# Technology Review:

# Point of Sale and Self Service Kiosk Touch Screens

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Version 5.2
December 20, 2006

# Contents

# Introduction

The purpose of this paper is to compare the major touch technologies used today in large screen (10.4" or larger) Point of Sale (POS) and consumer self-service solutions. This paper will deal primarily with finger input devices.

## Objectives

- Review Touch Technologies
- Functional Characteristic Comparisons
- Usage Model Comparisons
- IR Pros and Cons Relative to Competition
- Discuss Signature Capture capabilities of large touch screens

## IBM Retail Store Solutions Requirements & Selection Criteria

- Total cost of ownership - One must consider not only the initial purchase price, but long term costs including operation and maintenance costs.
- Accepted input devices - Will the technology work with a finger, a gloved finger, a metal stylus, a nonconductive stylus, a credit card, and/or a long fingernail? Are these input methods important to the application?
- Image quality of the underlying display - If the product will be used in very high ambient light, the effect of glare must be considered. Are clarity, brightness and readability of the display important to the application?
- Durability - Are there coatings or fragile surfaces that will wear out after repeated use? How harsh is the intended environment? Will it be used in the public sector (many end users, few of which are concerned with the life of the product or the cost of replacement or service)?
- Reliability - What is the impact of any downtime for repair?
- Sealability and Chemical Resistance - Is the screen likely to be subjected to spills and/or cleaning with harsh chemicals?

## Terminology

- Sensor - The instrument that is actually touched. For these technologies, this is always a piece of glass, sometimes with conductive coatings or plastic overlays.
- Transmittance - A measure of the amount of light that will pass through the touch sensor. Light is lost at each interface between differing materials, such as air/glass. The more interfaces, the more light is lost. This has a direct bearing on the Contrast Ratio (CR) of the underlying image, as well as the luminance.
- Specular reflection - A measure of the amount of light reflected in a single direction (as opposed to diffuse reflection, where a single beam of light will be reflected in many directions).
- Contamination – The existence of foreign matter on the touch panel. This can include fingerprints, dirt, cleaning agents, etc.
- Glare - A measure of the specular reflection. This directly (and dramatically) affects the CR of the underlying image.
- Response Time - A measure of the time from controller detection of a touch to the controller reporting the X/Y coordinates to the application.
- Resolution - The theoretical number of touch points that can be detected.
- Accuracy - A measure of the ability to actually touch the intended location.
- Palm Rejection - The ability of the touch technology to detect only the stylus while ignoring objects such as the palm when resting on screen as typically done for signature.

## Touch Technologies Discussed

- Resistive
- Capacitive
- Surface Acoustic Wave (SAW)
- Scanning Infra-Red (IR)
- Acoustic Pulse Recognition (APR)
- Dispersive Signal Technology (DST)

# Touch Technologies in Depth

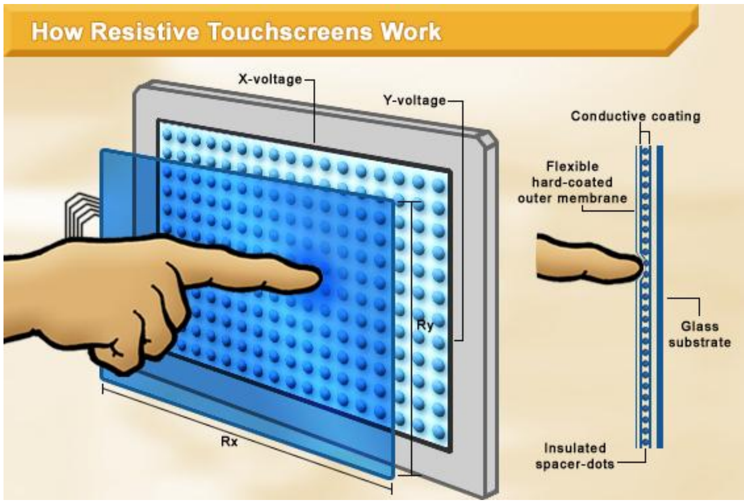
Each of the various types of touch technology has its own pros and cons. Before we proceed with a detailed analysis and comparison, we have provided a detailed summary of each technology below.

