but at lower overall application costs. Among the alternatives, conductive polymers are garnering particular attention. An acronym for the chemical name Poly (3, 4-ethylenedioxythiophene), PEDOT is emerging as a promising material offering excellent electrochemical, thermal, and solution processing properties ideal for capacitive switch design. Colorless and water-soluble, this polymer mixture is generally applied as a dispersion of gelled particles suspended in water. The conductive switch is formed by screen printing a layer of the dispersion over the surface of the substrate and subsequently drying out the water by heat. The PEDOT dispersion can be coated on a variety of molded or flexible substrates including PET, PC, PMMA, glass, or other material.

PEDOT mixtures have good adhesion qualities and are known for their high chemical stability, optical transparency, and electrical conductivity. Specially derived formulations have been developed using this compound to meet highly demanding optical applications, including backlit capacitive keys, sliders, and rotary wheel inputs. The technology has been deployed in robust automotive applications, typically behind a plastic bezel. As a conductive ink for backlit capacitive switches, PEDOT allows low-profile, user-friendly interfaces to be made at lower cost. PEDOT circuits are transparent and provide excellent flexibility (they can be easily bent). They do not require soldering (hence lower cost of application) and provide the low profile of a flexible circuit. The versatility of the PEDOT application also enables patterned conductive structures for sophisticated touch panels.

The PEDOT-based capacitive technology offers numerous advantages over traditional mechanical and PCB capacitive switches in home appliances and other consumer applications. A fully-qualified PEDOT-based capacitive solution will deliver measurable cost savings over standard ITO substrates. For backlit capacitive touch keys the possibilities for incorporating user-friendly controls and icons onto PEDOT-based switches are virtually limitless, which adds up to smarter, economical, and more aesthetically appealing designs.

Figure 2: PEDOT sensor with rotary switch and discrete buttons enabling backlit keys on capacitive user interface.

No longer a futuristic vision, smart homes are popping up in every neighborhood. Odds are you already have smart home entertainment media, perhaps a smart thermostat, alarm clock, security or surveillance system, washer and dryer. Leaders in the appliance industry are wisely keeping pace with trends in connectivity by leveraging proven technologies to attract new customers and gain a competitive edge. Manufacturers seeking strategies for integrating capacitive fluid-level sensor or PEDOT-based interface solutions are smart to consult with a trusted supplier early in the design stage to most efficiently utilize engineering and manufacturing resources, and customize design and functional options to distinguish your brand and create loyal customers.