Introduction to Touch Solutions
White Paper
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1.0 Introduction

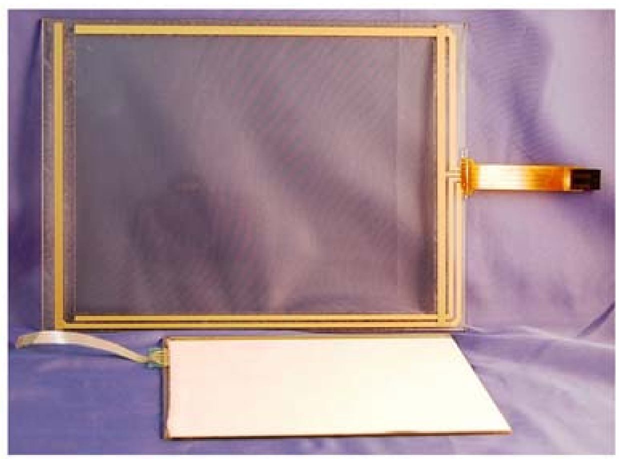
Touchscreens are found in a wide range of applications, from medical and industrial to public access kiosks and retail.

The ability to continue operating even when damaged along with the speed of response and whether users will have gloved hands must also be considered. Maintenance is important, as members of the public are highly likely to be dissuaded from using a kiosk if the screen is dirty and/or nonfunctional.

For a touchscreen integrated into a terminal that is going to be used in a heavy industrial environment, factors may include adequate levels of protection against shock and vibration in addition to resistance to chemicals and cleaning fluids. It is important, therefore, that touchscreens used in this type of environment are able to perform in the harshest conditions.

In the medical sector, accuracy is absolutely critical, and touchscreens used in such an environment must be easy to keep clinically clean and offer good light transmission. There are also safety standards to which the touchscreens must adhere.

2.0 Analog resistive touch screens



Analog resistive touch screens are available in three types, 4-wire, 5-wire and 8-wire.
Each type has advantages and disadvantages and is optimized for a specific type of application. Aside from Matrix touch screens; these are the least expensive of the technologies described. Most analog resistive touch screens consist of a ridged layer and a flexible layer with a separation layer between them. The flexible layer is exposed to the outside, towards the user. The inside surfaces of the ridged and flexible layers are coated with a resistive coating, usually ITO (indium tin oxide). When the flexible layer is pushed its conductive surface will make contact with the conductive surface of the ridged layer making an electrical connection between the two layers at the point of contact. Measurements are then made to determine the point of contact.

Resistive technologies provide the benefits of high resolution and the fact that any type of pointing device can be used. However, the drawback here is that the need for the overlay and spacer dots means that resistive touchscreens can suffer from reduced brightness and optical clarity while the flexible top layer can be prone to surface damage from scratches or chemicals.

2.1 4-Wire resistive touch screen

The active layers of a 4-wire type touch screen consist of a partially conductive (ITO resistive) coating applied uniformly to the panel. Conductive bus bars are screened with silver ink across opposing edges of the panel. The ridged and flexible panels are mounted with the bus bars perpendicular to each other. Measurements are made by applying a voltage gradient across one of the layers and measuring the voltage on the other layer. This measurement is made twice, once with the gradient across the ridged layer and the measurement taken from the flexible layer and again with the gradient applied to the flexible layer and the measurement taken from the ridged layer. The gradient is usually produced by grounding one bus bar and applying +5v to the other bus bar. This will produce a smooth voltage gradient in one axis across the panel. Figure 1 shows the electrical connections and a graph of the applied voltage gradient.

