

Advantages of Surface Capacitive Technology for Exercise Applications

Introduction

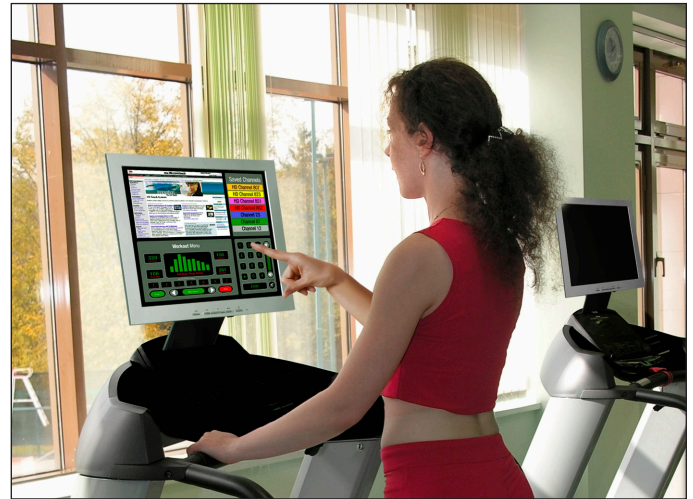
It is broadly accepted that regular physical activity can reduce the risk of chronic diseases such as obesity, heart disease, stroke, and high cholesterol. Unfortunately, social trends indicate a decrease in physical activity at work, at home and getting from one to the other. Even leisure-time activity, which is holding steady or just slightly increasing, can't overcome the overall decrease in society's physical activity.

To compensate for reduced physical activity in our daily lives, an increasing number of people are using exercise to offset this decline, which has created a growing demand for home gym and commercial gym exercise equipment. Most of these machines require a user interface to make selections, such as stationary bikes, treadmills, elliptical cross trainers, and stair climbers. Traditionally, these machines have used membrane switch interfaces with simplified LED displays that provided time, distance, heart rate information, and an exercise profile. In commercial applications these machines have evolved to include LCD TV's for user entertainment, yet many have maintained their membrane switch technology as the user interface of choice.

Typical interfaces that use membrane switches can include a user profile selection area, level and incline adjustments, a numerical pad for entering user information, an LED screen for displaying exercise session information, and a separate or integrated TV controller. When the LCD TV and user interface modules are separate devices, mounting, cabling, and enclosures for up to three separate modules is required, which can increase manufacturing costs and affect equipment aesthetics and reliability.

The concerns of product cost and improved industrial design have led many companies to explore touch enabling the LCD screen and using a software-driven graphical user interface (GUI) in order to combine the multiple modules into one, easy-to-use, cost effective and aesthetically-pleasing design. This transition provides equipment manufacturers with increased design flexibility since buttons no longer have a single-purpose limitation and the usability of these machines can be greatly improved with an intuitive user interface that enhances the user experience.

The commercial gym, where most high-end exercise machines are found, is a public-access environment where users of varying experience levels use the equipment's interface and upkeep of these devices will vary from facility to facility. Due to today's health concerns and typical exercise sessions of 15 to 60 minutes, these machines are normally cleaned two to three times every hour, mostly by users before or after use, to avoid the potential of transferring germs and viruses. In addition, vibrations from heavy exercise use can rattle the LCD display and any attached user interface module. The optimal touch interface



solution must be able to withstand all of the above conditions without affecting the functionality of the user interface.

This application brief explains the critical needs of exercise equipment with touch-enabled user interfaces and how the application needs are met in a unique way by 3M Surface Capacitive touch technology.

Critical Application Needs

In the exercise equipment market there are several high-level needs that equipment manufacturers need to address when designing a new user interface for their exercise machines. They are:

- Product Robustness
- Ease of Cleaning
- Optical Clarity
- Interface Accuracy
- Warranty

By addressing these end-customer needs for a robust system design, manufacturers can help ensure optimal system performance for the life of the exercise equipment.