## Resistive

This paper will not attempt to discuss all the various flavors of resistive (4-wire, 5-wire, 7-wire, and 8-wire), as they all fundamentally have the same operation. The sensor consists of a piece of glass with a conductive coating on top, plus a polyester top sheet with a conductive coating on the bottom. The conductive surfaces are held apart by "spacer dots", usually glass beads that are silk-screened onto the coated glass. On a 5-wire design (the most commonly used type of resistive in large screen POS applications); a voltage is applied to the 4 corners of the glass layer. When a person presses on the top sheet, it is deformed and its conductive side comes in contact with the conductive side of the glass, effectively closing a circuit. The voltage at the point of contact is read from a wire connected to the top sheet.

Advantages
- Can be activated with any device
- Low cost solution
- Low power consumption

Disadvantages
- Poorer durability compared to other technologies
- Very short life, especially considering cosmetic wear
- Poorer transmittance and overall optical quality (due to plastic overlay and multiple layers), compared to other technologies
- Requires periodic recalibration



## Capacitive

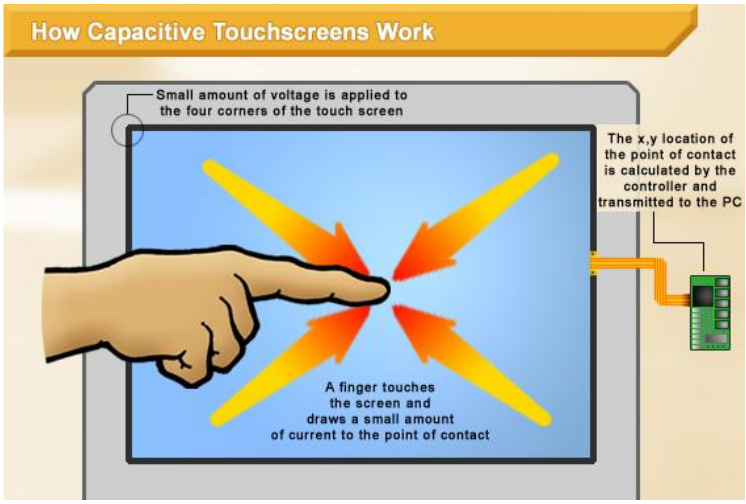
The capacitive sensor has a conductive coating on the front surface with wires connected to each corner. A small voltage is applied to each of these 4 corners. The operation relies on the capacitance of the human body. When a person touches the screen, a small current flows to the point of touch, causing a voltage drop which is sensed at the 4 corners.

Advantages

- More durable than resistive (because the top layer is not plastic)
- Higher transmittance than resistive (fewer layers)

Disadvantages

- Glare (worst of all technologies)
- Accepts input from finger only (or a special, tethered conductive stylus)
- Susceptible to electromagnetic interference (e.g. a Sensormatic security device used in close proximity will cause an erratic cursor location)
- Accuracy is dependent on capacitance of person touching as well as the capacitance of the “environment”. Some people with low body capacitance will have difficulty in even registering a touch.
- Requires periodic calibration



## Surface Acoustic Wave (SAW)

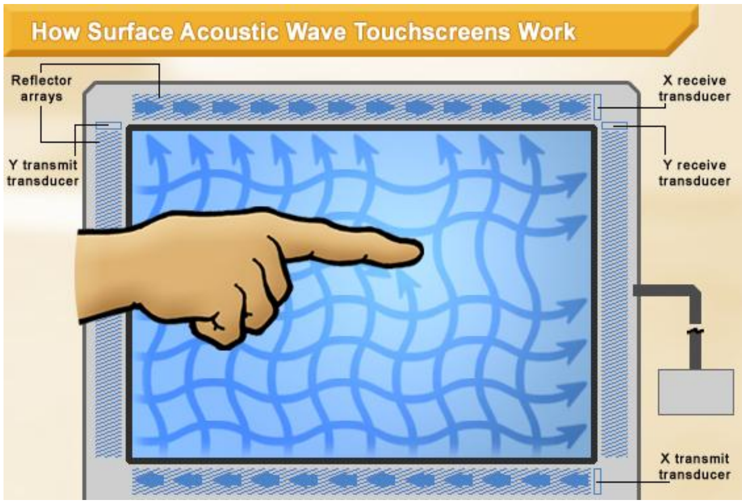
A SAW touch screen consists of a piece of glass with "sound wave reflectors" deposited along all 4 edges. Two emitting transducers are mounted in two corners and receivers are mounted in the opposing two corners. A sound wave travels parallel to the borders of the glass. As it encounters the sound wave reflectors, some of it is passed through to the next sound wave reflector, and some of it is reflected across the touch screen. On the opposite side, the wave is passed through the sound wave reflectors to the receivers. The receivers can detect a drop in amplitude of the sound wave when a sound absorbing material (such as a finger) is placed in contact with the glass.

