ULTRA – A D Metro Patented Technology

White Paper

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Introduction

A D Metro was established in 1993 in Ottawa, Canada and currently is one of the few remaining North American base touch sensor manufacturers. A D Metro designs and manufactures touch sensors, controllers and touch solutions. It specializes in customizing touch technology to meet customer's requirements.

A D Metro has been designing and manufacturing resistive touch screen sensors since 1995. In 2003, the company introduced the ULTRA technology. ULTRA is a patented glass/film/glass resistive touch screen. The ULTRA touch screen has many different features and specifications including:

- Abrasion and scratch resistance
- Impermeability to water, chemicals, solvents, flames, etc.
- All the typical benefits of resistive touch screen technology
- Harsh environments operation
- Shatter resistance
- The added safety feature of maintaining the shattered substrate glass, if it occurs behind the glass/film top layer
- Dramatically extended life expectancy due to the design's ability to considerably limit ITO fracturing failure, especially when using a stylus.
- Expanded environmental operating envelope.
- Large format designs enjoy reduced switch layer pillowing when operating at high temperature limits.

First the document will introduce the ULTRA and highlight the superiority of the ULTRA technology to standard resistive. Second, the document will highlight the ULTRA benefits. Some of the benefits covered in this paper include the ULTRA temperature and humidity tolerance, durability, and altitude resistance. The document will also list the current ULTRA applications, and illustrates how the technology can be modified to meet customer's requirements.

How does ULTRA work?

All resistive sensors including ULTRA are analogue membrane switches. They consist of a substrate with a conductive indium tin oxide (ITO) coating as well as a top sheet of flexible material such as polyethylene terephthalate (PET) coated with a similar layer of ITO. ULTRA versions enhance the top sheet with a bonded layer of thin borosilicate glass to armor the surface. With the ITO coated surfaces facing inward, these two layers are applied together around the perimeter with an adhesive. The two layers are separated from physically touching each other with some very small clear spacer dots that are applied to one of the surfaces in a grid pattern. When the flexible layer is touched, the ITO surface depresses between the spacer dots and makes contact with the ITO on the substrate. This construction is called a membrane switch. In a 4 wire sensor, two pairs of conductive buss bars are applied to the opposing edges of each of the layers – one pair for the X orientation and one pair for the Y orientation. A voltage is applied to the bars of the X layer and a voltage gradient is produced across the ITO surface. When touched, the opposing Y layer is used as voltage probe to read the voltage and therefore the X position of the voltage gradient. The process is then switched between the layers to obtain the Y position yielding an X Y coordinate. An 8 wire is essentially the same but with 4 additional connections going to each buss bar. These are used as no load voltage probes to measure the actual voltage directly at the buss bars to account for any variations in the applied voltage to the buss bars due to temperature swings which can cause the internal resistance of the connecting conductive traces to change. If any change is detected, an offset is applied to the voltage gradient reading to compensate. A 5 wire uses the same physical construction but instead of 2 opposing pairs of buss bars on each layer, 4 electrodes are placed on the substrate layer at the corners. The flexible layer has 1 electrode which is grounded. A voltage is applied to the 4 corner electrodes and when the flexible layer is depressed, the touch point is grounded causing current to flow from the 4 corner electrodes. The closer the touch is to a corner, the more current will flow from that corner. The controller measures the current flow from each of the corners and calculates where the touch point is from the 4 current flow values.

Why choose ULTRA?

The patented ULTRA technology is A D Metro's flagship product; a pressure activated flexible glass touch sensor that provides an enhancement to resistive type sensors and delivers a more durable, reliable, and cost effective touch sensor. A micro-thin sheet of borosilicate glass is laminated to an indium tin oxide (ITO) coated polyethylene terephthalate (PET) top sheet used in construction of the touch sensor, which increases the durability of the touch sensor, since the flexible glass membrane produced is waterproof, scratch-resistant and impervious to chemicals, fire and stylus use. A summary of the advantage of using an ULTRA over resistive are listed in Table 1 and discussed below.

