Switches and Encoders IN THE IOT AGE

Avoid these redesign issues and optimize the technology leap.

by tim sweet

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The man/machine interface evolution continues to morph and adapt to the technology around it and the expectations of the user. The humble but ubiquitous switch continues to rise to the challenges that appliances and devices face in an ever increasingly connected world. What are the trends and how can the changes be used to provide advantages in cost, performance and reliability? The following are observations and conclusions that provide insight to strategies and tactics for improved designs and more profitable and reliable products.

Technology innovations continue their ever expanding spiral at exponential rates. Improvements in materials, processes, intellectual property, componentry, etc., move at a dizzying pace. No more so than the electronics that have crept into almost everything we use. There are breakthroughs in technology on how to cool a space, but the basic mechanical motions of a blender or dryer have not changed appreciably in a century. The technology revolution and Moore's law are not at play. But the controls and interface technologies on these machines, if approached correctly can certainly benefit in performance, quality and cost improvement when the advances of the electronics industry are employed.

What has driven this electronic evolution into almost everything we use is the relentless pursuit of ever more powerful and less costly microprocessors (MCU). What exists on a watch today (Apple Watch not included) has as much power as the computing power that took man to the moon. Where that will be in five years or

ten years from now is almost unimaginable. Converging with that is the communications capabilities of the latest technologies that provide connectivity at a cost that can justify remote control features through a smartphone or any internet connection. What drives that technology revolution is the same microprocessor technologies that are employed in the appliance controls. In fact, the shift to embedded microprocessor controls within a device can provide wireless communication technology with little or no extra cost. It is already embedded in the chip.

This is not just a point of arrival. This is a path or journey. The cost and technology today, yes it will be obsolete in less than 18 months, will be replaced by something faster, cheaper, more reliable, more powerful… The conversion to the MCU controlled device may be a one-time development cost but once the base technology has shifted from an analogue based technology (switching power) to a digital based system with an MCU and power transistors and/or triacs, the new path reaps the rewards of the technology evolution that is driven by a host of industries that rely on that technology innovation. It is like riding the Gulf Stream or Pacific Current: enjoy the ride and reap the benefits.

Making that transition has its do's and don'ts. The device control remains a marriage between the operator controls and the functional controller: the man/machine interface, HMI, and the MCU. The more sophisticated the device and controls, the more attention to a simple HMI control is required. A good example of an over complex control system was the first generation of hybrid vehicles that put the controls of almost every device in the vehicle through the touch display but adjusting the heater fan speed up or down required paging through three or four pages on the screen. Distractions like these while driving 60 miles an hour on a busy freeway was not only annoying, it was dangerous. The next generation of product had dual controls: the display and a rotary switch. The human machine interface was and still is a very important factor in the design of any machine.

Hopefully none of the appliance migrations from the analogue to the digital control will put lives at risk but fingers, eyes, etc. are all injury targets when an appliance re-design was not intuitive, reliable, simple and accessible. The following are some re-design issues to avoid and some strategies to optimize the technology leap.

Mis-Matched Switching Technologies:

The interface design of the old product, its layout, graphics, sound and touch may be optimized for the product and features, but the underlying technology of analogue switches are not compatible with digital signals. Power contacts rely on current flow to keep the contacts clean which gives the switch its full potential life. Just like over current situations, under current usage degrades the life of the switch. Without the required power being transmitted by the switch, the contacts will oxidize and the low voltages used in a digital control system will result in a switch failure; the switch will fail to close. Perhaps even more annoying, it may become intermittent.

Incorporating switches designed for digital technology, a change of state switch inherently is more reliable because it has fewer moving parts and the contact surfaces are not exposed to high voltages or currents. Technologies such as tact switches, snap domes and carbon pills have typical actuations in the millions. Encoders using resistive film and wiper blades have life cycles four or five times longer than equivalent rotary switches with power contacts. Linear switches such as trigger switches that use similar digital technologies outperform their analogue counterparts. Newer technologies that are designed for the digital world including capacitive touch, hall effect and optical sensor devices have near infinite life. Choosing the right technology to create a new and more powerful user interface is the key step in the transition from analogue to digital.