Advantages

- Very high transmittance
- Very high durability

Disadvantages

- Cannot be sealed
- Requires "soft" input device
- Surface obstructions can cause a false touch



## Scanning Infra Red (IR)

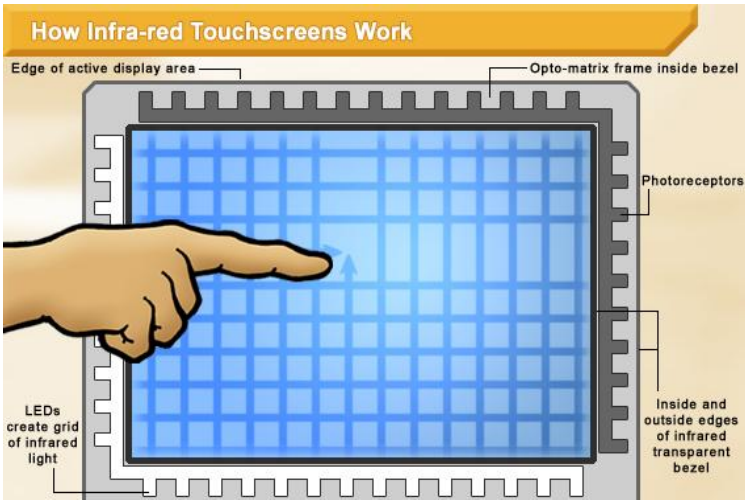
IR uses of a Printed Circuit Board (PCB) "frame" around the perimeter of the display. On two sides there are closely spaced IR LEDs and on the opposing two sides there are matching photo transistors. The LEDs are turned on in sequence and the signal is read from the matching transistor. If no signal is read, then that indicates a blocked IR beam, meaning a touch. No actual touch "screen" is required for operation, however a plate of glass is generally used to protect the underlying display from damage and to provide anti-glare.

Advantages

- Highest quality of underlying image
- Very high transmittance (no conductive layers, only glass between end user and image)
- Excellent anti-glare, with use of chemically etched glass
- Can be activated with almost any device
- Higher accuracy than other technologies
- Very high durability and reliability
- One time factory calibration
- Can be sealed
- No wear mechanism

Disadvantages

- Lower resolution than other technologies
- Surface obstructions can cause a false touch



## Acoustic Pulse Recognition (APR)

***NOTE:*** *The information provided below on APR is provided as an early look at one of the new technologies under development. It is not included in any of the details further in this paper.*

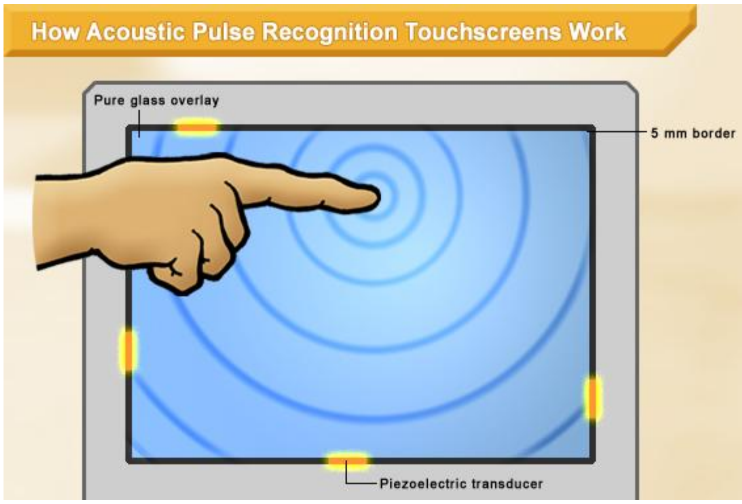
Acoustic Pulse Recognition (APR) works by recognizing the sound created when the glass is touched at a given position. APR provides optical qualities, durability, and stability, with dragging capability. It also supports use via stylus, glove and fingernail. It also provides palm rejection during signature capture.

