New Developments in Capacitive Multi-Touch Panel Controller IC for FPD

Solomon Systech Limited
晶閾科技有限公司
Contents

- Early History of Touch Sensing
- Technology Overview
- Technical Roadmap and Status
- Continuing Improvement and Future Expectations
Early History of Touch Sensing (1)

- 1969 Johnson: “Johnson Touch Displays” – touch sensitive contacts, placed adjacent the screen of a cathode ray tube, either resistive change or capacitive change (3,482,241)
- 1970, Lambright: “Interface Device and Display System” – an interface device including a transparent, flexible member which is coated with a suitable transparent, electrically conductive layer and a transparent base member which has been coated with a layer of a resistive material” (3,522,664)
- 1972, Johnson: “Touch Actuable Data Input Panel Assembly” – transmitters mounted along two adjacent edges of the panel to generate beams, either Rayleigh wave beams or light beams - detectors mounted along opposite panel edges (3,673,327)
1978, Welch: “Bar Graph Type Touch Switch and Display Device” - A user input/output device comprises a lighted, segmented bar graph type display and an array of light transmitting touch sensitive areas superimposed over the bar graph display (4,121,204)

1979, Eichelberger: “Self-Optimizing Touch Pad Sensor Circuit” – a plurality of capacitive touch pad sensors are multiplexed to the input of a common charge transfer analog-to-digital converter - - compared to no-touch memorized value, a touch-detection signal is given (4,145,748)

1983, Slater: “Multiplexed Touch Sensitive Screen System” – a plurality of touch sensitive screens which generate analog signals representing the coordinates of a position touched (4,386,232)

1986, Straton: “Intelligent Programmable Touchscreen System” – a computing system for detecting movement of a user’s touch on a touchscreen and to operate an intelligent programmable device (4,587,630)
Technology Overview
### Major Touch Technologies

<table>
<thead>
<tr>
<th>Touch technology</th>
<th>Resistive</th>
<th>Mutual capacitive</th>
<th>Self capacitive</th>
<th>SAW</th>
<th>Infrared</th>
<th>In-cell optic sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Touch detection</td>
<td>Potential difference</td>
<td>Signal coupling level</td>
<td>Capacitance</td>
<td>Propagation of wave</td>
<td>Blocking of infrared signal</td>
<td>Light intensity</td>
</tr>
<tr>
<td>Transparency</td>
<td>85%</td>
<td>over 90%</td>
<td>over 90%</td>
<td>92%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Touch media</td>
<td>- Finger - Stylus</td>
<td>- Finger (no gloves) - Conductive media (Tip size is critical)</td>
<td>- Finger (no gloves) - Conductive media</td>
<td>- Finger</td>
<td>- Finger - Non-transparent media</td>
<td>- Finger - Stylus</td>
</tr>
<tr>
<td>Cost</td>
<td>Low</td>
<td>Middle</td>
<td>Middle</td>
<td>Middle</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Remark</td>
<td>- Single touching point - Low transparency</td>
<td>- Reliable - High durability - Fast response - True Multi touch</td>
<td>- Sensitive to EMI - Fake touch location when multi-touch</td>
<td>- Sensitive to contamination - Error detection by dust/sweat</td>
<td>- Reliable - Error detection by dust/sweat</td>
<td>-Require extra pixel area - Sensitive to environmental light - Niche supplier</td>
</tr>
</tbody>
</table>

Mutual capacitive touch technology is the best cost effective solution for supporting true multi touch application.

