Understanding Multi-Stream

VESA DisplayPort Workshop, Taipei May 2013

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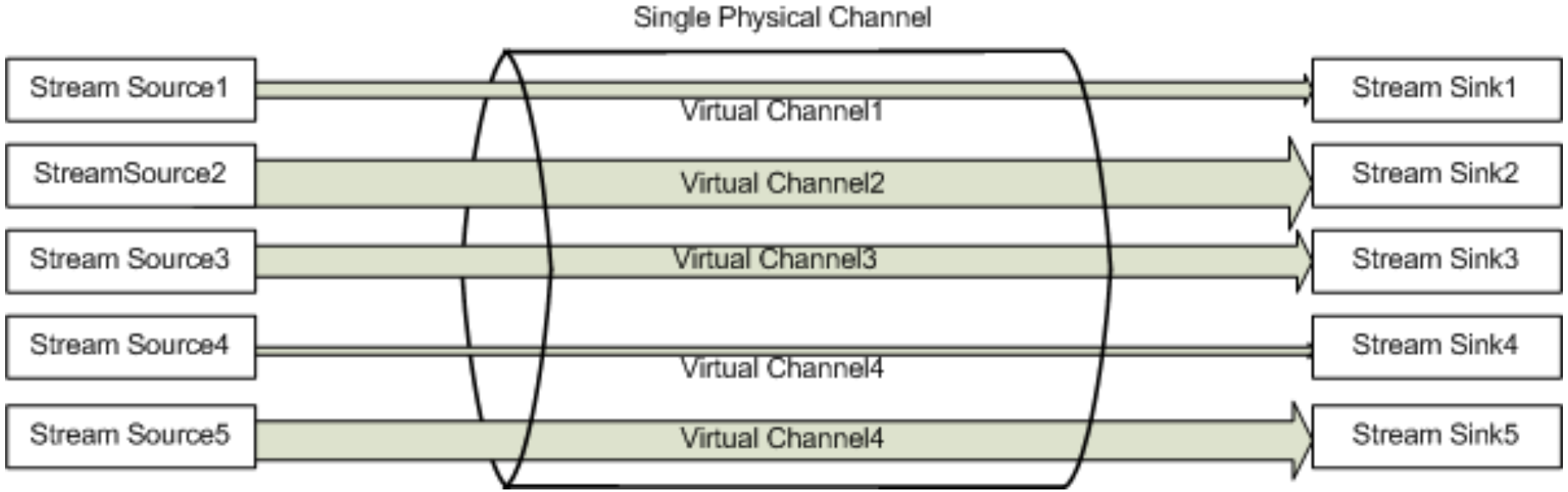
Multi-Stream Basics

- MST Extension
- MTP (Multi-Stream Transport Packet)
- VC (Virtual Channel) Payload
- Video Stream Symbol Mapping within VCP
- Addition/Deletion of Streams
- MST Topology Management

MST (Multi-Stream Transport) Extension

- **De-coupling of Virtual Channels between stream sources and stream sinks from physical channels**



NOTE: *Widths of the arrows imply stream bandwidths*

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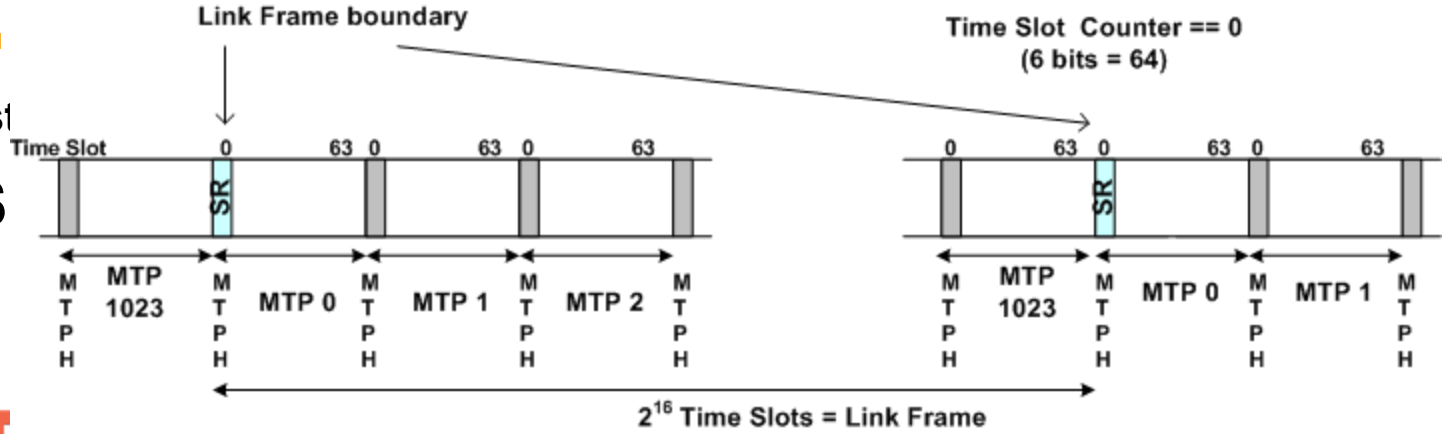
MST Extension *(continued)*

