Mainstream Touch Technologies

Geoff Walker
June 1, 2009

Agenda

- Introduction [2]
- Mainstream Touch Technologies [25]
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  - Surface Capacitive
  - Surface Acoustic Wave
  - Traditional Infrared
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  - Acoustic Pulse Recognition
  - Dispersive Signal Technology
  - Force Sensing
- Why There Are So Many Touch Technologies [6]
- Conclusions [7]

❶ Described here due to time limitations in the "Emerging Touch Technologies" seminar, which covers an additional six technologies

<begin>A Brief Commercial

NextWindow, Ltd.

- Founded in 2001 by CTO and private investors
- Brief history
  - 2003: First product to market (optical touch for large displays)
  - 2005: Entered USA market
  - 2006: First major volume contract signed (HP TouchSmart AiO)
  - 2008: Entered Taiwan market with ODM focus
- Global presence
  - Headquartered in New Zealand
  - Offices in USA, Taiwan & Singapore
  - Manufacturing in China, Thailand & Malaysia
- Currently focused on two touch-screen markets
  - Windows-7 consumer monitors & all-in-one computers
  - Professional audio-visual, including interactive digital signage
- 65 employees, 50% in engineering **<end>**

Introduction

Source: Elo TouchSystems

Two Basic Categories of Touch

- **Opaque touch**
  - Dominated by the controller chip suppliers
    - Cypress, Synaptics, Atmel, etc.
    - One technology (projected capacitive)
    - Sensor is typically developed by the device OEM
  - Notebook touchpads are the highest-revenue application
    - Synaptics ~60% share; Alps ~30% share; Elan ~10% share
    - Sensors are all two-layer projected capacitive
  - *There is no further discussion of opaque touch in this seminar*
- **Transparent touch on top of a display**
  - Dominated by the sensor manufacturers (80+ worldwide)
  - 12+ technologies

Touchscreen Market (2008)

Technology	2008					
	Small-Med (<10")		Large-Area (>10")		TOTAL	
	Revenue	Units	Revenue	Units	Revenue	Units
Resistive	$1,118M	95M	$473M	13M	$1,591M	108M
Surface capacitive	0	0	$150M	1.5M	$150M	1.5M
Surface acoustic wave	0	0	$90M	1.5M	$90M	1.5M
Infrared	0	0	$73M	0.8M	$73M	0.8M
Mainstream	$1,118M	95M	$786M	16.7M	$1,904M	111.8M
Emerging	$486M	27M	$57M	0.7M	$543M	27.7M
TOTAL	**$1,604M**	**122M**	**$843M**	**17.5M**	**$2,447M**	**139.5M**

Revenue growth over 2007:
60% <10"
4% >10"

Unit growth over 2007:
54% >10"
6% <10"

	Revenue	Units
Small-Medium	66%	78%
Large-Area	34%	22%
TOTAL	100%	100%

	Revenue	Units
Mainstream	78%	**80%**
Emerging	22%	**20%**
TOTAL	100%	100%

Mainstream & emerging in 2007:
90% & 10%

Market size estimates are based on iSuppli's 5/08 Touch Screen Report, with adjustments to remove obvious errors and extraneous data.

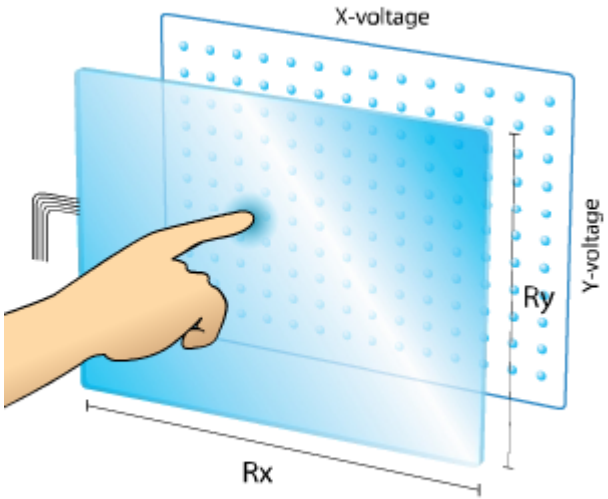
SID SOCIETY FOR INFORMATION DISPLAY

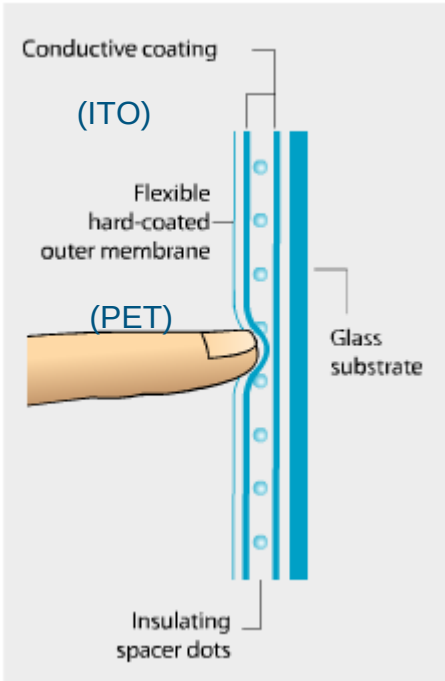
nextwindow

Source: Engadget

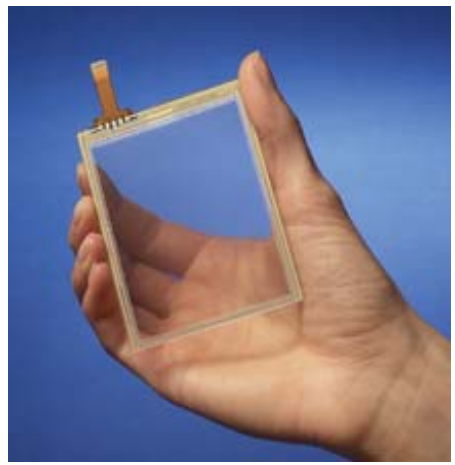
Analog Resistive

Analog Resistive…1





Source: Elo TouchSystems



Source: Bergquist

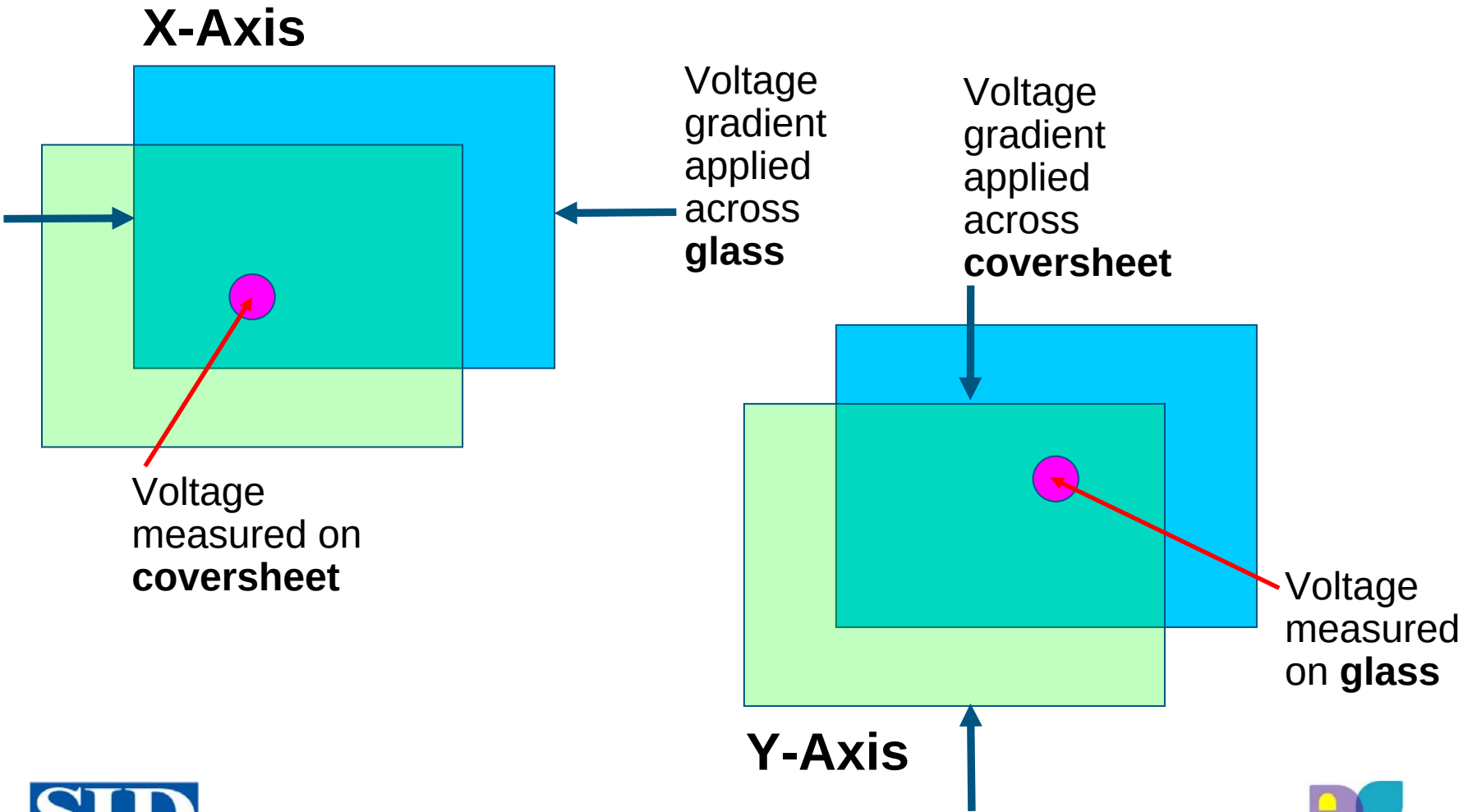
Analog Resistive…2

- **Types**
  - ***4-wire*** (low cost, short life) is common in mobile devices
  - ***5-wire*** (higher cost, long life) is common in stationary devices
- **Constructions**
  - Film (PET) + glass (previous illustration) is the most common
  - Film + film is the thinnest; sometimes used in cellphones
  - Glass + glass is the most durable; gaining share in automotive
  - Film + film + glass, others…
- **Options**
  - Surface treatments (AG, AR, AS), rugged substrate, dual-force touch, high-transmissivity, surface armoring, many others…

