Real Examples of MIPI Interfaces in AR/VR, Mobile, and Other Image Applications
Agenda

• Market Trends
• Evolution of MIPI Specifications
• Real Examples of MIPI Use Cases
  – Novatek
  – Inuitive
Enhancement to the “Eye” of Your Device Never Ends

- Camera continues to be a key focus in mobile handsets
- Video quality under high frame rate (60/120Hz) and dark light are highlighted and addressed by dedicated ISP ASICs
- Future XR device demands more cameras, 4K4K 90Hz and higher resolution/refresh rate are required for main stereo cameras
- Shifting from distributed to domain/centralized architecture brings more & specialized cameras for automotive display and sensing applications

Source: Xiaomi, HTC, OPPO, AFP.com
Mobile & Automotive Driving Display Innovations

Fold Display, 4K OLED Micro Display, 8K IVI Panel, 120+Hz Refresh Rate

Image source: OPPO, Samsung, SONY, LG, Cadillac, BMW, Audi, Magna, designhmi.com, confuindustries.com
Innovations at the Edge Driving a Smarter Experience
### MIPI Camera/Display Spec Is In the Middle of It All

**Continues to Evolve**

<table>
<thead>
<tr>
<th>MIPI CSI-2® v1.x</th>
<th>MIPI CSI-2 v2.x</th>
<th>MIPI CSI-2 v3.x</th>
<th>MIPI CSI-2 v4.x</th>
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<td>RES</td>
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<td>USL</td>
<td>AOSC</td>
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<td>FPS</td>
<td>PSD</td>
<td>SROI</td>
<td>CSEv1.0/FSAF</td>
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<td>BPP</td>
<td>LRTE</td>
<td>RAW24</td>
<td>PALv1.0/A-PHY</td>
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<td>CCI</td>
<td>DPCM</td>
<td>SCRAMB</td>
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**Data Rate (Per Lane)**

- **1.0**: Sep 2009, 1.0 Gbps* 8 bit
- **1.1**: Dec 2011, 1.5 Gbps* 8 bit
- **1.2**: Sep 2014, 2.5 Gbps* 8 bit
- **2.1**: March 2017, 4.5 Gbps 8/16/32 bit
- **2.5**: October’19, 4.5 Gbps 8/16/32 bit
- **3.0**: October’21, 9 Gbps 8/16/32 bit

**PHY Interface (Per Lane)**

- **8 bit**
- **8/16/32 bit**

### MIPI D-PHY℠

<table>
<thead>
<tr>
<th>Version</th>
<th>Adoption Date</th>
<th>Data Rate (Per Lane)</th>
<th>PHY Interface (Per Lane)</th>
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</tbody>
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### MIPI C-PHY℠

* Specifications released up to 2014 provide rate guidance based on the Legacy Channel.
MIPI Use Cases

Real Examples Including Novatek and Inuitive
Automotive Use Cases

Different Sensing Modalities
- Lidar
- Thermal
- Radar
- Image

Relevant Attributes
- RAW
- CSE℠/DSE℠
- Aggregation
- Auto grade IP
- Bandwidth
Mobile Use Cases
Low Power, Aggregation, Bandwidth, MPC, ARP
Smartphone Display is as Important as Camera

- Shift from LCD to AMOLED
- Upscaling SDR to HDR
- Higher refresh rates
- Reduce system power consumption
- Enable better user experience
Enabling Better User Experience

- **Picture Quality AI**
  - Scene detection – Faces vs Landscape/outdoor
  - Automatically adjust image settings for better quality
- **Motion Smoothing with MEMC for Gaming**
  - Artificially add frames to a video with a low frame rate
  - Play 24/30fps content at a higher fps
- **Dynamic refresh rate (1-120Hz) with LTPO**
  - Extended battery life
Example From Vivo X80 and X80Pro

Image source: VIVO, texch.net, gsmarena.com
Novatek’s Mobile Display SoC

Success with MIPI C-PHY/ D-PHY IP on FinFET Process

• Leading fabless company specializing in display driver IC & SoC solutions
• Novatek’s chips help companies meet emerging needs for sophisticated flat-panel display and audio/video applications for all digital devices
Improving Mobile Display Quality