Advantages

- Highest quality of underlying image
- Very high transmittance (no conductive layers, only glass between end user and image)
- Excellent anti-glare, with use of chemically etched glass
- Can be activated with almost any device
- Higher accuracy than other technologies
- Very high durability and reliability
- One time factory calibration
- Can be sealed
- No wear mechanism
- Palm rejection for signature capture

Disadvantages

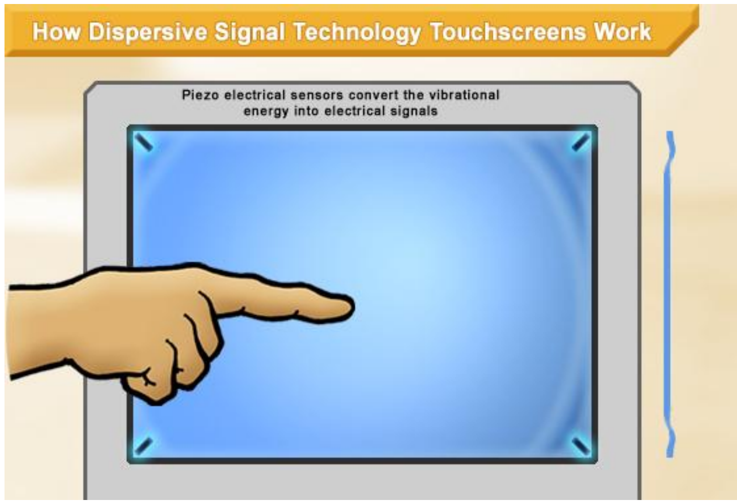
- Not available as OEM component for integration with products
- Based on new technology which has not yet been proven for reliability, durability, usability, etc.



## Dispersive Signal Technology (DST)

***NOTE:*** *The information provided below on DST is provided as an early look at one of the new technologies under development. It is not included in any of the details further in this paper.*

DST works by analyzing the deflection of the glass (bending waves in the glass) to determine touch location.



# Features and Specifications

The table below provides a comparison of the key features and specifications between the major types of touch screens available today.

## Comparison Table

| Parameter | Resistive | Capacitive | SAW | IR |
|---|---|---|---|---|
| **OPTICAL** | | | | |
| **Transmittance** | Poor (75% - 80%) | Good (80% - 91%) (10) | Best (90%) | Best (92%) |
| **Glare** | Good (Antiglare coating) | Poor (High gloss antiglare coating) | Better (Silica coated glass) (11) | Best (Chemically etched glass) |
| **General Image Quality** | Poor (spacer dots, Newton Rings', tint) | Better (tint) | Best | Best |
| **Reliability/Life** | | | | |
| **Durability** | Poor (8) | Better | Best | Best |
| **Reliability** | Good (8) | Better | Best | Best |
| **Sealability** | Good (12) | Best | Poor (12) | Best |
| **Calibration Required?** (1) | Yes (periodic) | Yes (periodic) | Yes (Initial only) | No (Never) |
| **Touch Resolution** (2,3) | Best (100k pts/in$^2$) | Best (100k pts/in$^2$) | Better | Good (450 pts/in$^2$) |
| **Accuracy** (4) | 0.08 | 0.08 | 0.08 | 0.05 |
| **Z axis** | No | No | Yes | No |
| **Response time** (5) | 20ms | 20ms | n/a | 22ms |
| **EMC Susceptibility** | Best | Poor (6) | Good | Best |
| **Usability** | | | | |
| **Finger Input** | Better | Good | Better | Best |
| **Gloved Finger** | Yes | No | Yes | Yes |
| **Metal Stylus** | Yes (8) | Yes (if active tethered) | No | Yes |
| **Credit Card** | Yes (7) | No | No | Yes (8) |
| **Long Fingernail** | Yes (8) | No | No | Yes |
| **Nonconductive Stylus** | Yes (8) | No | Yes (If sound absorbing) | Yes (Min. of 6mm diameter) |
| **Works even with Contamination** (7) | Yes | Yes | No (Blocked reflectors will not function) | No (Blocked beams will not function) |
| **Sensor Life** | 5 Years (8) | 5 Years | 10 Years | 11+ Years (12) |

