Tactile Force Measurement Testing

As a little boy watching *Star Trek: The Next Generation* with my dad, I dreamt that one day I'd have a PADD (a tablet for those who've never watched *Star Trek*) and my entire desk would be a giant touchscreen display. Now, with touchscreen tablets having become mainstream devices and larger, more expansive, touch panels being produced, we are beginning to see them not only in consumer devices but also in high performance applications, such as aircraft avionics and industrial control systems. These commercial markets demand 100% accuracy, reliability and consistent sensitivity.

With this increased performance demand, understanding the limits of human physiology is important for design and testing. Pointing strength is a critical metric for test design. A paper published by IBM on Finger Force Precision gave a maximum comfortable steady pointing force of 225 grams and a minimum steady point force of as little as 2 grams (Selker & Rutledge, 1991). Similarly, MIT's study, Touchlab, noted that the average width of a human finger is 1.6 to 2 cm (Dandekar, Raju, & Srinivasan, 2003). This shows that the range of finger force, which people use to interface with touchscreens, is relatively large, making testing over a wide range of parameters critical to ensure accuracy and precision in high performance applications.

ENDURANCE TESTING

With this information in hand, a multitude of tests can be performed. The simplest type is endurance testing: how much repetitive contact can the touch panel take before failure? These tests apply repetitive and random amounts of force, from the possible range, to determine operational life. Tests of this nature are already applied to mechanical switches and buttons since 100% functionality is an expectation of switches and buttons. With touch panels replacing physical buttons and switches with digital ones, the expectation of 100% functionality remains.

ACCURACY TESTING

Accuracy in input registration is critical in touchscreen testing. Touch panels have an accuracy down to which they can differentiate one contact location from another. Often this accuracy is given in Dots Per Inch (DPI). Higher DPI displays allow for a wider range of inputs over a given area. Additionally, DPI is a factor in UI design, determining how large or small onscreen controls can be made and how far to space them apart to prevent incorrect selection.

Figure 1: Dots per inch (DPI)

The goal of accuracy testing for your application can vary depending on your needs. For validation of accuracy over the entire touch panel or selected sections, repetitive inputs can be made at the desired

DPI accuracy. Ensuring that input mapping is correct over the entire product is crucial for delivery of panels with the promised specifications. For panels with documented accuracy, verification of UI behavior can be performed by automating repetitive testing near the borders of UI elements. If a neighboring element is triggered instead of the intended one, UI element spacing can be adjusted to compensate.

SENSITIVITY TESTING

Sensitivity in touch panels is based on the force required to register an input. The key indicator for touch panel sensitivity, how you test for sensitivity and what you measure for varies depending on panel type.

Resistive touch panels have a physical key performance indicator for sensitivity, which is the contact pressure needed to compress the panel layers and register an input. Often this is broken down into contact area and contact force. The reason is physiological: the human fingertip is soft and deforms easily, spreading contact force over a larger area, peaking in the center and decreasing outwards. This requires a relatively larger amount of force to achieve the correct pressure to register an input. A stylus however does not deform, which allows for the fine tip to exert a smaller force over a smaller area to achieve the same pressure.

Validation of sensitivity for resistive panels requires that activation pressure is consistent across the entire panel over a wide range of contact areas. This ensures that regardless of input device (stylus, finger, etc.), the panel behaves according to spec.

Capacitive panels do not require any force to activate. Since they measure the change in capacitance generated by a finger or capacitive stylus touching the panel, they are dependent on contact area. Validation of sensitivity in capacitive panels requires verifying the minimum contact area needed to register an input across the touch panel.

These two examples of how you test for sensitivity will vary over the multitude of available touch panel types.

TEST SYSTEM REQUIREMENTS AND EXAMPLE

The following are key performance indicators to aid in the design of your test and validation system.

First and foremost, the key to all of this is an accurate, precise, and durable force sensor. When choosing a sensor, whether a force sensor or a load cell, it must be able to handle the force applied in tension or compression (which changes depending on sensor mounting) in the same way.

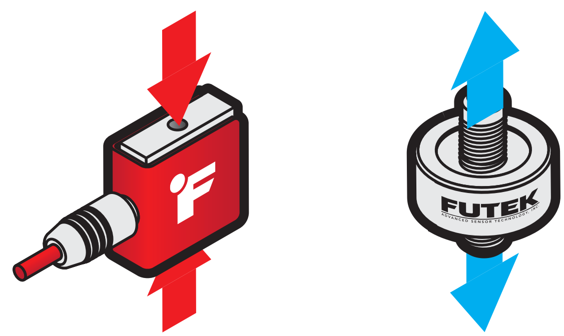

Figure 2: Compression (left), and tension (right).

