Ultra-Low Power Optical Links in Portable Consumer Devices

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Evolution of User Interface

• User interfaces of mobile and consumer electronic devices evolved from a couple of LEDs and mechanical switches to interactive touchscreen interfaces

• Increasing computing power yielded ability to process and display highest-resolution, deep-color video content at frames rates suitable for 3D-viewing
Trends in Display Pixel Densities

20/20 Vision

\[ \alpha = 1 \text{ arc minute} \]

Visual acuity is the spatial resolving capacity of the human eye as a function of the viewing distance.

Wikipedia (Visual Acuity):
“…20/20 standard can best be thought of as the lower limit of normal (vision)…”
“…the average visual acuity of healthy eyes is 20/16 to 20/12…”
# Resolutions of ‘Visual Acuity’ Displays

- Based on 20/10 Vision:

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<tr>
<td>Smart Phone</td>
<td>11</td>
<td>625</td>
<td>4</td>
<td>3 : 2</td>
<td>2.081</td>
<td>1.388</td>
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<tr>
<td>Tablet</td>
<td>13</td>
<td>528</td>
<td>10</td>
<td>16 : 10</td>
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<td>2.798</td>
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<td>Laptop</td>
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<td>15</td>
<td>16 : 10</td>
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<td>2.727</td>
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### Aggregated Gross Data Rates

<table>
<thead>
<tr>
<th>Visal Acuity Class: 20/10</th>
<th>Gbps</th>
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<tbody>
<tr>
<td>3D, 4&quot; Smart Phone Display</td>
<td>12.5</td>
</tr>
<tr>
<td>3D, 10&quot; Tablet Display</td>
<td>54.1</td>
</tr>
<tr>
<td>3D, 15&quot; Laptop Display</td>
<td>51.3</td>
</tr>
</tbody>
</table>

(Gross Data Rate at 24-bit, 120 Hz, 20% Blanking OH, 8B/10B)
Actual Display Pixel Densities

2010

326 ppi

3.5“: 960 * 640 pixels
approx.: 1.5 Gbps (24b, 60Hz, incl. OH)

2011

498 ppi

6.1“: 2560*1600 pixels
approx.: 9 Gbps (24b, 60Hz, incl. OH)

scaled up to 3D tablet screen size of 10“: 4224*2640 pixels
approx.: 45 Gbps (24b, 120Hz, incl. OH)
How to Get Data Across

• Number of physical lines at respective aggregated data rate*:

<table>
<thead>
<tr>
<th>Visal Acuity Class: 20/10</th>
<th>Gbps</th>
<th>D-PHY 1000 Mbps</th>
<th>M-PHY Gear 2</th>
<th>M-PHY Gear 3</th>
<th>M-PHY Gear 4</th>
<th>eDP 2.7G</th>
<th>eDP 5.4G</th>
</tr>
</thead>
<tbody>
<tr>
<td>3D, 4&quot; Smart Phone Display</td>
<td>12</td>
<td>26</td>
<td>10</td>
<td>4</td>
<td>4</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>3D, 10&quot; Tablet Display</td>
<td>54</td>
<td>110</td>
<td>36</td>
<td>18</td>
<td>10</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td>3D, 15&quot; Laptop Display</td>
<td>51</td>
<td>104</td>
<td>34</td>
<td>17</td>
<td>10</td>
<td>38</td>
<td>20</td>
</tr>
</tbody>
</table>

(8B/10B excluded)

* number of needed physical connections – number of differential lanes is half of that
Projected Channel Loss for Electrical Links

- ~ 50 dB loss at 10 GHz in a standard FR4 material
- To improve bandwidth lower loss material needed, more complex driver and equalization technologies needed ➔ Increased cost
- Beyond 10 GHz ➔ effect of reflections and crosstalk

Simulated data of frequency-dependent loss for a 20-inch long electrical interconnect link

Source: "20050423_wsh.pdf", E. Mohammed et al., Intel Corp.
Increasing Link Distances

- **Smartphone**
  - Video interconnect distances: 1”~ 3”

- **Tablet**
  - Video interconnect distances: 2”~ 10”