Source: Schott

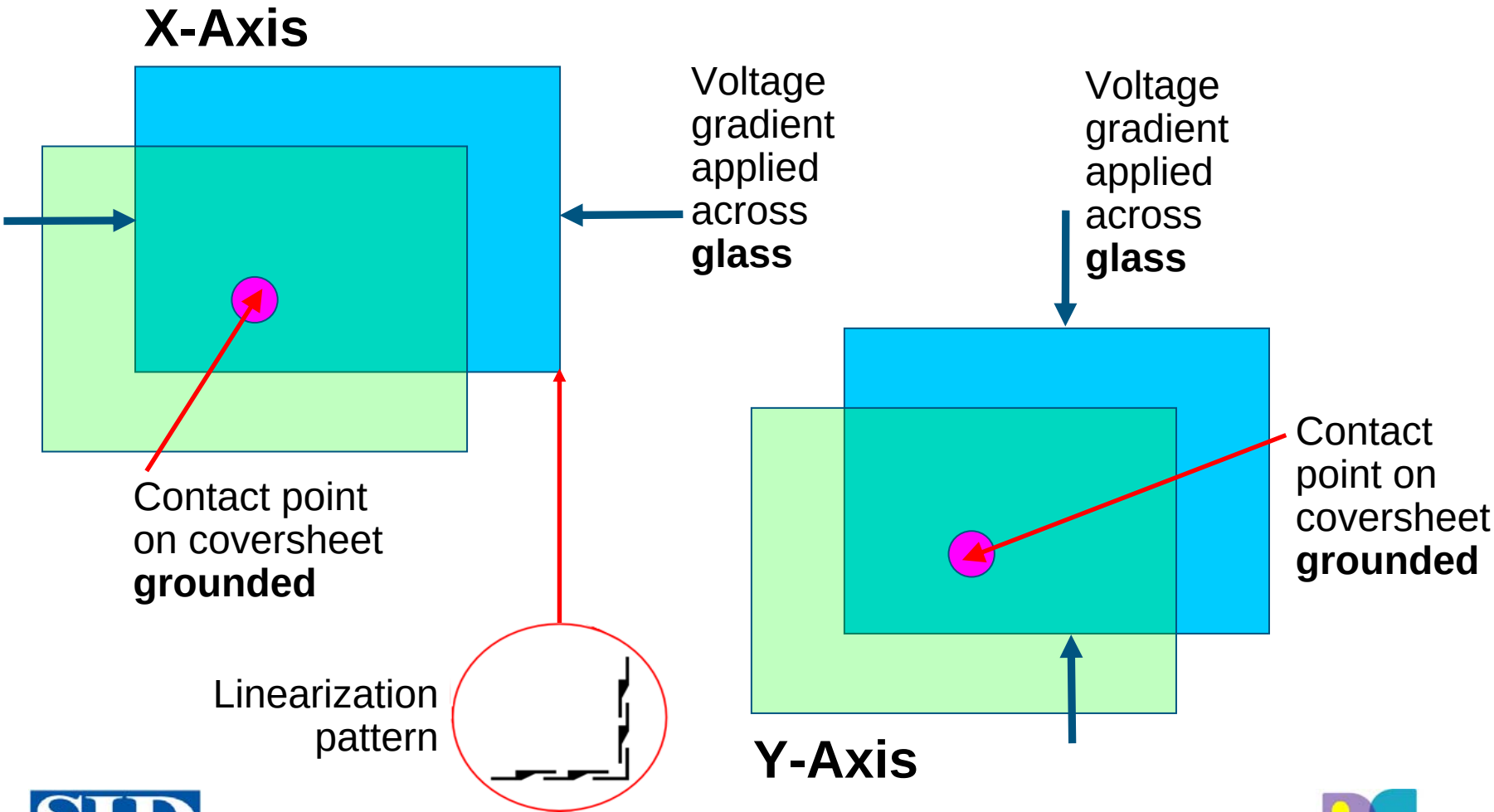
Analog Resistive…3

4-Wire Construction



Analog Resistive…4

5-Wire Construction



Analog Resistive…5

- **Size range**
  - 1” to ~26”
- **Controllers**
  - Many sources
  - Single chip, embedded in chipset, or “universal” controller board
- **Advantages**
  - Works with finger, stylus or any non-sharp object
  - Lowest-cost touch technology
  - Widely available (it’s a commodity)
  - Easily sealable to IP65 or NEMA-4
  - Resistant to screen contaminants
  - Low power consumption

Source: Liyitec

Source: Hampshire

Analog Resistive…6

- **Disadvantages**
  - Not durable (PET top surface is easily damaged)
  - Poor optical quality (10%-20% light loss)
  - Unstable calibration, no multi-touch…
- **Applications**
  - Mobile devices
  - Point of sale (POS) terminals
  - Wherever cost is #1
- **Market share**

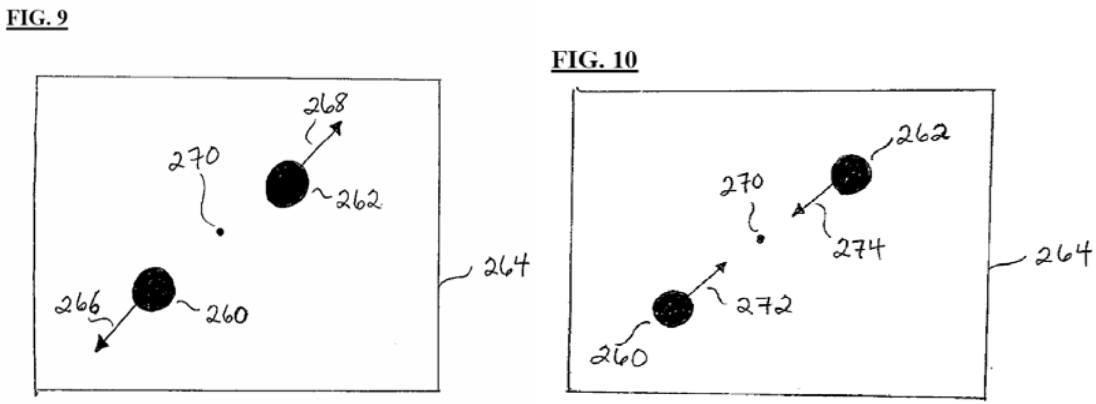
	2007	2008
Revenue	75%	65%
Volume	91%	77%

Analog Resistive…7

- **Suppliers**
  - Nissha, Young Fast, J-Touch, Gunze, Truly Semi, Fujitsu, EELY, Elo TouchSystems, SMK, Swenc/TPO, eTurboTouch…
  - 60+ suppliers
- **Market trends**
  - Analog resistive is losing share (1st time!) to projected capacitive in the mobile market
    - First significant challenge to analog resistive's dominance
  - Substantial price reductions in analog resistive in 2008
    - Some competitors dropped out
  - Analog resistive is still very important in mobile phones in Asia
    - It supports a stylus; projected capacitive doesn't

Something New: Analog Resistive with Two-Finger Gestures

- **An Elo TouchSystems invention recently filed at the patent office…**
- ***Two-finger gestures with <u>standard</u> resistive sensor !***

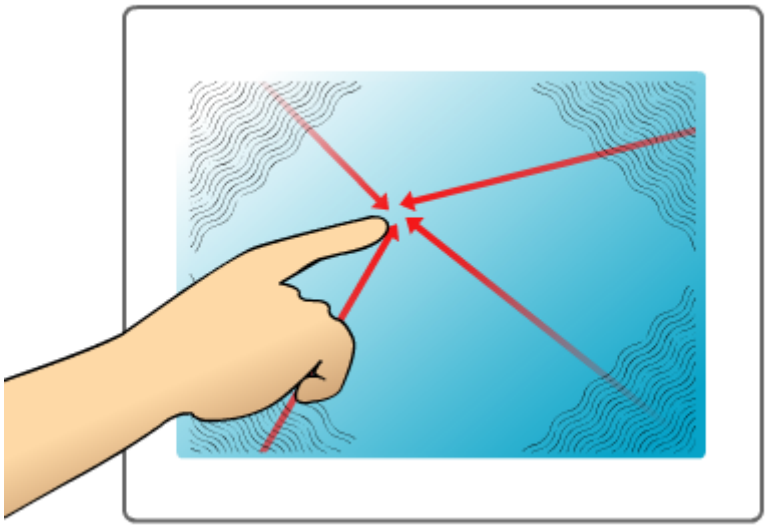


- Two components added to the controller
- Additional firmware in the controller to recognize two fingers
- Gesture-recognition software at a higher level
- Available for licensing from Elo TouchSystems

