James Goel
Technical Steering Group Chair
Display Working Group Vice-Chair

MASS: MIPI Automotive SerDes Solutions
Displays Using VDC-M Visually Lossless Compression

Deeper Dive symbol: Extra slides in backup material at the end of the presentation
Part I – MASS Display Use-Cases and Architecture

• Automotive displays undergoing rapid change driven by 5 new trends:
  – Connectivity, Over-the-Air Updates, Electrification, Autonomy and Ride Sharing
  – Increase in the number of displays
  – Increase in size
  – Increase in resolution

• **Massive increase in automotive display bandwidth** requirements.

• Countered with more stringent Power and RF interference constraints
Part I – MASS Display Use-Cases and Architecture

• Automotive engineers need new automotive display system solutions

• **MASS**: MIPI Automotive SerDes Solutions
  – Foundation is the next generation MIPI Automotive-PHY specification
  – Leverages MIPI low-power, low EMI display and camera protocols
  – Includes new End-to-end functional safety and security improvements

• Details in two new MASS Display and Compression whitepapers (Oct 2020)
# 5 Automotive Industry Trends Driving Display Architectures

<table>
<thead>
<tr>
<th>Trend</th>
<th>Description</th>
<th>Impact on Display Architecture</th>
</tr>
</thead>
</table>
| **Connectivity** | 5G, V2V and V2X standards will allow passengers to communicate, work, surf the Internet, and access high-bandwidth multimedia throughout the journey. | Increased need for visual bandwidth  
More, larger, higher resolution displays |
| **Over-the-Air Feature Updates** | Software subscription services will be offered to accelerate the pace of automotive hardware and software integration. These shorter innovation cycles will make use of all increased automotive display capability. Displays will be used to change the look-and-feel of the car’s interior with downloadable backgrounds and personalized content. | New display form factors to curve and match the style of the interior cabinet  
More, larger, higher resolution displays |
| **Electrification** | The transition to emissions free transportation creates new constraints on in-cabin electrical consumption. The distance traveled on a single charge is directly proportional to the power efficiency of the electrical and electronic sub-systems. The multiple displays required in modern cars can leverage the power efficient techniques pioneered in mobile wireless phones. | Dynamic display power reduction at the hardware protocol level  
Optimize display bandwidth through compression to reduce power |
| **Autonomy**     | Full or partial self-driving cars will have a profound impact on the industry. Vehicles that off-load the driving task allow the driver and automobile to interact differently with the potential to use advanced display capabilities for gaming, entertainment and information not related to the task of driving. | Increased use-cases for display content  
More, larger, higher resolution displays |
| **Car Sharing**  | Autonomous vehicles will enable highly customized car sharing solutions where driver preferences are automatically configured when the driver starts the car. Future vehicle display interfaces will be highly customizable with a much richer multimedia experience including animations, personalized content, wide colour gamut images and audio. | Customized user experience will travel with driver and individual passengers.  
Display must adapt to constantly changing requirements |
Modern Automotive Cockpit Displays – Close Up
## Modern Automotive Cockpit Displays

<table>
<thead>
<tr>
<th>Display Type</th>
<th>Example Size (Inches)</th>
<th>Example Resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left and Right-Side Mirror Displays</td>
<td>7”</td>
<td>1280x800</td>
</tr>
<tr>
<td>Driver Instrument Display (DID)</td>
<td>12.3”</td>
<td>3840x1440</td>
</tr>
<tr>
<td>Center Information Display (CID)</td>
<td>12.3”</td>
<td>3840x2160</td>
</tr>
<tr>
<td>Extended Co-Driver display (CDD)</td>
<td>12.3”</td>
<td>3840x2160</td>
</tr>
<tr>
<td>Lower Control Display</td>
<td>12.4”</td>
<td>3840x2160</td>
</tr>
</tbody>
</table>
Modern Automotive Cockpit Displays – Rear Screens

- Rear Mirror Display
- Side Mirror Reduced Profile
- Left Rear Display
- Right Rear Display
Digital Side View Mirror
Automotive Display Requirements

- Support multiple, high resolution displays from a single Electronic Control Unit (ECU)
  - Up to 15 meters with multiple simultaneous display channels
  - Low power, Electromagnetic Compatibility (EMC) and Ultra-low Packet Error Rate (PER) for safety and video compression support.
- Support scalable daisy-chain and hub-spoke topologies
  - **Daisy Chain Topology**
    - Best suited when central ECU drives multiple inline displays.
    - Dashboard applications
  - **Hub-Spoke Topology**
    - Best suited when central ECU drives multiple widely dispersed displays
    - Rear screen applications
- **Side-view mirror use-case**
  - External side-mirror camera sensor → ECU → side-mirror display
  - Functional Safety
MASS: MIPI Automotive SerDes Solutions
High-Level Conceptual Diagram
MASS: MIPI Automotive SerDes Solutions

