Miguel Rodriguez
Analogix Semiconductor

High-Performance VR Applications Drive High-Resolution Displays with MIPI DSI℠
Today’s Agenda

• VR Head Mounted Device (HMD) Use Cases and Trends
  – Cardboard, high-performance (tethered), all-in-one
  – Dedicated displays provide best user experience
  – Requirement for higher throughput for both video and data for high-end VR and mainstream VR

• MIPI DSI\textsuperscript{SM} delivers high performance for VR configurations
  – MIPI is the main interface for VR displays
  – Architecture examples: DisplayPort is the most common source for VR content
  – Combo MIPI C-PHY\textsuperscript{SM}/D-PHY\textsuperscript{SM} provides system flexibility for optimum performance
  – Leading VR display controller enables top VR headsets by leveraging key MIPI features

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## VR Head Mounted Device (HMD) Use Cases

<table>
<thead>
<tr>
<th>Cardboard</th>
<th>Tethered</th>
<th>Standalone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduced in 2014</strong></td>
<td><strong>Introduced in 2016 and 2017; refreshed in 2018</strong></td>
<td><strong>Introduced in 2018</strong></td>
</tr>
<tr>
<td>- Entry level, low cost VR system</td>
<td>- High-end level HMD with dedicated display(s) and sensors</td>
<td>- Mainstream, similar to cardboard predecessor</td>
</tr>
<tr>
<td>- Smartphone provides graphics engine, display and limited sensor capability</td>
<td>- Requires high-end GPU for video transmission</td>
<td>- Similar architecture as smartphones but tuned for VR use cases</td>
</tr>
<tr>
<td>- Apps running on smartphone provide VR experience</td>
<td>- Primary application is gaming and commercial/retail</td>
<td>- Uses higher performance display</td>
</tr>
<tr>
<td><strong>VR Video Performance</strong></td>
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<td><strong>VR Video Performance</strong></td>
</tr>
<tr>
<td>- Limited by smartphone specs; i.e. displays with low resolution and refresh rates</td>
<td>- Higher resolution and refresh rates than smartphone displays (up to 2880x1600 and 120Hz respectively)</td>
<td>- Achieves higher resolution and refresh rates than cardboard but still less than tethered HMDs</td>
</tr>
<tr>
<td>- High heat dissipation from smartphone battery</td>
<td>- Lighter and lower heat dissipation</td>
<td>- Lower heat dissipation and lighter than cardboard predecessor</td>
</tr>
</tbody>
</table>

Dedicated VR displays provide the best user experience
### High-End VR Head Mounted Device (HMD) Trends

<table>
<thead>
<tr>
<th>Year</th>
<th>Devices</th>
<th>Resolution</th>
<th>Refresh Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016</td>
<td>HTC Vive, Oculus Rift</td>
<td>2160x1200 at 90Hz</td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>HTC Vive Pro, SONY PSVR</td>
<td>2880x1600 at 90Hz</td>
<td></td>
</tr>
<tr>
<td>2018</td>
<td>HTC Vive Pro, SONY PSVR, Microsoft MR, Huawei VR2</td>
<td>2880x1440 at 90Hz, 2880x1600 at 90Hz</td>
<td></td>
</tr>
<tr>
<td>2019 and beyond</td>
<td>VirtualLink (recently announced)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Next Gen VR HMDs:
- Higher Resolutions
- Higher Refresh Rates
- Higher color depth
- Low persistence; i.e. fast scan-out
- Low power
- Etc.

Higher immersion experience drives the next gen high-end VR headsets
Mainstream VR Head Mounted Display (HMD) Trends

### Performance

#### Today
- **VR Performance**
  - 2560 x 1440 @ 90 FPS
  - 2880 x 1600 @ 90 FPS
  - 3 DoF only; i.e. head orientation only

#### Tomorrow
- **VR Performance**
  - 2880 x 1600 @ 90 FPS
  - 3600 x 1800 @ 90 FPS
  - 6 DoF and Inside-out positional tracking

#### Beyond
- **VR Performance**
  - 3600 x 1800 @ 120 FPS
  - 3840 x 2160 @ 90 FPS
  - 6 DoF and inside-out positional tracking with room scale setup

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6 DoF positional tracking, total immersive interaction, object detection, room-scale setup, etc.

6 DoF positional tracking $\Rightarrow$ head orientation and movement along X, Y, Z axis; Inside-out positional tracking

3 DoF Positional tracking $\Rightarrow$ head orientation only

Balance between performance, immersion and power is key for mainstream VR headsets
Case 1: High-End/Mainstream HMD with Standard Connections

VirtualLink use case bandwidth requirements are similar

<table>
<thead>
<tr>
<th>Resolution</th>
<th>Challenge</th>
<th>MIPI Bridge Functions</th>
</tr>
</thead>
</table>
| 3840x1920 @ 120 FPS | 1. Total bandwidth required is 32Gbps  
2. Uncompressed video | - MIPI C-PHYSM @ 1.2GSym/s provides enough bandwidth  
- Supported over 12-Trio MIPI port configuration |
Case 2: Mainstream HMD with USB-C Input

Supports VirtualLink configurations as well

<table>
<thead>
<tr>
<th>Resolution</th>
<th>Challenge</th>
<th>MIPI Bridge Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>4800x2400 @ 90 FPS</td>
<td>1. Available input bandwidth: 16Gbps&lt;br&gt;2. Low persistence requirements for both OLED and LCD panels</td>
<td>- MIPI C-PHY(^{SM}) @ 1.2GSym/s&lt;br&gt;- Vertical Blanking Interval (VBI) expansion timing for low persistence on LCDs&lt;br&gt;- Supported over 12-Trio configuration</td>
</tr>
</tbody>
</table>
Case 3: High-End HMD with High Resolutions

