Enabling Automotive Displays Using MIPI Automotive SerDes Solutions (MASS)

James Goel
TSG Chair and Display WG Vice-Chair

19 May 2021
# Table of Contents for MASS Displays Webinar

1. Introduction to MASS and MASS Display Specifications
2. MASS Example Automotive Display Applications
3. ISO26262-5: Functional Safety
4. MASS Topologies
   - Point-to-point and Daisy Chain
   - DSI-2 and VESA DisplayPort
5. Detailed Display MASS Data Pipeline
   - External A-PHY Bridge
6. Summary of Presentation
   - Table of MASS Specifications
Sensor and display endpoints with integrated long-reach connectivity (integrated A-PHY SerDes) connect to the ECU without intermediate bridges. Application-level functional safety and security data protection. HDCP for protecting premium content.
MIPI Automotive SerDes Solutions (MASS)

A family of specifications

Applications
- MIPI Protocol Layers
  - MIPI Security
    - Protocol Adaptation Layer (PAL)
    - Link Layer
    - Physical Layer
- Camera / Lidar / Radar
  - MIPI CCS
  - Camera Service Extensions
    - Functional Safety
    - Security
  - MIPI CSI-2
- MIPI Display
  - Display Service Extensions
    - Functional Safety
    - Security
    - HDCP
  - MIPI DSI-2
- VESA Display
  - Display Service Extensions
    - Functional Safety
    - Security
    - HDCP
  - VESA eDP / DP
- Supporting Interfaces
  - Other Protocols
    - Ethernet
    - GPIO
    - MIPI I3C
    - I2C
  - Future Protocols
  - Other MIPI PALs

MIPI A-PHY Data Link Layer
MIPI A-PHY SerDes Physical Layer
MASS Display Related Specifications (as of May 2021)

- **MIPI A-PHY℠ v1.0**
  - Automotive Physical SerDes Interface
  - Long-reach SerDes physical layer specification advancing ADAS, ADS, IVI and other automotive applications

- **MIPI Display Specifications**
  - DSI-2℠ v1.2 (v2.0 coming soon)
    - Display Serial Interface-2
  - DCS℠ v1.5
    - Display Command Set

- **New MIPI Display Functional Safety Enabling Specifications**
  - DSE℠ v1.0
    - Display Services Extension
  - MIPI PAL℠/DSI-2℠ v1.0
    - Protocol Adaptation Layer for Display Serial Interface-2
  - MIPI PAL℠/eDP-DP v1.0
    - Protocol Adaptation Layer for VESA embedded DisplayPort/DisplayPort

*NOTE: Previous versions of existing specifications are also compatible with MASS.*
MASS Automotive Display Applications

A Focus on Automotive Cabin
CASE – Driving Display Bandwidth

- **Connected**
- **Automated**
- **Shared**
- **Electrified**
Automotive Display Use-Case
Automotive Display Use-Case
MASS Daisy Chain Application
MASS Point-to-Point Application
Automotive Display Use-Case

- Head Up Display
- Rear Mirror Display
- Side Mirror Display (RIGHT)
- Side Mirror Display (LEFT)
- Centre Info Display
- Co-driver Display
- Driver Instrument Display
- Rear Seat Instrument Display (LEFT)
- Rear Seat Entertainment (LEFT)
- Rear Seat Entertainment (RIGHT)
- Rear Mirror Display (RIGHT)
- Lower Info Display

SoC
A-PHY
A-PHY
A-PHY
A-PHY
A-PHY
A-PHY
# 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>
MIPI A-PHY v1.0 – Gears and Profiles

- One rate/line-code/modulation per downlink gear
- Single uplink gear
- A-PHY Device supporting Gear N (i.e., N could be 1–5) shall support all lower gears.
- Two noise/performance profiles (with full inter-profile interoperability):
  - **Profile 1**: Optimized for low cost/power implementations for the lower gears with lower noise immunity and target BER of $10^{-12}$
  - **Profile 2**: Optimized for vehicle lifespan, link robustness for all gears with high noise immunity and target PER of $10^{-19}$

