How Use of DSI-2 and Video Compression is Essential for Next-Generation Digital Cockpits

Simon Bussières, MIPI Display Working Group Member
Product Manager, Hardent
Agenda

• MIPI DSI-2 overview and latest updates

• Use of video compression to solve the display bandwidth challenge in cars

• Meeting Functional Safety (FuSa) requirements when using video compression
MIPI DSI-2

Overview
MIPI Display Ecosystem Virtues

- DSI and DSI-2 serialize two-way data transfer
- Three high-speed transmission modes
  - Real-time video “pixel clock” timing
  - Faster-than-real-time burst video timing
  - Command mode data transfer, similar to writing to an addressable memory
- In-band, half-duplex, for control data reads and writes
- Low-power (LP) and ultra-low power sleep (ULPS) modes
- **Video compression option by standard visually lossless codecs**
  - VESA DSC and VDC-M

The world’s simplest, yet most effective standard display interface
MIPI Display Overview

Simplest **Video Mode Only** Host and Display Architecture
MIPI Automotive Display Overview

Host Processor

- GPU and Display Engine
- DSC/VDC-M Encoder (optional)
- Video Interface

DSI/DSI-2 CTRL

- Display Command Set (DCS)
- DSI-2 PAL + A-PHY Tx

Command Control Interface

DSI-2 over A-PHY Lane(s)

Display

- Display Command Set (DCS)
- DSC/VDC-M Decoder (optional)

Simplest Video Mode Only Host and Display Architecture
Transmission Mode: Real-time video mode

Each symbol replicates a portion of video timing
Transmission Mode: Burst mode

→ Extra nap time for the processor
Transmission Mode: Command Mode

Full Command Mode  Host and Display Architecture
Mixed Architecture for Multiple Transmission Modes

Mixed Command Mode / Video Mode  Host and Display Architecture
Latest Updates in DSI-2 Version 2.0

- **Video-to-command mode** enables displays to seamlessly transition from highly immersive video modes to power-saving command modes.

- **Adaptive refresh panel (ARP)** lowers the processor and interface refresh rate for displays capable of long image retention time. Saving power without requiring a frame buffer.

- **Latest VESA® Display Stream Compression (VESA DSC) and VESA Display Compression-M (VDC-M) codecs** lower power consumption and potentially saves pins between the host and display.
Display Bandwidth Challenge in Cars

Video compression as a solution
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</td>
<td>12.3”</td>
<td>3840x1440</td>
</tr>
<tr>
<td>Center Information Display</td>
<td>12.3”</td>
<td>3840x2160</td>
</tr>
<tr>
<td>Extended Co-Driver display</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>
More Displays Yes... But More Cables Is NOT The Solution

• A car’s wiring harness:
  – Represents the 3rd highest cost component in a car (after the engine and chassis)
  – Comprises 50% of the cost of labor for the entire car
  – Is a heavy component (60kg)

• Reliability, EMI, and signal integrity are major challenges

• For electric-only vehicles, power consumption of video links must be minimized

• FEWER cables reduces many problems!
Car Display Systems Using Video Compression

Benefits of using video compression:

- Reduced bandwidth for multiple feeds
- Enhanced image quality (enabling HDR with same bandwidth)
- Savings on expensive cabling
- Lower EMI
- Reduced power
MASS: MIPI Automotive SerDes Solutions
A Vision for End-to-End Systems
**VES Video Compression Codecs**

<table>
<thead>
<tr>
<th>Features</th>
<th>Display Stream Compression (DSC) 1.2b</th>
<th>VESA Display Compression-M (VDC-M) 1.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visually lossless compression performance verified by subjective testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 bit color, compression ratio (bits/pixel)</td>
<td>3.75:1 (8 bpp)</td>
<td>5:1 (6 bpp) &amp; 6:1 (5bpp)</td>
</tr>
<tr>
<td>24 bit color, compression ratio (bits/pixel)</td>
<td>3:1 (8 bpp)</td>
<td>4:1 (6 bpp) &amp; 6:1 (4bpp)</td>
</tr>
<tr>
<td>IC complexity</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Backwards compatibility</td>
<td>DSC 1.x</td>
<td>VDC-M 1.x</td>
</tr>
<tr>
<td>Both encoder and decoder are specified</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Normative C language code</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Frame-by-frame compression</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>8, 10, 12 bits per color support</td>
<td>8/10/12/14/16</td>
<td>8/10/12</td>
</tr>
<tr>
<td>High Dynamic Range-ready</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>RGB and YCbCr 4:4:4 native encoding</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>YCbCr 4:2:0 or 4:2:2 native encoding</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Image test database available from VESA</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Compliance test guideline and test scripts</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Publicly known adopting standards</td>
<td>MIPI DSI-2 SM v2.0, HDMI® 2.1</td>
<td>MIPI DSI-2 v2.0</td>
</tr>
<tr>
<td>VESA DP™ 2.0 &amp; eDP 1.4b MIPI DSI-2 v2.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 2013: DSC Task Group formed
- 2014: **DSC** released
- 2018: **VDC-M** released

Source: VESA
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
     • *For automotive applications, VDC-M 6x compression is visually lossless*
   – MIPI whitepaper “Validating the Use of Compression for Automotive Displays”
     • *Download: resources.mipi.org/download-mipi-whitepaper-automotive-display-compression*
VDC-M Visually Lossless Quality Assessment

Image A (Reference)

VDC-M Encoder

VDC-M Bitstream

VDC-M Decoder

Image A’ (Compressed)

Subjective Image Review

Exaggerated 5 Hz Flicker Image Comparison

Please select the image that is flickering.