## Comparison Notes

1. In practice, Resistive and Capacitive seem to require more frequent calibration than IR or SAW. They contain conductive coatings and metal bus bars. The resistance of these, as well as the connections between them, can change over time, requiring recalibration. SAW requires an initial calibration by the end user. Only IBM's IR requires no end user calibration, ever, and it self-calibrates the optics and electronics at every Power On Reset (POR) to maintain accuracy over the life of the product.
    a. It is important to distinguish between Calibration and Video Alignment. Calibration is required to account for variations and changes in the electrical characteristics of the system. Video Alignment is required to associate a particular touch point with a particular point on the underlying image.
2. Both Capacitive and Resistive contain continuous conductive coatings, so the resolution of the sensor is theoretically infinite. Therefore, in theory, the resolution is limited only by the depth (number of bits) of the controller. So what is generally quoted is the theoretical

resolution achievable by the controller. All controllers available on the market today, including IR, are capable of resolving 4096 x 4096 touch points. However, IR is limited in resolution, by the spacing of the LEDs. This can be improved via interpellation by the software. SAW is similarly restricted by the spacing of the sound wave reflectors.

3. In practice, resolution is limited by accuracy. The accuracy of IR is better than the accuracy of the other technologies. Even though it may be theoretically possible to have more touch points with the other technologies, one has no better chance of actually hitting them than with IR. In addition, Resistive and Capacitive accuracy depends on the distance between the conductive traces at the edge, and is often specified as a percentage of the total screen size. So as the size of the display increases, the absolute accuracy gets worse. Accuracy on IR is determined by the LED spacing, so it is fixed, regardless of screen size. All technologies have slightly reduced accuracy at the edges than at the center.
4. Response time is specified as the time from when the controller sees a touch until the x/y coordinates are reported. This does not take into account the overhead of the operating system or application. Thus, it is actually a small fraction of the perceived response time which is the period of time from when a person touches until some action is taken by the application. The very small differences in specified response time for the different technologies do not have a perceptible effect on the total response time.
5. Capacitive is affected by magnetic fields, and is susceptible to ESD. Due to the difficulty in sealing SAW, it is also more susceptible to ESD.
6. If there is sizable contamination on the screen, both SAW and IR will detect a touch. However the firmware has an algorithm to detect this and will ignore this area as well as an area along the x and y axes of the contaminant location. The rest of the screen will function normally. Moreover, it is possible to alert the end user when a “permanent touch” is detected, so that it can be corrected.
7. For resistive, sensor life is defined for complete functional failure. It does not take into account cosmetic damage which can be significant, even after just a short period, especially with usage of implements other than a finger such as pen, credit card, or fingernails. It also does not take into account the increasing frequency of required calibration, due to the breakdown in resistance of the coatings. If it can be made to work via calibration, it is considered functional. Of course, this life (both functional and cosmetic) can be considerably improved with the use of replaceable overlays, but that further degrades image quality due to more layers which then cause light loss).
8. If the corner of a credit card is held exactly perpendicular or exactly horizontal, a touch will not be detected by IR. However, with low profile, high density LEDs, if it is rotated even slightly, it will cause a touch. In tests, 80% of random hits with a credit card were detected as touches.
9. Since what is being touched is just a piece of glass, there is no wear out mechanism. The LEDs do have a life span of approximately 100,000 hours to ½ initial luminance (that’s over 11 years!). Since the photo transistors automatically adjust their gain (calibrate) at every POR, a drop in brightness will not affect the functioning of the frame, and thus the effective life of the frame is considerably longer than that.
10. With the use of embedded anti-reflective coatings, it is possible to improve the transmittance of Capacitive to near that of glass, but this lends a pinkish color to the underlying display. Moreover, the antiglare coating used on the front, in conjunction with these layers, has more glare than the conventional Capacitive product. There is no net improvement to image quality.
11. The silica coated glass has more glare than etched glass.
12. SAW cannot be sealed against many cleaners, since the sound waves must travel on the surface of the glass, and adhesives would block that. Using a highly aggressive adhesive on resistive could cause the top sheet to lift off the glass, resulting in a functional failure.

