



# Automotive Touch-Screen Technologies Tutorial

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October 20, 2011



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## ❖ IMS Research

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Automotive & Transport	Financial & ID Technologies
Communications & Wireless	Lighting & LEDs
Computer & Office Equipment	Medical (“InMedica”)
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Factory Automation	

- ◆ Offices in UK (HQ), USA, China, Taiwan, Korea & Japan
- ◆ >100 analysts worldwide
- ◆ Clients in >50 countries
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- ◆ Known for detailed, in-depth, highly analytical reports

# Agenda

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- ❖ **Introduction**
- ❖ **Dominant Technology: Analog Resistive**
- ❖ **Challenger Technology: Projected Capacitive**
- ❖ **Other Technologies**
- ❖ **Conclusions**

# Tutorial Coverage

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## ❖ This tutorial covers...

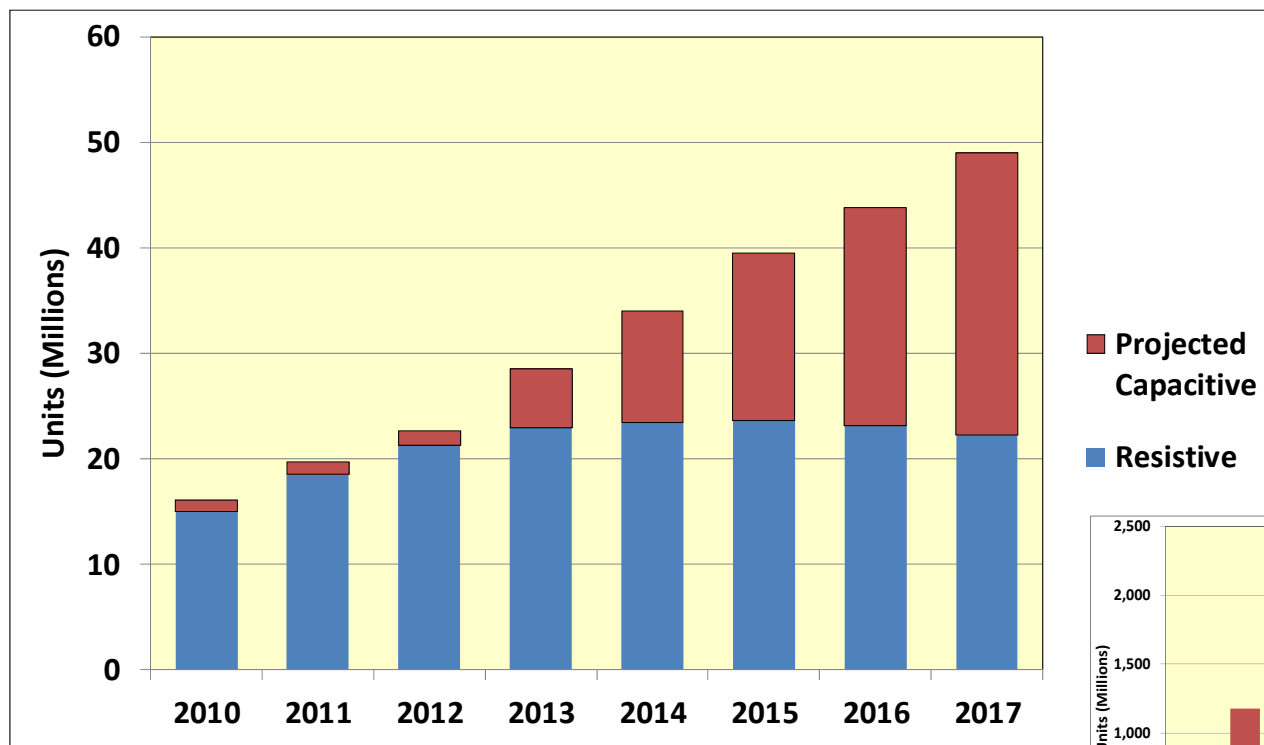
- ◆ Two technologies for transparent touch on top of a display (usually an LCD)

## ❖ This tutorial doesn't cover...

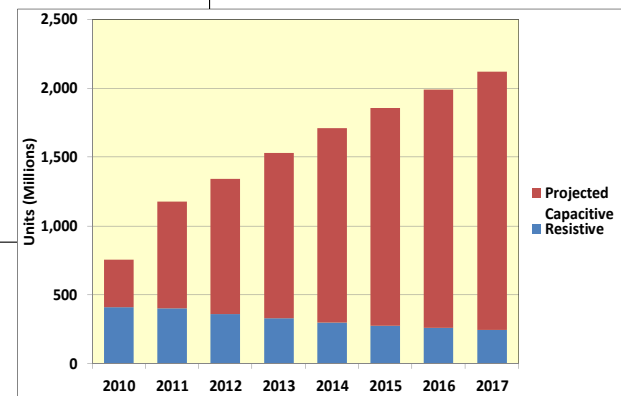
- ◆ Opaque touch (capacitive buttons)
- ◆ Haptics (tactile feedback)
- ◆ Vision-based gesture/motion touch for HUDs (“3D touch”)
- ◆ Ergonomics

