MIPI CSI-2 AVTP Format
Call for Interest

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Purpose of this Slide Deck

- Provide a quick overview of the CSI-2 interface. Caveat: This is based on a quick and cursory review of available public literature. It is not a definitive review of CSI-2.

- Generate discussion on possibly defining an IEEE1722 format based on CSI-2.

- Assess the group's interest in defining an IEEE1722 format for CSI-2

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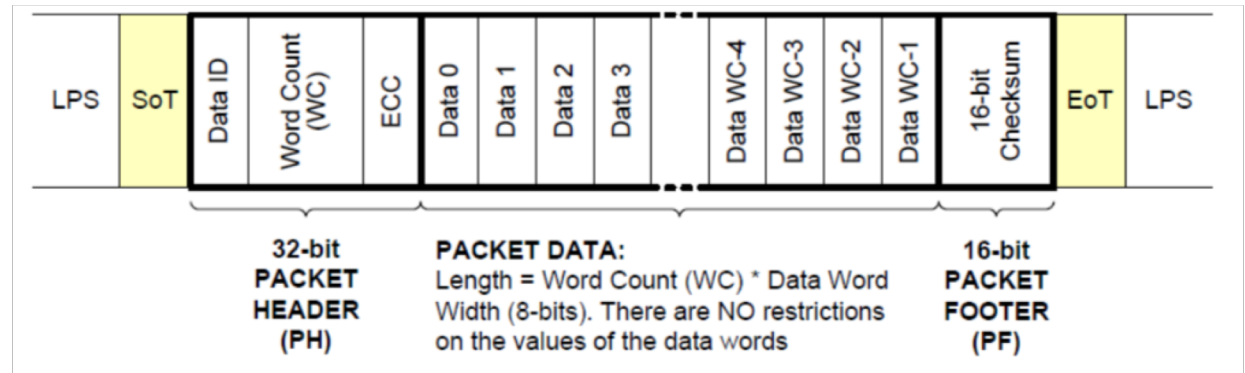CONSULTING

What is MIPI CSI-2?

- The MIPI Alliance is a key organization for the definition of interface specifications for mobile devices. They have defined a variety of interfaces.

- CSI-2 = Camera Serial Interface 2
  - The <u>most widely adopted</u> camera interface in mobile devices.
  - Enables single- and multi-camera transport. Suitable for cameras, radar, lidar and ultrasound sensors, because they are all raster based. It also supports other sensors such as ambient light, IR, gyro, accelerometer and MEMS.
  - Works in parallel with I^2C and I3C interfaces which provide command and control to the camera. I3C is another MIPI defined interface. I3C is basically high-speed I^2C.

CSI-2 Market Presence

- CSI-2 is provided by many silicon vendors for their products
  - Xilinx
  - Qualcomm
  - TI
  - Microsemi
  - Synopsys
  - NXP
  - Sony
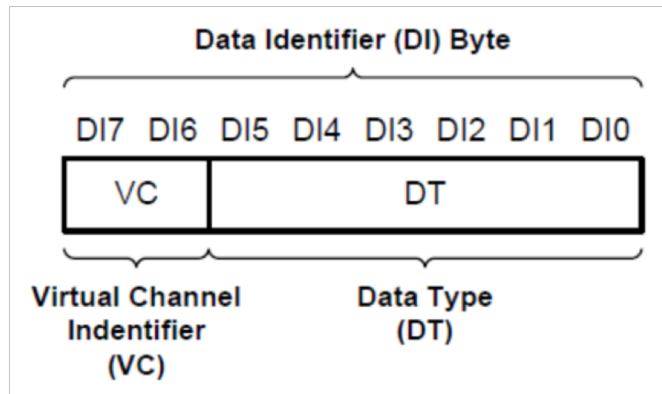 - Broadcom
  - …and many, many more. It's everywhere.

CSI-2 Structure

- ***Caveat***: All MIPI standards are available only to members of the MIPI Alliance. Therefore public information on CSI-2 is spotty and incomplete. (Unfortunately, Bechtech has access to only public information…)

- CSI-2 is packet based. This is a diagram of the CSI-1 packet. It appears that the CSI-2 packets is very similar, although there are changes.

| LPS | SoT | Data ID | Word Count (WC) | ECC | Data 0 | Data 1 | Data 2 | Data 3 | Data WC-4 | Data WC-3 | Data WC-2 | Data WC-1 | 16-bit Checksum | EoT | LPS |

32-bit PACKET HEADER (PH)

PACKET DATA: Length = Word Count (WC) * Data Word Width (8-bits). There are NO restrictions on the values of the data words

16-bit PACKET FOOTER (PF)

CSI-2 Packet "Information"

- CSI-1 DI byte is shown to the right.
  - 4 virtual channels
  - 64 data types (RAW8, etc)
- CSI-2 was published in Mar2017
  - Increases VC count to 32
  - Adds RAW16 and RAW20 data types
  - Changes LPS and SOT periods to reduce power and latency between packets
- Unfortunately preliminary research of public docs hasn't revealed details of the CSI-2 packet.