We believe mutual capacitive touch technology will become mainstream in future touch panel market which requires true multi-touch.
## Touch Controller End Applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Panel Size</th>
<th>Resolution</th>
<th>Accuracy</th>
<th>Multi-Touch</th>
<th>Pin Counts</th>
<th>Driving Voltage / Power</th>
<th>Auto-Calibration</th>
<th>ITO Resistance</th>
<th>Sensing Method</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3”</td>
<td>QVGA/HVGA</td>
<td>Low (one chip)</td>
<td>Two fingers</td>
<td>Low (5V)</td>
<td>Low</td>
<td>Key for Manufacturing</td>
<td>Low</td>
<td>Self Capacitive</td>
</tr>
<tr>
<td></td>
<td>5”</td>
<td>nHD</td>
<td>Low (one chip)</td>
<td>One hand four fingers</td>
<td></td>
<td>Low (5V)</td>
<td></td>
<td>Low</td>
<td>Mutual Capacitive</td>
</tr>
<tr>
<td></td>
<td>7”</td>
<td>VGA/WVGA</td>
<td>Low (one chip)</td>
<td>Two hands</td>
<td>Low (5V)</td>
<td>Low (20V)</td>
<td></td>
<td>Low</td>
<td>Mutual Capacitive</td>
</tr>
<tr>
<td></td>
<td>9”</td>
<td>SVGA/XVGA</td>
<td>Low (one chip)</td>
<td>Two hands</td>
<td>Low (5V)</td>
<td>Low (20V)</td>
<td></td>
<td>Low</td>
<td>Mutual Capacitive</td>
</tr>
<tr>
<td></td>
<td>&gt;11”</td>
<td>HD</td>
<td>Low (one chip)</td>
<td>Two hands</td>
<td>Low (5V)</td>
<td>Low (20V)</td>
<td></td>
<td>Low</td>
<td>Mutual Capacitive</td>
</tr>
</tbody>
</table>

- **Sensing Method**: Self Capacitive, Mutual Capacitive, CMOS Camera Infra-red
- **Auto-Calibration**: Key for Manufacturing
- **Driving Voltage / Power**: Low (5V), Low (20V)
- **ITO Resistance**: Low, High
- **Multi-Touch**: Two fingers, One hand four fingers, Two hands
- **Panel Size**: 3”, 5”, 7”, 9”, >11”
- **Resolution**: QVGA/HVGA, nHD, VGA/WVGA, SVGA/XVGA, HD
- **Accuracy**: Low (one chip)
Conceptual Touch Product Grouping

Toward True Multi-touch

Self-capacitive Controller
Self-capacitive Controller /w 16-bit uC
Self & Mutual-cap Controller /w 16-bit uC
Mutual-capacitive Controller
Mutual-capacitive Controller /w 16-bit uC

Increase Programmability

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Self vs Mutual Capacitive Sensing (1 of 3)

Definition:
From circuit theory, the term capacitance usually refers to Mutual-capacitance between two adjacent/isolated electrodes, such as the two plates of a capacitor. There also exists a property called Self-capacitance, which is the amount of electrical charge that must be added to an isolated electrode to raise its electrical potential by one volt.

In our contest, we borrow the terms

1) Self-capacitive sensing for approaches with driving and sensing from the same electrode.

2) Mutual-capacitive sensing for approaches with driving and sensing from different electrodes.
Self vs Mutual Capacitive Sensing (2 of 3)

Self-capacitive Sensing

Drive / Sense

Mutual-capacitive Sensing

Sense

Drive
Mutual Capacitive Sensing

[Diagram of mutual capacitive sensing system with labels for ITO on Glass / Film / PCB, Signal driving lines, TSD Software Driver plug into System OS, Signal sensing lines, SPI or IIC or UART transmit finger(s) position and status back to CPU]
SSL Multi-touch Controller Block Diagram

- Signal driving lines
- Signal sensing lines
- Capacitive Coupling of finger(s)
- Signal Driver
- Frame Scan Control (with I/P Noise Rejection & O/P EMI suppression Correlator)
- DSP Core
- ADC Array
- Peak Detect & Hold Array
- 1st RAM
- 2nd RAM
- Finger Tracking (with Finger Event Detector)
- Interface
- To Host Processor

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Power Saving - Power Mode (1 of 3)

- Changed from 3 Power Modes to 4 Power Modes.
- A low power management have been added to help further power saving.
Power Saving - Power Mode (2 of 3)

- **Sleep Mode**
  - Sleep Mode is the mode where no activities can be performed. Unlike total power cut off, register settings will be preserved. The main aim of the mode is to save power.

- **Idle Mode**
  - Touch panel scanning cannot be executed in Idle Mode but the communication between host and Digitizer can be performed. This mode can be used to setup a number of internal registers for the proper operation of the Digitizer.
Power Saving - Power Mode (3 of 3)

- Normal Mode
  - Normal Mode is the mode where the Digitizer is fully functional; touch panel scanning can be executed.