Table 1: ULTRA and resistive technology comparison

Features	Resistive	ULTRA
Touchscreen Surface	Polyethylene Terephthalate (PET)	Glass
Input Method	Finger, Glove, Stylus	Finger, Glove, Stylus
Activation Force	Maximum 60 grams	Maximum 80 grams
Touch Lifespan	5W: 30 million touches per point 4W: 4 million touches per point	230 million touches per point Expected.
Stylus/Pen Resistance	Susceptible to ITO cracking caused by pen	Less susceptible to ITO cracking caused by pen drags due to stiffer surface
Repeated Use Surface Wear	Wears through hardcoat, causing a milky appearance	Glass surface outlives lifespan of the sensor with no wear
Pillowing/Puffiness	Can occur at temperature, humidity and altitude extremes	Stiffer surface reduces chance of pillowing
Transmissivity	≥ 80%	≥ 80%
Environmental and Operational Envelope	-10°C to +55°C	Extended operating range over resistive. Size dependent.
Abrasion Resistance	Can withstand light scratches	Can survive deep scratches and gouges.
Moisture and Humidity Resistance	Moisture can permeate through polyester over time causing oxidation, shorts or false touches	Glass surface impervious to moisture
Chemical Resistance	Any that do not attack plastic	Any that do not attack borosilicate (PIREX) glass
Fire Resistance	None	Can withstand open flame for short periods and sparks
Altitude Resistance	10,000 feet operating 50,000 feet storage	14,000 feet operating 50,000 feet storage
Warranty	3 years	5 years (None Custom Designs)

Environmental Factors

The environmental factors that will be discussed in this section include temperature, humidity, and altitude resistance.

The ULTRA is waterproof and fire resistant as well as chemical resistant. Therefore, it can withstand open flames and sparks for a period of time. These features make the touch screen ideal for any extreme environment.

The ULTRA technology also reduces pillowing because the lamination of the glass/polyester layer has a closer expansion/contraction coefficient to the substrate glass. It has an expanded environmental envelope that allows ULTRA to be operated and stored at a higher temperature, which is more than a range of -10°C and +55°C. The result is the thin borosilicate glass, which is laminated to the PET, holds the PET in tension so it cannot expand with heat, which would cause the top switch layer to appear to be puffy or pillowed. The pillowing is more evident in larger touch screens making it difficult for resistive technology to be manufactured in larger sizes. Therefore ULTRA touch screens can accommodate this issue.

Another feature of the ULTRA is the moisture barrier, which allows the sensor to work in very humid or wet environments. In resistive technology, the bare PET switch layer is not waterproof, but only water resistant. As a result, the switch layer can allow moisture to penetrate through it eventually condense inside the switch layer air gap. The accumulated condensed water can short-circuit the touch screen. In ULTRA technology, the glass is used in addition to the PET to make a water-proof switch layer that eliminates the possible accumulation of condensation in the switch layer air gap.

ULTRA has a higher altitude resistance than existing resistive technology allowing it to operate from as high as 14,000 ft. In resistive technology, when exposed to a higher altitude, the air in the switch layer can expand and cause the switch layer to deform or ripple, causing short-circuiting or false activation

Durability

The ULTRA glass/PET top layer is not breakable and provides an effective vandal-proof solution. The glass is also scratch-resistant with a hardness of 6.5 Mohs. Resistive technology, however, uses polyester and has a hardness of only 3H, which can be easily scratched. As a result, the ULTRA can operate after extreme abuse such as deep scoring, repeated impact trauma, and other vandalism. The durability of the armor glass translates to a longer life cycle in the field.

Two safety features in ULTRA technology enhance resistive technology. One of the features is to ensure that if the substrate glass breaks, then the shattered glass is held between the armor glass/PET layers.

Another safety precaution eradicates the problem of static discharge in plastic such as PET, which in an environment with high exposure to flammable chemicals or gasses could be catastrophic. The glass, on the other hand, has a higher dielectric value, and a much higher static discharge resistance which would resolve this problem.

Life Expectancy

The armor glass used in the ULTRA construction is composed of a borosilicate glass making it an optimal alternative to the PET top layer used in resistive touch technology. As a result, the stiffness of the armor glass/PET switch layer makes the occurrence of something called ITO fracturing much less predominate. The most typical failure mode in a resistive touch screen is cracking of the ITO layer on the flexible switch layer. Because ITO is a ceramic and therefore brittle, it will gradually crack with repeated flexing or depression of the switch layer, particularly in the same spot such as the area over an enter key on an on-screen keyboard. When cracked enough, the ITO at the location will fail to conduct a current and result in a dead spot on the touch screen. This is particularly more severe with stylus operation as that bends the switch layer significantly more and greatly accelerates ITO fracturing. ULTRA's glass/PET switch layer is stiffer and retards the switch layer from bending too sharply, which inherently protects the ITO coating, greatly reducing instances of ITO fracturing failures.