Product Robustness

The most important application need is product robustness, which includes durability, reliability, and seal-ability. Being in a public environment, exercise machines are used repeatedly throughout the day, which results in numerous cleaning cycles, constant control interface use, contaminants from user perspiration, spilled water or sticky sports drinks, and constant mechanical vibrations. With most gyms operat-

ing 7 days a week and some gyms even operating 24/7, the ongoing use of the equipment can affect the reliability of the user interface. The most common user interface in this market relies on membrane switches for user input. The ASTM (American Society for Testing and Materials) defines membrane switches as "momentary switch devices where at least one electrical contact is part of, or made of, a flexible substrate." A membrane switch consists of multiple layers of plastic films which are held together with adhesive layers [FIGURE 1]. These films have conductive inks printed on opposing sides to perform the switching functions while the top surface is printed with a graphical design for displaying button functionality and improved aesthetics.

These membrane switches are available in two configurations, as a flat button or dome button [FIGURE 2]. Flat buttons allow the user to create a touch event without noticeable surface movement or "tactical feedback" during the pressing action. In a dome button design, touch pressure will cause the button to alter the concavity of the dome creating a noticeable snap or pop sound and give the user a tactile feedback. Flat membrane buttons are typically the preferred implementation due to their longer life expectancy. Membrane switches have a life expectancy of as little as one million cycles under normal conditions. With high-use buttons such as channel up/down and volume up/down, and the constant cleaning environment, this limited number of activations can be a concern to manufacturers, especially for equipment with 5- to 10-year warranties.

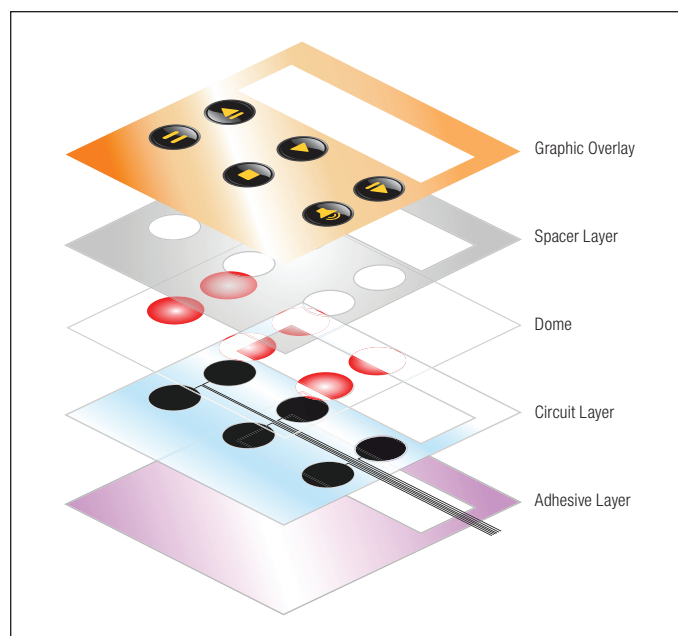


Figure 1. Example of membrane switch stack up

An alternative to membrane switches is a resistive touchscreen. This type of touch technology operates on the same principal as membrane switches as defined by the ASTM. The top layer of the resistive touchscreen is a PET/polyester material with a conductive coating on the underside that when pressed makes contact with the conductively-coated base layer. The two layers are separated by spacer dots which keeps the two layers from shorting [FIGURE 3]. And, like membrane switches, the mechanical movement of the top layer may degrade touch performance and optical clarity over the life of the machine. The key difference between membrane switches and resistive touch screens is that resistive touch screens are typically transparent, while membrane switches are mostly opaque with silk-screened graphics.

