DisplayPort™ Ver.1.2 Overview

DisplayPort Developer Conference | December 6, 2010 | Westin Taipei

Alan Kobayashi
R&D Director, DisplayPort Solutions, TVM, STMicroelectronics
VESA Board of Director
Editor of DisplayPort Task Group
Chair/Editor of TV Panel Task Group
Agenda

• DisplayPort Version Numbers

• Layered View of Isochronous AV Stream Transport

• DisplayPort Principles

• New Features of DisplayPort Ver.1.2
DisplayPort Version Numbers

• Only one DisplayPort Standard specification version number active at any given time
  • With the publication of DisplayPort Standard Specification Ver.1.2 in JAN 2010, Specification Ver.1.1a document was retired

• As for DPCD Revision Number (at DPCD Address 00000h), multiple revision numbers may co-exist
  • When people casually refer to a “DP1.1a” product, they actually mean a DP device supporting DPCD Revision Number 1.1 only
DisplayPort Standard Version Number (continued)

• Link and PHY Compliance Test Specifications following DisplayPort Standard Version Number
  • Ver.1.1a available
    • *NOTE: Link CTS Ver.1.1b with addition of audio transport test to be published in DEC 2010 ~ JAN 2010*
  • Phase 1 of Ver.1.2 covering some of the additional features in DisplayPort1.2 (e.g., HBR2, Audio HBR) going to GMR (General Membership Review) in DEC 2010 ~ JAN 2011

• Other DP-derivative standards (eDP and iDP) have their own version numbers
  • eDP Standard Ver.1.2 published in MAY 2010, Ver.1.3 release expected in JAN 2011
  • iDP Standard Ver.1.0 published in APR 2010
Layered View of Isochronous AV Stream Transport

- DisplayPort1.2 defines the Transport Layer serving Stream Layer
- Distinction between Transport Layer and Stream Layer clarified in DisplayPort1.2 with the addition of MST (multi-stream transport) and MST topology management enhancement

NOTE1: DP1.2 Section 5 defines 640x480, RGB18bpp as SAFE MODE

NOTE2: Not available/being developed at VESA
DisplayPort Principles

- 1 x Main Link
- AUX CH
- Hot Plug Detect
- Powered Connector (DP_PWR pin)

<table>
<thead>
<tr>
<th></th>
<th>Raw Bit Rate (incl. coding overhead)</th>
<th>Application Bandwidth/Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 x lane</td>
<td>1.62/-2.7/-5.4-Gbps</td>
<td>162/-270/-540-Mbytes/s</td>
</tr>
<tr>
<td>2 x lanes</td>
<td>3.24/-5.4/-10.8-Gbps</td>
<td>324/-540/-1080-Mbytes/s</td>
</tr>
<tr>
<td>4 x lanes</td>
<td>6.48/-10.8/-21.6-Gbps</td>
<td>648/-1080/-2160-Mbytes/s</td>
</tr>
<tr>
<td>AUX CH</td>
<td>1Mbps / 720Mbps (optional)</td>
<td>~ 16 bytes per 0.5ms *</td>
</tr>
</tbody>
</table>
<pre><code>                              |                                   | / ~ 64 bytes per 1.2 us **       |
</code></pre>

*: Maximum payload size of Manchester Transaction Mode (1Mbps) equal to 16Bytes
**: FAUX (720Mbps) throughput calculated with the payload size of 64Bytes
Main Link Transport

- Uni-directional
  - From an upstream device (e.g., Source) to a downstream device (e.g., Sink)
  - 1, 2, or 4 high-speed lanes (differential pairs)
  - Link established based on the receiver/stream sink capabilities, application bandwidth need, and Link Training result
    - DPCD (DisplayPort Configuration Data) access for receiver capability discovery, and Link Training
    - EDID access for stream sink capability discovery

- Transported data types
  - Main uncompressed video stream (or streams) *1
  - Audio
    - Via SDP (Secondary-Data Packet)
    - Transported with or without the main video stream
  - Metadata
    - Via MSA (Main Stream Attribute) Packet
    - Via SDP

*1: Compressed video may be supported via SDP definition extension
**AUX CH Transport**

- Half-duplex bi-directional
  - AUX transaction always initiated by an upstream device
  - A downstream device may prompt an AUX transaction via IRQ (interrupt request) pulse assertion over HPD line

- Two transport formats
  - Manchester transport format
    - 1Mbps, Burst transfer = 16 data bytes max
    - Capable of establishing ~ 200Kbps full-duplex link
  - Fast AUX transport format (New in DisplayPort Standard Ver.1.2)
    - 720Mbps, Burst transfer = 64/1024 data bytes max
    - Capable of establishing ~ 200Mbps full-duplex link