The touch lifespan of the ULTRA, over 200 million touches per point, is longer than the typical resistive sensor, which only has 30 million finger touches in its lifetime. The ULTRA provides better value because the sensor should not need to be replaced in the lifetime of the device in which it is used.

Above all, ULTRA technology is more durable than typical resistive touch technology. Its durability makes it ideal for outdoor and extreme environments. ULTRA is a better investment because it has a longer life cycle due to its durability and expanded environmental operational envelope.

ULTRA Applications

The ULTRA enhancements to the standard resistive type touch sensor make the ULTRA an ideal choice for many military, industrial, mobile, kiosk, and medical applications. In this section we will discuss each of these applications.

Military

Military applications invariably have to use resistive type technologies because of their electronic stealthiness and pressure activation. Resistive technologies, which are analogue membrane switches, use DC voltage or Direct Current to operate which is essential for frontline tactical touch screen equipment as this kind of operating power is very hard to detect by the enemy as it does not emit any kind of radio signature. The use of AC or RF types of operating power such as in capacitive type touch screens are not acceptable as when they operate, they light up like a Christmas tree should the other side be looking. There is no practical way to shield capacitive touch screens as the AC or RF power is what is used to sense the touch so if you shield that AC or RF from emitting then the touch screen cannot operate. Other technologies such as IR matrix and SAW (Surface Acoustic Wave) are as well undesirable as they do not stand up well to a dirty or dusty environment and in the case of IR Matrix are not NVIS (Night Vision) compatible.

The drawback with standard resistive touch screens for military use is the lack of surface durability given the PET (polyethylene terephthalate) film which is used as the switching layer on the surface of the touch screen. Also, environmental factors are limited with regular resistive touch screens. PET is moisture resistant but not moisture proof. Operating a standard resistive in an environment with high temperature and humidity swings can cause moisture to move through the PET switch layer and condense on the inside airspace of the touch screen causing it to short or register erratic touches. ULTRA's glass outer surface stops this from happening as glass is moisture proof. Coupled with the obvious surface durability of a Pyrex® type glass outer surface, ULTRA is the best choice for almost any military application.

Industrial

Industrial is another demanding application to fill. Commonly, gloved hands are used in this often dirty environment so the need for activation while wearing protective often thick gloves requires activation by pressure. Resistive technologies are pressure activated. IR Matrix and SAW technologies will work as well but in a dirty or wet environment their MTBF might only be counted in hours or minutes. Again, the only best option for harsh environments would be resistive. Drawbacks are similar to the military application concerns discussed above but again being mostly due to a relative lack of mechanical surface durability and chemical resistance. A 6.5 Mohs surface hardness of the borosilicate glass that composes the outer surface of our ULTRA resistive product certainly provides the best mechanical surface durability that can be had in a pressure activated membrane switch technology. Also, chemical resistance is second to none as about the only thing that can react with borosilicate glass is hydrofluoric acid. No other acids or chemicals can affect this type of glass as it is the same glass used to make chemistry glassware. Another significant benefit of ULTRA's glass surface is its inability to produce a static charge unlike regular PET surfaced resistive. This is a major concern in explosive environments such as oil and gas refining or dispensing facilities making ULTRA the only touch screen technology that meets the requirements of these kinds of applications.