Ease of Cleaning

Another need is the repeated cleaning that takes place on this type of equipment. Since most users perspire during a workout, they will usually thoroughly clean the control interface after each use. In addition, some users prefer to clean the equipment before and after each use. This means that each machine could be cleaned up to eight times (four 15-minute sessions) per hour depending on user habits and length of exercise session. Control interfaces comprised of plastic overlays can begin to wear under these conditions, which can lead to a breakdown of the water-tight seal. If water, cleaning agents, or perspiration enters the membrane switch assembly, delamination of the membrane lay-

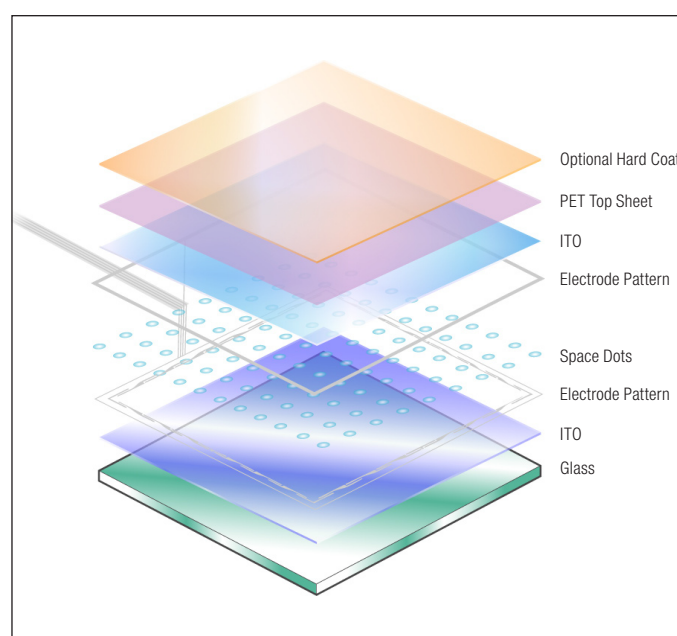


Figure 3. Example of 5-wire resistive touchscreen stack up

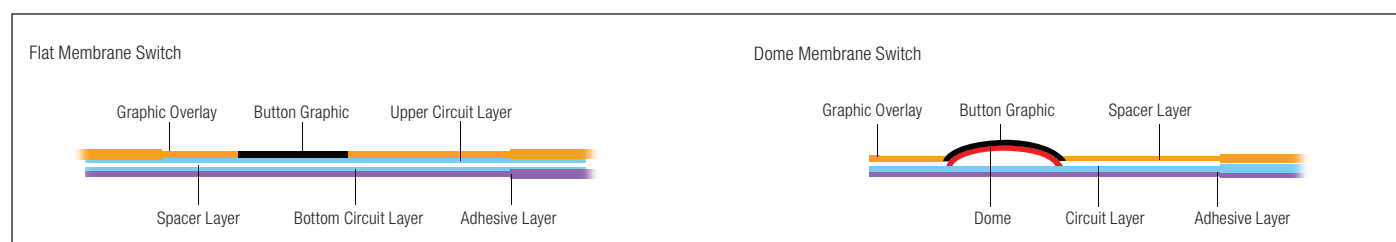


Figure 2. Flat membrane and dome membrane switch cross sections.

ers may cause bubbling or rippling of the top graphics layer and may degrade performance. This undesired effect can be a likely result in the unattended conditions of this public-access environment and due to the limited training of gym personnel, which rarely is extended to exercise customers.

Optical Clarity

With high-definition LCD's now being embedded in exercise equipment control panels, the touch overlay should not degrade the LCD's visual quality and should provide maximum optical clarity, especially after numerous cleaning cycles. The polyester surface of a resistive touchscreen typically allows for 80% light transmission. However, due to on-going harsh cleaning habits of users the polyester surface can begin to show wear and reduced optical clarity due to micro-scratches collecting on the surface. This can result in a hazy appearance to the viewer due to refracting light when the light emitted by the underlying LCD display hits the transition points of each scratch. This refraction created by the surface scratches also reduces the light transmission exiting this system. The result is that the actual light transmission can diminish over time and with heavy use.

In addition to minimizing surface scratches, equipment manufacturers need control interfaces with anti-glare properties. Anti-glare surfaces are created with a surface treatment or chemical etching that is applied to a surface to reduce the glare from overhead lighting or sunlight from outside-facing windows typically found in commercial gyms. Without an anti-glare finish, the surface appears very shiny and reflective, increasing the glare and making the display difficult to read. Also, non anti-glare surfaces are more susceptible to finger prints. In this type of environment, an anti-glare finish is recommended to ensure optimal display viewing in indoor lighting conditions.