- AUX transaction syntax
  - Native AUX, I²C-over-AUX
  - USB-over-AUX (Fast AUX required; full definition to be completed)
  - Other transport protocol may be mapped over Native AUX syntax
    - E.g., UART
**HPD, Upstream Device Detection, DP_PWR**

- **HPD (Hot Plug Detection)**
  - Asserted by a downstream device when it is ready for AUX transaction
    - HPD line also used for an IRQ assertion by a downstream device
    - Used by an upstream device to detect the plugging of a downstream device

- **Upstream Device Detection**
  - A downstream device monitors AUX+ and AUX- DC voltage levels to detect the presence of an upstream device and its power state

- **DP_PWR**
  - 3.3V+/−10% / 500mA max, available both on upstream/downstream device connectors
  - Mainly intended for powering cable adaptors
    - Standard DisplayPort cable does not have wire connected on DP_PWR pin
DisplayPort Ver.1.2 New Feature Summary

• Key new DisplayPort 1.2 Features
  • Additional link rate of 5.4Gbps/lane
  • Multi Stream Transport (MST) support
  • MST topology management
  • Additional 3D support
  • Wide color gamut support improvements
  • Audio enhancement
  • FAUX Transaction Mode option over AUX CH

• Provides backward compatibility with existing DisplayPort devices supporting DPCD Revision Number 1.1 only
  • No new pins/wires added to connectors and cables
Additional Link Rate of 5.4Gbps/lane

5.4Gbps/lane link rate increase the video data bandwidth to 2160Mbytes/sec, providing support for emerging display applications.

DP v1.2 enables Beyond Full HD Stereo support at 120Hz...

DP v1.2 enables High Color Range Quad Full HD delivered over standard DisplayPort connector...

Full 4K x 2K Support
Data Rate vs. Number of Displays

Digital Display Interface Examples

- Only DP 1.2 Supports Multiple Displays

Assumptions:
- 60 Hz refresh
- 24 bits-per-pixel
- Standard VESA pixel clock rates

Display Interface Video Data Rate (excluding channel coding overhead)
PHY Spec Changes Related to 5.4Gbps/lane

• New training pattern (TPS3, Training Pattern Sequence 3) added to allow for further fine tuning of TX drive setting and RX equalization
• TX EYE measured at TP3_EQ test point a signal analyzer supporting a mathematical cable model, a link CDR PLL emulation, and a reference equalizer
• Stressed signal generator for RX jitter tolerance test calibrated at TP3_EQ with the above signal analyzer
Multi-Stream Transport (MST)

- MST (Multi-Stream Transport) added in DisplayPort Ver.1.2
  - Only SST (Single-Stream Transport) was available in Ver.1.1a
- MST transports multiple A/V streams over a single connector
  - Up to 63 streams; not “Stream per Lane”
    - No synchronicity assumed among those transported streams; one stream may be in a blanking period while others are not
- A connection-oriented transport
  - Path from a stream source to a target stream sink established via Message Transactions over AUX CH’s prior to the start of a stream transmission
  - Addition/deletion of a stream without affecting the remaining streams
Multi-Stream Transport

- Source Device1 stream rendered on Stream Sink 2 of Sink Device1 and Stream Sink 1 of DP Sink Device2 ("cloned")
- Source Device1 stream from Stream Source1 rendered on Stream Sink1 of Sink Device 1
- Source Device 1 stream from Stream Source2 rendered on Stream Sink 2 of Sink Device2
- # of streams is different among the DP links in a given topology
  - 1 ~ 3 streams in this example
Micro Packet in SST Mode: TU

- DisplayPort uses a “micro-packet” as a vessel for transporting stream data
- In SST mode, the micro packet is called TU (Transfer Unit)
  - 32 ~ 64 link symbols per lane
  - Transported only during main video stream active period (that is, DE, or Display Enable, high period)
  - Uses BE symbol and BS symbol sequence to indicate stream active period
    - MSA Packet and Secondary-Data Packet, framed with SS and SE symbols, sent during stream blanking period
  - Number of valid pixel data symbols proportional to the ratio between pixel peak bandwidth and link bandwidth
**Micro Packet in MST Mode: MTP**