Mobile

This market can be very difficult to address with a touch screen solution particularly in northern hemisphere environments where climate can vary dramatically. In vehicle mounted applications the touch terminal must be able to survive rapid temperature swings and high amounts of humidity. Users are usually not able to remove the terminal from the vehicle as most are a fixed mount. That being the case, the terminal has to be designed to withstand environmental extremes especially when operating in northern climates. Winter operation in delivery trucks, for example may mean that the operator may need to operate the terminal with gloved hands so a pressure activated technology such as resistive is desirable. The developer must take into consideration the markets in which the terminal is expected to be sold and restricting a design to a specific geographical location because of environmental operating constraints is not a good idea. The expectation for worldwide deployment should be in the design plan for the terminal so as not to restrict market opportunities. Both surface and projected capacitive technologies do not fare well in this application because a mobile application is subjected to an ever changing environment of EMI and RFI interference which can cause these types of touch screens to operate unreliably. Saw and IR also are not suitable as in-vehicle applications can be quite dusty. Save for environmental issues, resistive technology works most reliably but can be prone to humidity. The PET surface of a standard resistive touch screen is moisture resistant but not moisture proof. Operating a standard resistive in an environment with high temperature and humidity swings such as in-vehicle environments can cause moisture to move through the PET switch layer and condense on the inside airspace of the touch screen causing it to short or register erratic touches. Double buffering the switch layer can be used to help reduce this. Double buffering ads an additional layer of PET optically bonded to the switch layer surface to make it thicker and more resistant to moisture migration. While this helps, it does not mitigate the problem and at best delays the inevitable failure of the touch screen due to moisture ingress. Moreover such a double buffered resistive can cost about the same as an ULTRA resistive. ULTRA's glass outer surface stops this from happening as glass is moisture proof making ULTRA the best choice for mobile applications.

Kiosk

Kiosk applications are mostly concerned with vandalism but also can be concerned with environmental factors when operating outdoors such as with an ATM machine. Hard glass technologies such as capacitive types work well when the kiosk is indoors but weather such as rain or snow can interfere with the RF signal operation of these screens and cause them to stop working. This is not a factor with ULTRA touch screens. ULTRA touch screens are not affected by weather at all and are even capable of operating under water in shallow depths. Surface Acoustic Wave (SAW) and IR Matrix have issues with dirt contamination and are not recommended for kiosk use even when operating indoors as cleaning maintenance is not expected to be frequent. Activation quite often is a concern which is overlooked. If you want people to use the kiosk it has to be easy to use so. If someone walks in from outdoors in winter and tries to use a kiosk with a capacitive touch screen wearing winter gloves, it's not going to works. Don't expect that the user will stand there and try to figure out why it doesn't work. The average person is not a touch screen expert and will just walk away assuming the kiosk isn't working and is broken. The same can be said when trying to use a capacitive touch screen with dry hands. If you ever experienced dry chapped hands during the winter, you will know that your cell phone, which uses a projected capacitive touch screen, doesn't work well if at all. Licking your finger so it can efficiently capacitvely couple makes it work but how can you expect a user to know that when trying to operate a kiosk and even if they did who would want to do that if they thought other users were doing that as well. Mysophobia or "germaphobia" is becoming a growing concern of users of public information systems. Some touch screen manufacturers try to push hydrophobic coatings on their touch screens as an anti-germ coating because hydrophobic coatings are like Teflon®. It's hard for germs or anything else for that matter to stick to it. But what good is it even though it may be effective if no one knows it's there? Mysophobic users will want to use their own method of isolation use which most often would be a pen, a key or the corner of a credit card. For that to work the touch screen has to be pressure activated and the only one that works that way is the very reliable resistive type. Using implements or styluses to activate a standard resistive touch screen is OK but can dramatically reduce its life expectancy due to ITO fracturing of the switch layer as described earlier in this paper. ULTRA type touch screens will work in any weather, with any touching implement, will not damage easily and will last indefinitely as it is not prone to ITO fracturing.

Medical

Medical environments can use touch screens in equipment such as patient monitors, blood pressure meters, X-ray machines etc. and are concerned with several issues. Firstly, the ability to sterilize the equipment to make it safe from pathogens that can spread infections. Secondly, the equipment's ability to be operated when wearing protective gloves. And thirdly, operational compatibility with other technologies used in hospitals so the equipment cannot emit any signals that interfere with the operation of other hospital equipment nor can signal interference from other hospital equipment interfere with its operation. Any of the hard glass technologies can satisfy the need to be able to sterilize all equipment surfaces so ULTRA, projected and surface capacitive technologies would be suitable if this was the only need. Regular resistive could potentially have a problem as the chemical or chemicals that would be used for cleaning and disinfection are changed frequently in order to stay ahead of pathogens becoming tolerant to a particular disinfectant. So the chemical composition of the disinfectants cannot be predicted for the life of the equipment and there might be a possibility that some solvent such as trichlorethylene, which could attack the PET surface of a regular resistive, may be scheduled for use at some point. A glass surfaced technology would be safest. SAW and IR matrix technologies have either crevices or porous gaskets that trap dirt and cannot be cleaned satisfactorily. Thin protective gloves used in health care environments would be compatible with all touch screen technologies. Double gloved hands might present a problem for some capacitive types but this by enlarge has been overcome with most present day designs. Radio emissions or interference can also be an issue such as in avionic applications. If your touch screen emits RF signals, it can interfere with other hospital equipment such as wireless patient monitors. Conversely, other equipment such as MRI scanners can emit radio signals that can cause touch screens that use RF signal processing to be unreliable. Surface capacitive and projected capacitive touch screens are not desirable for this reason. ULTRA does not use radio frequency to operate so does not present such a concern. In conclusion, ULTRA is a technology that can satisfy all the design concerns of most medical applications.

