Capacitive Touch Sensing

Paul Kleist
Technical Manager
EDT Europe

Adelco Electronics
Distributor for the Benelux

Projected Capacitive Touch

- Becoming very popular in all kind of products
- Enables a nice 'Touch and Feel' GUI
- Enables design of products using Customized Cover Lenses with different colour printing, Logos etc.
- Customers basically want a 'Smart Phone type' interface

Is it easy to integrate in any product…..?

Pitfalls when using CTP

- Spurious (False) touches
- Jitter on reported Touch Position
- Non linearity
- Varying sensitivity on touch area

How can we avoid the Pitfalls?

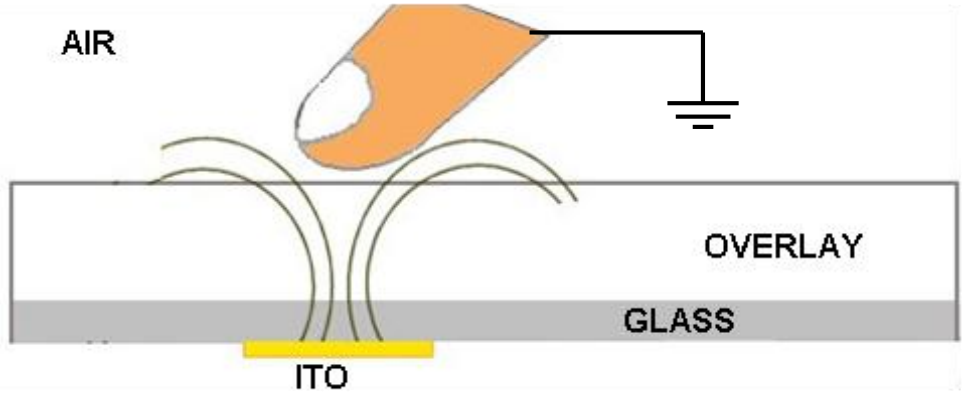
Understand the basic principles of Capacitive Touch Sensing, the noise sources and design around them!

First some Basic principles

- Self Capacitance technology
- Sensor layout
- Mutual Capacitance technology

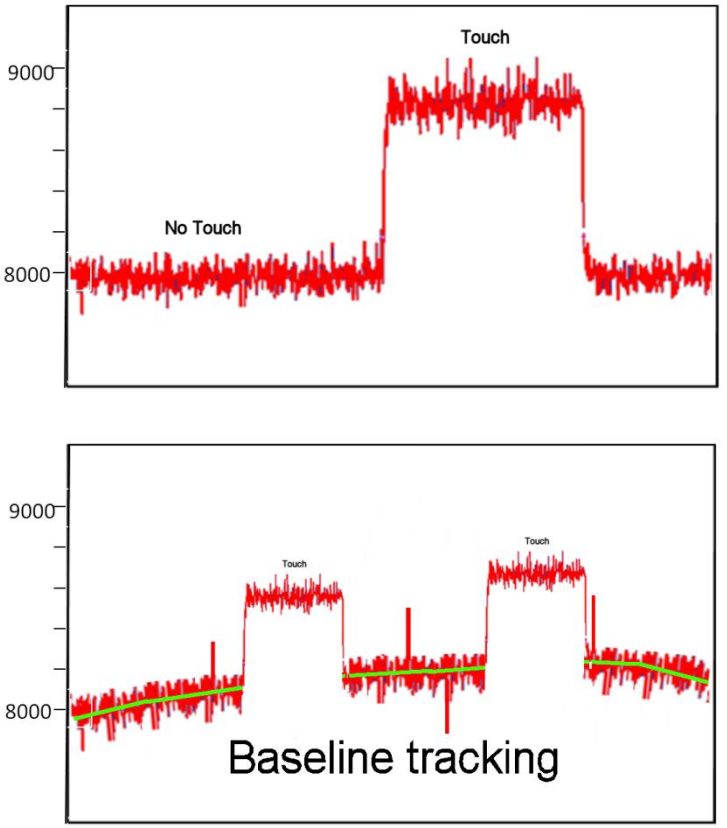
Self Capacitance

- Simplest form of Sensor:
  - ITO (Indium Tin Oxide) sensor has Self Capacitance Cs
  - Finger approaching gives total Cs + Cf
  - We detect the change in capacitance



Detection of Touch

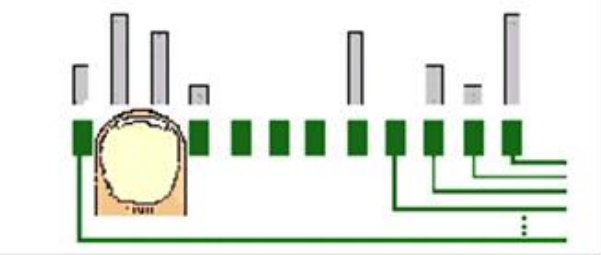
- Signal from A/D converter
  - Baseline ~8000
  - Difference signal ~ 800
  - Noise ~ 200
  - SNR ~ 4
  - Threshold we set ~ 400
  - Baseline tracking
    - Slow environmental changes
    - Noise spikes disregarded
    - Keeps Difference data level