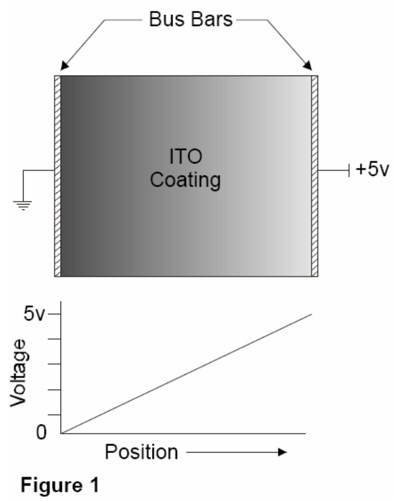


Figure 1

With a 4-wire touch screen two separate setups and measurements are required, one in the X-axis (left-right) and one in the Y-axis (up-down) to define the touch point. Figure 2 illustrates the setup for making the two measurements. The actual switching of the 4 touch screen connections is done using an array of low on-resistance FET transistors and the voltage measurements are made with an A/D converter. The host micro controller controls both these elements. When a layer is being used as a sense layer all other connections to that layer must be left floating.

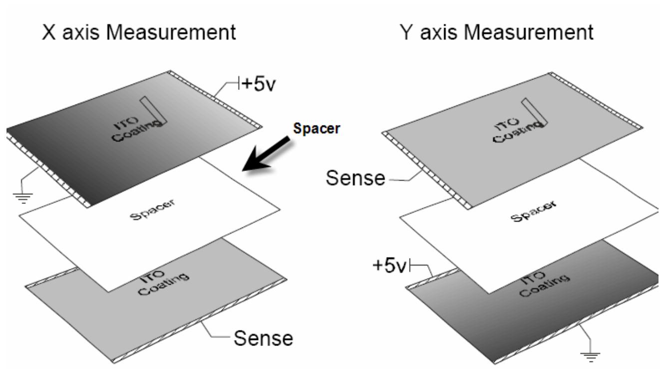
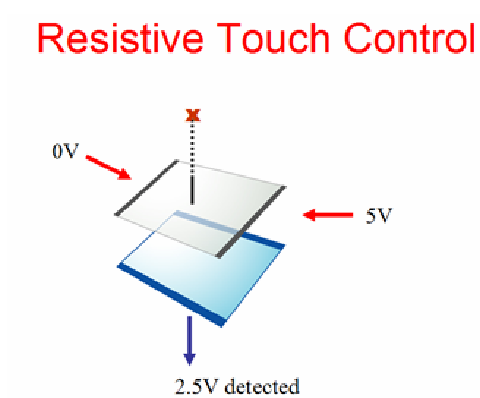


Figure 2

The resistance of the bus bars and the connection circuitry introduces an error (offset) in the voltage measurements. These offsets can also drift with changes in temperature, humidity and time. If the touch screen is to be used only with a finger the offsets will constitute a small percentage of the voltage represented by the large size of the finger and can be ignored. If, however, the touch screen is to be used with a stylus for drawing or signature capture then these offsets should be taken into account. This can be done by calibrating the screen periodically or by utilizing an 8-wire touch screen.



2.2 8-Wire touch screens

8-wire touch screens compensate for drift by adding 4 additional reference lines. This allows the voltage to be measured directly at the touch screen bus bars. Note: you can use an 8-wire touch screen in 4-wire mode by connecting the drive and reference lines together. Use of this type of touch screen won't eliminate the need for an initial calibration of the touch screen but should eliminate the need for any subsequent calibrations. Figure 3 shows the construction for making the measurements.

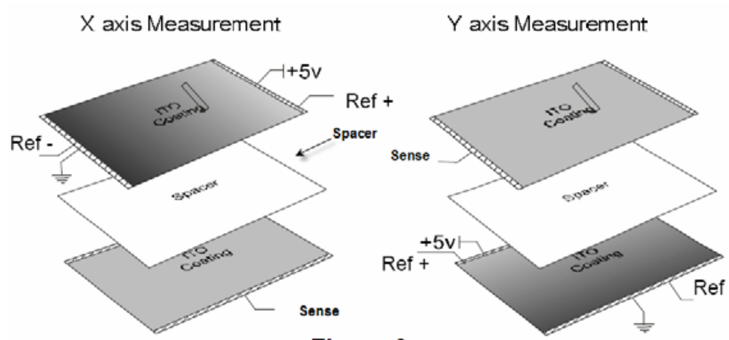


Figure 3

2.3 5-Wire resistive touch screen

The 5-wire touch screen differs from the 4-wire type mainly in that the voltage gradient is applied only to one layer, the ridged layer, while the other layer is the sense layer for both measurements. Figure 4 shows the setup for making the measurements. The sequence of events during the measurements is this. The voltage gradient is set up on the x-axis and a voltage measurement is taken from the sense layer. The voltage gradient is then switched to the y-axis and another voltage measurement is taken from the same sense layer.