- Power Saving Mode
  - Like Normal Mode, Power Saving Mode is fully functional. The difference between Normal and Power Saving is reduced scan rate and power level at parts of the controller IC.
General Properties of Finger Detection

- No. of Fingers

- Finger (X,Y) coordinates, Speed Index and Force Index.

- Events: Enter, Leave, Move, and Application Specific
Detection Accuracy – Finger Image Segmentation /w Slicing Levels

In this real finger image capture example, the embedded image segmentation algorithm identified that there are two fingers.
Detection Accuracy – Smart Running Average Scheme
Technical Roadmap & Status
Solomon-Systech Touch Panel Controller Roadmap

- **SSD2531 DSP Core**
  - Small-size 3” - 5”
  - Mid-size < 15”

- **SSD2533 MCU ROM**
  - 7” - 11”

- **SSD2532 DSP ROM**
  - < 5” Standard Panel

- **SSD2538 MCU eFlash**
  - 11” - 15”

- **SSD2528 MCU eFlash**
  - Projective Capacitive

- **SSD253X MCU ROM**
  - Self Capacitive

- **GPS Mobile**

- **Mobile Control**

<table>
<thead>
<tr>
<th></th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
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<td>2012</td>
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</tbody>
</table>

- Mass Production
- Sampling / Under Development
- Planning
The introduction of 16-bit uC (H/W layer) & Virtual Machine (S/W layer).

Programmability

- ROM (2K~16K)
- RAM (1K)
- Local Bus I/F
- 16-bit uC
  - Ctrl Data Addr
  - Reg Windows & Stack
  - Run Gesture Description Language
  - /w Speed-Step Technology
  - Scalable soft-core
- Program & Data

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## MCU Comparison

<table>
<thead>
<tr>
<th></th>
<th>Proprietary 16-bit MCU</th>
<th>Generic 16-bit MCU</th>
<th>Generic 8-bit MCU</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Average MIPS per MHz</strong></td>
<td>0.714 MIPS</td>
<td>0.667 MIPS</td>
<td>0.067 MIPS (emulate16-bit)</td>
<td>Clock cycle per instruction is average of: * 16-bit Arithmetic instructions, * 16-bit logic instructions, * 16-bit data transfer instructions, * PUSH/POP instructions, * Relative/Absolute jump instructions.</td>
</tr>
<tr>
<td><strong>Subroutine call speed</strong></td>
<td>2~3 clocks (/w Register Forwarding Technique)</td>
<td>20+ clocks (due to stack PUSH/POP mechanism)</td>
<td>20+ clocks (due to stack PUSH/POP mechanism)</td>
<td>Register Forwarding Technique allows three ways of subroutine calling that suit different situations: * Quick Subroutine Calling (Register Window Sliding), * Traditional Subroutine Calling (Stack PUSH/POP), and * IRQ Service Routine Calling (Register Bank Switching).</td>
</tr>
</tbody>
</table>
Functions carried out by DSP

- Touch Panel Drive/Sense Scanning Control
- Touch Panel Reference Data Calibration
- Calculation of Delta Data and 2D filtering
- Finger Image Segmentation
- Calculation of Finger(s) Coordinates
Advantages of a Dedicated DSP core:

- Dramatically lower the operating speed of the main MCU (from 64MHz to 16MHz).
- Guarantee precise frame rate at all conditions (i.e. can keep same high frame rate regardless of the number of finger touches).
- Lower total power consumption through dedicated DSP functions that cannot be implemented using 16-bit MCU.
Continuing Improvement & Future Expectations
Continual Improvement

- Power Saving
  - AC & DC
  - Panel and Application Specific
- Finger Coordinates Accuracy and Line Linearity
  - AFE and Control Scheme
  - DSP
  - Noise Reduction
- Large or Hi-Ohmic Panels
  - Parameterization and programmability
  - Adaptive
- Minimize External Component Count
  - Power Management
Future Expectations

- Natural user interface – replacing mouse and keyboard
- Fast pace in development of new touch sensing and touch panel technologies – matches past and continuing progress in FPD
- New applications and new markets – resulting from new technologies and ever increasing computing power
Thank You

http://www.solomon-systech.com

Email : sales@solomon-systech.com
Phone : 852-2207 1111  Fax : 852-2267 0800