



Choosing the Right Touch Technology

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Executive Summary

Touch has become the preferred user interface for a broad range of business applications, including industrial process control, retail point-of-sale (POS), medical equipment and instrumentation, factory automation, inventory management, self-service bill pay and financial transactions, and gaming machines. Increasingly, touch has made its way into consumer products, notably personal digital assistants (PDAs), tablet PCs, video games and various handheld systems.

Although there are more than 100 patented touch-sensing technologies ranging from AT&T's water bottle to Executec's ultrasonic acoustic, only six have been shown to be commercially viable:

- Analog Resistive
- Analog Capacitive
- Infrared
- Matrix
- Surface Acoustic Wave (SAW)
- Projective Capacitive

Although any of these touch technologies will work in most applications, some are better suited than others to specific environments. For each design or product challenge, the list can be refined to one or two technologies with the optimum combination of attributes to ensure success.

Note that there is a large number of modifications to the basic technology that can better adapt one technology to a specific application; an example of this is adding micro-glass to the first surface of analog resistive to improve its vandal resistance.

Designers, engineers and systems integrators must consider a range of variables, including sensitivity to touch, reliability, durability, power consumption, size, environment, and image quality, in order to select the appropriate touch technology for each application.

One touch technology, analog resistive, has demonstrated the widest applicability and broadest market acceptance. In fact, one day's production of analog resistive touch systems exceeds the annual production of all other technologies combined. Arguably, analog resistive touch is the standard against which designers must compare the requirements for each new product.

This paper will present an overview of the five major touch technologies, addressing the issues designers most often evaluate when determining which best meets the needs of specific products. A chart is provided which details the applicability of the various technologies to specific vertical market applications.

An Introduction to Touch Technology

Touch screens developed with the advent of computer displays. The first touch screen was developed at Honeywell when a series of Plexiglas bars were installed over the terminal, and when one of them was pushed, a micro switch was closed to indicate which row had been touched. A transparent version of this, a matrix touch panel, was developed by Sierrac in Transflex and first successfully commercialized as part of an automated chess game. Around the same time the infrared touch system was in development at the University of Illinois, the resistive touch sensor at Oak Ridge laboratories (and first commercialized by Control Data Corporation with the Plato project), and the zone capacitive as a venture product in Minnesota. Later, Zenith developed the surface acoustic wave (SAW), and Touch Technology commercialized the first analog capacitive touch sensor. These are the commercially successful products; however, there are hundreds of other patented technologies for sensing touch.

From an end-user standpoint, touch screens offer unparalleled ease of use, speed, and accuracy, drastically reducing the time required to learn new applications or acquire proficiency with handheld devices. For developers, designers, and users, durability is an added benefit: keyboards are more easily damaged by environmental hazards, such as liquids. Since keyboards are fully exposed, they are more vulnerable to abuse. Mice and other pointing devices also are impractical in many environments; they are fragile, susceptible to dust and liquid, and can contribute to repetitive-motion injuries. A recent industry report reveals that keyboards are the most common device to break in kiosks. In comparison, incidents of touch screen failure are rare; the lifecycle of a touch screen can be measured in years, far longer than the useful life of most keyboards and mice.

Registering the Touch

Most end users are unaware of minor distinctions among the various touch systems they encounter. Resistive touch is pressure sensitive and can use any finger, pen screwdriver, fingernail, or other probe to activate it. Infrared also registers most probes (except those that are very narrow (less than 1/10 of an inch, as is the case with some pens). Capacitive will not “trigger” unless there is body contact, so gloves and pencils will not work.

Capacitive and projective capacitive are capable of registering the lightest touch and are essentially well adapted to “swishing” for applications such as lottery or gambling machines. Surface acoustic wave must have a soft, absorbent touch, so pens and finger nails will not work. Depending upon the resolution of a matrix panel touches between active touch zones may not register.

Sometimes, especially in the case of pen entry systems, it is necessary to discriminate between a finger, palm or hand, and a stylus. Once again, only an analog resistive system is able to make the distinction.

For some applications, a “dual” touch, or touch two or more locations at the same time, is required. While no touch panel is particularly well suited to this, matrix touch technology can be a solution. A special class of touch screens, matrix analog, is designed to register dual touches. Under some circumstances, infrared and surface acoustic wave also can be implemented for dual touches.

Touch Resolution

All touch technologies, with the exception of matrix, have sufficient resolution to accept finger input. A finger is generally about .25 inches (6mm) wide. Typically, a touch screen controller will report coordinates of 1024 x 1024 pixels. The larger the screen, the fewer the points per inch, this is because resolution remains constant while the number of lineal inches goes up. Because most displays have fewer than 1024 pixels on each axis, touch screens are at least pixel accurate. When pen point resolution is necessary, only analog resistive has sufficient resolution to match the pen point.