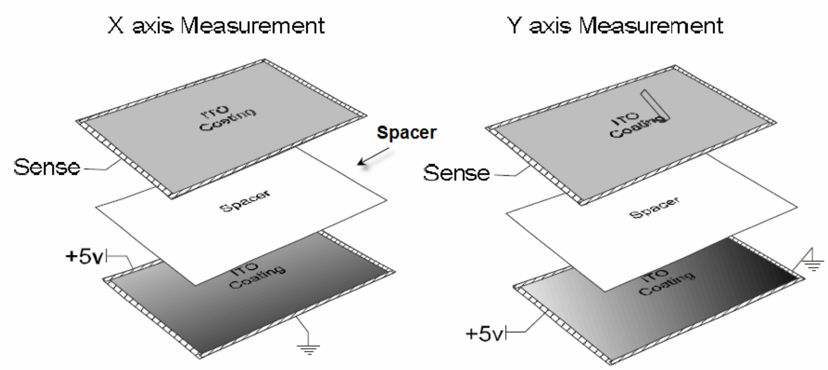


Figure 4

The 5 wire resistive touch screen provides outstanding endurance and reliability compared to the older 4-wire, 6-wire and 8-wire resistive touch screens.

New technology from some manufacturers extends the common 5-wire resistive film method, by fusing electrodes directly on the glass to enhance the touch-responding reliability and improving resistance to humidity, cold and heat. This extension enables accuracy to be maintained even if the film surface is damaged. With the endurance for repeated touches on the same spot exceeding 35 million times, it can be used for applications where a typical construction resistive touch screen could not be adopted previously. Response is also typically faster and more accurate.

MECHANICAL

- Input Method: Finger, Gloved Finger or Stylus Pen
- Touch Activation Force: Less than 110 grams
- Film Surface Hardness: Meets pencil hardness 3H
- Surface Durability: 10k times (250gf, pen speed 100±15mm/sec)

OPTICAL Light Transmission: 81% (550nm wavelength optimized for flat-panel displays)

RELIABILITY -Touch Life: More than 35 million touches in a single location

ELECTRICAL

- Accuracy: Standard Deviation of error is less than 1.5% on most displays.
- Direction "X”: 1.5 % or less, Direction "Y”: 1.5 % or less

2.4 Resistive Touch Screen Calibration

The resistance of the coatings on a touch screen will vary slightly from unit to unit due to the manufacturing process and can change under some environmental conditions and over time. Environmental factors such as temperature and humidity can alter the resistance characteristics of the coating which will affect the position measurements from the touch screen.

Changes over time in the touch screen coating and in the drift in calibration of the touch screen controller can also affect measurement accuracy. The physical position of the touch screen alignment to the display may also vary slightly from unit to unit.

Because of these factors an initial calibration of the touch screen is usually necessary, and in certain applications subsequent calibrations may be required periodically to maintain accuracy. The type of application will dictate the calibration requirements.

Common 4-wire/6-wire/8-wire resistive touch screens may require re-calibration due to the stress on the film side. 5 wire film does not use coordinates on the film side and hence forms and maintains more stable coordinates.

For example, a touch screen application that requires finger touch accuracy on a small LCD may require only about 10% accuracy of the touch measurement relative to a screen location. The combined amount of drift over time and initial variations in characteristics of the touch screen system typically amount to a total of about 5%. In this application calibration would not be necessary

In a second example, an application such as signature capture on a 5” LCD with a resolution of 320 x 240, an accuracy of better than one pixel is necessary over the life of the product. This amounts an accuracy of the position measurement relative to the LCD screen of better than 0.3%. In this application calibration would be required. A typical calibration procedure would be to first display a single pixel near one corner of the display and request the user to place a stylus at that point. A measurement is taken and stored. Next, the procedure is repeated near the opposite corner of the display. These two readings now represent the accurate positions of two points on the LCD display. A scaling factor can now be computed for each axis and all subsequent positional measurements can be adjusted using this factor.