A vision for End-to-End Systems
MASS Display Daisy Chain Topology

Application Processor

Raw Source Generator

Raw

DSI or DP Src

DP or D-C-PHY

A-PHY Tx Bridge

Driver Instrument Cluster

DSI or DP Sink

A-PHY Rx/Tx Bridge

Centre Information Display

DSI or DP Sink

A-PHY Rx/Tx Bridge

Lower Control Display

DSI or DP Sink

A-PHY Rx/Tx Bridge

Co-Driver Display

DSI or DP Sink

A-PHY Rx/Tx Bridge

Left Side Mirror Display

DSI or DP Sink

A-PHY Rx/Tx Bridge

Right Side Mirror Display

DSI or DP Sink

A-PHY Rx/Tx Bridge
Part II – DSI-2 Display Bandwidth Compression

• Evaluate 7 different display automotive use-cases
• Calculate raw and compressed bandwidth requirements
  – Use the most aggressive VDC-M 6:1 compression ratio
  – 30-bits per pixel (bpp) uncompressed -> 5 bpp compressed
  – 24-bpp uncompressed -> 4 bpp compressed
• Explain MIPI Automotive Compression Study
• Analyze and report visual quality results
## Automotive Display Bandwidth Requirements

<table>
<thead>
<tr>
<th>Display Config</th>
<th>Driver Instrument Display (DID) 12&quot;</th>
<th>Centre Information Display (CID) 10.2&quot;</th>
<th>Lower Control Display (CLD) 10.2&quot;</th>
<th>CoDriver Display (CDD) 12&quot;</th>
<th>Left Side Mirror 3.6&quot;</th>
<th>Right Side Mirror 3.6&quot;</th>
<th>Total Bandwidth</th>
<th>MIPI PHY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>1280x720</td>
<td>1280x720</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>2.846</td>
<td>0.474</td>
</tr>
<tr>
<td>Level 2</td>
<td>1920x720</td>
<td>1920x720</td>
<td>1920x720</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>6.405</td>
<td>1.068</td>
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<tr>
<td>Level 3</td>
<td>3840x1440</td>
<td>3840x1440</td>
<td>3840x1440</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>33.46</td>
<td>5.577</td>
</tr>
<tr>
<td>Level 4</td>
<td>3840x2160</td>
<td>3840x2160</td>
<td>3840x2160</td>
<td>640x390</td>
<td>640x390</td>
<td>None</td>
<td>50.97</td>
<td>8.495</td>
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<tr>
<td>Level 5</td>
<td>5120x2160</td>
<td>3840x2160</td>
<td>3840x2160</td>
<td>640x390</td>
<td>640x390</td>
<td>None</td>
<td>59.156</td>
<td>9.859</td>
</tr>
<tr>
<td>Level 6</td>
<td>5120x2160</td>
<td>7680x2800</td>
<td>3840x2160</td>
<td>640x390</td>
<td>640x390</td>
<td>None</td>
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<td>13.159</td>
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<td>640x390</td>
<td>640x390</td>
<td>None</td>
<td>133.242</td>
<td>22.207</td>
</tr>
</tbody>
</table>

### Uncompressed Rates

- **Src 24-Bit**: 2.846, 6.405, 33.46, 50.97, 59.156, 78.954, 133.242
- **Src 30-bit**: 3.558, 8.007, 41.824, 63.694, 74.136, 98.89, 166.558
- **VDC-M Comp 24-bit (6:1)**: 0.474, 1.068, 5.577, 8.495, 9.859, 13.159, 22.207
- **VDC-M Comp 30-bit (6:1)**: 0.593, 1.335, 6.971, 10.616, 12.356, 16.482, 27.760
- **Minimum A-PHY Gear Required**: G1, G1, G3, G4, G4/G5, G5/G5-2 lane, G5 2-lane
- **Minimum D-PHY 2.5 Required**: 1-lane, 1-lane, 2-lane, 2-lane, 3-lane, 4-lane, N/A
- **Minimum C-PHY 2.0 Required**: 1-lane, 1-lane, 1-lane, 1-lane, 1-lane, 2-lane, 2-lane
# Automotive Display Bandwidth Requirements