# Introduction

## Automotive Touch Technology Adoption



Overall  
Touch  
Market  
Adoption



Source: DisplaySearch *Touch Panel Market Analysis 2011 Annual Report*

# Automotive Applications Are Not Simple!

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*Note: Focus here is the center-stack (CSE) “navi-radio” application*

## ❖ **Temperature**

- ◆ -30°C to +85°C operating
- ◆ -40°C to +95°C storage

## ❖ **Light management**

- ◆ Sunlight readability
  - Relaxed requirement for rear-seat entertainment (RSE)

## ❖ **Crashworthiness**

- ◆ Top surface can't be glass (DOT)

## ❖ **Cost**

- ◆ Especially important for dealer-installed vs. OEM-installed

## ❖ **Vibration**

- ◆ Cables & connectors

# Automotive Applications Are Not Simple...2

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## ❖ Industrial design

- ◆ Narrow frame borders & flush (possibly curved) surface

## ❖ Usability

- ◆ Use with gloves

## ❖ Off-angle viewing

- ◆ Polarizer used for sunlight viewability narrows viewing angle

## ❖ Flammability

- ◆ Gaskets

## ❖ Humidity

- ◆ Condensation freezing into ice crystals

## ❖ ISO quality requirements

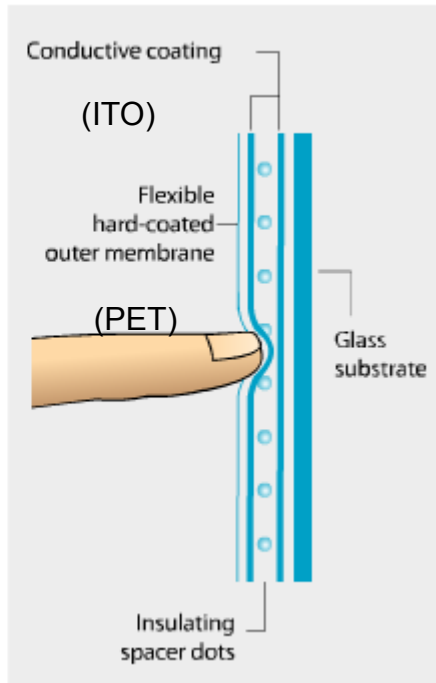
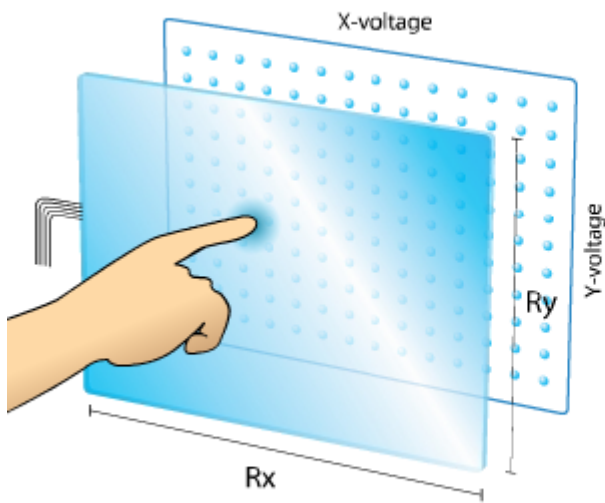
- ◆ Very difficult for a small or inexperienced company to meet