Initial calibration is still required with an 8-wire touch screen is critical applications but periodic re-calibration is usually not required.

2.5 Resistive Touch Screen Controller

The resistive touch screen controller is responsible for:

Switching of the drive and sense voltage to the proper layer/axis
Routing the sense voltage to the A/D converter input
Converting the analog voltage from the sense layer into a digital word
Interfacing to the host processor

Each of these tasks will be discussed separately.

Switching - This stage is used to apply the drive voltage and ground to the proper layer (4 and 8-wire) or axis (5- wire).

Routing - This task is usually accomplished by a multiplexer in the case of the 4 and 8-wire types. The 5-wire type does not need a multiplexer since there is only one sense line.

Converting - The voltage level from the sense layer is then converted to a digital word by an analog to digital converter (ADC).

Interfacing - The output of the ADC is then conditioned and perhaps latched by this element. It may also be converted to a serial stream if that is the type of interface desired. Figure 5 shows a block diagram of a typical touch screen controller.

2.6 Resistive Touch Screen Design Considerations

Electro Static Discharge (ESD) is not usually a problem since the flexible layer of the touch screen is a good dielectric.

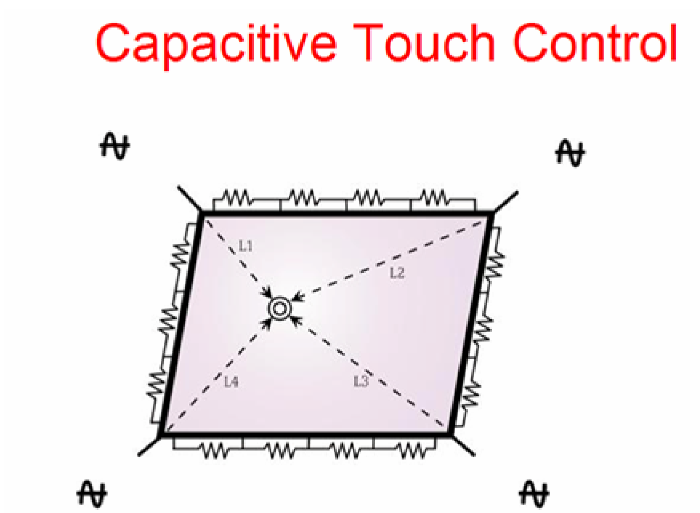
Noise can be an issue so some consideration should be paid to its elimination. The cable connection from the touch screen should be routed well away from any source of noise sources such as a CCFL or EL back light inverter. Noise suppression capacitors can be added between the touch screen connections and ground to suppress noise.

3.0 Capacitive Touch Screens

• Capacitive overlay technology uses a touch sensor that is a glass overlay with a conductive coating bonded to its surface. A low current flows across the capacitive panel and established the frequencies of four oscillator circuits at the panel's corners. When the screen is touched a conductive stylus, the impedance alters the frequency of the four oscillators. The touch coordinate is calculated from the differential frequency change of the four oscillators. This, in turn, determines the X and Y coordinate of the touch activation.

3.1 Surface Capacitive Touch Screen

Capacitive touch panels offer outstanding accuracy, optics durability and touch accuracy. Slim border design allows better integration for new generation flat panel displays.
With excellent optical transmission, low reflection, and minimized color distortion,



The capacitive touch panel consists of multilayer coatings on a glass panel. The layered structure is shown in figure 2. Transparent conductive coatings are coated on both sides of the glass panel. Specially designed electrodes are laid around the panel’s edge on top of the front-side conductive coating to evenly distribute a low voltage across the front-side conductive coating, creating a uniform electric field. The backside conductive coating is used for electromagnetic interference (EMI) shielding. A hard coat layer is laid on top of the front-side conductive coating to provide protection to the front-side conductive coating.