- **Micro-Packet-based, time-division multiplexing to enable transport of multiple AV streams over a single physical connection**
  - **In theory, up to 63 AV streams transportable concurrently**
    - **Not "one stream per lane"**
    - **No synchronicity assumed among streams transported over a single physical channel**
      - **E.g., Streams may have different frame rates (24Hz / 25Hz /50Hz/ 59.94Hz /60Hz / 72Hz /75Hz…)**
  - **Addition/deletion of a stream without affecting the remaining streams**
  - **Packetizing overhead as small as 1.6%**

MTP (Multi-Stream Transport Packet)

- The unit of Micro-Packet in MST Mode
- 64 time slots long
  - 1st time slot of MTP used as MTP Header
  - Remaining 63 time slots allocated to carry streams
    - Carries 00's when unallocated for a stream transport
- 1024 MTP's constitute a "Link Frame"
  - 1 Link frame = 2^{16} time slots long
  - 1st
    (S



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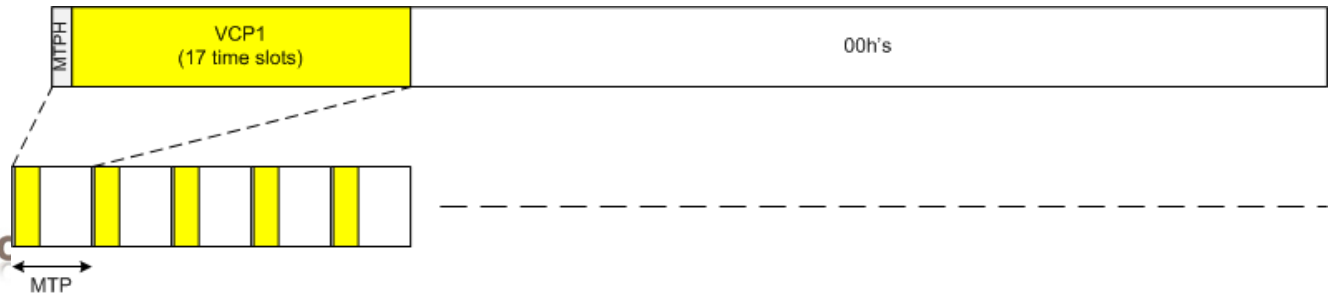
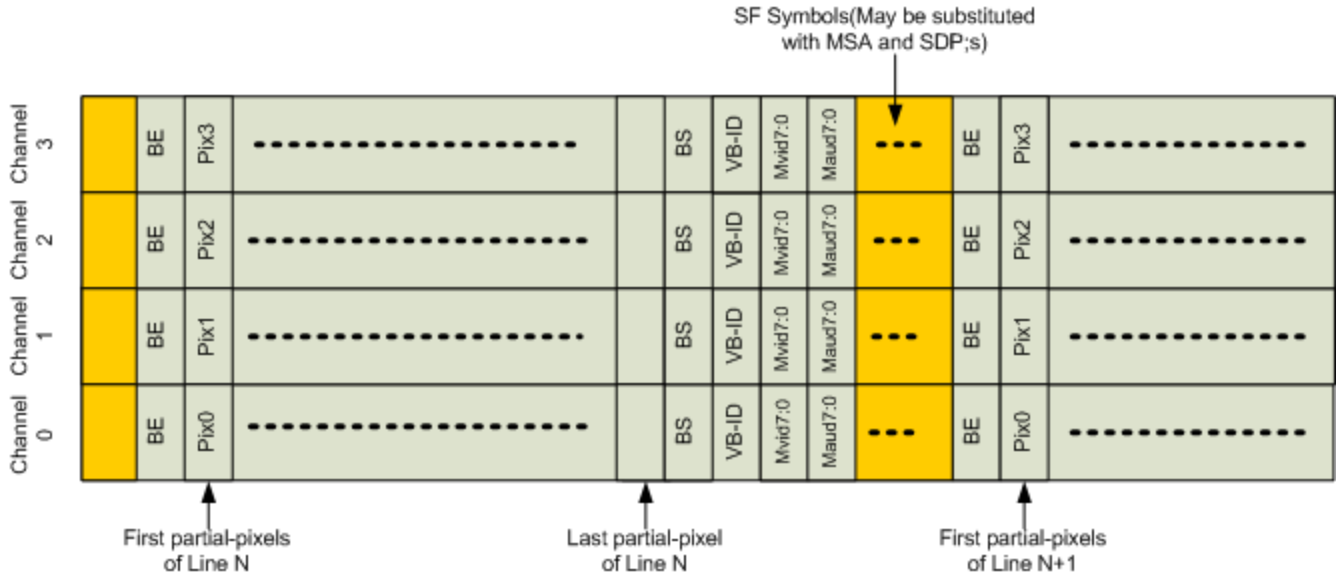
VC (Virtual Channel) Payload