Interface Accuracy

The next point of concern is the potential for user interface inaccuracy. At initial set up membrane switches are usually very accurate since the selection buttons tightly align with the underlying switch. However, if the buttons get damaged, for the reasons discussed above, the functionality of these buttons can be reduced in two ways. In the less severe case sensitivity is reduced so more pressure is required for activation, but in the more severe case the button functionality is lost all together and a complete replacement interface would be needed.

Warranty

A final need is a warranty period that aligns or exceeds the term of the exercise equipment. Commercial exercise machines represent a significant investment and most gyms will look for machines to provide a 5-year warranty. Some suppliers even offer up to a 10-year warranty. In order to be able to offer a warranty in the 5-10 year range, it is important to address the above mentioned critical needs as well as ensure only high quality parts are used in these commercial systems. If the equipment's control interface device is damaged, the required maintenance and refurbishing expense, and the brand image effects can be very costly.

The 3M Solution

3M Surface Capacitive touch technology (products: 3M™ MicroTouch™ System SCT3250EX and 3M™ MicroTouch™ System SCT3250CX) is an ideal solution for exercise equipment interface applications due to significantly improved performance and lower cost of ownership versus membrane switches and resistive touch screens.

The SCT3250 touch sensor is an all-glass surface capacitive solution with 3M patented coatings that offer enhanced optical performance, embedded anti-glare properties, and scratch resistance. The all-glass construction, combined with the 3M™ ClearTek™ hard coat and scratch-resistant top coat (FIGURE 4), addresses the first key need of the exercise equipment market – product robustness. Surface capacitive technology is inherently reliable due to its one layer, all-glass construction with no mechanical moving parts (FIGURE 5). Touch activation is achieved by a finger making contact with the top glass surface which couples with the conductive coating beneath the protective coatings. This causes a change in capacitance that is accurately measured by the connected electronics which then reports touch coordinates to the application. Since there is no movement within the glass touch sensor there are no layers to fatigue and breakdown over time.

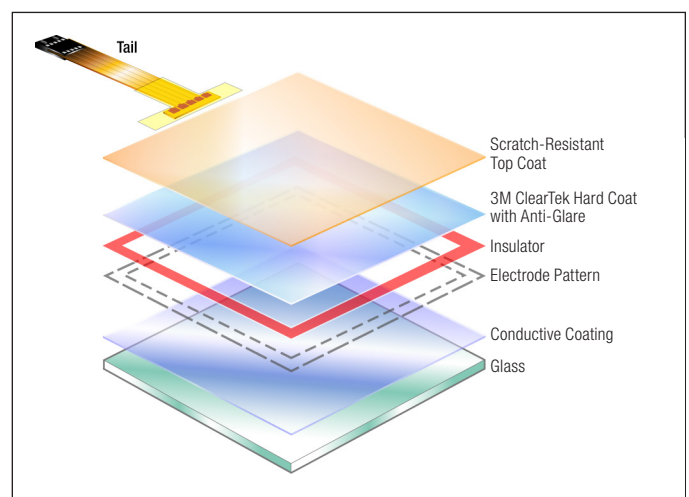


Figure 4. 3M Surface Capacitive Stack Up

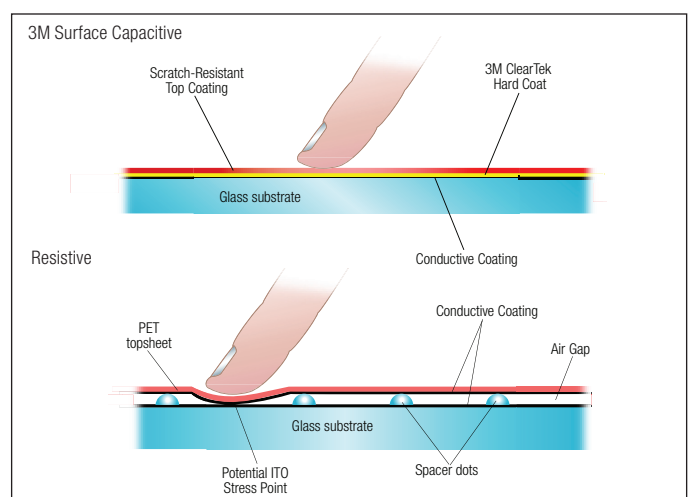


Figure 5. Unlike resistive touch technology, 3M surface capacitive with no moving parts increases long-term reliability and durability.