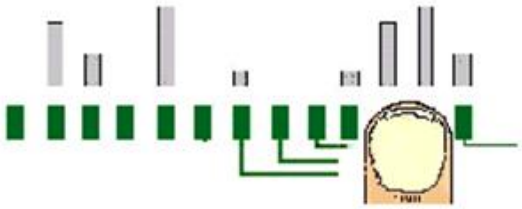
Self Capacitance

- Sensors are placed close to each other and we measure contribution from several sensors
- Calculate position by ‘interpolation’
- Resolution: 64 x no. of sensors
- Sensor pitch ~ 5mm => 0.08 mm resolution
- To build a Touch Screen we use both X and Y sensors

‘Active’ sensors random noise



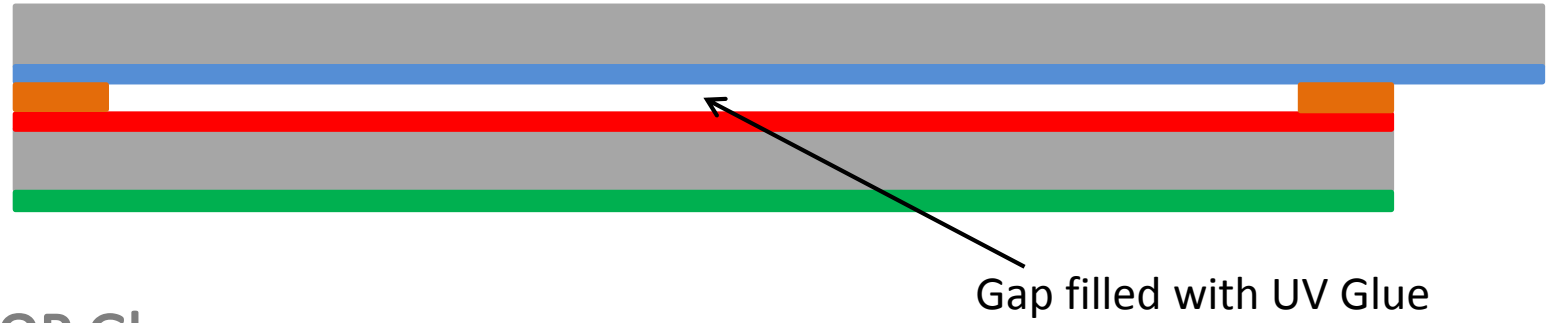