# Dominant Technology: Analog Resistive

Source: Engadget

# Analog Resistive...1

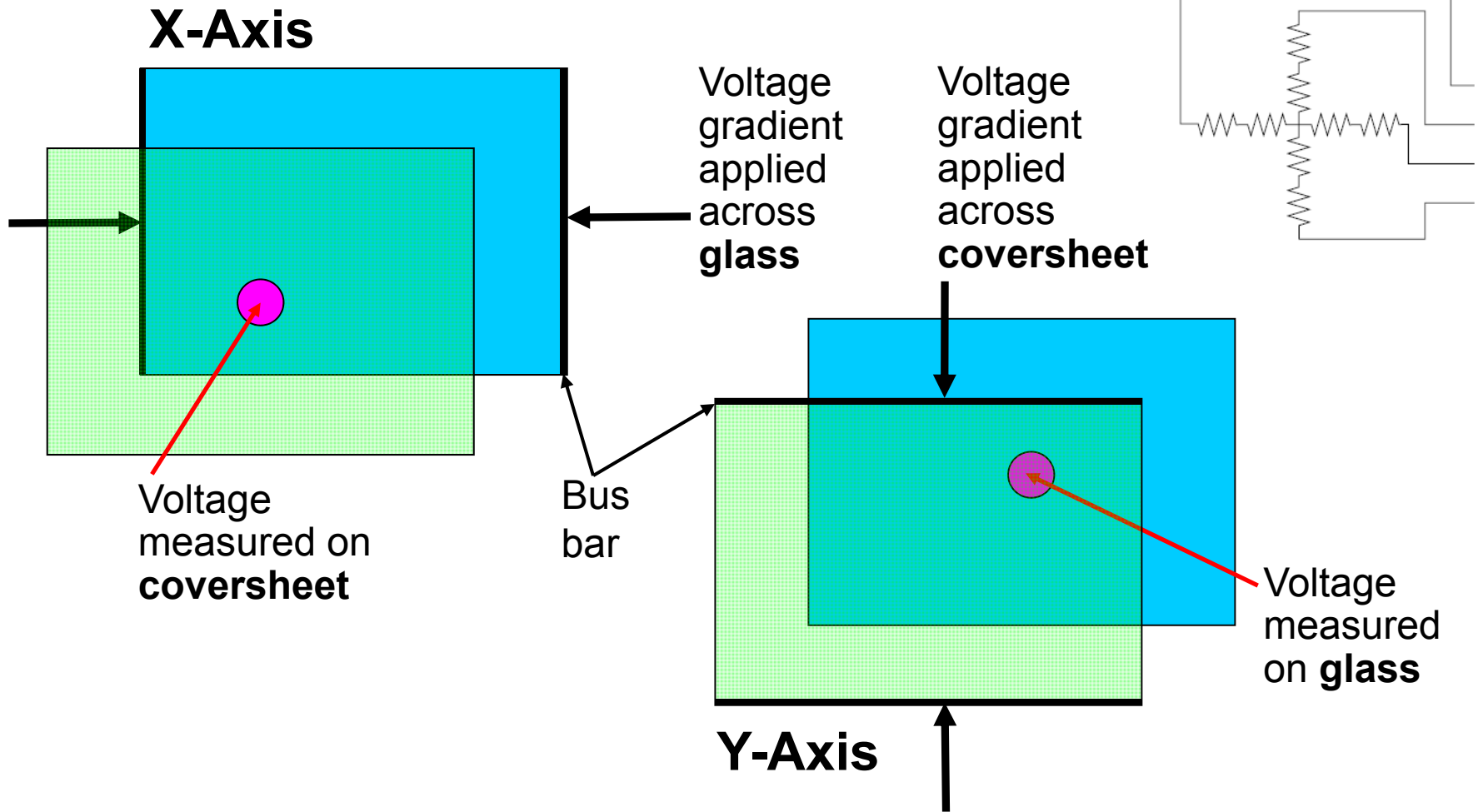


Source: Bergquist

Source: Elo TouchSystems

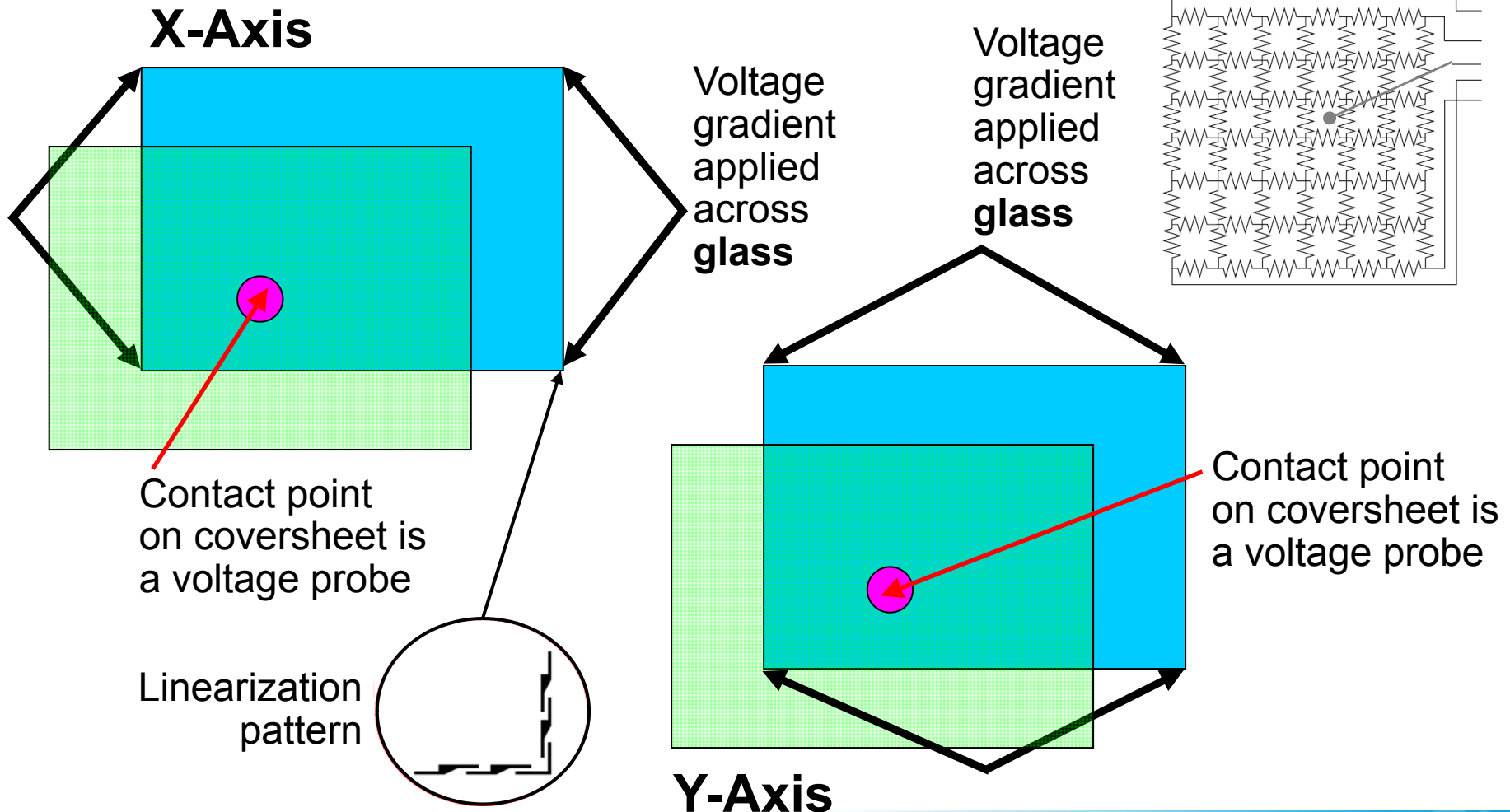
# Analog Resistive...2

## 4-Wire Construction



# Analog Resistive...3

## 5-Wire Construction



# Analog Resistive...4

## ❖ 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 (used in some cellphones) can be made flexible
- ◆ Glass + glass is the most durable; automotive is the primary use
- ◆ Film + film + glass, others...

## ❖ Options

- ◆ Surface treatments (AG, AR, AF, AC, AM), rugged substrate, dual-force touch, high-transmissivity, surface armoring, many others...



(50- $\mu$ m glass) Source: Schott

# Analog Resistive...5

## ❖ Size range

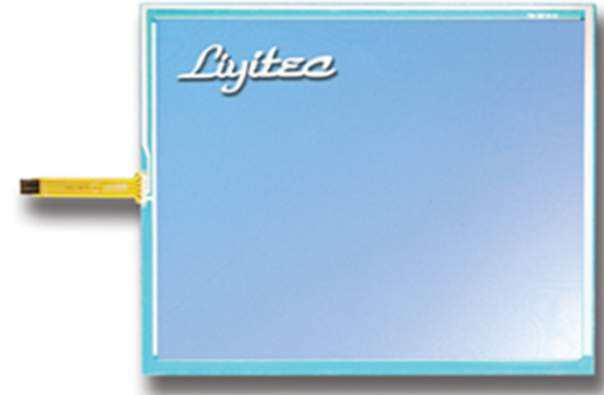
- ◆ 1" to ~24" (>20" is rare)

## ❖ Controllers

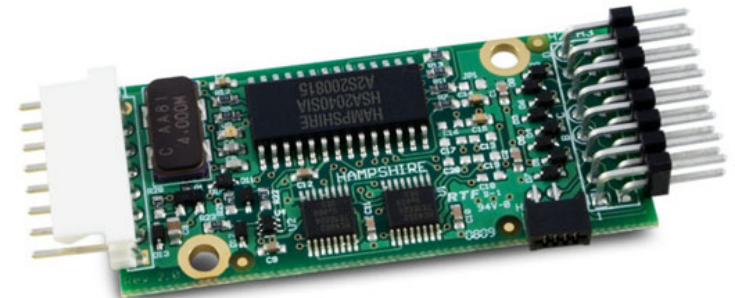
- ◆ Many sources
- ◆ Single chip, embedded in chipset/CPU, or “universal” controller board

## ❖ 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

- ◆ Film-glass is not durable (PET top surface is easily damaged)
- ◆ Poor optical quality (10%-20% light loss)
- ◆ Multi-touch resistive (AMR) is not getting any market traction

## ❖ Applications

- ◆ Mobile devices
- ◆ Point of sale (POS) terminals
- ◆ Wherever cost is #1

## ❖ Market share

	2010