Improve video and image quality
Refresh-rates of up to 120Hz and Beyond
Meeting Power & Picture Quality Requirements

Application Processor

- MIPI DSI-2 Host Controller
- MIPI CSI-2 Host Controller

MIPI DSI-2

- Device Combo Controller
- Host Controller

MIPI CD-PHY Rx

MIPI CD-PHY Tx

Video/Image processing path

BYPASS

MIPI CSI-2

- Device Combo Controller
- Host Controller

MIPI CD-PHY Rx

MIPI CD-PHY Tx
MIPI Use Cases in AIOT/Edge/Imaging SoCs

RAW, Aggregation, Bandwidth, Low Power

Image source: https://www.graimatterlabs.ai/sima.ai
Inuitive’s Vision Processor SoC
Success with MIPI D-PHY IP on 12nm FinFET Process

• NU4000AI is a superior multi-core vision processor for 3D imaging, deep learning and computer vision processing
• For augmented reality and virtual reality, drones, robots, and many other applications
• High quality depth sensing, SLAM on-chip, computer vision and deep learning (CNN) capabilities
• Advanced low power 12nm silicon process
• Connectivity to 6 cameras and 2 displays
Common Challenges with xR Use Cases

- Multiple sensors (6-10 CIS), loads of pixels, tight synchronization and fusion
- Heavy computer vision processing and extreme memory bandwidth needed
- xR requires low latency for optimal user experience
- xR use cases are mobile/battery powered - low power
Reducing Memory Bottlenecks with Dedicated Imaging/Vision Pipelines

- Route image from 6 CIS to processing pipelines
- Solely compact meta-data is directed to memory
Reducing Motion-to-photon Latency

• Time between detection of user’s movement and appropriate image refresh

• Up to 1ms with “Time-warp”
  – 6DoF engine
  – HW pipeline enabling image re-projection on-the-fly
  – Fast “loop-closure” between tracking and re-projection
Handling Multiple CIS with Different Resolutions

Flexible MIPI D-PHY Configuration

- Same MIPI D-PHY GDS can connect to (i) 1x4L CIS or (ii) 2x2L CIS
- Same set of pins
Single Porting CSI-2 for CIS and DSI-2 for Display

Flexible MIPI D-PHY Configuration

- 4Lane MIPI DSI-2 Device Controller
- 4Lane MIPI CSI-2 Host Controller
- 4Lane Rx MIPI D-PHY
- 4Lane MIPI DSI-2 Device Controller
- 4Lane MIPI CSI-2 Host Controller
- 4Lane Rx MIPI D-PHY
- 4Lane Display Input
- 4Lane Image sensor

Or configured at start-up
Conclusion

• Camera and display continue to be the focal point of mobile/consumer devices and automotive applications

• Driving requirements for higher resolution (4K/8K) and higher refresh rates (60-120Hz), use cases for multiple displays

• MIPI is the de-facto interface for consumer/mobile devices, and evolving to be the interface of choice for automotive camera and display

• Synopsys offers a portfolio of MIPI IP products from CSI-2 and DSI-2 controllers to D-PHY and C-PHY/D-PHY with over 70% market share

• On the board of MIPI Alliance and leading several workgroups, helping to drive development and adoption of the MIPI specifications
Synopsys MIPI IP Solution for Camera and Display

For Mobile/Consumer and Automotive applications

- Integrated MIPI C-PHY v2.0 / MIPI D-PHY v2.1
- MIPI D-PHY v1.2
- Available in 40-nm - 3-nm
- MIPI CSI-2/DSI-2 IP Controllers supporting key features of the latest specifications
- 2.5Gbps, 4.5Gbps/3.5Gsps, 6.5Gbps/Gsps
- ASIL B Ready ISO 26262 certified IP
- 900+ licenses; 35+ test chips
- Production proven by tier1s
- Mobile/drone/auto/ surveillance/IoT
- Interoperability with wide range of devices

Customer Success with Synopsys MIPI IP

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ADDITIONAL RESOURCES

THANK YOU!