Enhancement Options

As stated previously, ULTRA technology is the best choice for many applications. Often, it is the most cost-effective and flexible solution that meets stringent military and avionic requirements, highly durable industrial, or vandal proof applications. In many cases the standard ULTRA will require some enhancement to meet a particular requirement.

Strengthened glass substrates should also be touched on here as it is a critical factor in obtaining the most durable design of an ULTRA assembly. There are two types of strengthened glass commonly in use. The first and most common is heat tempered glass generally referred to as safety glass. This glass is made by introducing a glass such as regular soda lime glass into a furnace where it is heated to near melting then extracted from the furnace and quickly air blasted to cool the outer surface while the inner core remains hot. This shrinks the outer surface of the glass in tension to the inner core making it very strong much like pressurizing a balloon. When the outer surface is cracked, the tension is released and the glass explodes into harmless small pieces thus the term safety glass. This type of glass is not suited for displays because the tempering process warps the glass a bit compromising its optical properties. Chemically Strengthened glass is typically used in touch screen applications and is much better suited for display purposes because the process does not distort the glass. Regular soda lime glass is immersed in a bath of potassium nitrate at about 500 degrees centigrade for 8 to 16 hours. An exchange of salt molecules for potassium molecules takes place in the surface of the glass. The longer the bath, the deeper the exchange. The resultant surface of molecular exchange results in a surface tension of 20,000 to 50,000 PSI or up to 6 times the strength of regular annealed soda lime glass. Unlike heat tempered glass, you can cut chemically strengthened glass but you will lose the strengthening properties from about 1-1.5 inches from the edge making it useless for small format sensors. If you want a strengthened glass sensor substrate in small format, the glass must first be cut to size and then chemically strengthened to treat the edges as well. There is also no thickness limitation with chemical strengthening unlike heat tempered. With heat tempering, if you get below 3 mm in thickness, it becomes difficult to cool the outer surface quickly enough without the core cooling along with it so proper surface tension generally becomes unobtainable below 3 mm in thickness. You can use heat tempered or chemically strengthened glass for substrates on 4 or 8 wire resistive sensors because these sensors are processed with silver inks and dielectrics that do not require heating in the making of the substrate layer. You cannot use heat tempered or chemically strengthened glass for 5 wire or surface capacitive technologies because the processing of the silver patterning and trace ways are made from silver metal which provides a needed low internal resistance for the proper operation of 5 wire and surface capacitive. The silver must be melted onto the ITO glass in a firing process. This firing would release the surface tension in heat tempered glass and reduce it considerably in chemically strengthened glass. If you want a proper strengthened substrate on a 5 wire or capacitive, you must laminate a heat tempered or chemically strengthened back glass plate to the sensor substrate to provide a strengthened carrier for the 5 wire sensor.

Optical enhancements

- Anti-reflective coating—AR
- Anti-glare matte finish—AG
- Anisotropic film for use with polarized glasses

Strengthened substrates

- Chemically strengthened back glass lamination
- 1.1mm, 1.6mm, 2.0mm, 3.0mm

EMI shielding

- ITO coatings (4 ohm/sq, 13 ohm/sq standard)
- Military grade Micro Mesh/Laser Mesh/Wire Mesh
- Complete grounding options

Miscellaneous

- Infra-red reflection coatings and films
- Application of NVIS compliant filters
- Mullion heaters for extreme conditions
- Neoprene/Poron foam gasket
- Double sided adhesive mounting gaskets
- Custom tail assemblies
- Silk screened boarders
- Die-cut vinyl overlays
- Vented seal for extreme altitude operation