In addition to no mechanical moving components, the 3M™ ClearTek™ Protective Hard Coat requires a MoHS 7 or harder material to induce a functional scratch on the surface. For comparison, a finger nail or a house key have a MoHS rating of 2.5 and 3.5 respectively. As further clarification, since the MoHS scale is not a linear scale a MoHS 3 material has an absolute hardness value of 9, while a MoHS 7 material has an absolute hardness value of 100. This means that the SCT3250 sensor can withstand scratches from materials up to 10 times the hardness of the two most common materials (finger nail or key) that could scratch the screen in typical operation.

For comparison, most plastics are measured with a "pencil hardness test" and can only pass a 3H pencil rating. The SCT3250 sensor has been tested to exceed the 9H pencil without inducing a scratch, which is the hardest pencil rating in this test. For reference, a 3H pencil hardness has been estimated to measure between a MoHS 2 and 3 value.

Another key characteristic of surface capacitive technology is its ability to operate with a water-tight seal. Since the sensor has no moving parts and is an all-glass solution, closed-cell foams or even rubber seals may be compressed against the sensor to create a water-tight seal around the LCD perimeter to protect any underlying electronics. With this seal in place and the protection provided by the multiple 3M coatings, the SCT3250 sensor offers contaminant resistance to perspiration, cleaning agents, and spilled water and sports drinks, making it an ideal implementation for this environment.

In addition to product robustness, the SCT3250 sensor also offers significantly higher clarity and light transmission, as compared to the resistive touchscreen. The SCT3250 sensor's all-glass solution and optical coatings provide 91.5% light transmission and an anti-glare coating that has been engineered to meet the needs of indoor lighting conditions. This allows for bright and crisp LCD images and colors to shine through the sensor, which preserves the image quality and provides an enhanced user experience. For comparison, the membrane switch overlay material and resistive touch screen solutions typically offer 80% light transmission.

The key to the SCT3250 sensor's superior touch performance is being paired with 3M electronics. 3M offers two electronics options to meet the specific needs of each application.

The sophisticated EX controller, the industry standard for surface capacitive electronics and the electronics component of the 3M MicroTouch System SCT3250EX [FIGURE 6], offers 5.4 millisecond response time and greater than 99% accuracy. As an alternative, the cost-effective CX controller, part of the 3M MicroTouch System SCT3250CX [FIGURE 7], offers a 54% smaller form factor, greater than 98.5% accuracy and 22 millisecond response time. Both controllers can be paired with the same touchscreen design and use the same USB protocol. This gives manufacturers a design choice, especially if they offer multiple tier solutions and need a cost effective solution with the same superior all-glass sensor design to maintain a high level of quality.

With superior sensing technology and a complete system solution, 3M is able to offer a 5-year warranty with unlimited touches over this period. This allows for even high-use buttons in 24/7 gyms to be activated continuously for 5 years without performance or optical