# Usage Models

The method(s) in which a user is primarily interacting with the touch application is the key factor in considering the best touch technology to be used. Each Usage Model carries several requirements. No touch technology meets all requirements, and thus one must consider the technology which accommodates the most critical.

## Models Compared

**Finger Input – Finger Only**

A primary design point for RSS products. It assumes specialized applications that large touch features. To have good finger touch, the solution must consider long finger nails and gloves along with actual finger touch.

- The touch system is used for selecting large features with a finger
- It should allow usage with gloves and long fingernails

**Finger Input - Convenience-Stylus (C-Stylus) Only**

Considered an extension of finger touch. If the user has something in his/her hand it is sometimes convenient to use it for touch. For example after swiping a credit card the user may use the card, still in her hand, to select “credit” or “debit”. In this definition there is not a stylus designed for the application but something that is being used for the same function. It is important here for a wide variety of objects to be usable as the stylus.

- The touch system is used for selecting large or small features with a common object
- It should allow many common items to be used as a “stylus”

**Stylus Touch**

Using an actual stylus designed for the purpose of operating the touch screen. This method is preferred when the application has small features and sometimes required depending on the touch technology. This is also used for other functions like handwriting recognition and signature capture. For this type of input, a special stylus is acceptable. When used for handwriting, palm rejection is advantageous.

- The touch system is used for selecting small features with a stylus and can also be used for other functions like handwriting recognition
- A special stylus is acceptable
- Palm rejection is advantageous

**Signature Capture**

Applications that enable the end user to provide their signature by “writing” directly on the screen with either a stylus or their finger.

- The touch system is used to capture a representation of a signature
- A Stylus is required, use of finger for signature not feasible
- A special stylus is acceptable
- Palm Rejection is required
- The Sensor Performance must meet minimum requirements
- Should allow the user to comfortably and naturally sign.

## Criteria Used

| | |
|---|---|
| **- -** | Significant disadvantage(s), Not recommended |
| **-** | Some disadvantage(s), Could be OK in special cases |
| **+** | Some advantage(s), Recommended |
| **+ +** | Significant Advantages, Recommended - the best fit |
| N/A | Does not work |

## Comparison Table

| Technology | Usage Model | | | |
|---|---|---|---|---|
| | Finger Inputs | | Stylus | Signature Capture |
| | Finger Only | With C-Stylus | | |
| **Resistive** | + | + | - | - - |
| **Capacitive** | + | - - | + | + |
| **SAW** | + | - - | - | N/A |
| **IR** | + + | + | - | N/A |

## Comparison Results

**Resistive** is a good general purpose touch solution but does not receive the highest marks for any usage because it impacts display quality more than any other touch technology and can be damaged more easily than most. When used for signature capture, abrasion of the top surface can render the screen unreadable and should only be used with an overlay that is replaced on regular basis.

**Capacitive** has a few general issues: impact on display quality, Electromagnetic Susceptibility, and calibration requirements that keep its rating lower for all usage models. It works well for finger touch but it would typically not register a touch by the fingernail and with gloved hands. It was ranked at the bottom for C-Stylus operation since the only chance for C-Stylus operation is if the item used happened to be conductive – not likely and since that means metal and possible scratching of the screen it should be avoided. When a stylus is required by the usage model, one can typically be added to a capacitive touch system. It typically requires an active tether so is ranked lower; otherwise, capacitive works well for these applications and can provide Palm Rejection.

**IR** accepts finger input including with gloves and in most cases long finger nails. One key difference is that it does not actually require a touch as with other technologies. Hovering above the screen can register a touch. In terms a C-Stylus it has to be about a ¼" diameter and not transparent to properly function with IR. It ranks low on Stylus because of resolution and the requirement for larger diameter. It can sometimes be difficult to select small features. In addition to the issues noted for stylus operation it has no palm rejection and a slow scan rate which makes it unusable for signature capture.

**SAW** has the same resolution, scan rate, and palm rejection issues as IR when it comes to usages that require a stylus. It would also require a soft stylus that will absorb sound. It is considered lower on finger input since the fingernail is not accepted as input and due to its environmental rating.