Revenue	25%
Volume	52%



# Analog Resistive...7

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## ❖ Automotive suppliers

- ◆ Film-glass: Shenzhen TopTouch, Nanjing Wally, Panasonic, Fujitsu, DMC, Gzyulian, SMK, A-Touch, Gunze...
- ◆ Glass-glass: Shoei, SMK, Hosiden, Micro Technology, TechnoPrint...
- ◆ 60+ total suppliers for analog resistive

## ❖ General market trends

- ◆ Analog resistive has lost the #1 revenue position to projected capacitive
  - First time in ~40 years!
- ◆ Analog resistive is still important in mobile phones in Asia
  - It supports a stylus; projected capacitive doesn't (yet!)
- ◆ Most of the innovation is in the controller, not the sensor



# Analog Resistive...8

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## ❖ Automotive market trends

- ◆ Performance of film-glass materials has steadily increased such that film-glass is seriously challenging the dominance of glass-glass in OEM applications
- ◆ Cost pressure in dealer-installed applications has focused this market strongly on film-glass
- ◆ Top-glass is typically 0.2 mm (0.15 – 0.4 mm), so resolution is lower than film-glass, but applications are moving towards higher resolution (graphics & higher data-density)
  - Implication is towards stylus use, but there's hesitation because the stylus must be supplied and stored