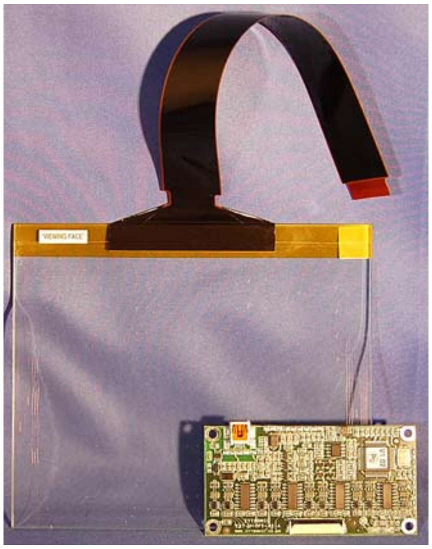
The touch screen coated material that stores electrical charges, when touched allows a small amount of charge to be drawn to the point of contact. Circuits located at each corner of the panel measure the charge and send the information to the controller for processing. Capacitive touch screen panels must be touched with a finger unlike resistive and surface wave panels that can use fingers and stylus.

Features
Surface scratch hardness of up to 9H
durability over 300 million touches life
high light transmission rate of 93%,
narrow border for easy integration
Glass Thickness 1.8mm/2.8mm
Accuracy 1.0% based on the diagonal dimension of the screen.
Chemical Resistance to chemicals that don't affect panel per ASTM-D-1308-87(1993) and ASTM-F-1958-95.
Abrasion Exceeds severe abrasion test per MIL-C-675;
Surface Scratch Hardness Can withstand more than 9H

3.2 Surface Capacitive Touch Controller

The controller measures the values of the current flow from the four corners and calculates the X, and Y coordinates of the touch location. The raw coordination data is further analyzed and compensated to give the optimized linearity accuracy. The controller utilizes its multi-point linearity compensation function to compensate non-uniformity of the panel. Each panel is calibrated in factory. Its compensation data is stored in EEPROM of the controller in pair with the panel and is used for linearity compensation. The compensated coordinates is then transmitted to the host computer through RS232 or USB interfaces.

3.3 Projected Capacitive (PCT) Touch Screen



Traditional touch screen sensing technologies such as capacitive, resistive and surface acoustic wave are surface-active and therefore are more susceptible to surface variance effects during the screen's lifetime. Capacitive sensor arrays are often subject to drift, which means that regular recalibration is required and consequently, maintenance is more expensive. Resistive touch technology is more prone to damage caused by sharp pointing devices such as a pen or the corner of a credit card. PCT eliminates all of these problems by providing a robust, reliable and calibration-free, non-surface active glass fronted touch solution.

Projected capacitive technology is accurate enough to control equipment precisely, yet sensitive enough to detect finger touches through gloves. Ideally suited for harsh environments, these touch screens withstand high pressure cleaning common in industrial environments and are unaffected by most surface contaminants found in automation settings, utilities and mining environments

It is exceptional in its ability to detect touches made by conductive objects - fingers or a conductive stylus as well as through gloves and other potential barriers (moisture, oil, gels and paints). Sophisticated sensing circuitry generates a precise profile of a touch through highly specialized data acquisition and image processing techniques. Made of strengthened glass and a laminated construction with no mechanically sensitive components, can withstand significant vibration and shock in extreme environments.

Projected capacitive technology (PCT) uses embedded microfine wires within a glass laminate composite. PCT is based on the principle of embedding this array of micro-fine sensing wires within a multi-layer laminated screen often behind a protective front surface, ensuring that the sensing medium is well-protected from accidental and malicious damage. Each wire has a diameter of around one third of a human hair, meaning that they become nearly invisible to the human eye when viewed against a powered display.

The wires are connected to an integrated controller board, which establishes an oscillation frequency for each wire. When a conducting stylus, such as a finger, touches the glass surface of the sensor, a change in capacitance occurs, which results in a measurable oscillation frequency change in the wires surrounding the contact point. The integrated controller then calculates the new capacitive values, this data is transferred to a host controller, and software is used to translate the sensor contact point to an absolute screen position.