- **Ultrabook**
  - Video interconnect distances: 2”~ 20”
EMI Consequences

- EMI Measurements taken from FPC and Micro-Coaxial Cable at 1.5 Gbps
Constrained PCB Layout with Electrical Links

- MCX cable length must be kept as short as possible to limit EMI
- This constrains the placement of the electrical connectors
- This in turn constrains the placement of the ICs
A Valid Alternative

• Ultra-Low Power Optical Links
The Power Benefit

- Ultra-Low Power Optical Links

![Diagram of optical link components]

**Key Data for Laser Driver and TIA/LA**

- Data rate support up to 12.5 Gb/s
- Ultra low power consumption
  - e.g. <1 mW @3Gbps (Driver)
  - <5 mW @3Gbps (TIA/LA)
- Sub-LVDS Electrical I/O (SLVS-200)

*Actual active optical cable based on Silicon Line ICs:
- Optical TX-size (L x W x H): 3mm x 1.8mm x 1mm
- Optical RX-size (L x W x H): 3mm x 1.8mm x 1mm

Source: Amphenol
Signal Integrity Benefit

- 50 cm optical fiber link @ 3 Gb/s

TX: Single supply (2.5 V)
RX: Dual supply (1.2 & 2.5 V)

Total power: 11.7 mW
The Mechanical Benefits

**Cross-sectional core image**
- Cladding Layer
- Core
- 10 μm
- Cladding Layer

**Low propagation loss**
- 0.07 dB/cm (@850nm) for POW
- 0.004 dB/cm (@ 850 nm) for POF

**Flexible durability**
- Bending radius
  - R=1mm passed 1 million bending test
- Change of loss
  - Cycle (×10^4)

**Twistable durability**
- Twisting length
  - L=5mm passed 1 million twisting test
- Change of loss
  - Cycle (×10^4)

The EMI Benefit

- EMI-Measurements taken from FPC with included planar optical waveguide and an optical fiber link
The Link Number Benefit

- Number of optical links at respective aggregated data rate:

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(8B/10B excluded)
Flexible PCB Layout with Optical Links

- Cable length is not constrained, no EMI issues
- Optical connectors can be placed anywhere on the boards
- ICs can be placed anywhere on the boards
- Enables customer to conceive new mechanical form factors and design

MAIN BOARD

APPLICATIONS PROCESSOR Or GPU

Optical Link

LCD DISPLAY MODULE

TCON

Row Drivers

Column Drivers

TFT Panel
Bridging to Optics

• Optical friendly signalling (e.g. DC-balanced 8B/10B encoding)
  • MIPI M-PHY
  • DisplayPort, embedded DisplayPort
  • SATA, USB 3
  • Next generation peripheral link (e.g. Thunderbolt, USB “4.0“) …

All above standards are defined electrically, but have optical-friendly signalling or explicit support for optics.

• Serialization of parallel interfaces
  • MIPI D-PHY
  • DisplayPort, embedded DisplayPort
  • RGB, LVDS

Ultra-low power serialization technologies for D-PHY, eDP, etc. are readily available as bridge ICs or IP enabling a smooth transition to optical link technology.
Serializing D-PHY Signals

SerDes Products for MIPI D-PHY Cameras and Displays

- Ultra-low power, high performance serial D-PHY bridge IC
- Bandwidth scalable up to 6 Gbps which supports:
  - The latest generation of high resolution cameras and 3D displays
- No EMI issues ➔ No RF reception problems
- Small size and footprint enables ultra-small and thin form factor designs
- Optional galvanic link feature supports bi-directional low power data transmission (LPDT)
Optical High-Speed Video Interconnects

- Optical links enable system designers to conceive new mechanical form factors and designs
- High-speed optical link bridge easily several meters without signal loss
- No EMI (aggressor or victim)
- Bandwidth scalable, future, proof to 100 Gbps and beyond
- Small in size and footprint
- Ultra-low power, little impact on battery life
- All video transport protocols are supported for smart phones, tablets and notebooks
Thank you!

• For more in information please visit us at:

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