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<th>Left Side Mirror 3.6&quot;</th>
<th>Right Side Mirror 3.6&quot;</th>
<th>Src 24-Bit</th>
<th>Src 30-bit</th>
<th>Comp 24-bit (6:1)</th>
<th>Comp 30-bit (6:1)</th>
<th>Minimum A-PHY Gear Required</th>
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<td>3.558</td>
<td>0.474</td>
<td>0.593</td>
<td>G1</td>
<td>1-lane</td>
<td>1-lane</td>
</tr>
<tr>
<td><strong>Level 2</strong></td>
<td>1920x720</td>
<td>1920x720</td>
<td>1920x720</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>6.405</td>
<td>8.007</td>
<td>1.068</td>
<td>1.335</td>
<td>G1</td>
<td>1-lane</td>
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</tr>
<tr>
<td><strong>Level 3</strong></td>
<td>3840x1440</td>
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<td>3840x1440</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>33.46</td>
<td>41.824</td>
<td>5.577</td>
<td>6.971</td>
<td>G3</td>
<td>2-lane</td>
<td>1-lane</td>
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<tr>
<td><strong>Level 4</strong></td>
<td>3840x2160</td>
<td>3840x2160</td>
<td>3840x2160</td>
<td>3840x2160</td>
<td>640x390</td>
<td>640x390</td>
<td>50.97</td>
<td>63.694</td>
<td>8.495</td>
<td>10.616</td>
<td>G4</td>
<td>2-lane</td>
<td>1-lane</td>
</tr>
<tr>
<td><strong>Level 5</strong></td>
<td>5120x2160</td>
<td>3840x2160</td>
<td>3840x2160</td>
<td>5120x2160</td>
<td>640x390</td>
<td>640x390</td>
<td>59.156</td>
<td>74.136</td>
<td>9.859</td>
<td>12.356</td>
<td>G4/G5</td>
<td>3-lane</td>
<td>1-lane</td>
</tr>
<tr>
<td><strong>Level 6</strong></td>
<td>5120x2160</td>
<td>7680x2800</td>
<td>3840x2160</td>
<td>5120x2160</td>
<td>None</td>
<td>None</td>
<td>78.954</td>
<td>98.89</td>
<td>13.159</td>
<td>16.482</td>
<td>G5/G5-2 lane</td>
<td>4-lane</td>
<td>2-lane</td>
</tr>
<tr>
<td><strong>Level 7</strong></td>
<td>7680x2800</td>
<td>7680x2800</td>
<td>7680x2800</td>
<td>7680x2800</td>
<td>640x390</td>
<td>640x390</td>
<td>133.242</td>
<td>166.558</td>
<td>22.207</td>
<td>27.760</td>
<td>G5 2-lane</td>
<td>N/A</td>
<td>2-lane</td>
</tr>
</tbody>
</table>

### Compressed Rates

- **Comp 24-bit (6:1)**
- **Comp 30-bit (6:1)**
- **Minimum A-PHY Gear Required**
- **Minimum D-PHY 2.5 Required**
- **Minimum C-PHY 2.0 Required**

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MIPI Automotive 6:1 Image Compression Study
1. MIPI automotive dashboard images
   – Optimized for low-impairment compression visual quality analysis
3. Expert reviewers evaluated images
4. Generated report results
   – All images *passed* a limited expert review
• MIPI study images are available for member experimentation. Please contact the MIPI executive team.
Subjective Image Review

Reference

A

B

Please select the lower image that is the closest match to the reference

Exaggerated Static Image Comparison
Subjective Image Review

Please select the image that is flickering.

Exaggerated 5 Hz Flicker Image Comparison
Summary of MIPI Commissioned Test Images
Key Focus Areas

- Background Shading
- Detailed Text and Graphics
## ISO Quality Results Report

<table>
<thead>
<tr>
<th>Image Name</th>
<th>Pass or Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIPI_Screen_Renders_01_InstrumentCluster_Day</td>
<td>Pass</td>
</tr>
<tr>
<td>MIPI_Screen_Renders_01_InstrumentCluster_Day-NoTelltale</td>
<td>Pass</td>
</tr>
<tr>
<td>MIPI_Screen_Renders_01_InstrumentCluster_Day-WhiteRing</td>
<td>Pass</td>
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<tr>
<td>MIPI_Screen_Renders_01_InstrumentCluster_Night</td>
<td>Pass</td>
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<tr>
<td>MIPI_Screen_Renders_01_InstrumentCluster_Night-NoTelltale</td>
<td>Pass</td>
</tr>
<tr>
<td>MIPI_Screen_Renders_01_InstrumentCluster_Night-WhiteRing</td>
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</tr>
<tr>
<td>MIPI_Screen_Renders_02_EntertainmentControls_Day</td>
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<td>MIPI_Screen_Renders_02_EntertainmentControls_Night</td>
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<tr>
<td>MIPI_Telltale_Icons</td>
<td>Pass</td>
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</tbody>
</table>
Summary

- Automotive displays are increasing in:
  - Number, Size and Resolution
- Driven by 5 new trends:
  - Connectivity, Over-the-Air Updates, Electrification, Autonomy and Ride Sharing
- Result: **Massive increase in automotive display bandwidth**
- **MASS:** MIPI Automotive SerDes Solutions
  - End-to-End Camera->ECU->Display Architecture
  - Leverages Display DSI-2 Compression
- MIPI DSI-2 **Compression for Automotive Display Study**
  - Compression for Visually Lossless Automotive MASS Displays
THANK YOU