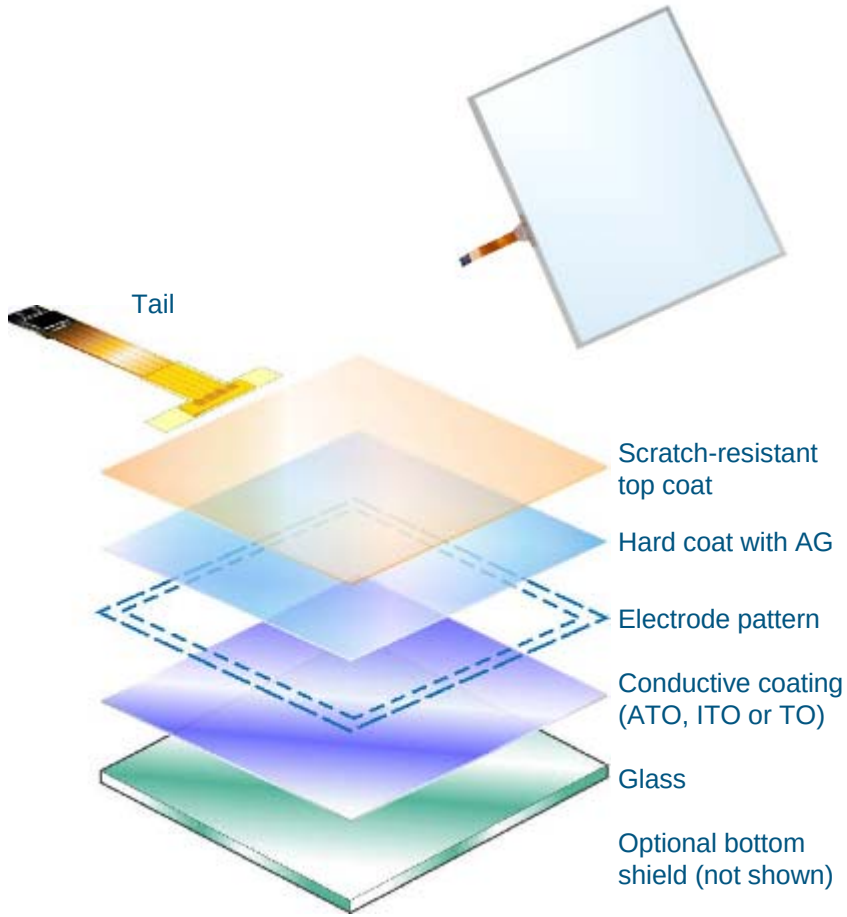
Source: 3M

Surface Capacitive

Surface Capacitive…1



Source: Elo TouchSystems



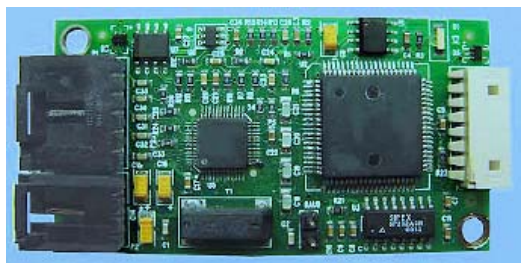
Source: 3M

Surface Capacitive…2

- **Variations**
  - Rugged substrate
- **Size range**
  - 6.4” to 32”
- **Controllers**
  - 3M, Hampshire, eGalax, Digitech and Billabs (ISI)

Source: 3M

- **Advantages**
  - Excellent drag performance with extremely smooth surface
  - Much more durable than analog resistive
  - Resistant to contamination
  - Highly sensitive



Source: Billabs

Surface Capacitive…3

- **Disadvantages**
  - Finger-only
  - Calibration drift
  - Susceptible to EMI (no mobile use)
  - Moderate optical quality (85% - 90% transmissivity)
- **Applications**
  - Regulated (casino) gaming
  - Kiosks
  - ATMs
- **Market share**

	2007	2008
Revenue	8%	6%
Volume	2%	1%

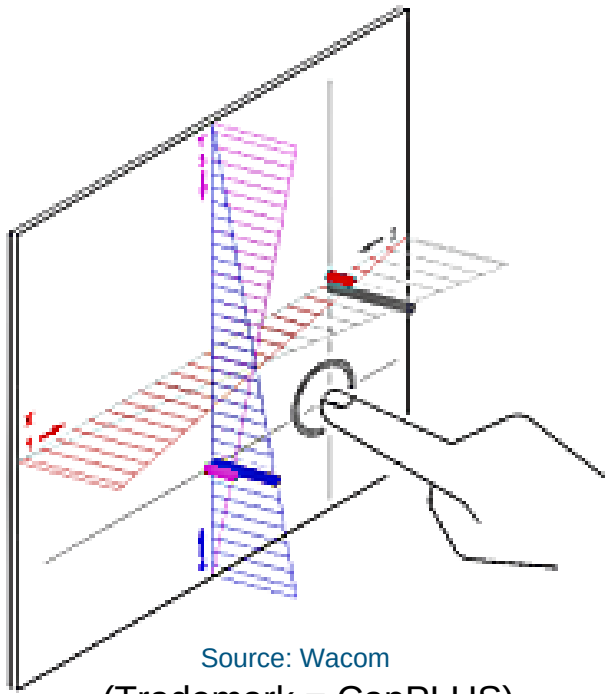
Source: 3M

Surface Capacitive…4

- **Suppliers**
  - 3M, DanoTech, Elo TouchSystems, EELY, DigiTech, eTurbo, Optera, Touch International, Higgstec…
  - 16+ suppliers (dominated by 3M)
- **Market trends**
  - Surface capacitive isn't growing with the touch market
    - No multi-touch capability; other significant disadvantages
    - Casinos (major market) are starting to experiment with other touch technologies
  - Price is dropping as Taiwanese and Chinese suppliers enter the market now that 3M's key patent has expired

Something New: Wacom's RRFC❶ Surface Capacitive Technology

- **How it works**
  - AC voltage on 2 adjacent corners; DC voltage on other 2 corners
    - Creates ramp-shaped electrostatic field across surface
  - Controller switches signals around all 4 corners, creating 4 ramp fields vs. single flat field in standard capacitive
    - Current flow is measured in each case
  - Resulting signal representing touch event is independent of all capacitance effects except those due to finger touch
  - Controller does additional digital signal processing to compensate for factors that affect accuracy and drift



Source: Wacom

(Trademark = CapPLUS)

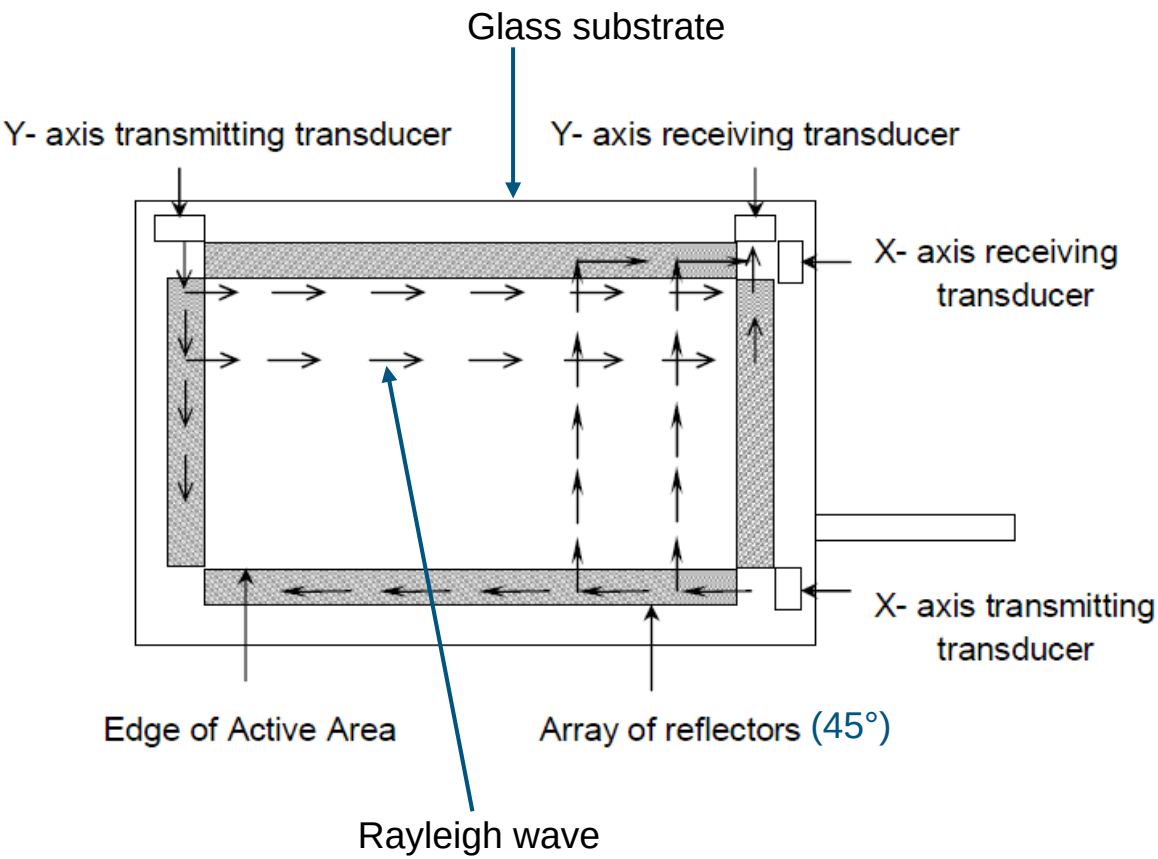
❶ RRFC = **R**eversing **R**amped **F**ield **C**apacitive