Densitron’s projected capacitive sensor is constructed from a combination of two plies of soda lime glass with a total thickness of 7 mm (3 mm for the viewing face and 4 mm at the rear). A polyurethane layer incorporating the touch sensor array is sandwiched and protected between the glass layers and is therefore impervious to accidental and malicious damage, day-to-day wear and tear and severe scratching.

A typical PCT touchscreen has a high impact resistance that meets UL-60950 and CSA 22.2 No. 60950 ball-drop test and resistance to shock and vibration in accordance with UL291. Able to accept input from bare and gloved hands, a PCT screen needs no additional sealing prevent the sensor from being affected by moisture and rain, dust, grease, and cleaning fluids.

The electric field generated by the microfine wires does not change with time or temperature, so the sensor accuracy will not drift with time, thus eliminating the need for screen calibration. PCT-based touchscreens deliver uncoated light transmission ratings of up to 88% and provide a resolution as low as 1 mm with a positional accuracy of less than 1% within the recommended viewing area. This technology is extremely robust and reliable, offers one of the industry's highest light transmission characteristics and can be operated with a gloved or ungloved hand.

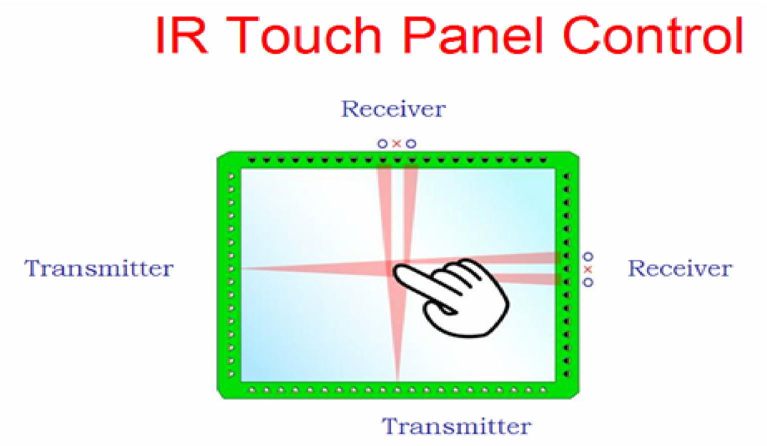
PCT has unlimited touch life, is drift-free, and so requires minimal maintenance. PCT is currently employed in a wide range of touchscreen-based applications that require high-end solutions, such as public access information kiosks, jukeboxes, ATMs, gaming machines and medical and industrial applications.

This technology is currently the most expensive of those described.

Highlights at a glance:

- Unlimited touches life expectancy. No moving parts.
- High Light Transmission- approaching 90%.
- Durability & Resistance to Vandalism: Shock, Scratch and Vandal resistant.
- Debris resistant - Impervious to surface contaminants such as dirt, grease and moisture/ rain water / ice snow.
- Moisture: Touch panel unaffected by severe levels of moisture or water droplets on the surface.
- Chemicals: Performance unaffected by cleaning solutions.
- "Through Glass" feature - can work through shop glass windows or through a piece of sacrificial glass placed in front of the touch sensor; the software has an adjustment for sensitivity. *Through Glass Feature is great for Banks, Retail Showroom Windows: The additional piece of glass -thermally toughened, minimum 3 mm up to 20 mm thick - can also act as an anti-vandal protective layer, so that in the event of breakage, only it needs to be replaced and not the entire touchscreen.*
- High Touch Resolution.
- Does not use a surface coating like "other Capacitive", instead uses a Micro-fine wire of 10 Microns set in a special pattern, and there is no yellowish tint like with "other Capacitive".
- Does not suffer from drift. No re-calibration required as it uses fixed wires to ensure zero drift over time with absolutely no need for maintenance.
- The controller is built (embedded) directly into the glass, so no extra wiring and the power is sourced through the RS232/USB port itself.
- Wide range of Sizes available: 5.7" up to 22".

