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INTRODUCTION
The importance of cameras in smartphones

WORLDWIDE 2 BILLION PEOPLE
smartphone users in 2014*.

Smartphone Usage**

- Taking photos: 92%
- Text Messaging: 92%
- Internet Browsing: 84%
- Sending photos: 80%
- E-mailing: 76%
- App downloads: 69%
- Gaming: 64%

* Global Smartphone User Penetration Forecast by Bill Countries, 2014, Strategy Analyst
** Internet & American Life Project, 2011, The Pew Research Center
Camera Serial Interface 2 and 3

OVERVIEW
Why Evolving Standards?

Mobile Phone Camera Resolution and Bandwidth

- Resolution [MP]
- Bandwidth [b/s]

Year (2000 to 2017)

Graph showing the evolution of mobile phone camera resolution and bandwidth from 2000 to 2017.
Designed for Performance
Power is Key
Going beyond mobile
MIPI’s Standards Today

**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
An established and evolving standard

THE CSI-2 SPECIFICATION
CSI-2 on D-PHY

Camera

CSI-2 on D-PHY

Host

CSI-2 on D-PHY

Data0+
Data0-
DataN+
DataN-
Clock+
Clock-
SCL
SDA

I2C Slave

Up to 2.5 Gb/s per lane
CSI-2 on C-PHY

Camera

CSI-2 on C-PHY

Host

CSI-2 on C-PHY

Data0_A
Data0_B
Data0_C

DataN_A
DataN_B
DataN_C

Up to 5.7 Gb/s per trio

SCL
SDA

I2C Slave
CSI-2 with “combo” PHY

Camera

CSI-2

Mode 0

C/D PHY

Mode 1

TX

SCL

SDA

Host

CSI-2

C/D PHY

Mode 0

RX

SCL

SDA

Mode 1

I2C Slave

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CSI-2 on D-PHY: 4K video 30FPS 12 BPP

Camera

CSI-2 on D-PHY

Data0+
Data0-
Data1+
Data1-
Clock+
Clock-
SCL
SDA

2 * 1.78Gb/s

Host

CSI-2 on D-PHY

Data0+
Data0-
Data1+
Data1-
Clock+
Clock-
SCL
SDA

I2C Slave
CSI-2 on C-PHY: 4K Video 30 FPS 12BPP
The CSI-2 Packets

Short Packets used for frame synchronization

Image data

Low Power states between image lines

First Packet of Data

Last Packet of Data

Frame Start
Packet

Frame End
Packet

VVALID
HVALID
DVALID

KEY:
SoT – Start of Transmission
PH – Packet Header
FS – Frame Start
LS – Line Start
EoT – End of Transmission
LPS – Low Power State
PF – Packet Footer + Filler (if applicable)
FE – Frame End
LE – Line End

Short Packets used for frame synchronization
Virtual Channels

- Virtual Channel 0 – Line 0
- Virtual Channel 0 – Line 1
- Virtual Channel 0 – Line 2
- Virtual Channel 0 – Line 3
- Virtual Channel 0 – Line 4
- Virtual Channel 0 – Line N
- Virtual Channel 1 – Line 0
- Virtual Channel 1 – Line 1
- Virtual Channel 1 – Line 2
- Virtual Channel 1 – Line 3
- Virtual Channel 1 – Line 4
- Virtual Channel 1 – Line M
The Road Ahead

- Latency Reduction
- More Virtual Channels
- New Data Types
- D-PHY 2.0
- I3C
- C-PHY 1.1
A new generation standard

THE CSI-3 PROTOCOL
CSI-3 System

Camera

CSI-3

UniPro

M-TX1

M-TXn

M-RX1

M-RXn

Host

CSI-3

UniPro

M-TX1

M-RX1

M-RXn

Reasonably to be kept below 1.25Gb/s

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

I2C Slave

Reasonably to be kept below 1.25Gb/s

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CSI-3 System: 4K Video 30FPS 12BPP

- Camera
  - CSI-3
  - UniPro
  - M-TX1
  - M-RX1
  - 5Gb/s signalling rate
  - I2C Slave

- Host
  - CSI-3
  - UniPro
  - M-RX1
  - M-TX1
  - 1Gb/s
The CSI-3 Protocol

Packet based transmission offers high flexibility and makes the protocol ideal for network applications.

Guaranteed delivery of data by use of CRC checks and retransmission in case of bit errors.
## Packet Transmission

<table>
<thead>
<tr>
<th>Virtual Channel 0 – Line 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virtual Channel 0 – Line 2</td>
</tr>
<tr>
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</tbody>
</table>
Network Example
The Road Ahead

- Networking Enhancements
- M-PHY 4.0
- New Data Formats
- I3C support