Wacom's RRFC Technology…2

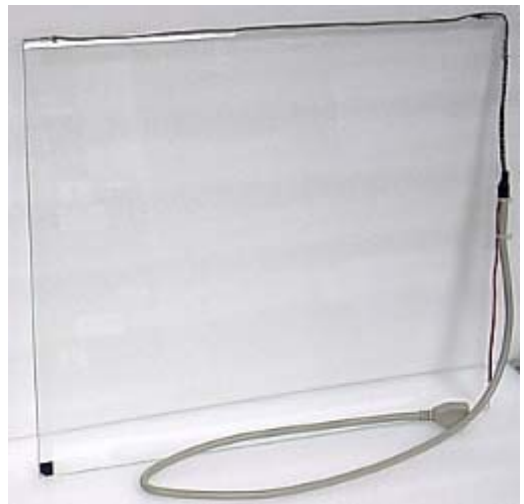
- **Advantages**
  - Works in mobile & stationary devices (3" to 46")
    - Unaffected by grounding changes, EMI, variations in skin dryness & finger size, temperature & humidity variations, metal bezels, etc.
  - Works through latex or polypropylene gloves
  - Allows 4X thicker hardcoat for improved durability
    - Can use standard surface capacitive sensor if desired
  - Screen works outdoors in rain and snow
  - Uses same ASIC as Wacom's EMR pen digitizer, so dual-mode input is lower cost & more efficient (e.g., in Tablet PC)
- **Disadvantages**
  - No multi-touch
  - Sole-source supplier

Surface Acoustic Wave

Surface Acoustic Wave…1

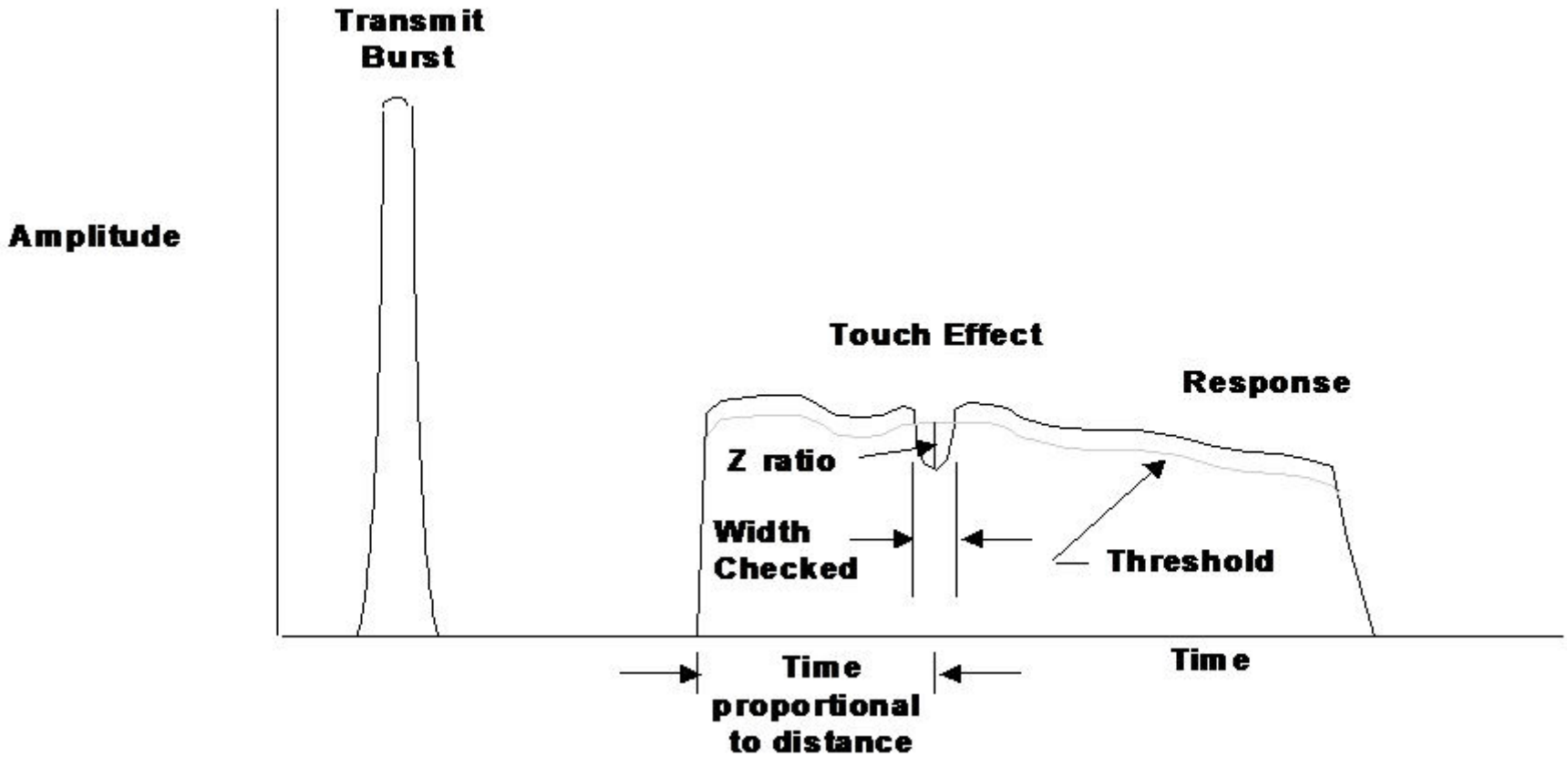


Source: Onetouch



Source: A-Touch

Surface Acoustic Wave…2



Surface Acoustic Wave…3

- **Variations**
  - Ruggedization, dust-proofing, surface treatments, etc.
- **Size range**
  - 6” to 52” (but some integrators won’t use it above 32”)
- **Controllers**
  - Mostly proprietary
- **Advantages**
  - Clear substrate (high optical performance)
  - Very durable
  - Can be vandal-proofed with tempered or CS glass
  - Finger, gloved hand & soft stylus activation

Surface Acoustic Wave…4

- **Disadvantages**
  - Very sensitive to any surface contamination, including water
  - Requires “soft” (sound-absorbing) touch object
  - Can be challenging to seal
  - Relatively high activation force
  - Projects slightly above touch surface (1 mm) so can’t be flush
- **Applications**
  - Kiosks
  - Gaming
- **Market share**

	2007	2008
Revenue	4%	4%
Volume	1%	1%

Source: Euro Kiosks Network

Surface Acoustic Wave…5

- **Suppliers**
  - Elo TouchSystems, General Touch, Shenzhen Top-Touch, Leading Touch, Shenzhen KeeTouch…
  - 10+ suppliers
- **Market trends**
  - Price is dropping as Taiwanese and Chinese vendors enter the market now that Elo TouchSystems' key patent has expired
    - Elo still has >50% of this market
  - SAW's growth is matching the market

Surface Acoustic Wave…6

Illustration courtesy of Fujitsu Labs

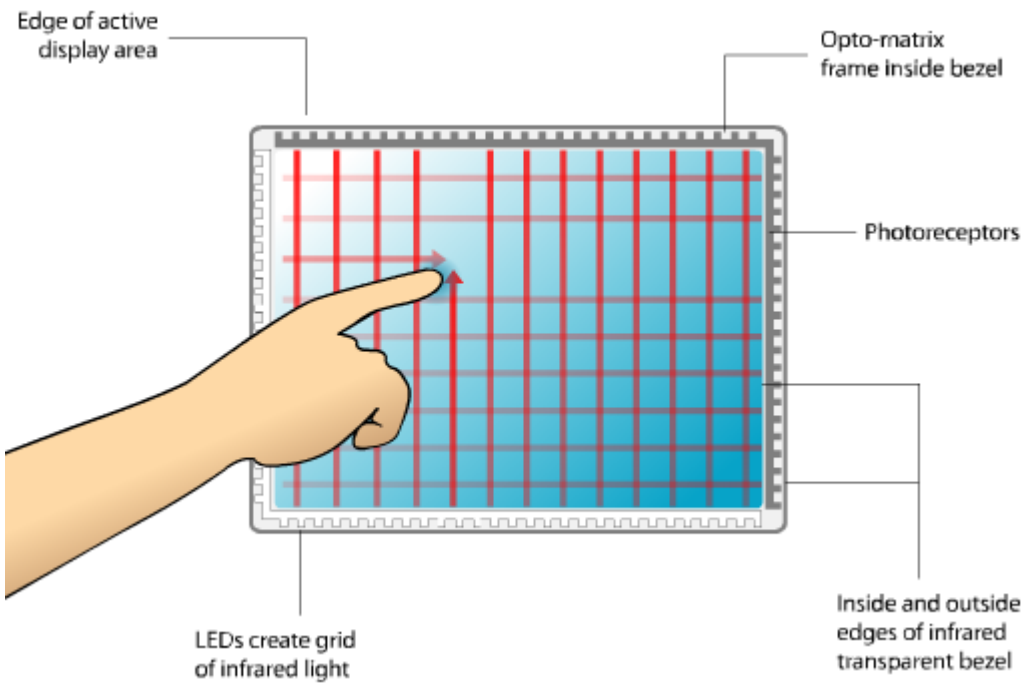
Special Case: Fujitsu Lab's Mobile SAW Prototype

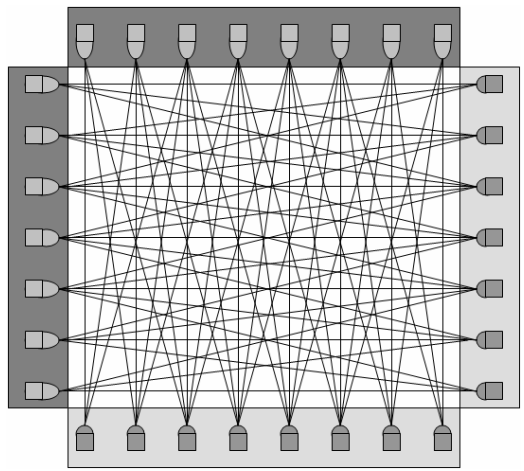
Enabling Technology:

Thin-film piezo transducers that are only 2 microns thick. The transducers are sandwiched in an electrode structure consisting of an array of V-shaped electrodes, all around the screen.

