Understanding “Waterproof” Touch Screens

A D Metro White Paper

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Understanding "Waterproof" Touch Screens

The purpose of this paper is to explain what waterproofing means, its application in resistive sensors (briefly), and waterproofing challenges facing projected capacitive (PCAP) touch screen technology.

On its face, you might assume that waterproof means just that – waterproof. But in the world of touch screens that's not so simple particularly when it comes to touch sensors. A better description might be "water resistant". Waterproof taken literally would mean the touch screen can operate reliably underwater for long periods of time.

Waterproof displays or touch screen monitors refers to the sealing of the sensor face and housing from dust, dirt and moisture. An ingress Protection (IP) rating such as IP-67 is a common standard used to identify the equipment seal quality. A good seal does not mean the equipment will work under water. For example, most late generation smartphones using PCAP touch screens are now waterproof. One can submerge it, fish it out, dry it off and continue using it. You cannot, however, operate the touch screen while it is underwater.

Resistive Touch Screens

The only touch sensor that can indefinitely and reliably operate underwater is A D Metro's patented flagship product ULTRA, a thin glass faced resistive touch sensor. Though standard resistive sensors can operate underwater, they can't survive in wet conditions indefinitely. Standard resistive touch sensors have a flexible polyethylene terephthalate (PET) film that comprises the switch layer or cover sheet of the sensor to allow the user to depress the switch layer in contact with the ridged inner layer of the sensor to provide an electrical contact. PET film is a thermoplastic polymer and though it is very durable, like many plastics, it is not waterproof but only moisture resistant. If exposed to enough moisture, eventually water at a molecular level can migrate through PET film and condense inside the airspace of a resistive sensor and cause erratic operation or an electrical short. For that reason, standard resistive touch sensors are not suitable for outdoor or fixed mount in-vehicle applications where there is high probability of exposure to water or moisture condensation. ULTRA, on the other hand, is immune to water exposure because the external glass layer is water and moisture proof. There is no possibility for moisture to migrate through ULTRA's PET/Glass switch layer.

PCAP Touch Screens

This section starts by presenting an overview of PCAP technology as well as PCAP touch screen function and how this limits its water resistance. Water deposit types and their effect on PCAP operation are also discussed. Finally, the section ends by covering how signal processing used by A D Metro PCAP technology adapts to tolerate some water.

PCAP technology is the most popular and highly accepted type of touch sensor for use in mobile phones, tablets, laptops and many other consumer devices because it offers excellent optical properties, very light touch performance and popular multi-touch capability. PCAP touch screens do have limitations that restrict their use in outdoor applications (kiosk, military, mobile, marine) including incompatibility with thick gloves, poor performance at temperature extremes, and in the presence of moisture.

What does waterproof mean for PCAP touch Screens? Unfortunately, some vendors are using the term ‘waterproof’ loosely when describing their PCAP products. Stating “PCAP is waterproof” is misleading because PCAP touch screens do not work under water or when soaked. There have been advancements in PCAP technology that allow these touch screen to work better under some moisture conditions. A D Metro offers this technology.

Some vendors demonstrate what appears to be waterproof PCAP touch screens working perfectly underwater. Further investigation reveals that these vendors are demonstrating standard PCAP sensors with resistive type switch layers applied to their surface to keep the PCAP touch screen dry. This PET switch layer is used to trigger the PCAP RF signal when depressed into it providing similar functionality as a finger touch. While this arrangement does provide multitouch capability, it does so poorly compare, for example, to a two-touch resistive touch screen. Lost is the light touch that is valued in PCAP touch screens (and the very best resistive touch screens). The switch layer in this demonstration needs to be pressed firmly enough to close the outer layer gap then more firmly still to create capacitance at the PCAP touch sensor (that exceeds the capacitance from moisture elsewhere on the screen). This demonstration attracts attention, but it doesn’t represent an improved touch experience. To better explain the PCAP water limitations, let’s review how PCAP technology works.

PCAP Touch Screen Operation

There are different types of PCAP sensing, all are triggered the same way. PCAP, believe it or not is an old technology – one of the first touch technologies. It’s the same technology as used on your laptop’s touch pad and is almost identical to those digitizers with the tethered pens that early mainframe computer aided design (CAD) systems used for pointing and drawing graphics as far back as the 70s. Not much has changed except that materials advancements have allowed the technology to be made in a transparent configuration which is clear enough to be placed over an LCD with acceptable optical degradation.

PCAP sensor construction has a number of "channels" which are placed in separate X and Y configurations to form a grid. These channels are constructed of transparent conductive coating on film or glass plate. This is where the term "Capacitive" comes in. If you have two opposing conductive coatings on glass or film plate, (which is a dielectric or non-conductive insulator), you have most of a capacitor. The only thing missing is that the two conductive areas don't overlap well. Your finger, having moisture in it, improves this overlap, allowing two perpendicular channels to become a better capacitor. This creates a signal path for radio frequency (RF) energy between X and Y sensor channels. A PCAP sensor, using the most common sensing method called "Mutual" sensing, works by sending RF through each of the channels in one axis of the grid, lets say the X axis in this example. Each X channel is energized with radio frequency by the controller one at a time and in sequence so the controller electronics always know which channel is energized. While each X channel is energized, the controller senses the Y channels in turn, to sense and measure any arriving RF energy.

