KEY TRENDS IN APPLIANCE DESIGN:
CHALLENGES AND OPPORTUNITIES

molex

creating connections for life

As technology and buyer expectations change, home appliance makers are facing a host of new challenges.

To provide consumers a wider menu of choices for the way they clean clothes, cook, and wash dishes, appliance OEMs are loading machines with sensors and electronics to make the machines smarter. This requires the manufacturers to rethink designs. At the same time, they must comply with new safety regulations (some of which are pending release) and find ways to tighten operational efficiency and use more environmentally preferable processes to keep up with customer demands and regulatory changes.

To meet these demands, manufacturers will need to closely follow evolving regulations and master the use of state-of-the-art technologies and materials to keep pace with competitors. Those who succeed will design a new generation of innovative connected products that capture market share and offer new opportunities for aftermarket servicing.

Adopting New Designs and Materials

The proliferation of electronics and controls has several implications for manufacturers, including a heightened focus on the human-machine interface. For customers who grew up with smartphones and tablets, that means using touchscreens, rather than more dials and buttons.

Fortunately, in addition to pleasing buyers, capacitive touch interfaces offer manufacturers several advantages. For one thing, there are fewer mechanical parts to break down. Touch switches can also be programmed for a wide range of functionality and designed to withstand the harsh conditions of appliance interiors.

By using the right materials, OEMs can also create the distinctive form factors consumers are seeking while saving on production costs.

One of the most promising new materials is poly (3,4-ethylenedioxythiophene), commonly known as PEDOT. A printable organic polymer, it can be deposited onto inexpensive polyester film, providing more efficient use of materials than the current standard of indium tin oxide (ITO). It's also transparent, less brittle and more flexible, allowing OEMs to create keypad backlighting on curved surfaces, such as user-friendly fingertip depressions **(Figure 1)**.
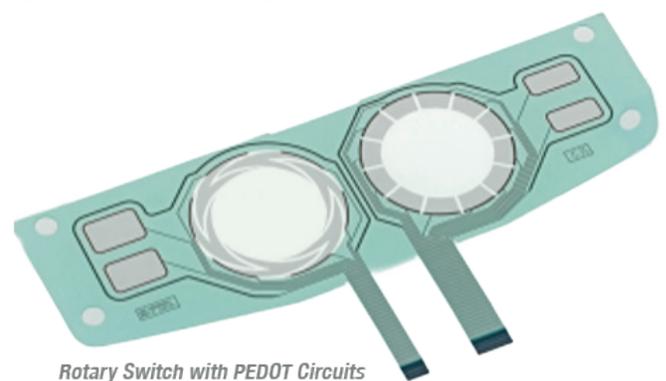

Rotary Switch with PEDOT Circuits

Figure 1: *Molex PEDOT enables the inexpensive production of flexible, transparent sensors, enabling keypad backlighting on curved surfaces.*

The Rise of Electronics and Sensors

Today's consumers, accustomed to managing everything from work and home management tasks to personal fitness through software applications, now expect similar experiences from their appliances. Demand for internet-connected home appliances is rising sharply. Over 40% of U.S. homes owned a smart home device in 2021, and by 2024, the proportion is expected to rise to over 57%, according to Statista.

Manufacturers are responding with a broad portfolio of products to satisfy consumer needs, including refrigerators with multiple devices and sensors to maintain different temperatures across zones, ovens with Wi-Fi-connected cameras to display food as it roasts and browns, washers that sense load sizes and auto-dispense detergent and cooktops that send owners an alert or turn off the burner if they detect a dry boil.

While some new capabilities add convenience, others address homeowners' desire for greater energy savings and efficiency. Along with IoT within home security, lighting, water heaters and HVAC systems, various sensor-enabled appliances are part of a smart home environment in which everything will eventually be connected to function at optimal efficiency. Or, at least, that's the theory. We're not there yet, but as the movement grows, industry leaders and stakeholders are working together to get closer.

Adding features to confined spaces also means manufacturers must reconsider the configuration of the electronics, finding ways to miniaturize printed circuit boards and connectors while still maintaining adequate power delivery and preserving signal integrity for the many new controls. They must also have the capacity to manage large volumes of data flow within the appliance, as well as data flow to and from other smart home devices.

These are considerable challenges calling for expertise in electronics and connector design. Addressing them in the early stages of the IoT rollout will help OEMs get ahead of the game as the smart home movement gains steam.

As connected appliances catch on, there is a growing need for interoperability of software developed by different manufacturers. Over 200 OEMs have joined the Connectivity Standards Alliance, a consortium committed to developing universal, open standards that enable products to securely connect and interact. This is expected to broaden the playing field significantly, resulting in a more rapid adoption of new functionality, higher performance levels and faster time to market.

Another consortium is the Home Connectivity Alliance. Established in 2021, its mission is to provide consumers with more options within a safe, secure and interoperable connected home ecosystem.

The Drive to Maximize Safety

As manufacturers design new products, they will need to closely follow changes as regulators modify home appliance safety standards. A push to strengthen protections began with IEC committees in Europe and has spread to U.S.-based UL Solutions, which partners with stakeholders in more than 100 countries.

Authorities need to review their standards as more connectors are added to heat-producing machines and their material composition changes. The main thrust of the regulating authorities are considering is reducing the possibility of fire—and if a fire does occur, ensuring that it can self-extinguish and not spread outside the machine. It will be several years before new standards are completed and become effective,

but manufacturers are already starting to get ahead of the changes, so they don't have to redesign products after these new regulations are rolled out.

One of the most important measures is glow wire testing requirements for unattended appliances, which exposes electrical connectors to extreme heat that makes them ignite and determines their effectiveness in resisting ignition and self-extinguishing the resulting fire.