Traditional Infrared

Traditional Infrared…1





Source: Elo TouchSystems

Traditional Infrared…2

- **Variations**
  - Bare PCA vs. enclosed frame; frame width & profile height; enhanced sunlight immunity; force-sensing
- **Size range**
  - 8” to 150”
- **Controllers**
  - Mostly proprietary
- **Advantages**
  - Scaleable to very large sizes
  - Multi-touch capable
  - Can be activated with almost any object
  - High durability, optical performance and sealability
  - Only solution for glass-free mainstream touch (acrylic substrate)

Traditional Infrared…3

- **Disadvantages**
  - Profile height (IR transceivers project above touch surface)
  - Bezel must be designed to include IR-transparent window
  - Sunlight immunity can be a problem in extreme environments
  - Surface obstruction or hover can cause a false touch
  - Low resolution
  - High cost

- **Applications**
  - POS
  - Kiosks
  - Large displays (digital signage)
- **Market share**

	2007	2008
Revenue	4%	3%
Volume	1%	1%

Traditional Infrared…4

- **Selected suppliers**
  - Elo TouchSystems, IRTouch, SMK, Minato, Nexio…
  - 10+ suppliers
- **Market trends**
  - Interest in IR is re-awakening as Asian vendors bring down prices, large displays become more common, and digital signage becomes more affordable
  - IR is growing, but isn't keeping up with the market

50" plasma display with infrared touch-screen from Netrax

Traditional Infrared…5

- **Special Case:** Neonode cellphone implemented with traditional infrared touch
  - Same battery life as iPhone
  - Low profile height (~1.7mm)
  - Finger-only
  - No multi-touch

- May be the only current mobile device that uses traditional IR

Illustrations courtesy of
Neonode & Pen Computing

Three Emerging Touch Technologies

- Acoustic Pulse Recognition (APR)
- Dispersive Signal Technology (DST)
- Force Sensing

None of these currently support multi-touch

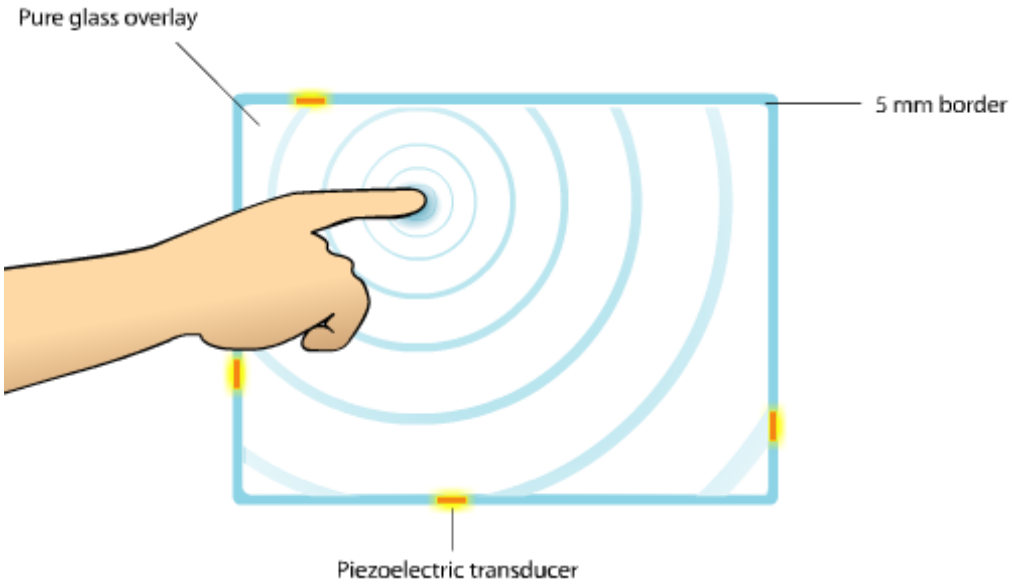
Acoustic Pulse Recognition (APR)

"Zero-Bezel"

Single piece of glass (no bezel); black margin is fired-on glass frit on underside

Source: Elo TouchSystems

Acoustic Pulse Recognition (APR)…1



Source: Elo TouchSystems

- Plain glass sensor with 4 piezos on the edges
- Table look-up of acoustic touch “signatures”

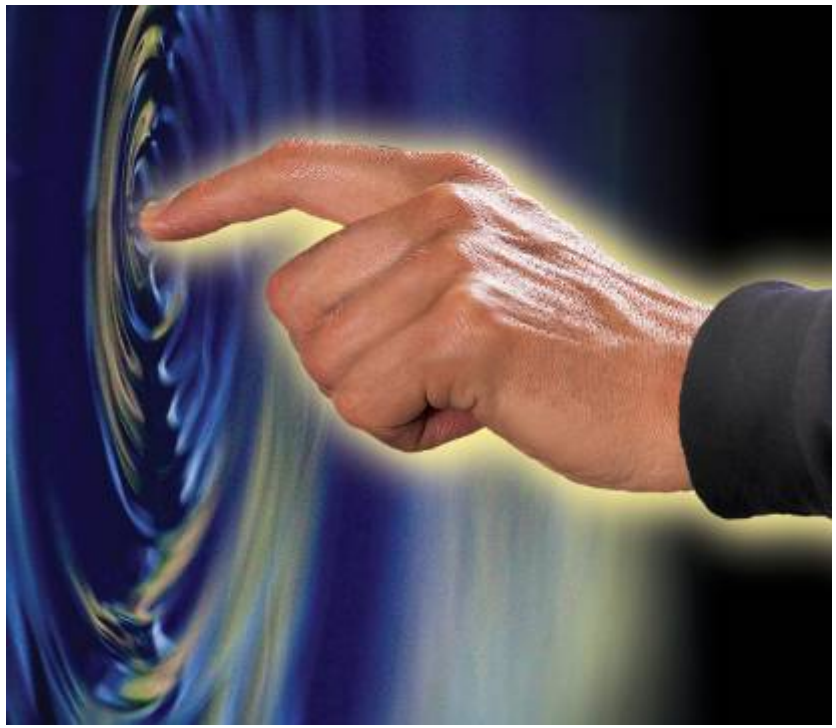
Acoustic Pulse Recognition (APR)…2

- **Variations**
  - "Stationary APR" from 10" to 52" with controller board
  - "Mobile APR" from 2.8" to 10" with controller ASIC
- **Size range**

  2.8" to 52"
- **Controllers**
  - Proprietary
- **Advantages**
  - Very simple sensor (plain glass + 4 piezoelectric transducers)
  - Works with finger, stylus or any other touch object
  - Very durable & transparent touch sensor
  - Resistant to surface contamination; works with scratches
  - Totally flush top surface ("Zero-Bezel")