Source: Apple

# Challenger Technology: Projected Capacitive



# Projected Capacitive...1

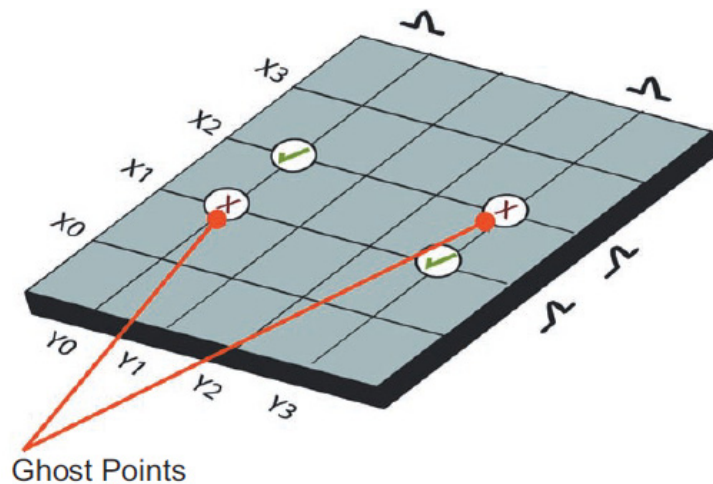
## ❖ Types

### ◆ Self capacitance

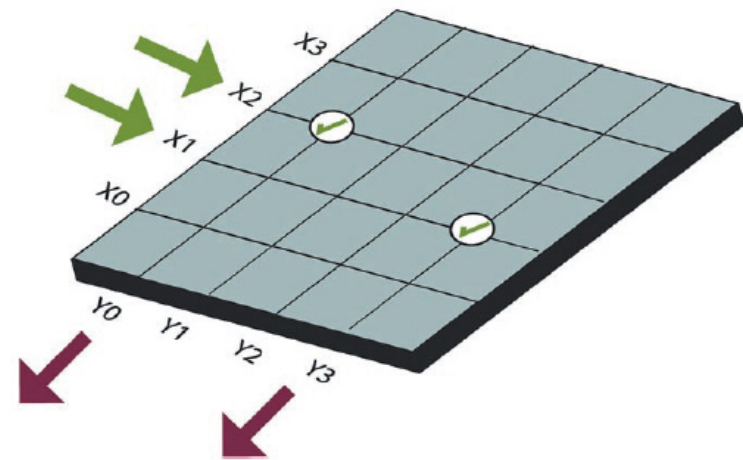
- Controller measures capacitance of single electrode to ground