Subjective Image Review

Exaggerated Static Image Comparison

Please select the lower image that is the closest match to the reference.
Summary of MIPI Commissioned Test Images
ISO Quality Results Report

Source: Hoffman & Stolitzka, 2015
# Automotive Display Bandwidth: Case Study

<table>
<thead>
<tr>
<th>Display Config</th>
<th>Display Parameters</th>
<th>Total Bandwidth (Gbps)</th>
<th>MASS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Display (DID)</td>
<td>Centre Information</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12&quot;</td>
<td>Display (CID)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.2&quot;</td>
<td>Lower Control Display</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10.2&quot;</td>
<td>CoDriver Display (CDD)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12&quot;</td>
<td>Left Side Mirror 3.6&quot;</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Right Side Mirror 3.6&quot;</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1280x720</td>
<td>1280x720</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>1920x720</td>
<td>1920x720</td>
<td>1920x720</td>
</tr>
<tr>
<td>3</td>
<td>3840x1440</td>
<td>3840x1440</td>
<td>3840x1440</td>
</tr>
<tr>
<td>4</td>
<td>3840x2160</td>
<td>3840x2160</td>
<td>3840x2160</td>
</tr>
<tr>
<td>5</td>
<td>5120x2160</td>
<td>5120x2160</td>
<td>5120x2160</td>
</tr>
<tr>
<td>6</td>
<td>5120x2160</td>
<td>7680x2800</td>
<td>3840x2160</td>
</tr>
<tr>
<td>7</td>
<td>7680x2800</td>
<td>7680x2800</td>
<td>7680x2800</td>
</tr>
</tbody>
</table>

- **Src**: 30-bit
- **VDC-M Comp**: 5bpp (6:1)
- **Minimum A-PHY Gear Required**
Video Compression for Automotive Displays

Is it safe?
Functional Safety in Display Applications

• Display systems, when involved in ADAS, are required to meet ASIL and ISO 26262 requirements

Safety Critical Information!
MIPI DSE protocol adds Functional Safety (FuSa) features for displays:

- SEP
- Message Counters
- CRCs
Additional Challenge with Video Compression

- When compression is used, the compressed image payload and DSI-2 packets are protected by DSE FuSa, but not the image content itself.
- However...
  - Failures could occur during the encoding or decoding process.
  - Even when there is no failure, the decoded image is NOT identical to the original image (it is visually lossless but not bit exact).
FuSa with DSC & VDC-M Video Compression

- For DSC and VDC-M, the decoded image is generated during the encoding process

FuSa with DSC & VDC-M Video Compression

- The integrity of the decompressed image in the display can be verified by comparing the CRC(s) of the decoded image generated by the encoder with the CRC(s) of the decoded image generated by the display.

```
DSC or VDC-M Encoder → DSI-2 TX → A-PHY → A-PHY → DSI-2 RX → DSC or VDC-M Decoder
```

- Image A
- Image A'

Higher Level FuSa Protection

CRC(s) A' Expected
CRC(s) A' Expected
CRC(s) A' Expected
CRC(s) values match?
MIPI DSE: Support for FuSa Compression CRCs

- Per “Slice Column” Decoded Image CRCs are calculated in both the Host (Expected) and the Display (Observed)

- Expected CRCs inserted in Frame Service Extension Data (FSED)

- Comparison of Expected and Observed CRCs in the display
FuSa with DSC & VDC-M Video Compression

• Benefits of the Decoded Image CRC(s) approach:
  – **End to end protection** that includes compression / decompression
  – Easy to implement, **low area footprint**, removes the need for duplicated logic (a common technique for fault detection)
  – **Very high safety goal violation coverage** for both Single Point Faults (SPF) “Stuck bits” and Transient Faults (TF) “Glitches”, for the whole display subsystem

• With the addition of Decoded Image CRC(s) when DSC or VDC-M compression is used, it becomes possible to meet the safety goals
Conclusions

• MASS incorporates DSI-2, a simple, efficient, and low power display protocol offering high scalability and flexibility

• Video compression is essential for meeting the bandwidth requirements of current and future automotive display applications

• VESA DSC & VDC-M offer proven visually lossless performance

• Using video compression for automotive applications offers many benefits and it can be used safely with SerDes solutions
Additional Information

- MIPI Display Serial Interface
  - www.mipi.org/specifications/dsi
- MIPI Display Serial Interface-2
  - www.mipi.org/specifications/dsi-2
- MIPI Display Command Set
  - www.mipi.org/specifications/display-command-set
- MIPI Display Services Extensions
  - www.mipi.org/specifications/mipi-dse
- MIPI Bytes Video: Introduction to the Video Compression Standards Within MIPI DSI-2
  - www.mipi.org/resources/knowledge-library/videos
- MIPI Whitepaper: Validating the Use of Compression for Automotive Displays
  - resources.mipi.org/download-mipi-whitepaper-automotive-display-compression
- VESA Compression Codecs
  - vesa.org/vesa-display-compression-codecs
MIPI Automotive Workshop

An in-depth look at the MIPI Automotive SerDes Solutions (MASS) framework

Q&A