noise finger moved



Sensor Layout

- EDT POLYTOUCH Structure
- SITO Structure (Single ITO layer)
- Other types

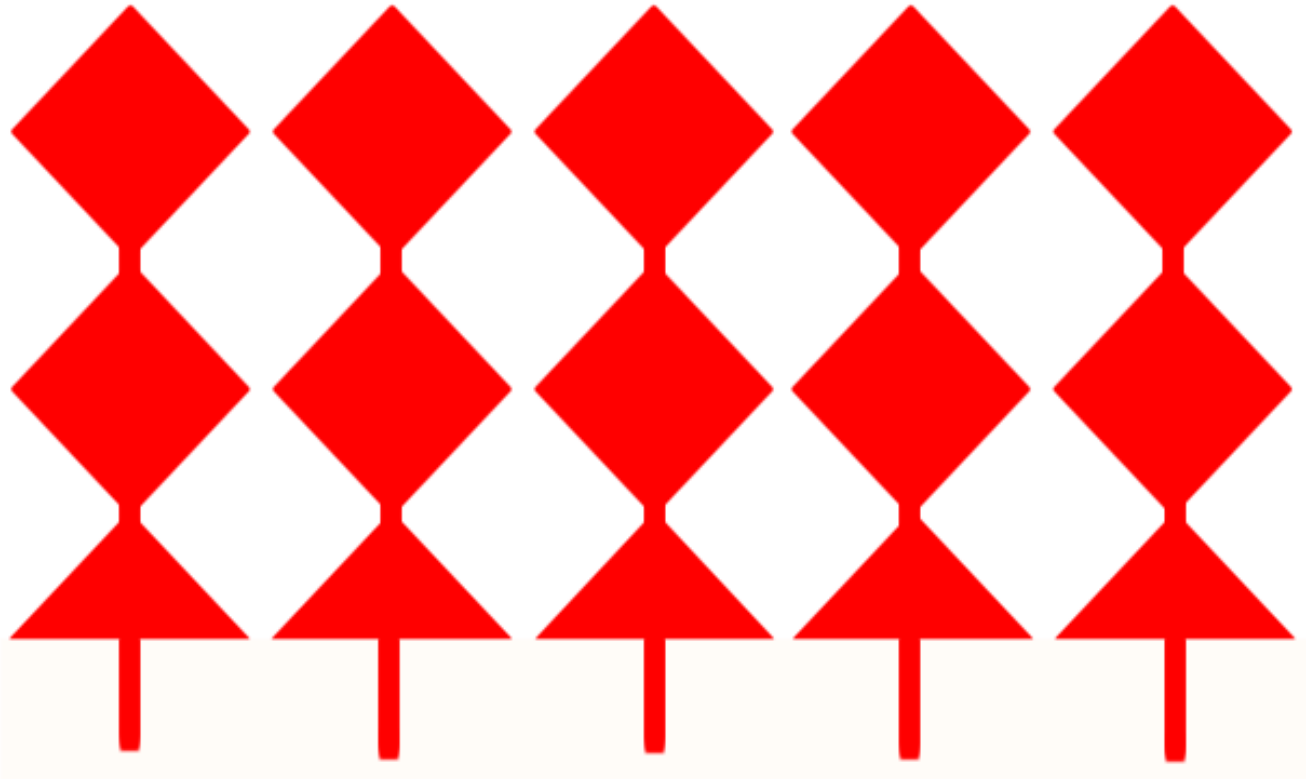
Polytouch Structure



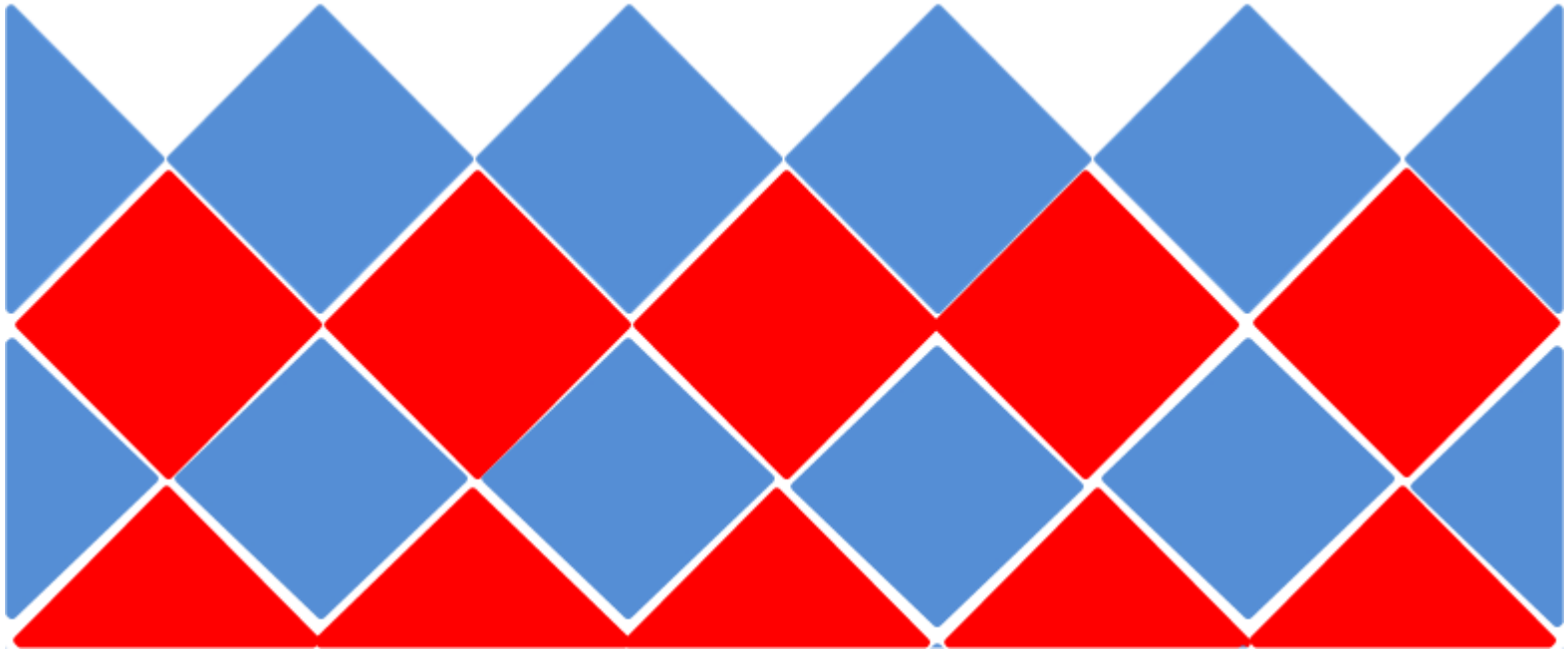
- TOP Glass
- Top ITO
- Sealing, Cell Gap – filled with UV Glue
- Bottom ITO
- BOTTOM Glass
- ITO Shielding connected to GND to isolate LCD noise, Transmissivity > 87%