Features versus Controls:

Many product redesigns will take advantage of the new features available with a microprocessor, but the HMI must remain simple and intuitive. With more features and choices, the tendency is to add more buttons, switches, displays and/or indicator LEDs. Not only does this take up more real estate but it also becomes more confusing to the operator. Cramming all of this onto the existing appliance front panel will not only confuse but often make the actuation of switches near impossible without activating an adjacent switch or control.

Matching new or different switch technologies to take advantage of the more powerful, feature rich microprocessor is a critical step in creating more powerful and more user-friendly appliance applications. To avoid the confusion of more inputs using more switches replace these switches with a rotary or linear encoder. Combined with feedback mechanisms such as detents, indicators, or displays, the user interface becomes more informative and intuitive. The user experiences of the digital world have embraced the thumb wheel of the iPOD to the touch scroll displays of the Android adding thousands of choices at the fingertips. Most appliance applications do not require the sophistication of these types of solutions but utilizing simpler rotary or linear encoders to take advantage of multiple settings in a very limited space takes advantage of the microprocessor's power without sacrificing space, cost or the great HMI experience the product has relied on for customer satisfaction.

Maintaining Sensory Feedback:

Converting to new switch technologies can sometimes miss the important sensory feedback techniques used in conventional switches. Customers that have used products for many years rely on sensory feedback including audible, visual and tactile cues. Without these, the operator may become confused when double or triple actuations are made without sensory feedback creating undesired or even dangerous conditions.

Attention to the haptics and other sensory feedback is an absolute must. Analogue switches have a built-in snap action. Many digital technologies lack this snap or their snap ratios are too low to be perceived in the applications. Enhancements in the switch design can be employed to replicate the desired feel. Visual aids such as the positional indicator of the rocker or paddle of the conventional switch can and should be replicated when visual cues are required for safety or other performance characteristics. Other visual, audio or Haptic cues can easily be added into the base digital switch technology without adding significant cost or space. Detents, torque adjustments, linear force curves etc. in rotary and trigger encoders, can easily replicate the feel of existing analogue switches. The use of snap domes and tack switches enhanced with paddles or rocker actuators can magnify the snap action providing the feel or Haptics of the older analogue switch. Caution must be taken to not over complicate the technology. Using a digital rotary switch versus a rotary encoder can carry extra cost and a more complex solution without any net benefit. Upgrading to a touch display requires the development of a new GUI (Graphical

User Interface) that may take months to perfect the user experience versus retaining a toggle switch type interface that has been converted to low power contacts.

Human vs. Machine Speed:

Failing to account or compensate for the speed at which a microprocessor operates can provide undesired conditions. Switch bounce, vibration, static electricity and other 'noise' conditions in the control circuit can be misinterpreted by the microprocessor. Analogue devices either operated at a speed that this did not matter or the force created to close the contacts completely eliminated any false opens.

Optimizing the new switch technology with the speed of the microprocessor can eliminate some inherent causes of failure but also add to the user experience. Desensitizing the system feedback to account for switch bounce or ambient noise can also provide extra protection against intermittent loss of main power, power surges, and other external interruptions. Simple programming techniques and routines can cancel out unwanted 'false' signals but also detect worn components, motors, etc., and provide early warning of unsafe conditions. (Precision vs cost, encoder vs rotary switch)

The leap from the analogue world to the digital world does not need to be complicated and the user interface can remain near identical. But once on the new digital platform, literally the world is at your doorstep. Adding smart features that connect the appliance to the Internet, the IOT, becomes one more new selling point that creates a new user experience. Part of that transition does require careful attention to the switch technologies applied. Often, switch manufacturers provide digital versions of a switch in the same form factor. Working with an experienced switch manufacturer that understands the technologies, the human factors: visual, auditory and Haptics, and has the experience of working with customers through the digital transition including 'Smart' and IOT applications is essential. ■

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