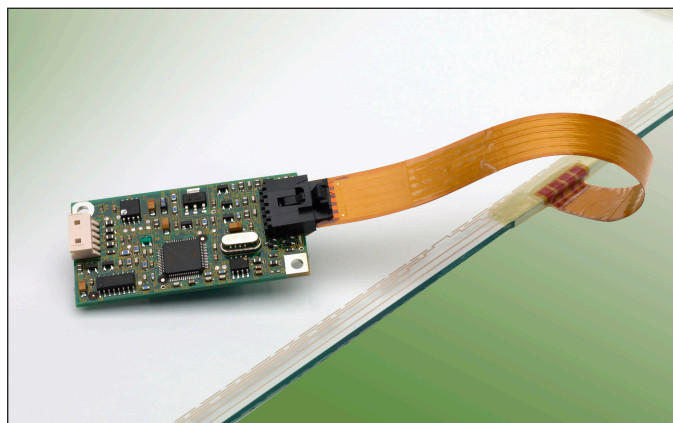


Figure 6. 3M MicroTouch System SCT3250EX Product

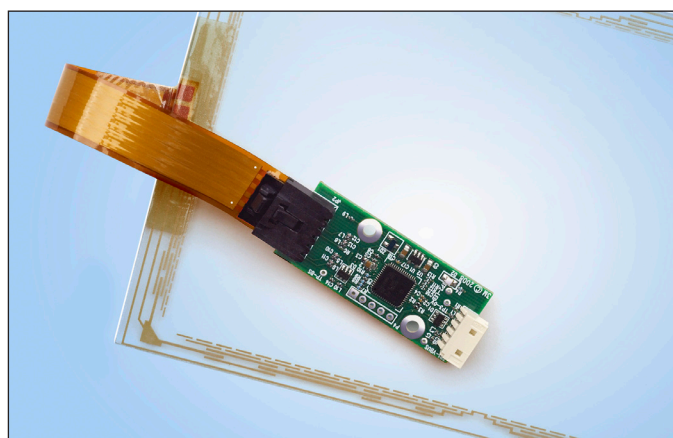


Figure 7. 3M MicroTouch System SCT3250CX Product

degradation. This level of reliability reassures manufacturers that using this 3M solution in their application will help maintain the robustness of their overall product offering, even for lower tier models.

The final key benefit that this optically-clear, all-glass solution offers manufacturers is a complete system design that will enhance the user interface experience and the aesthetics of the exercise equipment. By replacing membrane switches with a touchscreen the user interface can be implemented over the LCD [FIGURE 8]. This reduces the number of modules, currently as many as three, down to only one which saves on product costs while delivering a sleek industrial design element. The new aesthetic design will also benefit from the software-based graphical user interface (GUI) that can dynamically change in accordance with the user's needs. The GUI can be customized for the start-up sequence, in-use monitoring, TV mode, post-workout report, and many other options. This simplified product design gives manufacturers unlimited flexibility in developing user interfaces that enhances and improves usability, while also allowing for field updates and easy implementation of feature enhancements.

3M also offers the 3M™ MicroTouch™ Software MT7 product which is a touchscreen driver package and a touch gesture interface to help ensure optimal system performance and provide content developers increased design flexibility. With less time spent on programming the touch driver interface, the content developer can focus exclusively on the GUI software which can help reduce design cycle time and allows for advanced interface solutions.



Figure 8. Example of three separate devices merging into one.

Conclusion

The SCT3250EX and SCT3250CX systems meet the critical application needs of the exercise equipment environment while offering additional benefits to the manufacturer. The table below is a summary of the critical needs and benefits of the SCT3250 systems:

Application Need	SCT3250 Benefit
Product Robustness	
Durability	MoHS 7 or higher needed to induce a functional scratch Patented hard coat and scratch resistance top coat
Reliability	All glass solution with no mechanical moving parts Unlimited touches with a 5-year warranty
Seal-ability	NEMA 4 or IP66 for improved resistance to spilled water, perspiration, sports drinks, and cleaning agents
Optical Clarity	
Transmission	91.5% allows for enhanced display performance
Anti-Glare	Patented anti-glare coating for reduced light reflection

Application Need	SCT3250 Benefit
Touch Accuracy	
	EX electronics offers >99% accuracy for small button applications and industry-leading 5.4 ms touch response. CX electronics offers >98.5% accuracy in a small form factor for tight integrations and 22 ms touch response
Software Support	
	Full driver support for all touch requirements for optimal system performance Full gestures support package for design flexibility and enhanced user interface options
Single Module Design	
	Integrated touch display allow for a reduction of two modules which helps to reduce system cost Single module all-glass design offers improve design aesthetics and increase reliability Integrated touch display allows for software-based field updates and feature enhancements

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