Top ITO Pattern

Bottom ITO Pattern



X Y Combined Pattern

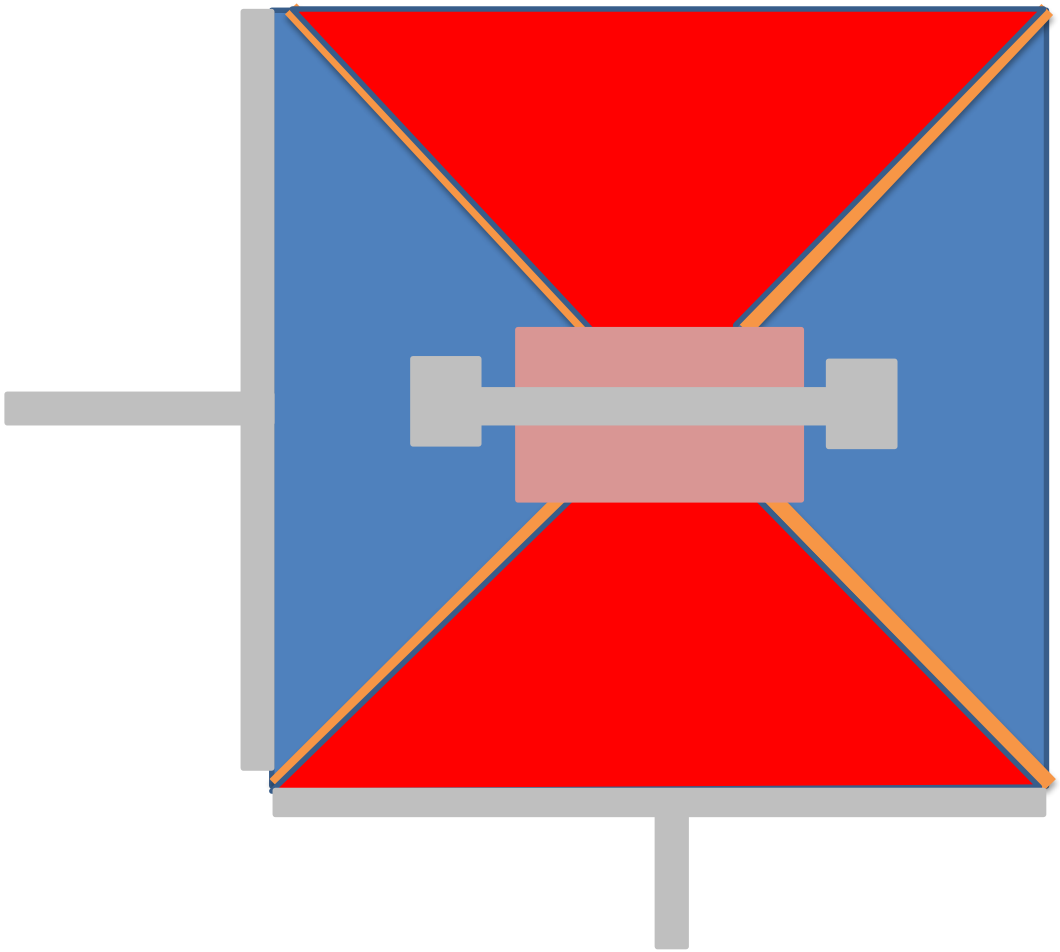


Single ITO Stack Up

- SITO Sensor - One Glass with one ITO layer (Single ITO)

- Multi step process to build ITO Sensors on one layer
- Isolation Layer with Metal Bridges
- Metallized wires to keep impedance low for >7” Sensors
- Used to build very thin Sensors for Consumer products
- Transmissivity > 87%

SITO PROCESS



Other Structures / Materials

- Glass and PET ITO Film with variations:
  - G2F
  - G1F and others…
- Nanowire
- Graphene
- Metal Mesh

Structures with PET ITO Film

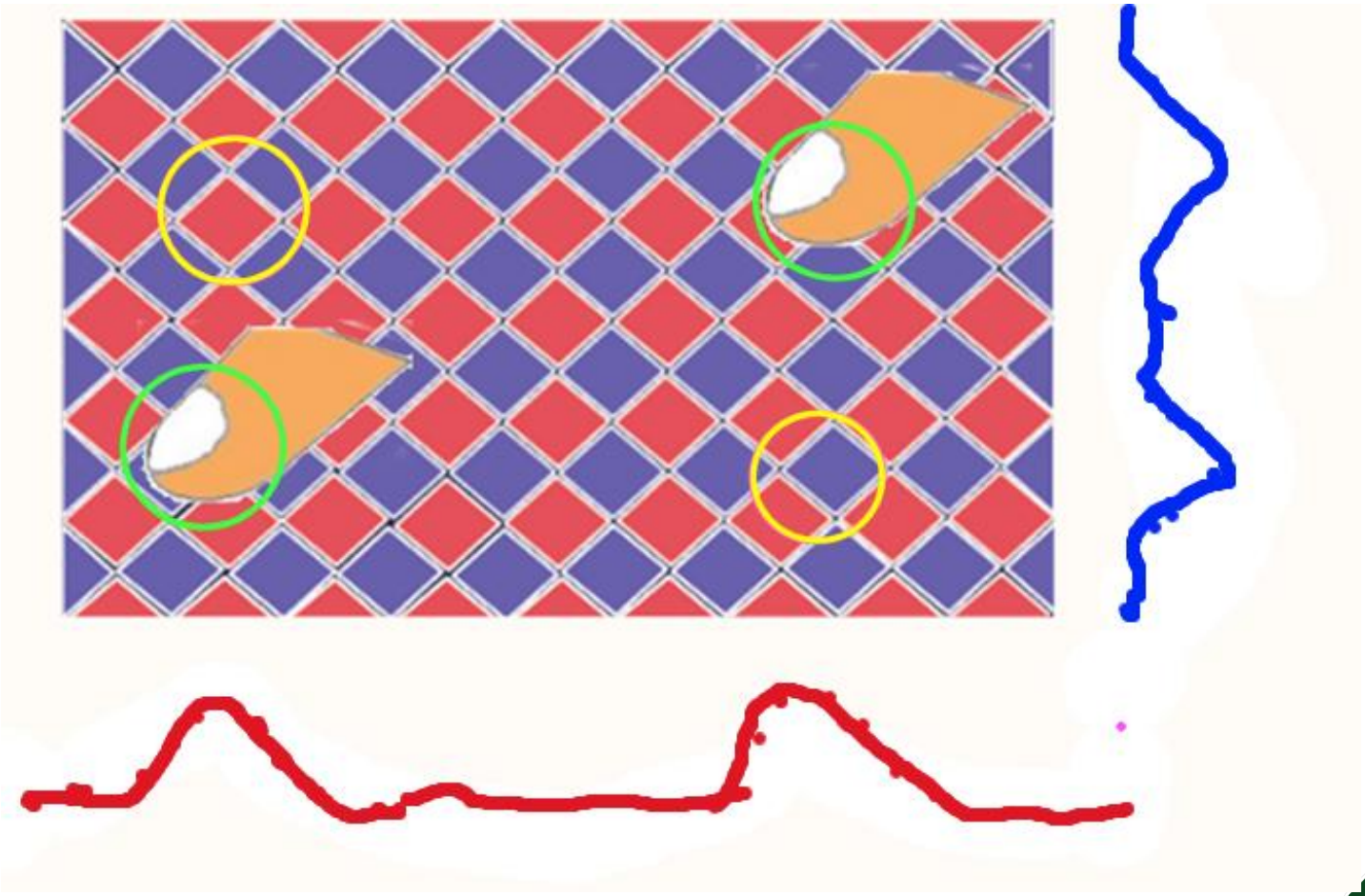
G2F, Glass Cover Lens with 2 x PET ITO Film