- In MST mode, the micro packet is called MTP (Multi-stream Transport Packet)
  - 64 link symbols per lane; 1\textsuperscript{st} symbol reserved for MTP Header
  - Transported all the time
  - VC Payload established to transport a stream via “ALLOCATE_PAYLOAD” message transaction
    - \# of VC Payloads = \# of streams transported
    - Allocated time slots for a given VC Payload must meet the pixel peak bandwidth requirement
  - BE/BS/SS/SE transported as part of stream symbols within VC Payload

### Time Slot Allocation Diagrams

<table>
<thead>
<tr>
<th>Time Slot</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>63</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTP Header</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time Slot</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>63</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTP Header</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**No Time Slot allocated to a VC Payload**

<table>
<thead>
<tr>
<th>Time Slot</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>63</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTP Header</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Time Slots 1-5 allocated to VC Payload 1**
Link Timing Generation in MST Mode

- MTP transported all the time
- Link Frame period = $2^{16}$ time slots long, agnostic to timings of streams
  - Predictability of transmission pattern
    → Improved robustness of multi-link topology

![Diagram showing Link Timing Generation in MST Mode](image)
MST Topology Management

- Node addressing through discovery procedure
  - Topology Manager (typically, a DP Source device) discovers the path to the other DP devices in the topology
  - Attachment/detachment of a device handled without resetting the address set of the entire link
- Enables remote DPCD/EDID/MCCS access
  - Transaction routed to a target DP device
- Supports topology containing multiple DP Source and Sink Devices
  - Initial main focus: a single DP Source device driving multiple displays
Device Types

- **Primitives**
  - uPacket TX / uPacket RX / Branching Unit (BU) / Stream Source / Stream Sink

- **Connection type**
  - Between uPacket TX and uPacket RX = Physical Connection
  - Between BU and Stream Source/Sink/Another BU = Logical Connection

- **Branch device**
  - BU with at least one uPacket TX and at least one uPacket RX

- **Source device**
  - One or multiple stream sources plus at least one uPacket TX, no uPacket RX
  - Source device with MST mode = MST Source device

- **Sink device**
  - One or multiple stream sinks plus at least one uPacket RX, no uPacket TX
  - Sink device with multiple stream sinks with BU = MST Sink device

- **Composite device**
  - Branch device with stream source(s) and/or sink(s)
Relative Address (RAD)

- Topology Manger (Source#1) establishes the topology map of relative addresses of devices in the topology with LINK_ADDRESS message transactions
- Port# Bit 3
  - 0 for Physical Port
  - 1 for Logical Port
- Devices with BU act as Topology Assistant
- GUID (Globally Unique ID) used by Topology Manger to handle a topology with parallel paths or a loop
DPCD Fields for MST Capability/configuration

• **uPacket RX capability:** DPCD Address 00021h (MSTM_CAP)
  - Bit 0 = MST_CAP
    - 1 – Supports MST transport format and has a Branching Unit, and therefore supports Message Transaction/Sideband MSG handling
    - 0 – Does not support MST transport format and has no Branching Unit, and therefore does not support Message Transaction/Sideband MSG handling

• **uPacket TX configuration:** DPCD Address 00111h (MSTM_CTRL)
  - Bit 0 = MST_EN (indicates the transport format over Main Link)
    - 1 – Upstream Port will transmit audio/visual data in Multi-Stream Format
    - 0 – Upstream Port will transmit audio/visual data in Single Stream Format
  - Bit 1 = UP_REQ_EN (indicates the support of Message Transaction)
    - 1 – Allows the Downstream uPacket RX to originating/forwarding an UP_REQ message transaction.
    - 0 – Prohibits the Downstream uPacket RX from originating/forwarding an UP_REQ message transaction.
  - Bit 2 = UPSTREAM_IS_SRC
    - 1 – Set to 1 by a DP Source device to indicate to the Downstream device the presence of a Source device, not a Branch device
    - 0 – Upstream device is either a Source device predating DP Standard Ver.1.2 or a Branch device
Base Topology in Usage Case Example Guide

- Volume 1 will be published in DEC 2010 ~ JAN 2011
- DisplayPort Standard explains the frame work of MST transport and topology management
- Usage Example Guideline document uses a practical example to describe the operation sequence of a Source device and a Branch device (Splitter)
- More volumes with additional topology examples will be added in the future
Topology with Audio Stream Sinks in the Guide

Multiple stream sink monitor with multiple audio sinks
Additional 3D Stereo Display Support

• DisplayPort Ver.1.1a already natively supported 3D Stereo display transport
  • 1080Mbytes/sec bandwidth over standard cables
    • Sufficient for Stereo Display modes: 1080p 60Hz per EYE
  • MSA packet provides for in-band metadata for frame-sequential 3D Stereo transport format (MISC1 field bits 2:1)
    • 00: No stereo video transported
    • 01: The next (upcoming) video frame is RIGHT eye
    • 10: Reserved
    • 11: The next (upcoming) frame is LEFT eye