Acoustic Pulse Recognition (APR)…3

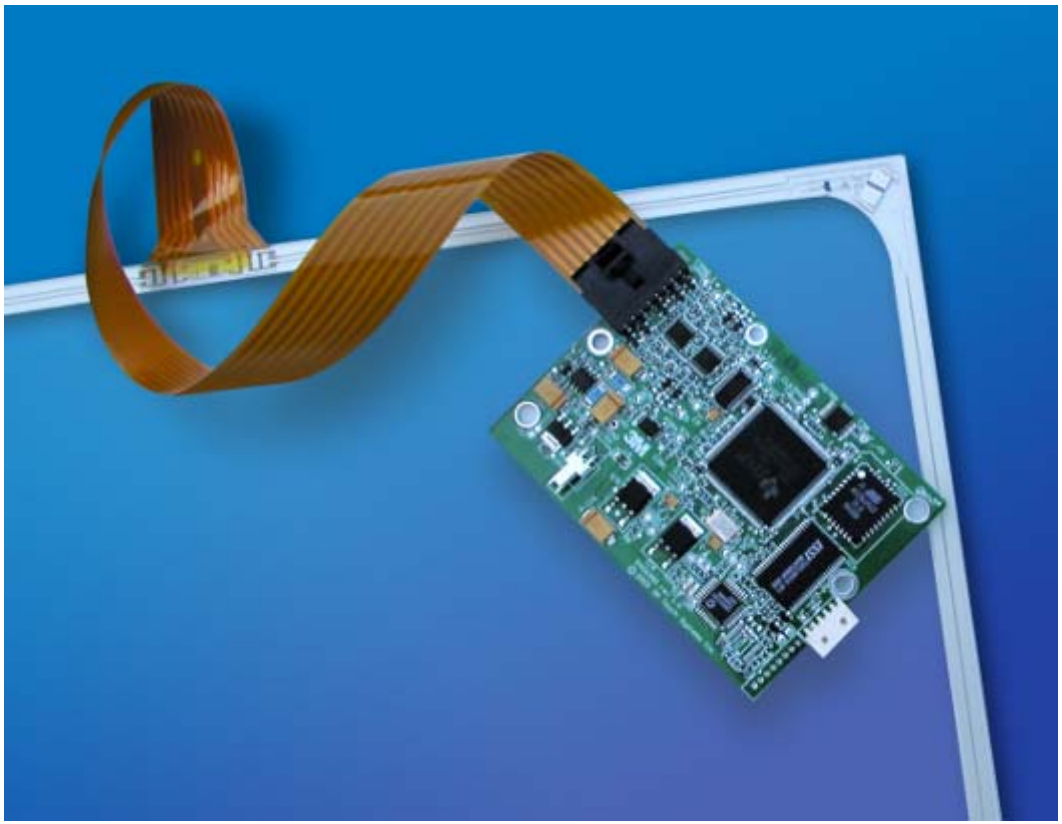
- **Disadvantages**
  - No “touch & hold”; no multi-touch (both under development)
  - Requires enough touch-force (tap) to generate sound
  - Control of mounting method in bezel is critical
- **Applications**
  - POS, kiosks, gaming, mobile devices
- **Market share**
  - <1% (first production in Elo monitors was at the end of 2006)
- **Supplier**
  - Elo TouchSystems (sole source)
- **Market trends**
  - Elo is just beginning to make APR available as a component for mobile devices



Source: 3M

Dispersive Signal Technology (DST)

Dispersive Signal Technology…1



Source: 3M

- Plain glass sensor with 4 piezos in the corners
- Real-time analysis of bending waves in the glass (“time of flight” calculation)

Dispersive Signal Technology…2

- **Variations**
  - Initial product performance was unsatisfactory; product was withdrawn from market for 16 months and re-launched 4/07
- **Size range**

  32” to 46” (3M will probably expand into larger sizes)
- **Controller**
  - Proprietary
- **Advantages**
  - Very simple sensor (plain glass + 4 piezoelectric transducers)
  - Works with finger, stylus or any other touch object
  - Very durable & transparent touch sensor
  - Operates with static objects or scratches on the touch surface
  - Fast response; highly repeatable touch accuracy; light touch

Dispersive Signal Technology…3

- **Disadvantages**
  - No “touch & hold”; no multi-touch
  - Control of mounting method in bezel is critical
- **Applications**
  - Interactive digital signage; point-of-information (POI)
- **Market share**
  - < 1%
- **Supplier**
  - 3M (sole source)
- **Market trends**
  - DST still has a relatively low market profile due to 3M’s very conservative rollout
  - 3M avoids cannibalizing their surface-capacitive sales (<32”)

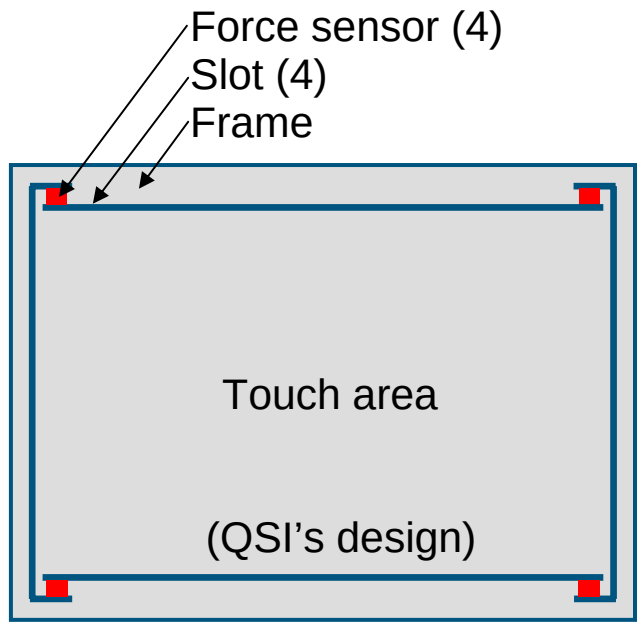
APR vs. DST (Differences)

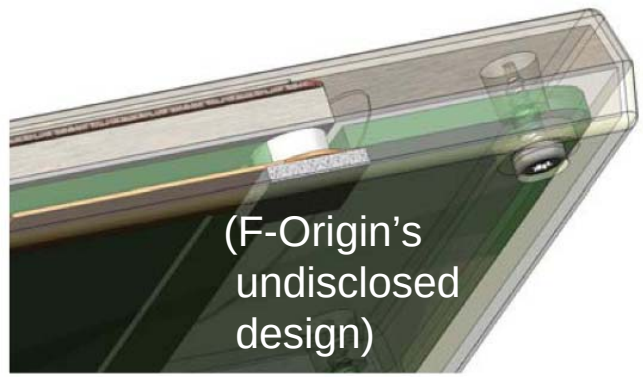
Characteristic	APR	DST	Notes
Size range	2.8”-52”	32”-46”	3M surface capacitive is 5.7”-32”
Methodology	Table lookup	Real-time	
Measurement	Sound waves	Bending waves	
Multi-touch	Under development	Gestures announced	3M’s “multi-touch gestures” only work with moving points
Touch & hold	Under development	No	
Activation force	Moderate	Light	
Controller	Chip (mobile) Board (fixed)	Board (fixed)	
Mounting	Critical	Critical	
Availability	In monitors; components for mobile devices	In monitors	Neither technology has reached the “drop-in touch-screen” component state yet
Others	Similar	Similar	Performance, materials, surface treatment, interface, etc.

Force Sensing

Force Sensing…1

- **Principle**
  - Suspend the touch-screen from force-sensors (strain gauges or piezos) such that movement is constrained to only the z-axis
- **Variations**
  - **QSI:** “Beam-mounted” sensors
  - **F-Origin:** Uses monofilament
  - **IBM “TouchSelect”:** Strain gauges (early 1990s, unsuccessful)
- **Size range**
  - **QSI:** 5”-48”
  - **F-Origin:** 6.5”-15”





Force Sensing…2

- **Controller**
  - Proprietary
- **Advantages**
  - **QSI:** Complete substrate design freedom – no other touch technology can handle three-dimensional substrates with embedded moving objects
  - **F-Origin:** High durability, stylus independence, simple controller
- **Disadvantages**
  - **QSI:** No vibration under 10 Hz; no rapid-fire touches (>200 ms required between touches); no multi-touch
  - **F-Origin:** TBD (probably similar to QSI)

Force Sensing…3

- **Applications**
  - **QSI:** 3D architectural applications
  - **F-Origin:** Smartphones to kiosks (no clear focus yet)

Source: QSI

- **Market share**
  - <<1% (both suppliers are really just getting started)
- **Market trends**
  - **QSI's** "architectural" focus (e.g., a 3D elevator control panel made of steel, glass & stone containing an embedded LCD with "soft keys" and a speaker) is strongly differentiated with some unique capabilities
  - **F-Origin's** attempt to compete in the "traditional" touch-screen space seems a bit like a solution looking for a problem…

Force Sensing…4

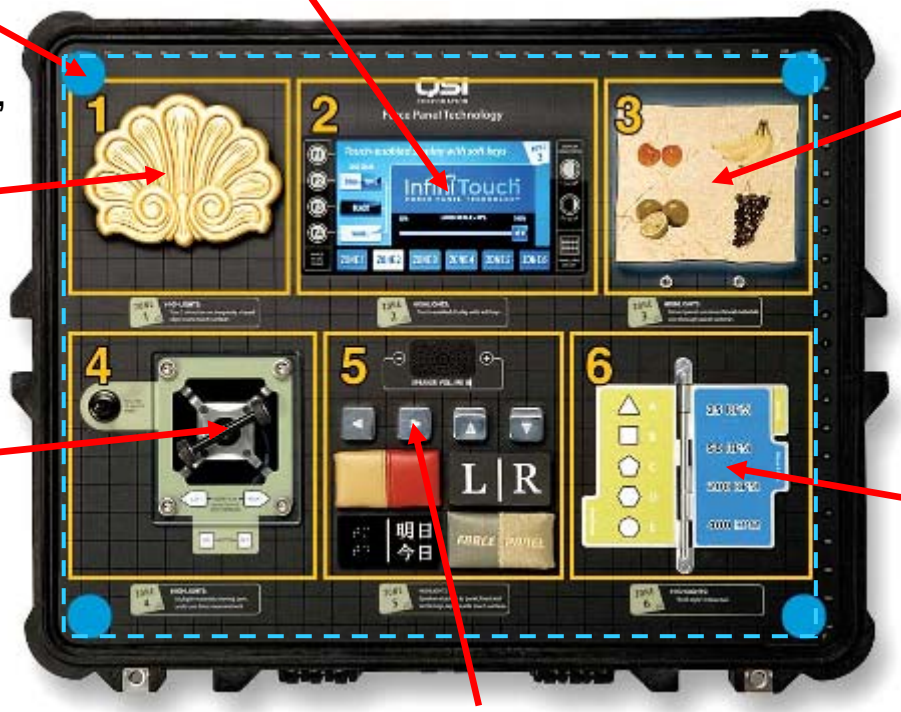
QSI's Demo Box

4 strain gauges supporting one touch panel

Glass-covered LCD integrated into touch panel with "soft keys" printed on back of glass