Cover Lens
OCA - Optical Clear Adhesive
ITO Film
OCA
ITO Film

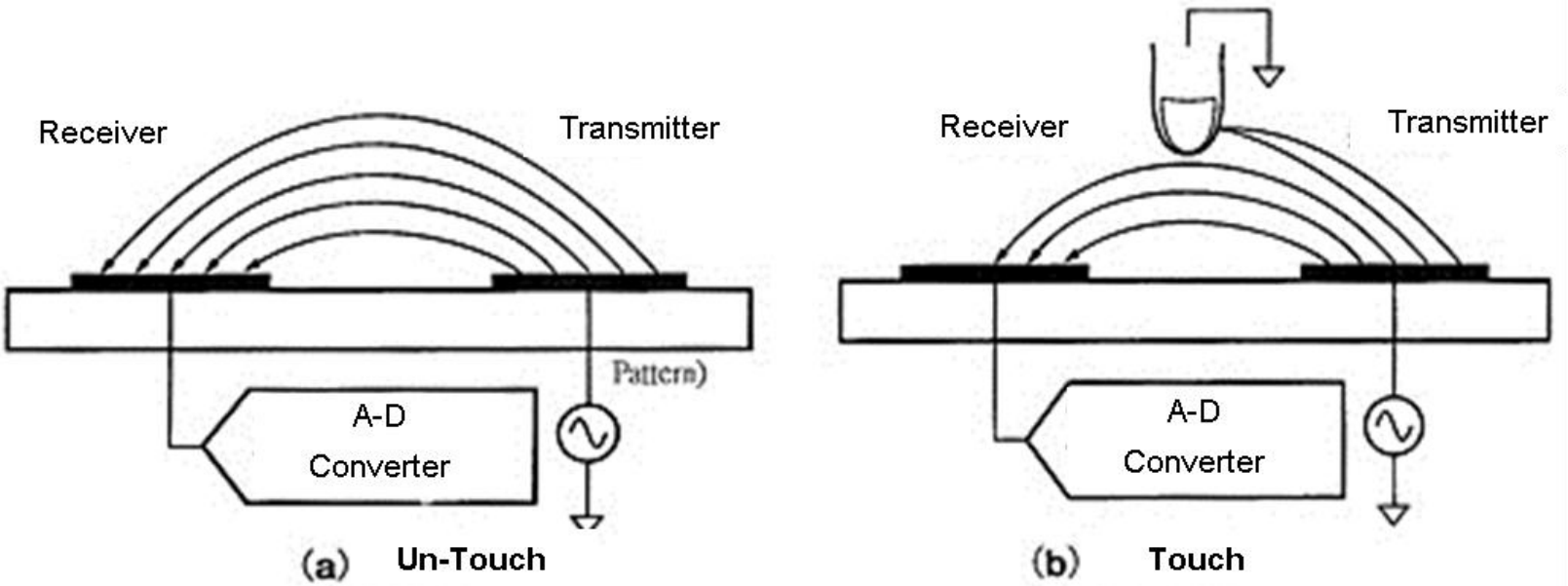
G1F, Glass Cover Lens ITO + 1 x PET ITO Film