- VC Payload = Time slots within MTP (excluding MTP Header) allocated for transporting a stream
  - One AV stream per VC Payload
- Example: 1080p60Hz, 30bpp over 4-lane, 5.4Gbps/lane Main Link
  - Pixel bandwidth = 148.5Mpixels/sec * (30/8) bytes/pixel = 556.875Mbytes/sec
  - 1 time slot per MTP = 540Mbytes/sec/lane * 4 lanes / 64 time slots per MTP
    = 33.75Mbytes/sec/time slot
  - VC Payload time slot count for this stream over this Main Link (VCP1)
    = CEIL (556.875 / 33.75) = 17 time slots



Video Stream Symbol Mapping within VCP

- **Active video pixel data framed with BE and BS Control Symbols**
- **When no pixel to transport (e.g., video blanking period), insert SF (Stream Fill) control symbols**
- **MSA (Main Stream Attributes) Packet to replace SF symbols once per vertical blanking interval to describe video stream attributes**



NOTE: *Stream symbols carried in a VCP form the above when concatenated across MTP's*

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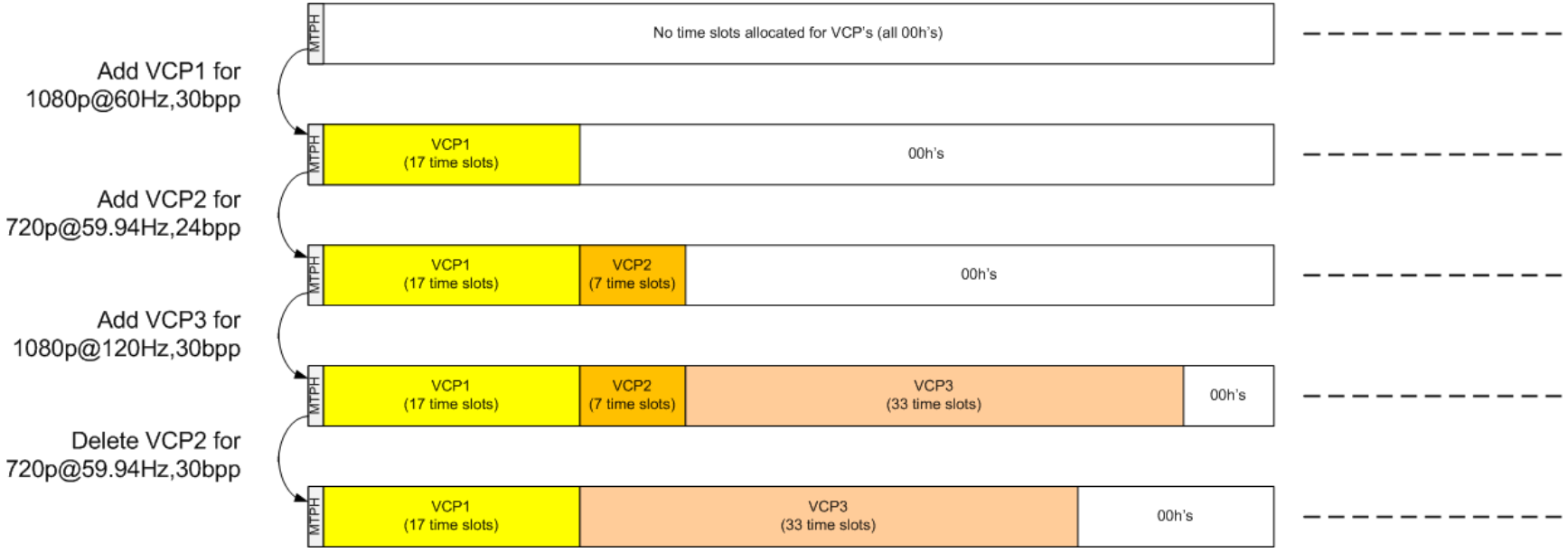
Addition/Deletion of Streams

- One stream at a time
  - Time slot allocation change agreed on between TX and RX via sideband communication
  - Addition/deletion of a VC Payload over Main Link synchronized between TX and RX by inserting ACT (Allocation Change Trigger) symbol in four consecutive MTP Headers preceding the change



NOTE: *Four MTP Headers preceding the allocation change carry ACT symbol sequence*