4.0 Infrared Touch Screens



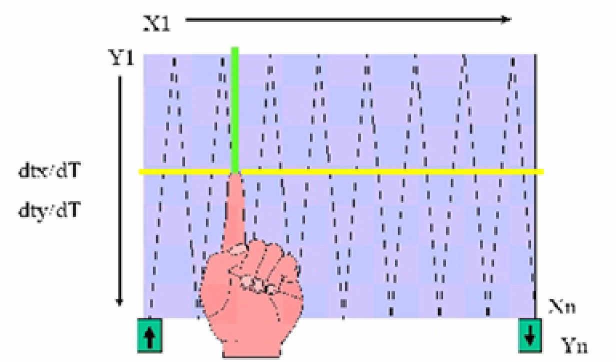
Infrared touchscreens rely on the interruption of an IR light grid in front of the display screen. An opto-matrix frame is integrated into the display bezel that contains a row of LEDs and phototransistors, each mounted on two opposite sides to create a grid of invisible light.

The opto-matrix frame is isolated from the outside environment by an IR transparent barrier. The IR controller sequentially pulses the LEDs to create a grid of IR light beams. When a stylus enters the grid, it obstructs the beams, causing one or more of the phototransistors to detect the absence of light and transmit a signal with the x and y coordinates.

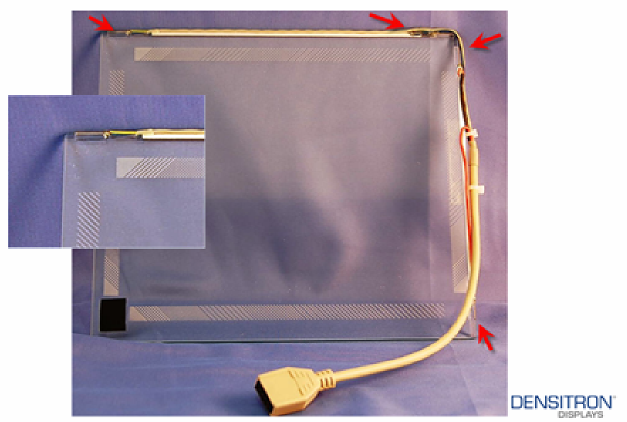
Infrared technology has no limitations in terms of objects that can be used to touch the screen, but one of the disadvantages of this technology is that the screen may react before it is physically touched. They are characterized by medium resolution and a small liability to be subject to parallax. They are also difficult to accommodate below 8.4” due to the size constraints of the opto-matrix frame. Otherwise, they are fast, transparent and durability is dependant on the display itself.

5.0 Surface Wave Touch Screen

Surface Acoustic Wave (SAW) Touch Control



Surface Acoustic Wave (SAW) Touch Control



Surface-acoustic-wave (SAW) touchscreens work by transmitting inaudible sound waves across the screen surface and using sensors in the x and y axes to receive these waves. When the screen is touched, some of the sound wave energy will be absorbed, and the level of attenuation of the sound waves can then be used to determine the touch location.

SAW touchscreens combine high resolutions with zero drift and they have no limitations in terms of objects that can be used for screen contact. They are not, however, well suited to applications where there is the possibility of contaminants getting onto the screen, as these will absorb the acoustic waves and create 'dead' spots.

7H Pure-glass (No active overlays or coatings) for excellent image clarity, resolution & highlight transmission. Durable, scratch-resistant 7H glass surface continues to work even if scratched. High touch point density: over 10,000 touch points per square inch. Very Stable- No calibration drift, automatic correction, accurate operation. (with controller) Long almost forever service life, unlimited touches in one location without failure. Antiglare, Anti-Reflection, Clear or Tempered glass option.

This technology is moderately expensive, requires special mounting considerations to allow the sound wave transmission and typically has a greater unusable border to accommodate the deposited sound wave reflectors (sea photo above).