Cover Lens with ITO
OCA
ITO Film

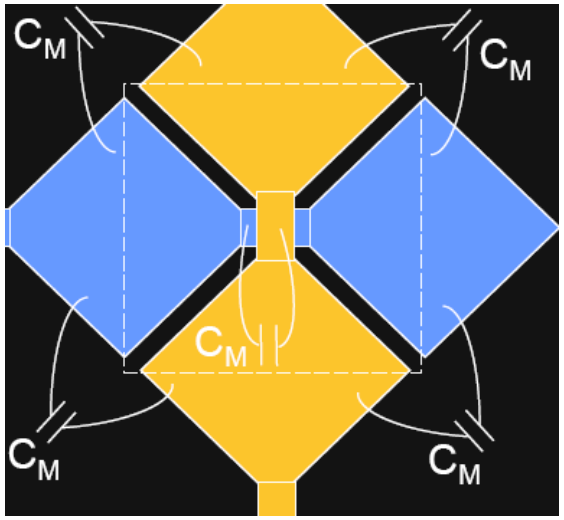
Self Capacitance Ghost Points

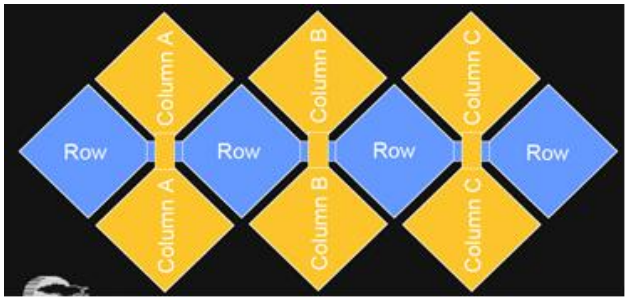


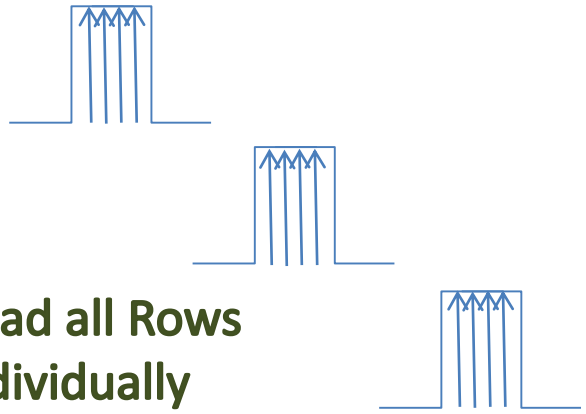
Mutual Capacitance Sensing



Mutual Capacitance







- We send a signal out on one Column, and read all Rows
- By scanning we can detect many touches individually
- Used on both Polytouch and SITO Sensors
- Mutual Capacitance between X and Y sensors: 0.6pF ~ 1pF

Signal levels

- Mutual Capacitance is in the 0.6pF to 1 pF range
- Finger Touch change (for full sensor) ~ 0.2pF
- To calculate the exact position we use signals from surrounding sensors that adds changes of ~ 0.002pF
- Signal Charge produced by TX signal (3 Volt TX signal):

  $Q = C * VTX$, $Q = 1pF \times 3V = 3pC$
- Charge *change* we must detect is 6 to 600 **f**C (0.002pF)
- Finger touch also introduces coupling capacitance to earth ground of around 1-3pF.

Noise Sources

- LCD noise coupling
- Power supply noise (Common Mode Voltage)

The thinner construction, the smaller distance from LCD to Sensor, the higher the noise.

This is solved by a) ITO Shielding, b) Smart filter algorithms

If system is floating (following common mode noise) it is not a problem until the Sensor is touched. Then the body will introduce a capacitive path to earth.

Common mode voltage = 5 volt, charge change ~2pF* x 5V = 10pC

This is **3 times** the charge produced by the Tx signal.

No surprise that we sometimes see noise issues and false touches!

* Finger capacitance to Earth

Cover Lens

- Properties of Cover Lenses
- Optical Bonding TFT / CTP

Properties of Cover Lens

- Material type, strength and hardness
- εr (dielectric constant of Cover Lens material)
- Thickness of Cover Lens
- Air gap
- Surface treatment (AR- AF- AG)
- Strength (Chemically Strengthening)

Dielectric of Cover Lens

Material	εr
Air	1.0006
PMMA	~2.5
Polycarbonate	~3
Glass	~8

- The higher εr the better
- We can use glass 2.6 times thicker than PMMA
- We want to avoid air gap between Sensor and Cover Lens or at least make it as thin as possible

Do's and don'ts

- Use only good quality Power Supplies
- Avoid Common Mode voltages
- *Always* use grounding to Earth
- Avoid or minimize air gap
- Use the thinnest Cover Lens possible
- Glass is better than PMMA / Polycarbonate

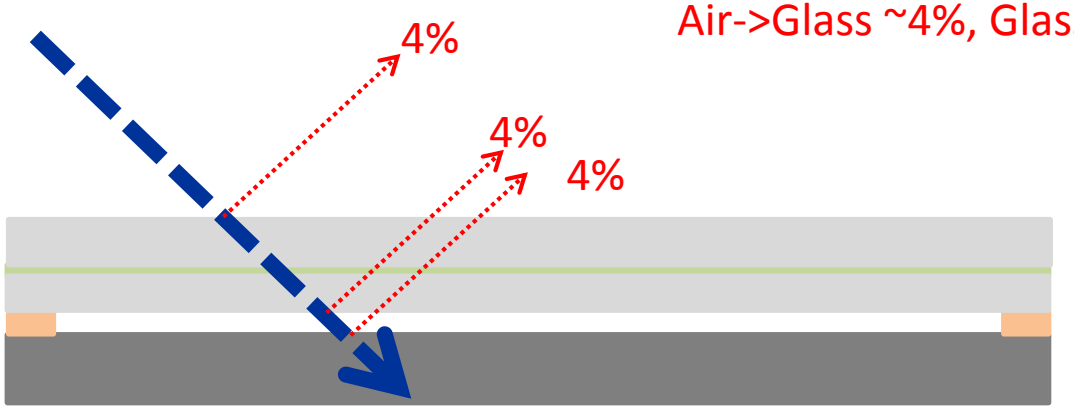
Sunlight Readability

Sunlight readability is becoming a must in many systems

- This can be achieved by boosting the Backlight (a lot)
- This has a negative impact on Power Consumption and Life Time of Backlight
- Alternative: Use Optical bonding between TFT and CTP

Light Reflection (1*)