Irregularly shaped, raised, textured, wooden touch surface

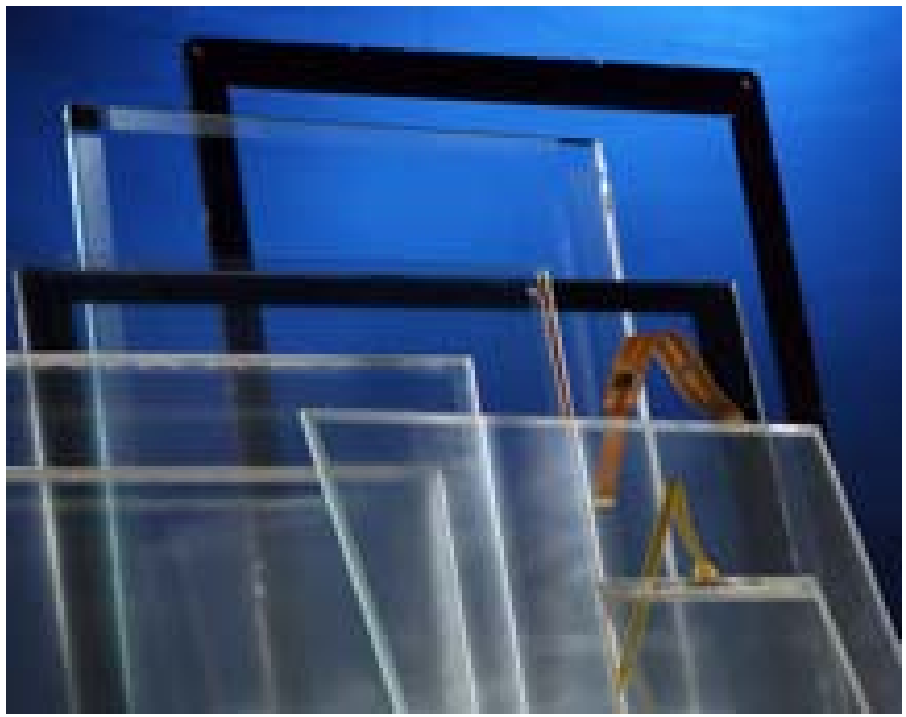
Motor attached to and penetrating touch panel with printed speed control keys and push-pull control lever



Raised, marble touch surface with toggle switches penetrating touch panel

Multi-page "book" with touchable & movable metal pages

"Snap-dome" keys attached to touch panel; removable padded and textured keys; speaker attached with holes through the touch panel.

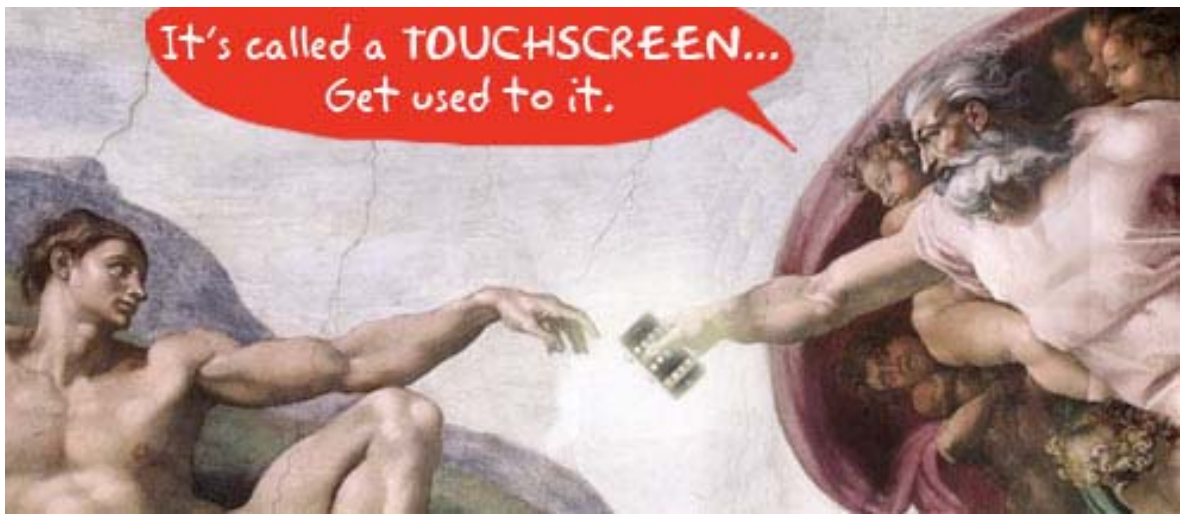


Source: Elo TouchSystems

Why There Are So Many Touch Technologies

Why There Are So Many Touch Technologies

1. **Proliferation of touch**
2. **Touch is an indirect measurement**
3. **There is no perfect touch technology**
4. **The drive for fundamental intellectual property**
5. **Vertical integration**



Source: Gizmodo

❶ Proliferation of Touch

- Self-service eliminates humans & saves $$
- Increasing display ubiquity & decreasing display cost
- Simplification of the user interface
- Hand-eye coordination
- Shrinking device size
- Single global hardware device
- Increased awareness of value
- Viral behavior (the iPhone effect)

Source: Apple

❷ Touch Is An Indirect Measurement

What's Being Measured	Touch Technology
Voltage	**Resistive** (all forms)
Current	**Surface capacitive**
Time delay	**Surface acoustic wave**
Change in capacitance	Projected capacitive; LCD in-cell (capacitive)
Absence of light	**Infrared** (all forms), camera-based optical, LCD in-cell (optical in high ambient)
Presence of light	LCD in-cell (optical in low ambient)
Image	Vision-based optical
Sound	**Acoustic Pulse Recognition (APR)**
Bending waves	**Dispersive Signal Technology (DST)**
Force	**Force sensing**
Resistance (contact closure)	LCD in-cell (resistive)

The ideal method of detecting touch has yet to be invented!

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❸ There Is No Perfect Touch Technology

Characteristic	Analog Resistive	Projected Capacitive	APR	Waveguide Infrared	Traditional Infrared	Digital Resistive	LCD In-Cell
Stylus Independence	☑	🕷	💰	☑	🕷	☑	🕷
Multi-Touch	🕷	💰	🕷	☑	☑	💰	💰
Durability	🕷	💰	💰	💰	💰	🕷	☑
Optical Performance	🕷	☑	💰	💰	💰	🕷	💰
Flush Surface	☑	💰	💰	☑	🕷	☑	💰
Power Consumption	💰	☑	💰	☑	🕷	💰	🕷
Stable Calibration	🕷	💰	💰	💰	💰	🕷	💰
Narrow Borders	☑	☑	💰	☑	🕷	☑	💰
Substrate Independence	☑	💰	☑	💰	💰	☑	💰
Cost	💰	🕷	☑	☑	🕷	☑	🕷

Selecting touch technology for a smartphone

💰	Best
☑	OK
🕷	Worst

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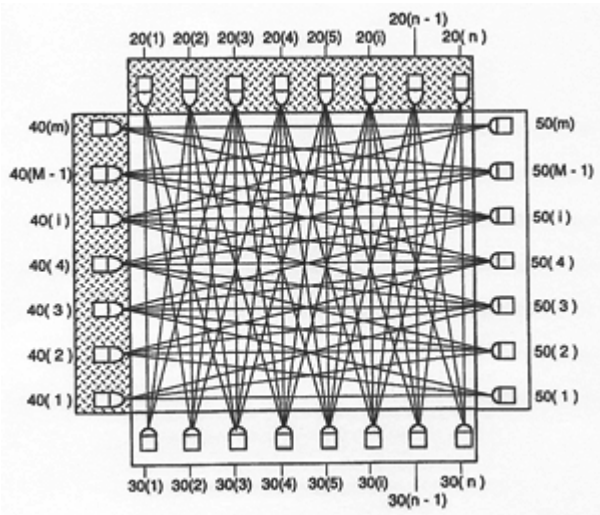
❹ The Drive For Fundamental Intellectual Property

- **The fundamental intellectual property (IP) on all four of the traditional touch technologies <u>has expired</u>**
  - ✦ New patents tend to be on enhancements



"Cross-beam" light paths increases resolution and fault-tolerance in infrared touchscreens (Elo)

- **Companies trying to establish a <u>sustainable competitive advantage</u> in touch create new technologies**

❺ Vertical Integration

- **LCD in-cell touch**
  - When touch was insignificant, LCD manufacturers ignored it
  - Now that it's becoming more significant LCD manufacturers want to incorporate it into their products
- **Three types**
  - Optical: Phototransistor in each pixel
    - ✖ Can't sense touch on a dark on-screen object in low light
  - "Resistive": Contact-closure sensing in each pixel
    - ✖ User must touch the surface of the LCD (poor durability)
  - Capacitive: Laminated projected capacitive sensor ("on-cell")
    - ✖ Standard shortcomings of projected capacitive (e.g., no stylus)

"There is no perfect touch technology"

Source: CG4TV

Conclusions

There Is No Perfect Touch Technology!

