Agenda

- **Touch-Usage Requirements [1]**
- **System-Level Requirements [1]**
- **Current Touch Technologies [4]**
  - Electromagnetic resonance pen digitizer (EMR), capacitive, traditional infrared, and resistive
- **Emerging Touch Technologies [2]**
  - EMR with integrated force-sensing [Hanvon]
  - Waveguide infrared [RPO]
- **Potential Touch Technologies [3]**
  - Traditional force-sensing, Acoustic Pulse Recognition/ReverSys [Elo], and embedded (“in-cell/on-cell”)
- **Conclusions [1]**

[Total = 12]
Touch-Usage Requirements (EPD-Based Devices Only!)

- **Selection**
  - High accuracy

- **Swipes**
  - Very light touch & fast response (iPhone set the standard)

- **Zoom**
  - Multi-touch
    - Better with images stored at higher resolution than displayed

- **Annotation**
  - Stylus with palm rejection
    - Better with software infrastructure for saving annotations with location in text, even when text is reflowed
  - High-resolution ink for readability
  - Desirable: Handwriting recognition (conversion from ink to text)
System-Level Requirements
(EPD-Based Devices Only!)

- **Zero light loss (eReader = EPD!)**
  - Transmissivity: Light goes through the touch-screen twice!
  - Reflectivity: Reflected light reduces image contrast

- **Very low power consumption**
  - Typical usage model doesn’t help

- **Durable & light weight**
  - Very Desirable: No added glass
  - Hard surface for annotations

- **Insensitive to ambient light**
  - Works in bright sunlight with lots of IR
Current Touch Technologies…1
(Being Shipped Today in e-Readers)

❖ Electromagnetic resonance pen digitizer (EMR)
  ✦ Most common “touch” technology in eReaders
    ● Wacom & Hanvon are primary suppliers
  ✦ Sensor goes behind EPD, so no light loss
    ● But NO finger touch, and electronic pen is at risk for being lost
  ✦ High resolution ink & inherent palm rejection
  ✦ Lack of infrastructure reduces value of annotation today
Current Touch Technologies...2
(Being Shipped Today in e-Readers)

- Capacitive
  - Same technology as in iPhone & 100% of tablets
  - Light touch & multi-touch
  - Surface can be flush (“zero-bezel”)
  - Light loss can be minimized to 2-4%
  - Finger-only (so far), so no annotation
    - Palm rejection is achievable when stylus arrives
  - Still very expensive: 7” \(\approx\) $25 OEM cost with controller (film/film/cover-glass)
    - AUO/SiPix is using laminated film/film/no-glass with a hard-coat cover film

Source: HowStuffWorks.com
Current Touch Technologies...3
(Being Shipped Today in e-Readers)

- Traditional infrared (for mobile)
  - Only one supplier today: Neonode (Sweden)
    - Small company licensing IP, not selling hardware
  - Used in Sony, Koobe, Nook Simple Touch, and maybe others
  - No glass, so no light loss
    - IR beams above EPD surface ➔ non-flush bezel
  - Relatively low resolution
  - Doesn’t scale very well

Source: Neonode and Pen Computing Magazine
Current Touch Technologies...4
(Being Shipped Today in e-Readers)

- **Resistive on top of EPD**
  - All single-touch today
    - Nobody has announced the use of multi-touch resistive yet; it seems unlikely because it’s not enough of an improvement
  - Least desirable current technology
    - 15% to 20% light loss (glass + 2xITO + PET + air-gap)
    - Reducing surface reflectivity is expensive
    - Requires heavier touch
    - No palm rejection

- **Resistive *underneath* EPD**
  - Demonstrated by E-ink at SID 2010
  - Potential solution, especially once EPD backplane becomes totally flexible

Source: Sony
Emerging Touch Technologies...1

- Hanvon’s EMR + force-sensing
  - High-resolution stylus plus finger-touch
  - Adds an array of piezo-capacitors (used in pen tip to sense pressure) to EMR sensor behind EPD display
    - EMR controller enhanced to support force-sensing ➔ still one chip
    - Nothing added in front of display ➔ no light loss
    - Very light touch (under 10 grams)
    - Palm rejection with auto-switch between pen and finger
    - Multi-touch planned by end of 2011
    - Fast response (200 pps)
    - Low cost & low power consumption
  - Will be validated in Hanvon-branded products first, then released to market

