MIPI Alliance Introduction & MIPI Camera Serial Interface Overview

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About MIPI Alliance

- 260 Members (as of 4 May 2015)
- 45+ specifications and supporting docs
- We drive mobile and mobile-influenced interface technology through the development of hardware and software specifications
- We work globally and collaboratively with other standards bodies to benefit the mobile ecosystem
MIPI Alliance Member Ecosystem
Active MIPI Alliance Working Groups

- Analog Control Interface
- Battery Interface
- Camera
- Debug
- Display
- Low Latency Interface
- Low Speed Multipoint Link (New - SoundWire℠)
- Marketing
- PHY (C / D / M)
- Reduced Input Output (RIO) (New)
- RF Front-End (RFFE℠)
- Sensor / I3C℠ (New)
- Software (New)
- Technical Steering Group
- Test
- UniPro℠
Recent Announcements

• 18 February 2015 - MIPI Alliance Updates its Widely Adopted CSI Specification to Bring High-Resolution Imaging, Richer Color and Video to Mobile and Mobile-Influenced Applications

• 12 March 2015 - MIPI Alliance Updates its MIPI RFFE Interface for Mobile Device RF Front-End Architectures
The Future of MIPI – Beyond Mobile

• Mobile influences everything
  – Automotive
  – IoT
  – Wearables

• Everything gets faster, smaller and lower power
  – MIPI will continue to evolve specs to take advantage of the evolution of technology in mobile devices
Evolution of imaging on mobile products

- Trend 1 - Performance imaging to match compact camera / SLR capabilities:
  - MP
  - FPS
  - BPP

- Trend 2 – Capturing beyond visible spectrum (400nm – 700 nm)

- Forward-looking imaging use cases:
  - Always On Imaging
  - Always Aware
  - Thermal / IR
  - Low-light / Night Capture
  - Medical
  - Security

- Form Factors:
  - Monolithic, Wearable, Tablets, Automotive
Two Highly Capable Imaging Architectures

**CSI-2** protocol contains transport and application layers, and natively supports **D-PHY & C-PHY**

**CSI-3** application stack connects to **UniPro** transport layer, which in turns bolts onto **M-PHY**
Imaging performance (MP, FPS, BPP)

Effective (usable) BW: 5 Gbps
- Gross BW: 5 Gbps
- Channel Rate: 2.5 Gbps

Effective (usable) BW: 11.43 Gbps
- Gross BW: 11.43 Gbps
- Channel Rate: 2.5 Gbps

Effective (usable) BW: 8.9 Gbps
- Gross BW: 11.6 Gbps
- Channel Rate: 5.8 Gbps

Pin compatible coexistence supports CSI-2 over combo C/D-PHY solutions
## Popular Imaging Format

### 4K @ 30 fps and 12 BPP

<table>
<thead>
<tr>
<th>Required MIPI Specs (IPs)</th>
<th>PHY pins</th>
<th>Channel rate</th>
<th>Required BW</th>
<th>Variable link rate</th>
<th>Control Interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>[CSI-2] [D-PHY]</td>
<td>6</td>
<td>1.78 Gbps</td>
<td>3.56 Gbps</td>
<td>Yes</td>
<td>I2C</td>
</tr>
<tr>
<td>[CSI-2] [C-PHY]</td>
<td>3</td>
<td>1.55 Gbps</td>
<td>3.56 Gbps</td>
<td>Yes</td>
<td>I2C</td>
</tr>
<tr>
<td>[CSI-3] [UniPro] [M-PHY]</td>
<td>4</td>
<td>5.0 Gbps</td>
<td>3.56 Gbps</td>
<td>No</td>
<td>In-band</td>
</tr>
</tbody>
</table>

- I2C control interface requires 2 GPIO pins and widely used in camera subsystems (VCM), and used to integrate imaging solutions with a wide array of (MEMS, ALS, IR, Gyro, Presence, Accelerometer) sensors on mobile platforms (p8)
CSI-2 v1.3 over C/D-PHY  
(Adopted Specs)