<table>
<thead>
<tr>
<th>Resolution</th>
<th>Challenge</th>
<th>MIPI Bridge Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>8000x4000 @ 90 FPS</td>
<td>Requires DSC compression at DisplayPort input and MIPI VR displays</td>
<td>- MIPI C-PHY&lt;sup&gt;SM&lt;/sup&gt;/D-PHY&lt;sup&gt;SM&lt;/sup&gt; @ 1.2GSym/s</td>
</tr>
<tr>
<td>6000x3000 @ 120 FPS</td>
<td></td>
<td>- DSC compression passthrough to VR display</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Supported over quad-DSI or 12-Trio configuration</td>
</tr>
</tbody>
</table>

1. Requires DSC compression at DisplayPort input and MIPI VR displays.
## MIPI DSI<sup>SM</sup> Enables High-Performance Video

<table>
<thead>
<tr>
<th>Signal Speed</th>
<th>MIPI C-PHY&lt;sup&gt;SM&lt;/sup&gt; Effective Bandwidth over 12-trios</th>
<th>MIPI D-PHY&lt;sup&gt;SM&lt;/sup&gt; Effective Bandwidth over 16-DSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1GHz</td>
<td>1.2GHz</td>
<td>1.5GHz</td>
</tr>
<tr>
<td>16 Gbps</td>
<td>19.2 Gbps</td>
<td>24 Gbps</td>
</tr>
<tr>
<td>32.83 Gbps</td>
<td>41.04 Gbps</td>
<td></td>
</tr>
<tr>
<td>27.36 Gbps</td>
<td></td>
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</tr>
</tbody>
</table>

### Typical VR Resolutions

- **Combo MIPI C-PHY<sup>SM</sup>/D-PHY<sup>SM</sup>** provides system flexibility for uncompressed and compressed video support at VR specific resolutions
- Higher resolutions and frame rates can be achieved with MIPI C-PHY<sup>SM</sup> + compressed video

### Notes:

- Additional blanking will result in higher bandwidth requirements; above assumes very little blanking
- 4K @ 120 resolutions cannot be supported without compression (VESA DSC) for MIPI D-PHY<sup>SM</sup>
- ANX7538/39 is the only VR HMD controller that can support uncompressed 4K2K @ 120 FPS including extended blanking for low persistence
- Higher resolutions (greater than 3K per eye) requires DSC passthrough

### Achieve the optimum power & performance with MIPI Combo MIPI C-PHY<sup>SM</sup>/MIPI D-PHY<sup>SM</sup>

**Analogix Semiconductor**
ANX7539 is the Industry’s First VR/AR controller with VBI, Scalar, MIPI C-PHY℠ and compression
On-Chip Video Scaler Supports VR Display Resolutions

- Existing content format can leverage larger resolution VR displays with MIPI DSI™ interfaces
- Allows upscaling to larger native VR display resolutions; it prevents
  - Pillarboxing, letterboxing
  - No video in some cases

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Vertical Blanking Interval (VBI) Expansion

Without VBI:
- Sample-and-hold motion between frames; i.e. previous image is displayed until next frame is available

With VBI:
- Black frame insertion and strobing backlight provide an impulse image reducing the perceived motion blur

VBI helps reduce power on DisplayPort interface while maximizing MIPI DSI\textsuperscript{SM} bandwidth
# ANX7539 Ideal for High-End VR HMD Applications

<table>
<thead>
<tr>
<th>Item #</th>
<th>Input Resolution, FPS</th>
<th>ANX7539</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Left + Right Eye Views</td>
<td>On-chip VBI Expansion (% of input frame)</td>
</tr>
<tr>
<td>1</td>
<td>4800x2400 @ 90 FPS</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>3840x2160 @ 90 FPS</td>
<td>20%</td>
</tr>
<tr>
<td>3</td>
<td>4800x2400 @ 90 FPS</td>
<td>50%</td>
</tr>
<tr>
<td>4</td>
<td>4320x2160 @ 90 FPS</td>
<td>50%</td>
</tr>
<tr>
<td>5</td>
<td>4176x2160 @ 90 FPS</td>
<td>50%</td>
</tr>
<tr>
<td>6</td>
<td>3840x2160 @ 90 FPS</td>
<td>50%</td>
</tr>
<tr>
<td>7</td>
<td>6000x3000 @ 120 FPS</td>
<td>0%</td>
</tr>
<tr>
<td>8</td>
<td>8000x4000 @ 90 FPS</td>
<td>0%</td>
</tr>
</tbody>
</table>

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In Summary

- MIPI DSI\textsuperscript{SM} interface provides the necessary feature set to enable today’s and tomorrow’s high-performance displays.
- Immersion and user experience continues to drive the performance requirements for VR HMDs.
- Intelligent VR and AR display controllers will power the next generation of HMDs.
- Analogix leads with innovative technology and products for AR/VR by leveraging and maximizing industry standards (MIPI DSI\textsuperscript{SM}, DisplayPort, USB-C, etc.).

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ADDITIONAL RESOURCES


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THANK YOU

MIPI ALLIANCE DEVELOPERS CONFERENCE
19 OCTOBER 2018
SEOUL

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