In our example, the X plane is called the drive plane and the opposing Y plane is the sensing plane. Let's consider a sensor that has 50 X channels and 30 Y channels for example. Now suppose the controller in its sequence has now energized X channel number 7. The controller is looking for any signal that appears in the Y plane but if there is none then it knows there is no touch by the user. If the user touches a point where the X channel 7 is adjacent to the Y channel 10, then the controller will detect an RF signal on the Y channel number 10. This is because the user's finger is bridging the X and Y channels, capacitively coupling them together allowing the RF signal to flow from the energized X channel to the Y sensing channel. The controller knows the RF at that point in the sequence is on X channel 7 and it is detecting a returned RF signal on Y channel 10 so the level of touch detected at position X7 Y10 gets measured. By continuing to excite and sense all channels combinations, the controller measures the level of touch at all nearby positions. From these measurements of the level of touch at nearby channel intersections, the controller decides on the precise location of the touch. All this signal sampling happens hundreds of times a second.

Given that PCAP technology works with RF, it is easy to see the waterproof limitation of PCAP touch screens. Water is a fair conductor of electricity. Salt water is much better. RF is just another form of electricity but still electricity none the less. Water provides conductive paths for RF. With a PCAP sensor, if enough water gets on the surface, the water itself can couple X and Y channels similar to a finger touch causing the sensor to activate without being touched or if you touch one spot, the water is able to couple that spot with another spot on the screen causing erratic operation.

Types of Water Deposits and PCAP Operation

Let's now talk about water deposits and how they might affect PCAP operation.

Mist

Is usually a very thin layer of water caused by condensation from fast temperature changes in humid air. This would be the same as the fog film on your mirror when you get out of the shower. On PCAP this is usually not enough to couple channels causing a false touch because the mist droplets are very fine and don't come into significant contact with each other so as to cause a good continuous conductive layer such as with a water film.

Frost

A frozen film of moisture that due to the crystallization of the water molecule after freezing creates a uniform conductive layer that can short all X and Y channels together.

Droplets

Depending on size, may not affect operation at all. If the droplet is less than 4mm, it is unlikely to be large enough to couple any channels causing a false touch or couple a touch in another location to other channels causing erratic operation. If the droplets are able to join to make a "puddle" then expect your PCAP to not work very well, if at all. Some PCAP vendors have relied on hydrophobic coatings that can be applied to the sensor surface to stop water droplets from getting too large or puddling. These coatings act like wax on your car. The water beads up and rolls off rather than sheeting on the surface.

Sheeting

This is where there is enough water on the surface of the screen that there is a film that covers the sensor surface or a good portion of it. Water on its own typically doesn't sheet very well but salt water, coffee, soda and other contaminated forms of water do. If your standard PCAP is exposed to sheet water, it's not going to work.

PCAP Signal Processing

Now let's talk about signal processing and how we lessen the water problem. While there is not really any such thing as water proof PCAP operation, there are a few signal processing techniques used to address some of the water related issues.

Water Rejection

If your screen gets wet, you don't want it to falsely activate before you have had a chance to wipe it dry. By identifying multiple and large areas on the sensor of coupled channels, the controller electronics can be programed to reject inputs from the sensor until it sees something that looks like a normal touch. This is similar to palm rejection on your tablet. This water rejection technique does not mean you can operate the wet touch screen. It means that the touch screen won't falsely activate when wet.

Wet Tracking

Wet Tracking or Wet Finger Tracking can be made to work to varying degrees of acceptability. The controller assumes a certain threshold of X to Y signal "leakage" due to water contamination and is programmed to ignore this amount of leakage RF. If the user touches the sensor, then additional capacitance is added to the water's capacitance providing higher X to Y radio signal at that co-ordinate. The signal exceeding the water contamination's threshold level is then interpreted as a valid touch. There is a limit to the amount of water that can effectively be managed using this technique. Also, if the screen is dry a firmer touch force is required to register a touch due to the need to exceed the higher threshold sensitivity of the screen. Wet Tracking performance varies from manufacturer to manufacturer, so be sure to evaluate whether a particular offering works well enough for your needs. Be mindful that not all water contamination is equal. Salt water is particularly difficult to deal with even in small amounts as it is far more conductive than pure water.

In closing, if you want true waterproof touch screen performance, nothing is better than A D Metro's glass armoured resistive product ULTRA. If your requirement must have multi-touch, A D Metro has a line of PCAP products including its own controller to provide state of the art Water Rejection and Wet Tracking capability.

If we can be of any further help, please don't hesitate to contact us.