Data Identifier (DI) Byte

DI7	DI6	DI5	DI4	DI3	DI2	DI1	DI0
VC	VC	DT	DT	DT	DT	DT	DT

Virtual Channel Indentifier (VC)

Data Type (DT)

MIPI CSI-2 has Several PHY Options

- D-PHY
  - Connects megapixel cameras and high-resolution displays to an application processor.
  - Asymmetric bandwidth to support data moving primarily on one direction.
  - Typically requires more wires. Based on a 2-wire clock lane and one or more 2-wire data lanes.
  - Max rate is 2.5Gbps/lane for a rate of 10Gbps with 4 lanes on 10 wires.

- C-PHY
  - Provides high throughput performance over bandwidth-limited channels to connect displays and cameras to an application processor.
  - Utilizes 3-wire lanes with an embedded clock. Each lane provides 2.28 bits/symbol at up to 2.5Gsps providing 5.7Gbps/lane. 3 such lanes can provide up to 17.1 Gbps on 9 wires.

MIPI CSI-2 has Several PHY Options (cont'd)

- **M-PHY**
  - Designed for data-intensive applications that require fast communications channels for high-resolution images, high video frame rates and large displays, or for memories. Often used for inter-processor communications.

- **A-PHY**
  - Targeted at automotive applications, supporting 12 to 24Gbps at distances up to 15m.
  - It is still in the definition phase. The MIPI Automotive Working group is writing the requirements for A-PHY.
  - Target release of specification at end of 2019, with anticipated deployments in 2024 vehicles.

- Many technical questions: How is the CSI-2 packet stream divided into lanes at the transmitter? How are lanes reassembled at the receiver?

Why Consider an Ethernet Format for CSI-2?

- Ethernet transport is much more flexible and well established
  - Ethernet networks are much more mature and offer a richer and broader suite of networking tools.
  - Ethernet, AVB and TSN toolbox offers a lot
    - Accommodates a variety of data profiles (best effort, AVB, TSN)
    - Stream bandwidth and routing flexibility
    - Security
    - Common management
  - Ethernet provides a *real network, supporting many topologies*. Enables more use cases and topologies needed in autonomous vehicles:
    - Redundancy (802.1CB)
    - Fail Operational compute clusters require a network
    - Multicast
    - Cable density optimization
- Newer and higher-rate Ethernet PHYs will need a format for RAW video, radar and lidar. We should be ready to utilize these new PHYs

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Why Consider an Ethernet Format for CSI-2? (cont'd)

- A standardized mapping allows silicon vendors to integrate Ethernet directly into the camera/lidar/radar/sensor without changing the underlying CSI-2 architecture.

- Many cars already include Ethernet as a primary cabling and transport solution.
  - An Ethernet format for CSI-2 dovetails into these existing and growing architectures
  - Utilize common data, management, and security architectures

Scope of Work (A Very Early and High-Level View)

1. Liaison with MIPI
   - As already noted, MIPI standards are only available to members. A liaison would be essential.
   - ***Question***: Is this going to be problem in terms of standardizing an interface in the IEEE? What if MIPI doesn't allow 1722 to publish the format because it opens their standard to the public??
   - ***Concern***: Is there a divergence between Ethernet and the MIPI Alliance? (Hoping this is not the case…)
2. Identify key use cases
   - Includes key parameters for each use case: Throughput, worst-case latency, jitter, synchronization time error, etc.
   - Not necessarily the same parameters as provided by the CSI-2/C-PHY combination
3. Determine technical structure of the format. Include data and C&C. (There is a lot of work here.)
   - CSI-2
   - I^2C
   - I3C
4. Draft and formalize standard format, iteratively with steps 2 and 3.

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Is Anyone Else Interested??

- During the 4Dec2018 IEEE 1722 meeting in Berkeley, CA., seven individuals from seven companies expressed interest pursuing this format and participating in its development.

- Next Steps
  - Interested individuals please work to advance this format. Use the avbtp list for discussion AVBTP@listserv.ieee.org and to set up further meetings.

Thanks!