### ◆ Mutual capacitance

- Controller measures capacitance between two electrodes



Self capacitance



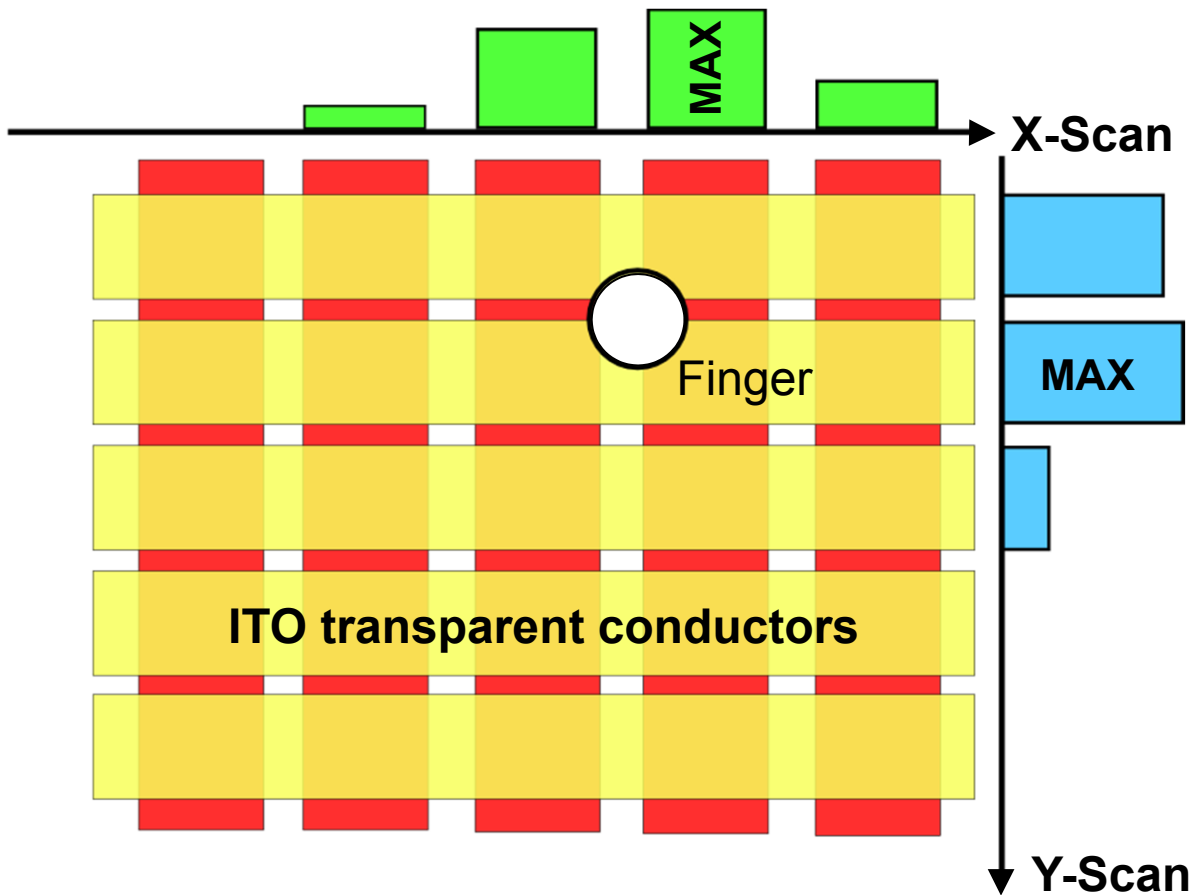
Mutual capacitance

# Projected Capacitive...2

<b>Self Capacitance</b>	<b>Mutual Capacitance</b>
Older technology, but still used	Newer technology
Limited to 1 or 2 touches with ghosting	Two or more unambiguous touches
Lower immunity to LCD noise	Higher immunity to LCD noise
Lower touch accuracy	Higher touch accuracy
Sensor is usually diamond pattern	Allows more flexibility in pattern design
Harder to maximize SNR	Easier to maximize SNR
Simpler, lower cost controller	More complex, higher-cost controller
Usually a single-layer sensor	Always a two-layer sensor (may change)

# Projected Capacitive...3

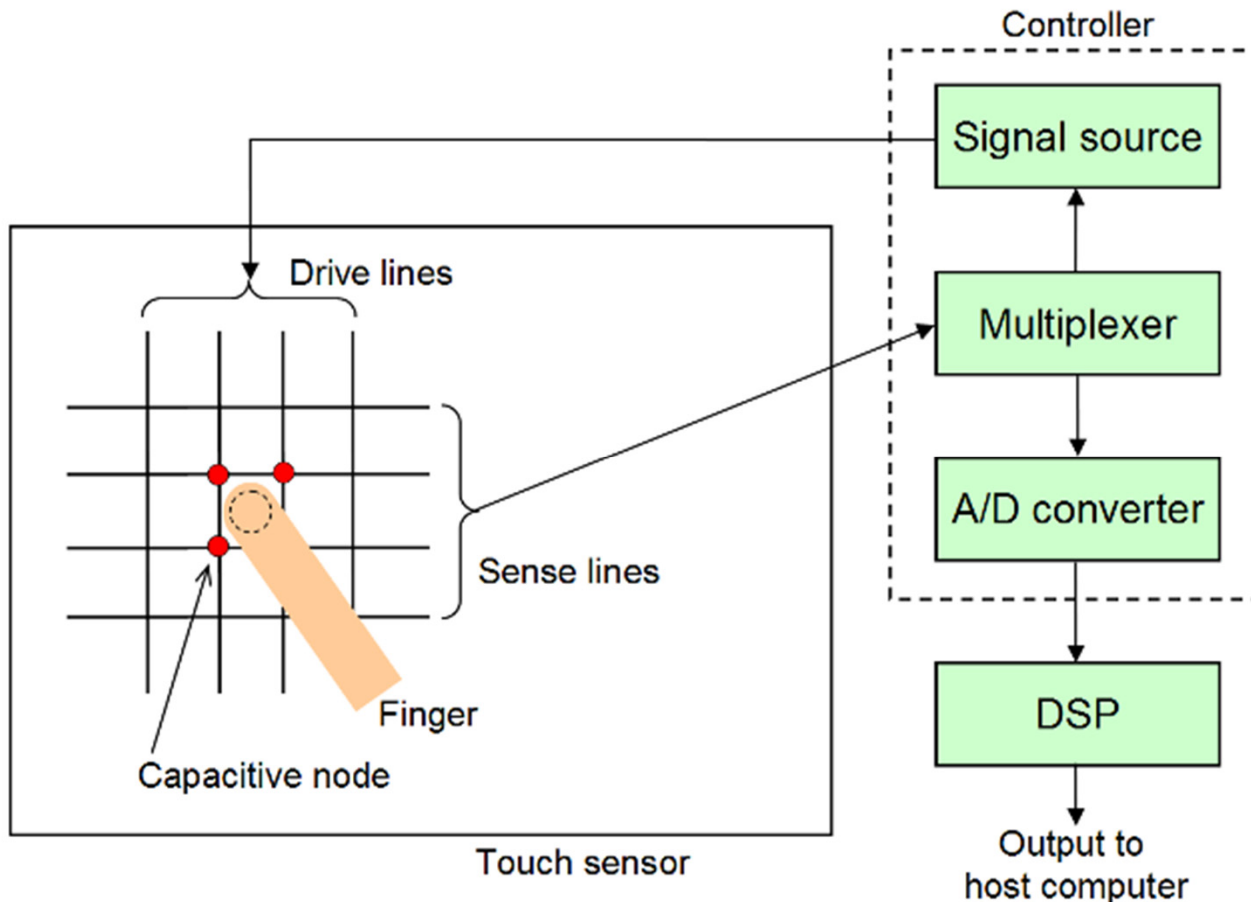
## Self-capacitance notebook touchpad (before Apple iPhone)



- ❖ X-axis and then Y-axis electrodes are scanned sequentially, looking for point of maximum capacitance to ground
- ❖ Ghost points are a problem with 2 touches

# Projected Capacitive...4

## Mutual capacitance touchscreen (Apple iPhone)



- ❖ Output is an array of capacitance values for each X-Y intersection

# Projected Capacitive...5

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## ❖ Constructions & locations