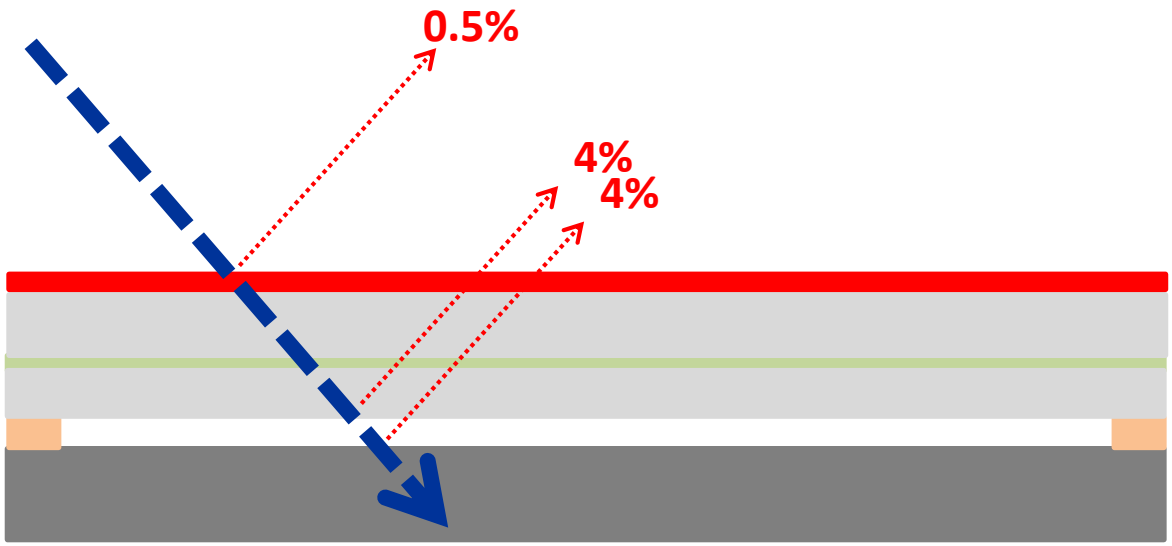
Every transition introduces REFLECTION
Air->Glass ~4%, Glass -> Air ~4%



Top Glass
UV Glue
Bottom Glass
Air gap
TFT

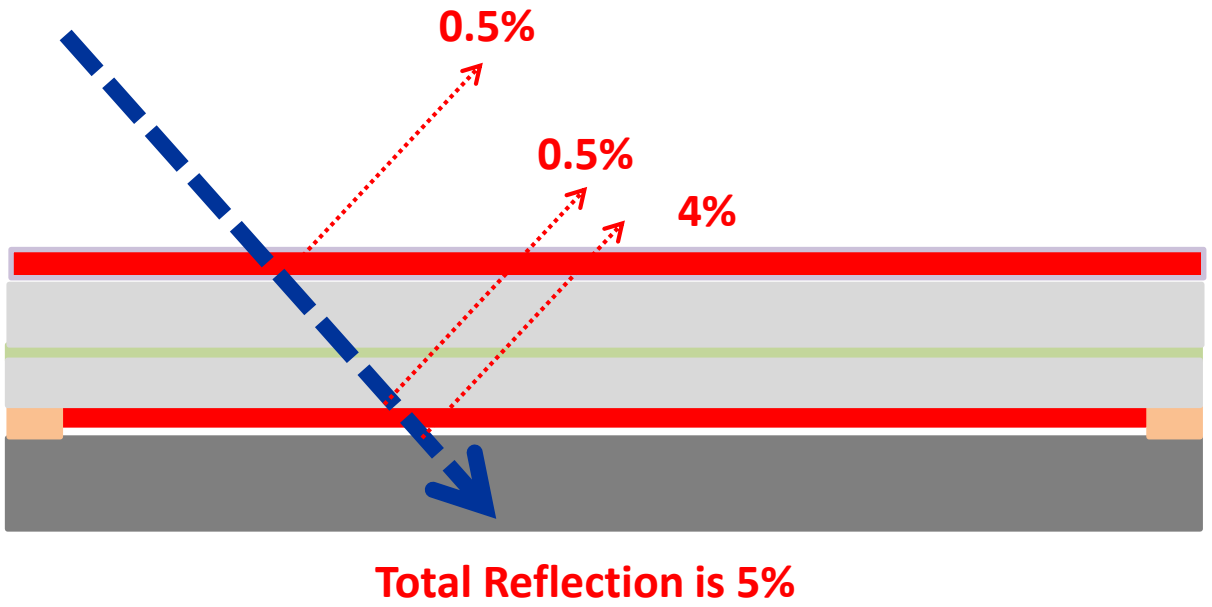
Total Reflection is 12%

AR Coating on Top Glass (2*)

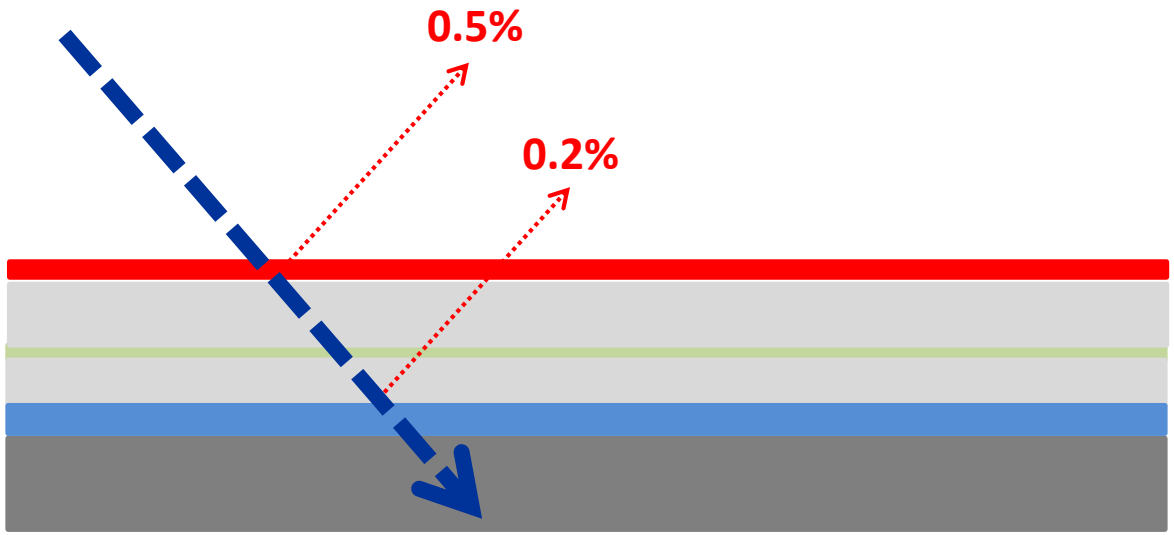


Total Reflection is 8.5%

AR Coating Top and Bottom Glass (3*)