Next, considering that the range of force exerted via human contact onto a touch panel starts below 200 grams, testing requires load cells with very low hysteresis, non-repeatability, and non-linearity. These sensors also have to be compact enough to fit either on the testing apparatus, to measure contact force by threading itself directly between the testing apparatus and the finger simulant/stylus or below the touch panel between the panel and the panel mount.

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acquisition system must not be overlooked. Your DAQ must be capable of high resolution to capture the fine range of human interaction. If you are strictly performing endurance testing, then use a data logger. However, for accuracy and sensitivity validation, you will need feedback from your force sensors for closed loop control, which requires a PLC or logic controllers.

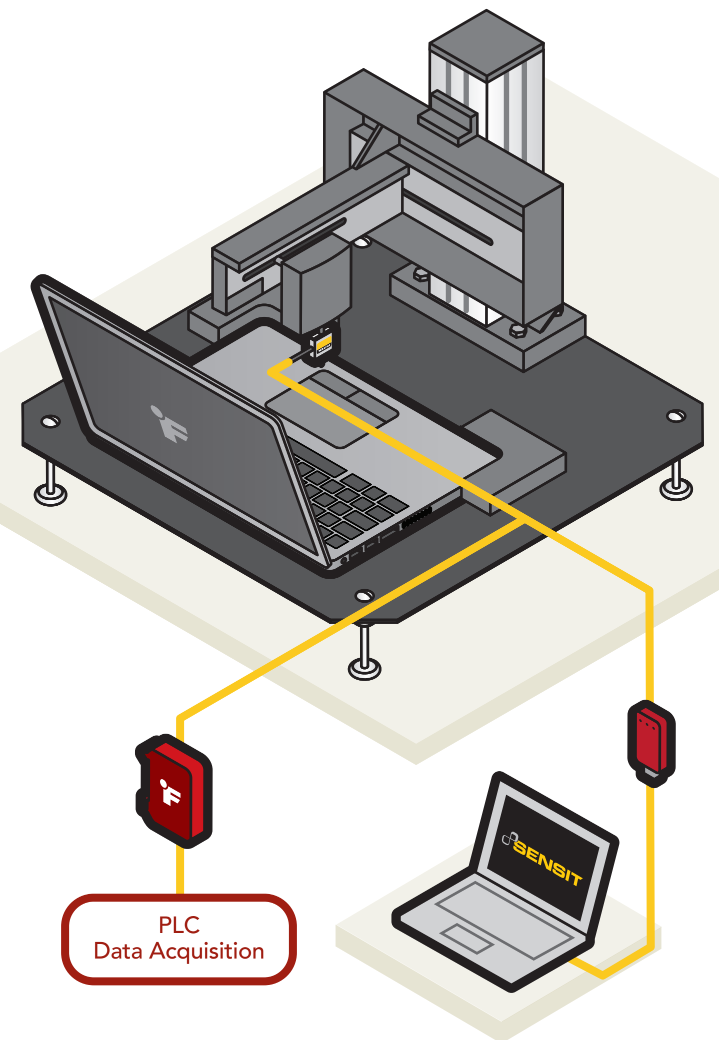

Figure 3: This tactile force test stand is using a FUTEK S-Beam Load Cell and USB Output module or Digital Amplifier.

An example of a simple yet robust testing rig that incorporates all of the above, is shown here. It utilizes a 3-axis Cartesian robot. Fitted between the finger simulant/stylus is a miniature tension and compression load cell, which reads the applied force to the panel. For simple endurance testing the sensor is connected to a USB DAQ that logs the loading data to a PC. For feedback into the robot to allow for closed loop control and for specified and consistent applied forces, a more complex DAQ is used that independently logs sensors data to the PC while simultaneously passing an amplified sensor signal to the robot's control systems.

With the ever-increasing demand for higher performance and reliability touch panels to replace buttons, knobs, switches, etc., the need for more rigorous testing and verification is necessary. Hopefully you have a clearer understanding of the how and the why and the potential simplicity of testing your panels and interfaces.

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