<table>
<thead>
<tr>
<th>Downlink Gear Data Rate</th>
<th>Modulation</th>
<th>Modulation Bandwidth (GHz)</th>
<th>Max Net App Data Rate (Gbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 2 Gbps</td>
<td>NRZ-8B/10B</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>G2 4 Gbps</td>
<td>NRZ-8B/10B</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>G3 8 Gbps</td>
<td>PAM4</td>
<td>2</td>
<td>7.2</td>
</tr>
<tr>
<td>G4 12 Gbps</td>
<td>PAM8</td>
<td>2</td>
<td>10.8</td>
</tr>
<tr>
<td>G5 16 Gbps</td>
<td>PAM16</td>
<td>2</td>
<td>14.4</td>
</tr>
<tr>
<td>Uplink 100Mbps</td>
<td>NRZ-8B/10B</td>
<td>0.05</td>
<td>55 Mbps</td>
</tr>
</tbody>
</table>
Focus on MASS Display

MIPI A-PHY℠ v1.0, DSI-2℠ v2.0, DCS℠ v1.5, DSE℠ v1.0
MIPI PAL℠/DSI-2℠ v1.0, MIPI PAL℠/eDP-DP v1.0, VESA DisplayPort 1.4a

Previous versions of existing specifications are also compatible with MASS
Use of Multiple SST DP Interfaces

Use of Singe MST DP Interface
Functional Safety for Automotive Displays

ISO26262:5 Product Development at the Hardware Level
MASS Functional Safety Application

Digital Side Mirror Replacement
ISO26262 Part 5: Product development at the Hardware Level

• ISO26262 automotive functional safety standard
  – Reference for automotive safety lifecycle
  – Automotive-specific risk-based analysis for Automotive Safety Integrity Levels (ASILs)
  – Uses ASILs to specific applicable requirements

• Part 5: Hardware level
  – Specification of hardware safety requirements
  – Evaluation of safety goal violations due to random failures
  – *Annex D: informative guidelines for appropriate safety mechanisms*
ISO26262-5 Annex D – Communications Bus

Annex D – Communication bus safety mechanisms:

- One-bit hardware redundancy
- Multi-bit hardware redundancy
- Read back of sent message
- Complete hardware redundancy
- Inspection using test patterns
- Transmission redundancy
- Information redundancy
- Frame counter
- Timeout monitoring
- Combination of information redundancy, frame counter and timeout monitoring
Adding Service Extensions Packets (SEPs)

Figure 23 SEP Formatting in the Display Source

MIPI DSE℠ v1.0, MIPI PAL℠/DSI-2℠ v1.0
C.1 Converting DSI-2 Long and Short Packets to SEP

Figure 20 illustrates conversion from a DSI-2 Long Packet to SEP carried within DSI-2 Long Packet.

Figure 20 Converting DSI-2 Long Packet to SEP Within DSI-2 Long Packet

Figure 21 illustrates conversion from a DSI-2 Short Packet to SEP carried within DSI-2 Long Packet.

Figure 21 Converting DSI-2 Short Packet to SEP Within DSI-2 Long Packet

MIPI DSE℠ v1.0, MIPI PAL℠/DSI-2℠ v1.0
MASS Display Services Extension (DSE 1.0)
Services Extensions Protocol (SEP) Header and Footer

- eDT – extended Data Type
  - CSI, DSI
  - VESA eDP/DP
- Message Counter
- CRC-32
  - Hamming distance of 3 or more
MASS Display Protocols

End-to-End Protocol Stack Up
Incorporating Solutions for Data Protection

Bridge-to-Bridge Data Protection

End-to-End Data Protection (Integrated SerDes)
Detailed Display Protocol Stack

- **ECU Display Source**
  - ECU Pixel Frame Buffer
  - Generate SEP Packet Payload (Optional HDCP)
  - Generate SEP Header and Footer
  - Generate DSI-2 Long/Short Packet
  - Lane Management
  - C/D-PHY Tx