Technology	Major Advantage	Major Flaw
Analog Resistive	Low cost	Low durability
Digital Resistive	Multi-touch	Low resolution
Surface Capacitive	Touch sensitivity	High drift
Projected Capacitive	Multi-touch	Finger-only
Surface Acoustic Wave	Durability	Hard to seal
Traditional Infrared	Reliability	High cost
Waveguide Infrared	Low cost	Contamination
Camera-Based Optical	Scalability	Profile height
Acoustic Pulse Recognition	Any touch-object	No touch & hold
Bending Wave	Any touch-object	No touch & hold
Force Sensing	3D substrate	No multi-touch
Vision-Based Optical	Multi-touch	Rear projection
LCD In-Cell (Optical)	Integration	Sensitivity
LCD In-Cell (Capacitive)	Integration	Durability
LCD In-Cell (Resistive)	Integration	Durability

13 Usability Characteristics

There is

Desirable Characteristic	Touch Technologies													
	Analog Resistive	Digital Resistive	Surface Capacitive	Projected Capacitive	SAW	Traditional IR	Optical Waveguide IR	Camera-Based Optical	APR	Bending Wave	Force Sensing	LCD In-Cell (Optical)	LCD In-Cell (Capacitive)	LCD In-Cell (Resistive)
Usability														
Touch with any object	H	H	L	L	M	H	H	H	H	H	H	L	L	L
No unintended touch	H	H	H	H	H	L	L	L	H	H	H	H	H	H
Multi-touch	L	H	L	H	M	M	M	H	L	L	L	H	H	H
Touch & hold	H	H	H	H	H	H	H	H	L	H	H	H	H	H
High durability	L	L	M	H	H	H	H	H	H	H	H	L	L	L
High sensitivity (light touch)	H	H	H	H	M	H	H	H	M	H	L	H	H	M
Fast response & drag	H	H	H	H	M	M	H	H	M	H	M	M	M	H
Stable calibration	M	M	L	H	H	H	H	H	H	H	H	H	H	H
Very smooth surface	L	L	H	M	M	M	M	M	M	M	M	L	L	L
No liquid crystal pooling	H	H	H	H	H	H	H	H	H	H	H	H	L	L
Resistant to contaminants	H	H	M	H	L	M	M	M	H	H	H	L	L	L
Works in rain, snow & ice	H	H	L	H	L	L	L	L	L	L	H	L	L	L
Works with scratches	L	L	M	H	H	H	H	H	M	H	H	L	L	L

13 Performance Characteristics

no perfect

Desirable Characteristic	Touch Technologies													
	Analog Resistive	Digital Resistive	Surface Capacitive	Projected Capacitive	SAW	Traditional IR	Optical Waveguide IR	Camera-Based Optical	APR	Bending Wave	Force Sensing	LCD In-Cell (Optical)	LCD In-Cell (Capacitive)	LCD In-Cell (Resistive)
Performance														
High optical performance	L	L	M	H	H	H	H	H	H	H	H	M	H	H
High resolution	H	L	H	H	M	L	H	H	M	M	L	H	H	H
High linearity	H	L	M	M	M	M	H	H	M	M	H	H	H	H
High accuracy & repeatability	H	H	M	H	H	M	H	H	M	M	H	H	H	H
Low power consumption	H	H	L	M	L	L	M	M	H	L	H	M	M	H
Insensitive to vibration	H	H	H	H	H	H	H	H	H	M	L	H	H	H
Insensitive to EMI & RFI	H	H	L	M	H	H	H	H	H	H	H	H	M	H
Insensitive to ambient light	H	H	H	H	H	M	H	H	H	H	H	L	H	H
Insensitive to UV light	L	L	H	H	H	H	H	H	H	H	H	M	M	M
Touch-object size recognition	L	L	L	H	L	L	H	H	L	L	L	H	H	H
Measures Z-axis	L	L	L	L	M	L	L	L	L	L	H	L	L	L
Handwriting recognition	H	L	L	H	L	L	M	H	L	L	L	M	M	L
Works with bi-stable reflective	H	H	H	H	H	H	H	H	H	H	H	L	H	L

13 Integration Characteristics

touch technology!
(Burma Shave)

Desirable Characteristic	Touch Technologies													
	Analog Resistive	Digital Resistive	Surface Capacitive	Projected Capacitive	SAW	Traditional IR	Optical Waveguide IR	Camera-Based Optical	APR	Bending Wave	Force Sensing	LCD In-Cell (Optical)	LCD In-Cell (Capacitive)	LCD In-Cell (Resistive)
Integration														
Substrate independence	H	H	L	H	L	H	H	H	L	L	H	L	L	L
Scalable	M	L	M	H	M	L	L	H	H	H	H	L	L	L
Easy integration	H	M	L	M	M	M	M	H	L	L	M	H	H	H
Flush surface (low profile)	M	M	M	H	M	L	M	L	H	H	M	H	H	H
Narrow border width	H	M	M	M	L	L	M	L	H	M	M	H	H	H
Thin and light	H	H	L	H	L	L	M	L	L	L	L	H	H	H
Easy to seal	H	H	H	H	L	M	M	L	H	H	M	M	L	L
Can be vandal-proofed	L	L	M	H	H	M	M	L	H	H	H	L	L	L
Works on curved surface	L	L	L	H	L	L	L	L	L	L	H	L	L	L
Can be laminated to LCD	H	H	H	H	H	H	H	H	M	M	L	H	H	H
HID (Plug & Play) interface	L	L	L	L	L	L	L	H	L	H	L	L	L	L
Simple controller	H	H	L	L	L	L	M	M	M	L	H	L	L	M
Controller chip available	H	L	L	H	H	L	H	L	H	L	H	L	L	L

Touch Technology vs. Application

Application	Example	Touch Technologies													
		Analog Resistive	Digital Resistive	Surface Capacitive	Projected Capacitive	SAW	Traditional IR	Waveguide IR	Camera-Based Optical	APR	Bending Wave	Force Sensing	LCD In-Cell (Optical)	LCD In-Cell (Capacitive)	LCD In-Cell (Resistive)
Kiosk Point of Info (POI)	Museum information	O	X	O	X	O	O	X	O	O	O	X	X	X	X
Kiosk Commerce	Digital photo printing	O	X	X	O	O	X	X	X	O	O	X	X	X	X
Kiosk Ruggedized	Gas pump	X	X	O	O	O	O	X	X	X	X	O	X	X	X
Point of Sale (POS)	Restaurant; lottery	O	X	O	O	X	O	X	X	O	X	O	X	X	X
Office Automation	Office monitor	O	X	O	X	O	X	X	X	X	X	X	X	X	X
Industrial Control	Machine control	O	O	O	X	O	O	X	X	X	X	O	X	X	X
Medical Equipment	Medical devices	O	X	X	O	O	X	X	X	O	X	X	X	X	X
Healthcare	Patient info monitor	O	X	X	X	O	X	X	X	O	X	X	X	X	X
Military Fixed & Mobile	Submarine console	O	X	O	X	X	O	X	X	X	X	X	X	X	X
Training & Conference	Boardroom display	O	X	X	X	O	X	X	O	X	O	X	X	X	X
Legal Gaming	Casino machine	X	X	O	X	X	X	X	X	X	X	X	X	X	X
Amusement Gaming	Bar-top game	X	X	O	X	O	X	X	X	O	X	X	X	X	X
In-Vehicle	GPS navigation	O	X	X	O	X	X	O	X	X	X	X	X	X	X
ATM Machine	ATM machine	X	X	X	O	O	O	X	X	X	X	X	X	X	X
Mobile Device	Smartphone	O	X	X	O	X	O	O	X	O	X	O	O	O	O
Appliance	Refrigerator door	O	X	X	X	X	X	X	X	O	X	X	X	X	X
Architectural	Elevator control	X	O	X	X	X	X	X	X	X	X	O	X	X	X
Consumer AiO & Monitor	HP TouchSmart	O	X	X	O	X	X	X	O	X	X	X	X	X	X
Music Controller	Jazz Mutant	O	O	X	O	X	X	X	X	X	X	X	X	X	X
Digital Signage	Thru-window store	X	X	X	O	O	O	X	O	O	O	X	X	X	X

Touch Technology vs. Screen Size

Touch Technology	Small 2" – 10"	Medium 12" – 30"	Large 32" – 150"
Analog Resistive	High	Medium	X
Digital Resistive	High	Low	X
Surface Capacitive	X	High	X
Surface Acoustic Wave	X	High	Low
Traditional Infrared	X	High	High
Projected Capacitive	High	Low	Medium
Camera-Based Optical	X	High	High
Acoustic Pulse Recognition	Medium	High	Low
Bending Wave (DST)	X	X	Medium
Force Sensing	Low	Medium	Low
Waveguide Infrared	High	Medium	X
LCD In-Cell Optical	High	Low	X
LCD In-Cell Capacitive	High	Low	X
LCD In-Cell Resistive	High	Low	X

Market penetration and/or applicability

- High
- Medium
- Low
- X (None)

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A Prediction of Which Technologies Will Win in the Next Five Years

Application	Winning Technology	Runner-Up Technology
Mobile Devices	Analog Resistive	Projected Capacitive
POS Terminals	Analog Resistive	Infrared
Consumer AiOs and Monitors	Camera-Based Optical	Projected Capacitive
Consumer Notebooks	Projected Capacitive	Camera-Based Optical
Kiosks	Surface Acoustic Wave	Surface Capacitive
Casino Gaming	Surface Capacitive	Projected Capacitive
Digital Signage	Camera-Based Optical	Infrared

Thank You!

Geoff Walker
Product Marketing Manager
NextWindow, Ltd.
7020 Koll Center Parkway, Suite 138
Pleasanton, CA 94566
1-925-272-4529
gwalker@nextwindow.com

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