AR Coating + Optical Bonding (4*)

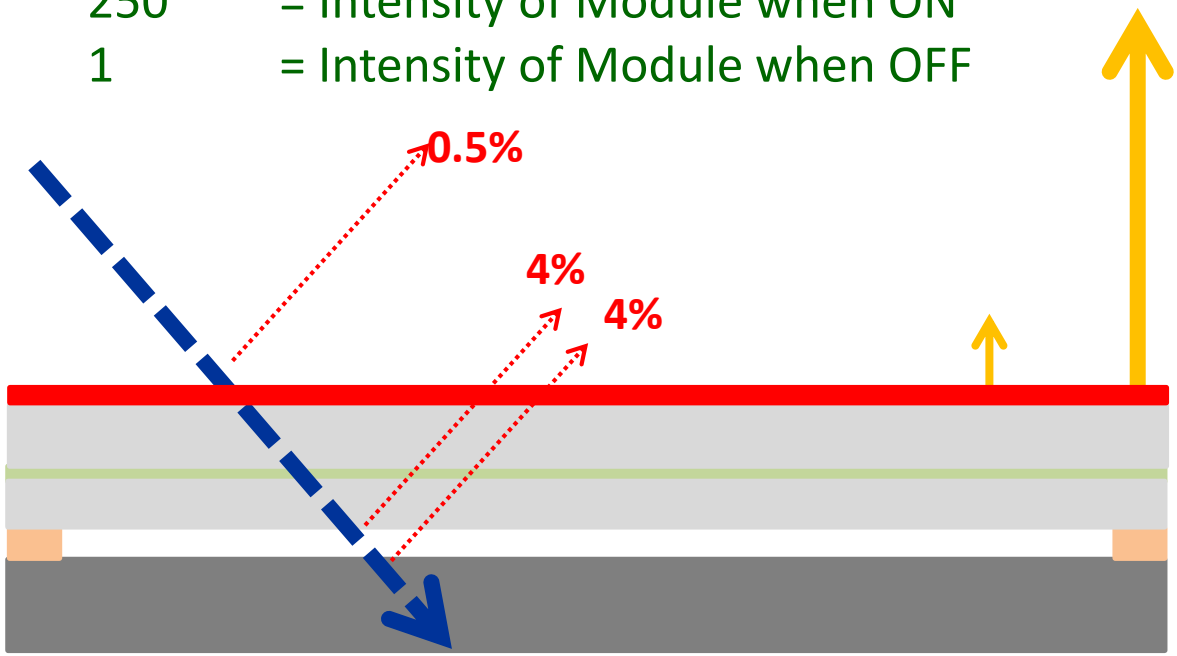


AR coating
Top Glass
UV Glue
Bottom Glass
OCA Bonding
TFT

Total Reflection is 0.7%

Contrast calculation conditions

10000 = Intensity of light on a Sunny day (nits)
200 = Intensity of Indoor Light
250 = Intensity of Module when ON
1 = Intensity of Module when OFF



Contrast calculation formula

- CR = $\frac{Intensity\ ON}{Intensity\ OFF}$
- Calculation using 8.5% reflection

$$CR = \frac{(10000 \quad or \quad 200) \times 8.5\% + 250}{(10000 \quad or \quad 200) \times 8.5\% + 1} = 1.29 \quad or \quad 14.83$$

- Outdoor = 1,29, CR Indoor = 14.83

CR with different structures

10000 = Intensity of light on a Sunny day (nits)
200 = Intensity of Indoor Light
250 = Intensity of Module when ON
1 = Intensity of Module when OFF

		CONTRAST RATIO	
Example	Reflectance	Indoor	Outdoor
1*	12.0%	11.0	1.2
2*	8.5%	14.83	1.29
3*	5.0%	23.6	1.5
4*	0.7%	104.8	4.5 (OCA)

Increasing Backlight Intensity

10000 = Intensity of light on a Sunny day (nits)
200 = Intensity of Indoor Light
1000 = Intensity of Module when ON
1 = Intensity of Module when OFF

		CONTRAST RATIO	
Example	Reflectance	Indoor	Outdoor
1*	12.0%	41.0	1.8
2*	8.5%	56.5	2.2
3*	5.0%	91.8	3.0
4*	0.7%	417.3	15.1 (OCA)

Touch Controllers

- IC Manufacturers used by EDT
  - PolyTouch 3.5” to 7”: FocalTech
  - SITO with Cover Lens for Custom Designs:
    - EETI, Ilitek, Cypress, Atmel, FocalTech and others….

Programmability

- EDT series of Touch Sensors, from 3.5” to 7” size
- Same Interface on all models (HW and SW)
- Programmable Gain, Threshold and Offset
- Why? European Market, Low Volume and High Mix

‘Hands On’ Programming

- Using FocalTech PC Toolkit at Adelco Booth.