# Overall Results – Keys to Selection of Scanning Infra-Red (IR)

IR is best suited for POS and self service applications because of its extremely high durability, reliability, sealability, immunity to the environment, and display quality. It offers the customer the best "total cost of ownership" (TCO) compared to all other technologies.

## IR Versus Capacitive

- IR is best fit for "finger touch" usage
- IR allows brighter display and best display quality
- IR is the most durable and reliable
- If Stylus is used for Capacitive reliability could be issue, which in turn impacts the TCO
- Capacitive is more immune to screen contamination

## IR Versus Resistive

- Both work well for "Finger Input" usage
- IR allows brighter display and best Display Quality
- IR is the most durable and reliable
- Resistive is more immune to screen contamination

## IR Versus SAW

- Both work well for "Finger Input" usage – although SAW has difficulty with fingernail usage.
- Comparable Display Quality. IR has slight advantage here.
- IR is the most durable and reliable.  Most importantly is the ability to seal the IR panel and avoid problems due to contaminants
- IR allows convenience Stylus – SAW does not

# Signature Capture On Touch Screens

There are certain applications where the capability to enable the end user to provide their signature by "writing" directly on the screen with either a stylus or their finger may be under consideration. This section identifies the challenges with implementing this capability as well as the unique challenges with the various Touch Technologies we have discussed thus far.

## Key Considerations

There are three key topics which must be considered when discussing the use of a large touch screen (> 10.4") as a Signature Capture device.

**Usability**

For POS and Self Service Kiosks, the best mounting locations can typically make Signature Capture on the screen difficult, even impossible in some cases. In addition, the angles for viewing and interacting with a touch enabled application properly are generally much different from that required for signature.

As an example, standard guidelines for a Self Service Kiosk display require that the top of the screen be 54" above the floor. At that height, it is difficult to easily, and accurately provide a signature even when using a stylus. The standard guidelines for the angle of a self service device takes into consideration the effects of lighting, glare, varying user heights and avoiding parallax (the effect of viewing angles on the perceived location of objects on the screen). When keeping within these guidelines the self service screen is typically mounted at an angle between 40 and 90 degrees.

When providing your signature, the surface is ideally mounted flat with as little angle as possible. This allows the person to sign in the most comfortable, consistent manner to obtain the most accurate signature copy.

**Application Design**

The overall design of your application will include several additional complexities to accept signature input. For example, depending on the type of touch technology used and the input method used (i.e. finger or stylus) your application will need to interact directly with the touch screen to make necessary configuration changes allowing the capture, then returning to normal operation after it is complete. Also, the preferred location of the signature capture area on the screen may interfere with existing application design rules such as logo and graphic placement, usability guidelines, etc.

**Associated Costs**

Generally speaking, the concept of Signature Capture on a large touch screen is primarily driven by an attempt to reduce the initial investment to the solution being considered. Although the use of an attached signature capture device has obvious initial costs associated with it, there are other costs associated with the use of the touch screen for signature capture which must be considered.

The largest impact to the TCO is the resulting damage to the panel from the users "signing" over time. Solutions without a glass top surface can easily be functionally damaged by scratching the top surface. Signature Capture increases the probability of sensor damage either due to "signing" with the wrong stylus or just long term wear. In addition, any solution, even those with a glass top surface, will have some abrasion on the surface which, over time, will impact Display Quality in the signature area.

Other costs can be incurred from the requirement to add an active stylus, additional mounting hardware, etc. to complete a customized solution. These additional costs can be comparable to adding an attached Signature Capture / PIN Pad device.

## Signature Capture Requirements

| Characteristic | Recommended Capability | IR Capability |
|---|---|---|
| **Resolution** | 72 dpi<br>(minimum 36 dpi) | 22 dpi |
| **Scan Rate** | 150 sps<br>(minimum 100) | 50 sps |
| **Palm Rejection** | Yes | No |
| **Stylus** | “Pen Like” | Minimum of 1/4 inch (6mm) “touch point” is required, which is not “pen like” |

## Touch Screen with a PIN Pad/Signature Capture Device

Recommended solution for signature capture on Point of Sale and Self Service Kiosks is the integration of a PIN Pad or Signature Capture device. Below is an example of one of the most common mounting options.