- ◆ Bottom side of cover glass (“lens”)
  - Not common yet, but industry is heading this way (“one glass”)
  - Good place for sensor with largest sensing area
- ◆ Discrete **glass or film** substrate(s) between cover glass & LCD
  - Current industry standard
  - Many different layer arrangements & configurations
  - Sometimes requires a shield layer
- ◆ On top side of color filter (CF) glass
  - This is “on cell” → allows integration with display
  - Requires two-sided CF glass processing, which reduces yield

# Projected Capacitive...6

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## ❖ Options (ITO-based )

- ◆ Top surface treatment (AR, AG, AF, AC, AM...)
- ◆ Degree of indexing matching on ITO (invisibility)
- ◆ Number of electrodes per inch (resolution)
- ◆ Electrode patterns

## ❖ One more variation: Wires vs. ITO

- ◆ Wires (10 microns): Visible, acceptable for intermittent use
- ◆ ITO: Invisible, needed for continuous use

## ❖ Wire-based uses slightly different concept (IP)

- ◆ ITO-based pro-cap directly measures a change in capacitance
- ◆ Wire-based pro-cap measures a change in RF signal frequency caused by a change in capacitance

# Projected Capacitive...7

## ❖ Size range

- ◆ 2" to 100"+
  - ITO up to 32" (so far); wires up to 100"+

## ❖ Controllers

- ◆ Key variable is number of electrodes (matrix size)
  - Larger screens generally require multiple (ganged) controller chips today
- ◆ High signal-to-noise ratio (SNR) is a key characteristic → enables stylus use
- ◆ Lots of innovation still happening, such as synchronization with LCD timing
  - But, lack of available support from major controller vendors (e.g., Atmel) is driving many touch module companies to create their own controllers; this is delaying standardization and slowing down commoditization



LG-Prada mobile phone with Synaptics' projected-capacitive touch-screen; launched 3 months before iPhone

# Projected Capacitive...8

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## ❖ Advantages

- ◆ Very durable (protected sensor)
- ◆ Unaffected by debris or contamination
- ◆ High optical quality (ITO)
- ◆ Enables “zero-bezel” industrial design
- ◆ Works with curved substrates (electrodes on PET)
- ◆ Unlimited multi-touch

## ❖ Disadvantages

- ◆ Finger or tethered pen only (changing now!)
- ◆ High cost (dropping as usage increases)
- ◆ Challenging to integrate due to noise sensitivity



# Projected Capacitive...9

## ❖ Applications

### ◆ Consumer devices

- Mobile phones
- Tablets, netbooks, notebooks, AiOs
- Almost any consumer device

### ◆ Vertical-market devices

- Signature-capture & other POS terminals
- “Through-glass” interactive retail signage

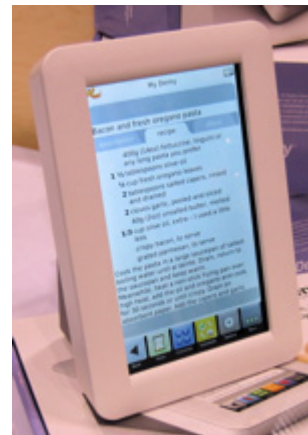


Source: Mildex

## ❖ Market share

	2010
Revenue	59%
Volume	46%

Demy  
Digital  
Recipe  
Reader  
(CES 2010)



Source: Verifone

# Projected Capacitive...10

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## ❖ Business models

- ◆ Sensor company buys controller, sells module
  - Example = TPK
- ◆ Controller company buys sensor, sells module
  - Example = Synaptics
- ◆ Module company buys sensor and controller, sells module
  - Example = TPK when they don't have enough sensor capacity
- ◆ Display manufacturer builds sensor into display, buys controller, and sells touch-display
  - Example = AUO

# Projected Capacitive...11

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## ❖ Suppliers

### ◆ Sensors (only)

- Cando (part of AUO Group), Sintek Photonics, other former color-filter manufacturers, former STN LCD manufacturers (total number = ?)

### ◆ Controllers (only)

- Atmel, Cypress, Pixcir, Maxim, TI, ELAN, Microchip, Sentelic, Melfas, EETI, STMicro, SIS, Avago, Sitronix, M-Star, Broadcom, and more coming...

### ◆ Modules

- TPK (biggest), Wintek, Synaptics, Nissha, Panjit, Digitech, CMI, Young Fast, Touch International, and >20 more

