Capacitive Touch Sensing



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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



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%



Gap filled with UV Glue

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 x 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 *cr* 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*)



Total Reflection is 12%



AR Coating on Top Glass (2*)



AR coating Top Glass UV Glue Bottom Glass Air gap TFT

Total Reflection is 8.5%



AR Coating Top and Bottom Glass (3*)



Total Reflection is 5%

AR Coating Top Glass UV Glue Bottom Glass AR Coating Air gap TFT



AR Coating + Optical Bonding (4*)



AR coating Top Glass UV Glue Bottom Glass OCA Bonding TFT

Total Reflection is 0.7%



Contrast calculation conditions





Contrast calculation formula

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

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

• 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

		CONT	RAST 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

		CONTRA	AST 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.

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3	10	-2	3	2	0	2	2	4	-5	10	-1	2	0	3	1	-3	30
4	3	2	1	13	6	0	1	-3	1	0	6	1	3	4	2	0	30
5	6	3	9	-3	7	-1	5	0	0	2	-3	9	2	4	-1	-7	30
6	5	0	16	6	3	4	3	0	-1	7	4	2	6	3	-2	1	30
7	13	-1	8	0	4	-3	-3	7	-5	3	-1	-5	2	-6	-1	4	30
8	-2	-5	-1	8	0	-5	1	5	6	0	1	2	-4	-3	-4	1	30
9	-5	-2	10	-4	-4	-6	5	1	-5	-4	0	3	6	3	-9	-8	30
10	11	2	12	-3	1	5	6	3	4	-2	3	-3	-1	-3	8	1	30
11	12	8	6	2	0	1	5	3	1	10	-2	-1	2	4	5	2	30
12	0	6	5	5	-9	6	-5	11	4	7	5	-1	2	0	-2	1	30
13	0	2	5	4	-5	2	4	10	47	28	7	1	11	-5	-2	1	30
14	7	6	0	7	-3	9	0	34	368	264	17	6	2	7	-2	7	30
15	4	-4	-4	4	0	-5	4	17	222	210	8	4	-1	-13	-8	2	30
16	0	6	1	-17	3	-1	3	10	8	17	4	2	0	-4	3	1	30
17	3	7	0	6	5	5	5	7	5	2	10	-4	7	4	-5	4	30
18	-2	-5	-2	7	-9	-2	-2	-7	2	-2	-3	-4	-3	0	-5	5	30
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20	5	3	2	2	10	6	0	9	5	0	7	1	0	0	-4	0	30
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1	8516	8513	8440	8471	8462	8407	8416	8298	8396	8366	8262	8476	8297	8342	8226	8368	9
2	8599	8621	8547	8578	8566	8524	8526	8423	8511	8480	8390	8598	8429	8454	8347	8459	9
3	8608	8608	8553	8568	8563	8528	8527	8423	8502	8479	8371	8594	8425	8449	8339	8453	9
4	8583	8596	8534	8569	8551	8505	8505	8398	8494	8467	8377	8582	8401	8431	8333	8461	9
5	8563	8576	8521	8537	8532	8492	8501	8385	8484	8454	8353	8579	8400	8422	8325	8442	9
6	8546	8550	8505	8531	8513	8487	8488	8374	8465	8444	8342	8561	8394	8417	8312	8436	9
7	8531	8543	8484	8510	8507	8467	8477	8370	8452	8423	8334	8548	8391	8403	8306	8435	9
8	8421	8435	8386	8422	8408	8366	8375	8269	8366	8329	8236	8453	8291	8317	8223	8352	9
9	8405	8430	8390	8404	8396	8357	8372	8256	8352	8320	8232	8451	8295	8311	8209	8337	9
10	8361	8381	8333	8336	8340	8322	8340	8215	8309	8270	8181	8402	8246	8261	8173	8288	9
11	8352	8375	8312	8331	8334	8305	8319	8203	8296	8270	8171	8390	8240	8266	8171	8285	9
12	8319	8354	8297	8327	8307	8290	8289	8185	8286	8257	8162	8376	8227	8256	8161	8290	9
13	8315	8348	8292	8312	8301	8273	8287	8180	8312	8270	8158	8374	8233	8247	8155	8276	9
14	8326	8353	8287	8319	8301	8289	8288	8205	8639	8512	8177	8391	8225	8265	8151	8283	9
15	8321	8338	8280	8313	8305	8280	8295	8184	8494	8458	8170	8384	8224	8236	8148	8274	9
16	8296	8337	8274	8286	8299	8278	8293	8172	8274	8256	8145	8370	8216	8246	8153	8275	9