Source: Hanvon
Emerging Touch Technologies...2

Waveguide infrared (“Digital Waveguide Touch”)

- Only one supplier (RPO), and their IP is on the market
- At least one major eReader OEM had committed to use them
  - That OEM (or someone else) may buy the IP & other assets, and the technology may survive

- Good solution for eReaders
  - Light guide (glass or plastic) underneath the EPD, so no light loss
  - Zero-force touch & multi-touch
  - Very low power consumption
  - Higher resolution ➔ finger or stylus
  - Easily scalable up to 14”
  - Very good ambient light rejection

Source: RPO
Potential Touch Technologies...1

❖ “Traditional” force-sensing

❖ FloatingTouch, LLC (early-stage startup)
  ● Any-touch with nothing added in front of display
  ● Display mounts on 2-mm flexible adhesive pad that contains sensors
  ● May support multi-touch & palm rejection (TBD)

❖ Impress (spin-off from Pressure Profile Systems)
  ● Similar concept to FloatingTouch
Potential Touch Technologies…2

- **Elo’s Acoustic Pulse Recognition (APR) + Sensitive Object’s Reversys**
  - Any-touch with nothing added in front of display
  - Prototype with piezos integrated into E-ink display
  - Second generation of combined technology is still under development
  - Too early to determine if it meets all the requirements

Source: Sensitive Object

Source: Elo TouchSystems
Potential Touch Technologies...3

- **Embedded in EPD backplane (“in-cell”)**
  - Light-sensing: LGD showed concept at SID 2009
    - Visible light → Can’t touch black object
    - IR light → No reliable source
  - Voltage-sensing: *Not possible*
    - Depends on micro-switches between top & bottom of rigid cell
  - Charge-sensing: *Not possible*
    - Depends on change in dielectric constant of LC material

- **Deposited on EPD frontplane (“on-cell”)**
  - Charge-sensing: Possible with 2nd film layer for protection

Source: LG Displays
## Conclusions

<table>
<thead>
<tr>
<th>eReader Touch Technology</th>
<th>Current Usage/Status*</th>
<th>Geoff’s Rating</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMR Pen Digitizer</td>
<td>15%</td>
<td>B</td>
<td>No finger-touch</td>
</tr>
<tr>
<td>Capacitive</td>
<td>25%</td>
<td>B</td>
<td>No stylus (yet)</td>
</tr>
<tr>
<td>Traditional Infrared</td>
<td>40%</td>
<td>B</td>
<td>Low resolution &amp; scalability</td>
</tr>
<tr>
<td>Resistive (on top of EPD)</td>
<td>17%</td>
<td>D</td>
<td>Worst choice (but low-cost)</td>
</tr>
<tr>
<td>EMR + Resistive (on top)</td>
<td>3%</td>
<td>C</td>
<td>Only Samsung (expensive)</td>
</tr>
<tr>
<td>Hanvon’s EMR + Force-Sensing</td>
<td>Close</td>
<td>A</td>
<td>Needs real-world validation</td>
</tr>
<tr>
<td>RPO’s Waveguide Infrared</td>
<td>IP For Sale</td>
<td>A</td>
<td>Will the technology survive?</td>
</tr>
<tr>
<td>FloatingTouch’s Force-Sensing</td>
<td>Development</td>
<td>B</td>
<td>Potentially very low-cost</td>
</tr>
<tr>
<td>Impress’ Force-Sensing</td>
<td>Development</td>
<td>B</td>
<td>Potentially very low-cost</td>
</tr>
<tr>
<td>Elo’s APR + ReverSys</td>
<td>Development</td>
<td>C</td>
<td>Long development cycle</td>
</tr>
<tr>
<td>Capacitive on Frontplane (on-cell)</td>
<td>Concept</td>
<td>B</td>
<td>Still some light-loss; stylus?</td>
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<tr>
<td>Resistive (underneath EPD)</td>
<td>Concept</td>
<td>D</td>
<td>Expensive force-sensing</td>
</tr>
<tr>
<td>Embedded in Backplane (in-cell)</td>
<td>Concept</td>
<td>D</td>
<td>No apparent solution</td>
</tr>
</tbody>
</table>

* Shipment share of eReaders with touch (author’s estimates)