- **Display Sink**
  - DSI-2 Display Controller
  - Unpack SEP Packet Payload (Optional HDCP)
  - Unpack SEP from DSI-2 Payload
  - Parse DSI-2 Long/Short Packet
  - Lane Management
  - C/D-PHY Rx

- **A-PHY Bridge**
  - C/D-PHY Rx
  - Lane Management
  - DSIA-SRC

- **A-PHY Source**
  - A-PHY Source
  - Asymmetric Bi-Direction High Speed Data

- **A-PHY Bridge**
  - C/D-PHY Tx
  - Lane Management
  - DSIA-SNK

- **APPI**
  - Data+Control

- **APPI**
  - Data+Control

- **Asymmetric Bi-Direction High Speed Data**
ECU Display Source and Sink

ECU Display Source
- ECU Pixel Frame Buffer
  - Generate SEP Packet Payload (Optional HDCP)
  - Generate SEP Header and Footer
  - Generate DSI-2 Long/Short Packet
  - Lane Management
  - C-/D-PHY Tx

Display Sink
- DSI-2 Display Controller
  - Unpack SEP Packet Payload (Optional HDCP)
  - Unpack SEP from DSI-2 Payload
  - Parse DSI-2 Long/Short Packet
  - Lane Management
  - C-/D-PHY Rx

Previous versions of existing specifications are also compatible with MASS.
Detailed A-PHY Bridge PAL

A-PHY Bridge

C-/D-PHY Rx

Lane Management

Data

Control

DSIA-SRC

APPI

Data + Control

A-PHY Source

A-PHY Sink

A-PHY Bridge

C-/D-PHY Tx

Lane Management

Data

Control

DSIA-SNK

APPI

Data + Control

MIPI A-PHY℠ v1.0,
PAL℠/DSI-2℠ v1.0, C-/D-PHY℠
MASS Legacy ECUs with an External A-PHY Bridge

**ECU MIPI Display Source**
- Display Pixel Data Path
- Display Command and Control
- Pixel to Byte Packing
- Display Command Services DCS
- DSI-2 Protocol
- Lane Management
- Transmitter C-PHY or D-PHY Tx

**MIPI DSI-2 Receiver to A-PHY Transmitter Bridge**
- Receiver C-PHY or D-PHY
- Lane Management
- DSI-2 Protocol Adaptation Layer with DSE 1.0
- A-PHY Data Link Layer
- A-PHY Physical Layer Transmit

**ECU VESA Display Source**
- Display Pixel Data Path
- Display Command and Control
- VESA eDP/DP Protocol
- Lane Management
- VESA Transmitter eDP/DP PHY Tx

**VESA Receiver to A-PHY Transmitter Bridge**
- VESA Receiver eDP/DP PHY Tx
- Lane Management
- VESA eDP/DP Protocol Adaptation Layer with DSE 1.0
- A-PHY Data Link Layer
- A-PHY Physical Layer Transmit
MASS New ECU with Fully Integrated A-PHY
Summary and Review

1. MASS Display Specifications (as of May 2021)
   – A-PHY 1.0, DCS and DSI-2, DSE PAL/DSI and PAL/eDP_DP

2. MASS Example Automotive Display Applications
   – Cabin displays with point-to-point and daisy-chain topologies

3. ISO26262-5: Functional Safety
   – Meeting safety goals using DSE CRC-32, Message ID and Time out

4. MASS Protocol Stack Up
   – DSI-2/DCS through DSE/PAL DSI-2 through A-PHY bridges

5. Display MASS Data Pipeline
   – External A-PHY Bridge
   – Integrated A-PHY solutions
Thanks for listening

MASS Display Stack Press Release: [Link](#)

Reach out to us: [admin@mipi.org](mailto:admin@mipi.org)