• DisplayPort Ver.1.2 provides for:
  • Link bandwidth sufficient for 1080p 120Hz per EYE
  • Additional 3D Stereo transport format indicated by a new VSC (Video Stream Configuration) SDP
    • Stacked top bottom
    • Stacked left right
    • Line interleave
    • Pixel interleave
  • DisplayID Standard as an extension block of EDID Ver.1.4 being extended for better description of 3D rendering capability of a display
Standards Extension for Wide Color Gamut Support Improvement

• Enhancement of DP1.2, DisplayID (as an EDID extension block), and MCCS so as to address the "Color Issues" for:
  • Consistent Color
  • Accurate Color
  
  **NOTE:** The consistent and accurate color may not be achievable in some scenarios (e.g., content gamut larger than display gamut)

• Layers of Standards
  • DP1.2: Link (or Transport) Layer
  • DisplayID/EDID and MCCS: Stream (or Application) Layer
  • Compliance test/enforcement should be comprehended even though it may be outside the scope of Link Layer/EDID CTS documents
Main Goals of Standards Extensions

- Expose both native and emulate-able color space/gamut of Display (i.e., a Sink device) to a Source device
  - Color management system needs to know both content and display color profiles
- Allow the Source device to indicate the color space/gamut of choice to Display based on content color profile and capability of the Display
  - Permit a Source device to disable/specify color-space emulation by Displays
### DisplayPort Ver.1.2 Extension for Wide Color Gamut

- **MSA MISC0/MISC1 field extension**
  - A Source device indicates color space, color data representation format, and color bit depth of the content it is transmitting

<table>
<thead>
<tr>
<th>MSA bits</th>
<th>MISC1</th>
<th>MISC0</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[7]</td>
<td>[2:1]</td>
</tr>
<tr>
<td><strong>RGB unspecified color space (legacy RGB mode)</strong></td>
<td>0</td>
<td>00</td>
</tr>
<tr>
<td><strong>sRGB</strong></td>
<td>0</td>
<td>00</td>
</tr>
<tr>
<td><strong>AdobeRGB1998</strong></td>
<td>0</td>
<td>00</td>
</tr>
<tr>
<td><strong>DCI-P3</strong></td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td><strong>RGB wide gamut fixed point (XR8, XR10, XR12)</strong></td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td><strong>RGB wide gamut floating point (scRGB)</strong></td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td><strong>Y-only</strong></td>
<td>1</td>
<td>00</td>
</tr>
<tr>
<td><strong>YCbCr (ITU601/ITU709)</strong></td>
<td>0</td>
<td>01 = 422 10 = 444</td>
</tr>
<tr>
<td><strong>xvYCC (xvYCC601/xvYCC709)</strong></td>
<td>0</td>
<td>01 = 422 10 = 444</td>
</tr>
<tr>
<td><strong>Simple Color Profile</strong></td>
<td>0</td>
<td>11</td>
</tr>
</tbody>
</table>
Audio Enhancement

- Audio Copy Protection, Category Code
  - Call out the Copy protection details
- DRA, Dolby MAT, DTS HD
  - High Def Audio formats supported in Blu-Ray and HD-DVD
- Synchronization assist
  - AV Lip sync
  - Audio inter-channel sync among multiple DP Audio Sink Devices, with sub-us precision /accuracy via GTC (Global Time Code) synchronization
GTC

- Either an upstream device or a downstream device can be a GTC master
  - Source device is the GTC master by default
  - GTC accumulator of a GTC master: Free-running
  - GTC accumulator of a GTC slave: Retains lock to that of a GTC master using the first differential edge at the end or following the AUX_SYNC pattern as a reference point

- A stream source sends a GTC value representing a presentation time of the beginning of an audio frame (consisting of 192 audio samples) using a channel status field
Optional higher speed auxiliary channel enables bi-directional bulk data transfer over a single DisplayPort cable...

Fast AUX application
- USB peripheral device data transfer
- Microphone audio transfer
- Camera video transfer
FAUX Transaction Mode over AUX CH

• Half-duplex, bi-directional channel
• Turn-around delay 200ns or below for a high throughput
  • Excess turn-around delay wastes the peak bandwidth
  • 12-symbol pre-amble including “Squelch” pattern
• An upstream device may fall back to Manchester Transaction Mode any time
  • A downstream device must be able to detect Manchester Transaction Mode
Thank You