Many leading manufacturers are working with electronics experts to ensure that their engineers keep up with new developments and gain a solid understanding of where and how testing should be implemented and which products they need to use to satisfy current and proposed requirements.

Designing Connectors for Safe Assembly and Better Reliability

It's not just consumers who need to be protected from safety hazards. While appliance hardware and electronic components are mass-produced in distant factories, mating connectors to electronics is often a manual process performed by human operators. The proliferation of connections has increased the potential safety risks for these workers, as today's cooking appliances, often have higher-wattage elements, requiring more power and more connections. These higher-density electronics in various types of appliances have higher pin counts, resulting in higher mating forces.

Both situations can increase pressure and physical stress on operators, who may need to manually mate up to 15 connectors on a control board in a minute, for example, making sure each aligns, seats properly and locks into place. Fatigue can set in, resulting in errors and the potential for repetitive stress injuries such as carpal tunnel syndrome.

Poorly-seated connectors are less reliable, adding to service costs if they malfunction during the warranty period. Forty percent of refrigerators and 25% of oven ranges experience some sort of problems within their first five years, according to Consumer Reports.

To lower the chances of problems and to ensure they have a consistent, healthy labor force that adheres to workplace safety regulations, manufacturers must seek processes that improve reliability and enhance ergonomics. For example, using connectors with lead-in push points or blind mating makes it easier for operators to correctly seat wires inside the increasingly tight spaces where they must maneuver. Using connector designs that offer lower mating force contact systems aid in improved overall operator assembly and safety.

Solving the Backout Problem

Engineers are also using a technology called terminal position assurance (TPA) to hold connector contacts securely in place. Conventional crimp/snap connectors often suffer from backout, where wires are not fully seated in the connector housing and become loose under stress.

Backout can occur due to stubbing or mis-mating within the contacts of a connector system. This drives higher insertion forces, potentially unseating contacts when an operator mates the connector. Backouts also occur in high vibration applications, which can disengage contact retention features.

A TPA system provides a secondary contact locking mechanism for contacts, ensuring that they are fully seated and locked in place within the core housing. These designs largely eliminate contact back-out issues, significantly improving connector reliability.

As shown in **(Figure 2)**, the TPA is sometimes implemented as a separate piece of plastic. In these cases, the TPA is inserted into the connector housing after the wires have been terminated. In other instances, the TPA can be molded into the connector housing itself.
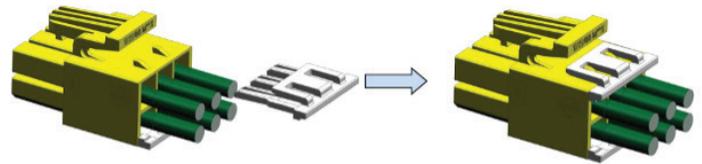

Figure 2: *A TPA system uses locking mechanisms to prevent backouts.*

As a secondary benefit, a TPA system may aid in alignment of contacts for improved connector mating. Often, these systems are ergonomically designed, providing larger push points that operators can easily press into place, reducing fatigue and improving productivity.

Keeping Up with Sustainability Initiatives

The home appliance industry has a longstanding commitment to sustainability and energy efficiency and has achieved some notable successes, documented by the Association of Home Appliance Manufacturers in the following examples:

- Modern refrigerators—even with all their new electronic features—use less energy than a 60-watt incandescent light bulb.
- New clothes washers hold 20 percent more laundry than they did 20 years ago, but are nearly 90% more energy-efficient.
- Today's dishwashers use 44% less water than they did in 2005.

Despite these advances, governments and consumers continue to push for even greater efficiency and impose stricter environmental controls. Halogen lightbulbs are now banned across Europe, and in the U.S., most incandescent and halogen products will be phased out by August 1, 2023. Manufacturers are replacing these bulbs with more energy-efficient alternatives, such as LEDs.

Canada is in the process of overhauling its extensive environmental protection law (CEPA), including introducing new restrictions on the production of certain chemicals. So far the government has reviewed more than 150 flame retardants and restricted or phased out a dozen, with plans to take further action in late 2023. It is also changing labeling requirements for flame retardants.

These are just a few of the changes under consideration as governments worldwide press for environmental improvements and consumers seek to lower their energy costs. While leading manufacturers are committed to staying on top of evolving rules, others need assistance, including finding partners who can help them source the products and components they will need to ensure future compliance.

A New World of Connected Products

Creating safe, reliable, and efficient connected appliances is an extremely complex endeavor, but for those who achieve success, rewards can be substantial. Designing user-friendly machines with the versatile functionality and aesthetically appealing designs consumers want has the potential to increase sales and market share.

And that may be just the beginning. Digitally connected products could change the model for service delivery, adding potential new revenue sources through IoT monitoring, preventive maintenance, remote fixes and Wi-Fi upgrades – as well as data that can be

monetized to support multiple outcomes. Two-thirds of manufacturing executives believe that digital services will be a significant driver of future revenues, a Deloitte survey found.

OEMs who take a proactive approach to design and prepare for rapidly evolving industry standards stand the best chances of achieving success in the connected appliance environment of the future.

Molex – Providing Expert Help from Design to Final Assembly

As built-in electronics in manufactured products grow—accompanied by a maze of regulations affecting their composition and design—it helps to consult with experts from the start.

Molex can provide critical early involvement with your design engineers to ensure that the products you build not only meet standards, but provide the highest possible levels of safety, reliability, and efficiency. Whether you're building a brand-new product or modifying your existing models, Molex can help you incorporate the next-generation of electrical and electronic connectors and user-interface capabilities that your customers are seeking.

To learn more, please visit https://experience.molex.com/embracing-the-opportunities-of-smart-appliances/

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