Evolution of CSI-2 Performance Capabilities
Image Sensor @ 60 fps

Optimal Link rate matched to Pixel rate using C/D-PHY conduits

- Achieves 34 Gbps using 18 wires; and beyond with scaling
- Achieves 20 Gbps using 18 wires with scaling
CSI-3 over UniPro & M-PHY
(Adopted Specs)

CSI-3 v1.1 Performance

Link Rate [Gb/s]

Sensor Resolution [Megapixels]

- 8BPP,30FPS
- 10BPP,30FPS
- 12BPP,30FPS
- 8BPP,60FPS
- 10BPP,60FPS
- 12BPP,60FPS
- 1xHS-G2
- 1xHS-G3
- 2xHS-G3
- 3xHS-G3
- 4xHS-G3

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Adopted CSI Specs

CSI-2 1.3
- D-PHY 1.2, C-PHY 1.0 or “combo PHY” is possible
- 4 Virtual Channels
- I2C based control interface
- Line based transmission
  - Easy implementation
  - Low gate count
  - Matched data rates for sensor and link
- In-band interrupts
- RGB, YUV, RAW, JPEG
- Embedded Data
- CRC/ECC for payload and header protection

CSI-3 1.1
- M-PHY 3.0
- 32 Virtual Channels
- In-band control
- Packet based transmission
  - Line-buffer-less architectures
  - Interleaving on message basis
  - Integration in network architectures
- In-band interrupts
- RGB, YUV, RAW, JPEG
- Embedded Data
- Notification channels for metadata, audio, etc.
- CCI bridging
- Guaranteed delivery of data
Sensor integration beyond traditional camera sensors (CSI-2)

- Optimal pathway for multiple forward-looking advancements in imaging
  - Drivers: Health, Convenience, Security, Lifestyle, Efficiency
  - High-perf pixel conduit needs met with C/D-PHY advancements
  - Broad definitions and fuzzy range: (i.e. Wearable: Near Body, On Body, In Body)
  - Define imaging requirements for CCI, emerging AOI, array, and non-symmetrical applications

- Camera Controller Interface (CCI) advancement considerations:
  - Point-to-Point and Multi-Drop configurations
  - Energy consumed / Gb transfer
  - Limit latency for VB & HB
  - Precision Timing & Sync
  - Independent Transport: Pixel Data & Control
  - Channel Integrity (Error Detection)
  - FW Upload (ISP, Neural)
  - AOI Image Sensors
Benefits of Embedded Clock & Data (CSI-2)

- Multiple port configurations are required to map Imaging Use Cases
- Embedded clock and data provides logical port realizations

A x8 port maybe supported by allotting 16 pins for data and 2 pins for clock
CSI-3 System

 CSI-3

Camera

Host

Signalling rate, up to 5.8 Gb/s per lane.

CCI (I2C) bus

Reasonably to be kept below 1.25Gb/s

Control Interface Parameter | Value
---|---
Command Latency | < 1us
Bandwidth for commands | 1Gb/s peak
Transfer of 4KB of data (e.g. firmware) | 4us

AF
OIS
Gyroscope
Microphone

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Some of many options of multiplexing of M-PHY pins

Option 1:
2 Cameras
1 UFS Device
1 SSIC

Option 2:
2 Cameras
1 dual lane UFS Device

Option 3:
2 Cameras
1 UFS Device

Option 4:
2 Cameras

M-PHY pins on the Application Processor
CSI-3 over UniPro Switch Network

Camera 1

CSI-3

UniPro

M-PHY

UniPro

M-PHY

UniPro

M-PHY

Switch

Camera 2

CSI-3

UniPro

M-PHY

UniPro

M-PHY

UniPro

M-PHY

Host

CSI-3

UniPro

M-PHY

UniPro

M-PHY

UniPro

M-PHY

Memory

UniPro

M-PHY

UniPro

M-PHY

UniPro

M-PHY

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Questions?