Features

Surface Acoustic Wave (SAW)
Material Pure glass 3mm
Deviation of Error <2mm
Light Transmission 90%~92% min.
Touch Activation Force Touch force 85g-100g (adjustment allowed)
Colour Distortion None
Touch Point Drift does not drift, one time calibration is enough
EMI Unaffected by other peripherals around the site

6.0 Conclusion

There are many choices in today's market for one to select the right touch screen technology and each technology has its own advantage and disadvantages. The choice of technology depends on the intended application or design; whether it is a small size portable application or a large size home entertainment device to high end medical/industrial applications. The correct choice of Touch screen technology will help enhance the human machine interface experience.

Below is the comparison table for the current existing Touch screen technologies:

Some BASIC TOUCHSCREEN Technologies (Not exhaustive)

	CAPACITIVE		SAW	INFRARED	RESISTIVE		
	Surface	Projected			4 Wire	8 Wire	5 Wire
Technology	Electrostatic field	Electrostatic field	Sound waves	Light interruption	Resistive	Resistive	Resistive
Activitation	Low activation pressure required	Low activation pressure required	Low activation pressure required	Zero activation force required	Low activation pressure required	Low activation pressure required	Low activation pressure required
Input Method	Finger or conductive pointer.	Finger, Gloved Finger or Stylus Pen	Finger, Gloved Finger or Soft Tip Stylus Pen	Finger, Gloved Finger or Stylus Pen	Finger, Gloved Finger or Stylus Pen	Finger, Gloved Finger or Stylus Pen	Finger, Gloved Finger or Stylus Pen
Transmissivity/Optics	Very good ->92%	Very good ->92%	Very good ->92%	No distortion - >100%	<82%, some distortion to graphics due to coatings	<82%, some distortion to graphics due to coatings	<82%, some distortion to graphics due to coatings
Drag and Drop	Requires constant pressure to draw smooth lines		Requires constant pressure to draw smooth lines	Low resolution due to spacing of IR sensors and interpolation	Requires constant pressure to draw smooth lines	Requires constant pressure to draw smooth lines	Requires constant pressure to draw smooth lines
Calibration	Requires periodic recalibration	Does not periodic recalibration	Does not typically require periodic recalibration	No drift	Requires periodic recalibration due to wearing of coatings and environment if accuracy of greater than 10% required.	Requires periodic recalibration due to wearing of coatings and environment if accuracy of greater than 10% required.	May require periodic recalibration due to wearing of coatings
Surface Contaminants/Durability	Resistant to moisture and other surface contaminants	Not affected by moisture or surface contaminants	Adversely affected by moisture or surface contaminants	Potential for false activation or dead zones from surface contaminants	Unaffected by surface contaminants. Polyester top sheet is easily scratched	Unaffected by surface contaminants. Polyester top sheet is easily scratched	Unaffected by surface contaminants. Polyester top sheet is easily scratched
Sensor Substrate	Glass with ITO coating	Glass top sheet, substrate with embedded wires	Glass with perimeter sensor deposition	Any substrate	Polyester top sheet, glass substrate with ITO coating	Polyester top sheet, glass substrate with ITO coating	Polyester top sheet, glass substrate with ITO coating
Multi-touch	NA	Available	NA	NA	NA	NA	NA
Film Surface Hardness	Can withstand more than 9H	Can withstand more than 9H	Can withstand more than 7H	Can withstand more than 9H	Film Surface Hardness: Meets pencil hardness 3H	Film Surface Hardness: Meets pencil hardness 3H	Film Surface Hardness: Meets pencil hardness 3H
Size Constraints	Originally designed for smaller sizes, and may not scale easily; largest is currently 19"	Originally designed for smaller sizes, and may not scale easily; largest is currently 19"	Originally designed for smaller sizes (6.4" and above) and may not scale easily; largest is currently 30" smallest is 5.7"	Scales to larger size, not suitable for below 5.7"	Originally designed for smaller sizes and may not scale easily; largest sensor is 19"	Originally designed for smaller sizes (6.4" and above) and may not scale easily; largest sensor is 19"	Originally designed for smaller sizes (6.4" and above) and may not scale easily; largest sensor is 19"