Image Quality

Image quality is one area where the non-resistive technologies out-perform resistive ones. Infrared touch has no glass or other barrier in front of the display, and yields the best image. Capacitive and surface acoustic technologies make use of a glass surface over the display. Typically, the glass is either clear (that can cause mirror-like reflections) or anti-glare (etched), which reduces reflections but slightly distorts the image. Analog resistive shares these limitations exacerbated by the fact that there are several reflecting surfaces between the display and the point of touch.

Cost

Analog resistive and matrix systems are, by far, the least expensive touch technology. While, in theory, the capacitive sensor should be the least expensive, it requires more costly control electronics. Control functions can be added to analog resistive and matrix touch products with the use of single-chip touch controllers, which are not available for capacitive, infrared, and surface wave acoustic touch systems. A projective capacitive touch screen is slightly more expensive than an equivalent resistive sized touch sensor.

Durability

The maximum life of a touch screen is estimated to be less than 50 million touches in any one location. Each of the technologies discussed here is capable of meeting this expectation. Infrared, projective capacitive and surface acoustic wave should (theoretically) have a nearly unlimited life, but for a variety of reasons, they don't last forever.

Capacitive sensors can wear out, but extra non-conductive coatings on the touch screen surface all but eliminate this concern; vandalism is of greater concern for this technology. The materials used for analog resistive sensors have greatly improved over the last few years to the point where they show little or no wear over the useful life of the touch screen – analog resistive sensors are, in fact, the technology of choice for pen input on handhelds. After several years of use and millions of touches in the same location, the protective coating can wear out, although improved coatings promise to eliminate this problem on new units.

Vandal Resistance/Breakage

Vandalism of touch screens falls into two categories: permanently damaging the terminal or incapacitating the system. The touch systems least vulnerable to damage are infrared and projective capacitive, followed by surface acoustic wave, capacitive, and matrix/analog resistive. On infrared touch screens, LED's are hidden behind an infrared-transmission bezel. Only glass and coated glass are in front of the display on surface acoustic wave and capacitive screens. Analog resistive screens use a hardened poly-ester substrate as the outer surface, although a determined vandal with a sharp knife might be able to cut the surface. Because most people are aware of the explosive (actually implosive) nature of CRTs, vandals have been reluctant to take a hammer to terminals.

“Tricking” touch sensors is difficult. Surface acoustic wave and infrared screens are most vulnerable; sticking chewed gum on the sensor or display, for example, will cause a perpetual false touch. Inadvertent touches to surface acoustic sensors can be caused by fluids or rain, but in real world applications, this is seldom problematic. The electronic controllers are programmed to eventually ignore a constant touch and will reactivate much of the remaining sensed area. Infrared sensors can be triggered by reflections or sunlight, but pulsed sampling has all but eliminated these issues.

Accidental breakage is primarily a problem limited to handheld or semi-portable equipment. As noted earlier, matrix and resistive touch screens are the touch technology of choice for this class of mobile products. (Of these technologies, matrix is often least susceptible to breakage because it is the last technology still made entirely from plastics.

Power Consumption

Matrix and analog resistive technologies are the first choice when power is an issue, and are the only choice for handheld applications. Both technologies can be made to work with the signal power from a COM port, thus obviating the need for external power supplies. Infrared touch consumes the most power and is applicable only to products where power is abundant and battery power is not used.

Special Features

Touch screens are often called upon to perform other functions.

These include:

- EMI and Tempest Shields
- Display Brightness Enhancement
- Color Filters and Color Changes
- Contrast Enhancement
- Implosion Shields
- Privacy Filters
- Phosphor Persistence Filters

Generally, any of these attributes can be incorporated easily into any touch technology. Infrared touch, however, has no sensor, glass or plastic panel over the display and requires a separate non-integrated solution.

Technology	Total System Cost	Image Quality	Life Touches	Vandal Resistance	Resolution	Pen Input	Power Consumption	Typical Market
5-Wire Analog Resistive	Lowest	Medium	50 Million	Moderate	Highest	Yes	Low	Point of Sale
4-Wire Analog Resistive	Lowest	Medium	10 Million	Moderate	Highest	Yes	Lowest	Mobile
Matrix (All Plastic)	Lowest	Lowest	50 Million	High	Lowest	No	Lowest	Factory Automation
Analog Capacitive	Medium	Medium	50 Million	Moderate	Medium	No	High	Gaming & Amusement
Projected Capacitive	Low	Medium	Unlimited	High	Highest	Yes	Low-Medium	Transaction
Surface Acoustic Wave (SAW)	Medium	Best	100 Million	Moderate	Medium	No	High	Kiosk
Infrared (IR)	Highest	Best	Unlimited	High	Lowest	No	High	Ticketing & Medical

Conclusion

Touch technology is as revolutionary a human-machine interface as is the ubiquitous mouse. For many applications – including industrial process control, medical and clean room equipment, handheld devices, and kiosks. Touch systems offer the best combination of functionality, cost, life span and ease-of-use. For designers, engineers and product developers, the choice of touch technology and vendor should include an analysis of these factors as well as the expertise, application experience, cost-deliver-quality track record, and flexibility of the various touch systems vendors.

For More Information

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