## ❖ Supplier countries

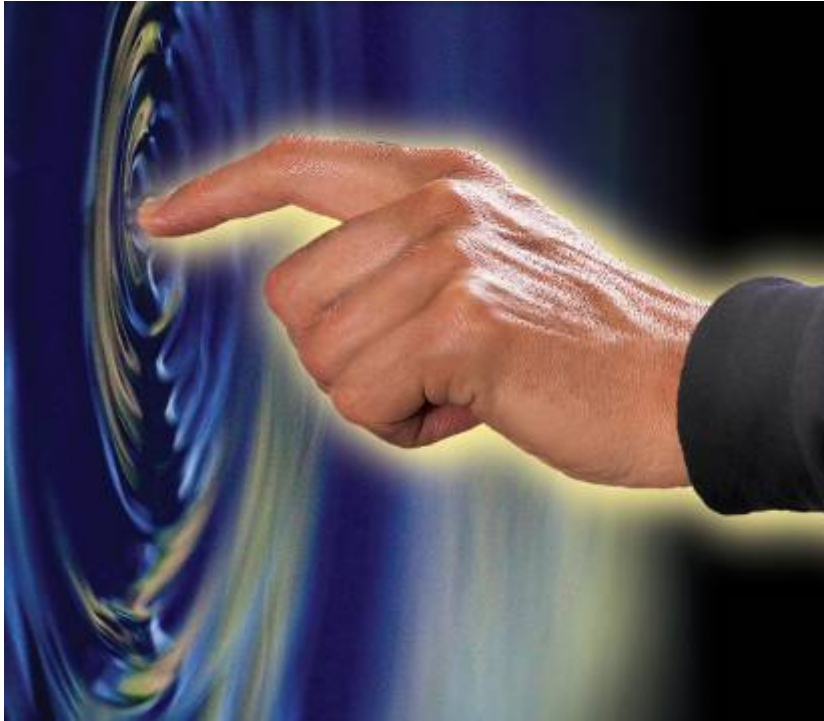
- ◆ Taiwan, USA, China, Japan, Korea, Israel, UK...

# Projected Capacitive...12

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## ❖ Market trends

- ◆ Device OEMs' desire for multi-touch is a key driving force, along with durability and high optical performance
- ◆ Extremely rapid sales growth worldwide
- ◆ Steadily increasing number of suppliers
- ◆ Prices are dropping, but rate is slow due to current capacity
- ◆ Massive capacity expansion (Apple is using 60% today)
- ◆ TPK's amazing growth is likely to change structure of industry
- ◆ Applications broadening beyond consumer electronics (verticals)
- ◆ Starting to see a few small-order vertical-market suppliers
- ◆ Pro-cap has overtaken analog resistive, ending a 40-year reign
- ◆ Continued maturation – name has changed to just “capacitive”



Source: 3M

# Other Touch Technologies

# Other Touch Technologies

<b>Touch Technology</b>	<b>Issues in Automotive</b>
LCD In-Cell	It's still in development! Performance isn't good enough, and nobody is in volume production.
Traditional Infrared (IR)	High cost, profile (bezel) height, false touches, low resolution
Waveguide Infrared	Only producer (RPO) is in liquidation
Camera-Based Optical	Environmental requirements, bezel height, false touches, flatness requirement
Surface Capacitive	Requires stable ground (not suitable for mobile)
Surface Acoustic Wave (SAW)	Touch-force, contamination, integration
Acoustic Pulse Recognition (APR – Elo)	Environmental requirements, glass surface, critical mounting, sole-source
Dispersive Signal Technology (DST – 3M)	Not available under 32"
Vision-Based Optical	Requires rear projection
Force Sensing	Can't handle vibration under 10 Hz, few suppliers



Source: CG4TV

# Conclusions



# Conclusions

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- ❖ **There are only two touch technologies available for automotive use today**
  - ◆ Analog resistive and projected capacitive
  - ◆ All the 10+ others are basically disqualified
- ❖ **The forecasted use of touch-screens in automotive in 2015 was ~28M units in 2009; now it's ~40M units**
- ❖ **The forecasted use of projected capacitive in automotive in 2015 was 1% in 2009; now it's 40%**
- ❖ **Author's opinions...**
  - ◆ Touch in automotive is still riding the wave of consumer enthusiasm; it's a little like touch on consumer notebooks
  - ◆ Car OEMs are very concerned about the safety aspect of touch (driver distraction)

# Suggested Reading On Touch Technologies

<http://www.informationdisplay.org/pastissue.cfm>



March 2011



March 2010



December 2007



December 2006



# Thank You!

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# Three Things to Remember about Touch and Situation Awareness

Geoff Walker  
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October 21, 2011



# Touch & Situation Awareness...1

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## ❖ Touch is one of several possible ways to interact with a Situation

- ◆ Others include voice and direct control/action

## ❖ Touch can be used to...

- ◆ Control the display or **any** automotive function
- ◆ Respond to information provided by the display or **any** source
  - Touch and the display don't have to be congruent; touch surfaces can be used anywhere – including on the wheel
  - “Direct manipulation” isn't always required – e.g., laptop touchpad

# Touch & Situation Awareness...2

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## ❖ It's **not** about the touch technology; it's about the user experience

- ◆ Discoverable
- ◆ Easy to use
- ◆ Consistent
- ◆ Configurable or customizable
- ◆ Fun, not frustrating
- ◆ Safe, not distracting



# Touch & Situation Awareness...3

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## ❖ Four categories of touch

- ◆ **On the surface** of the display or control (excluding stylus use)
  - All current automotive touch applications
- ◆ **Just above the surface** (“mouseover, hover, proximity”)
  - Mouse has done this forever; MS Tablet PC stylus since 2001
  - BUT there is no consistent definition (yet) for the meaning of proximity in automotive applications
    - SEMTECH suggested a few applications
  - Touching with a glove is really a special case of proximity
- ◆ **Within arm’s length** of the display (“near-field”)
  - “3D touch” in desktop monitor and laptop space
  - Could be applied in automotive, *but with only one hand on the wheel*
- ◆ **At a distance** from the display (“far-field”)
  - Microsoft Kinect (licensed from PrimeSense)
  - No obvious application in automotive



# Thank You!

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