GUID

Global Unique Identifier

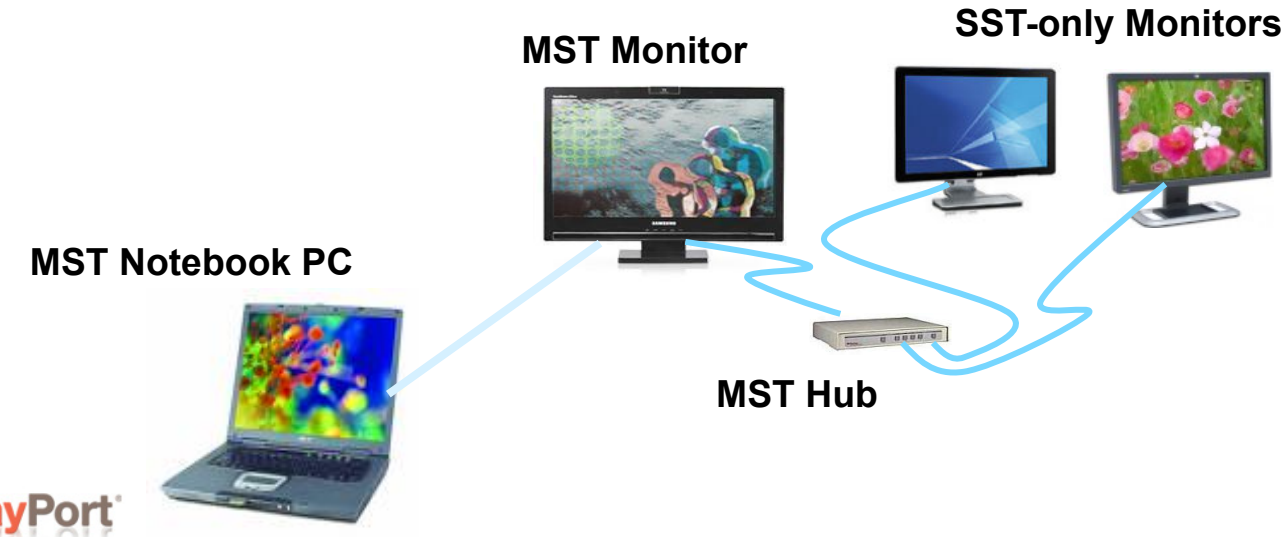
- **Topology Management Layer identifies each MST device in a branching unit**
- **MST device may perform more than one function i.e. USB hub.**
- **GUID identifies the physical unit that contains multiple functions**
  - **Source assigns 16-byte GUID unless the device already has one**

DP Audio Transport

- Available bandwidth supports 4Kx2K 60Hz progressive, YCbCr444 30bits per pixel and 2 streams of 192kHz, 22.2ch audio
- Audio transport without video supported
- Multi-Stream allows routing of multiple audio streams to multiple audio rendering devices
- Audio inter-channel synchronization across multiple audio rendering devices supported
  - Aligns real-time clock of each device in 100-ns precision via GTC (Global Time Code)
  - Audio stream source device to specify the presentation time of an audio frame in the audio stream packet

MST Topology Management

- **Node addressing through discovery procedure**
  - **Topology Manager (typically a DP Source device) discovers the path to the other DP device**
  - **Plugging/unplugging of a device handled without resetting the address set of the entire link**
- **Supports topology containing multiple DP Source and Sink devices**
  - **Initial main focus: a single DP Source device driving multiple displays**



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Multistream Reference

Multi-Stream Use Case Example 1.0

1 Example MST Topology without Audio Stream Sink

This document covers how an MST DP Source device and a device containing MST Branching Unit are to interact to perform typical topology and payload bandwidth management functions in the following logical topology.

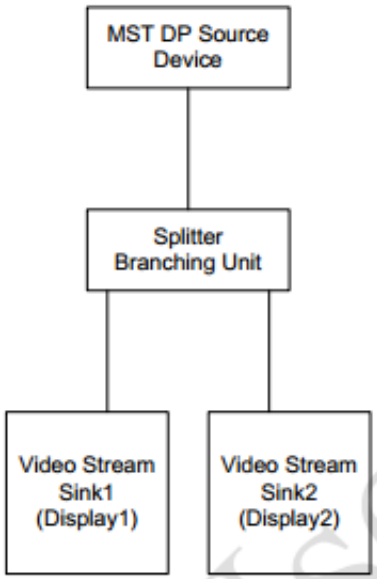

Figure 1-1: Logical Topology Covered in this Document

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MST Compliance Test Introduction

- MST Compliance Test Introduction
  - Protocol Test
    - Source
    - Branch Sink or Hub
    - Multi-Stream Sink
  - Interoperability Test
    - Source
    - Branch Sink or Hub
    - Multi-Stream Sink

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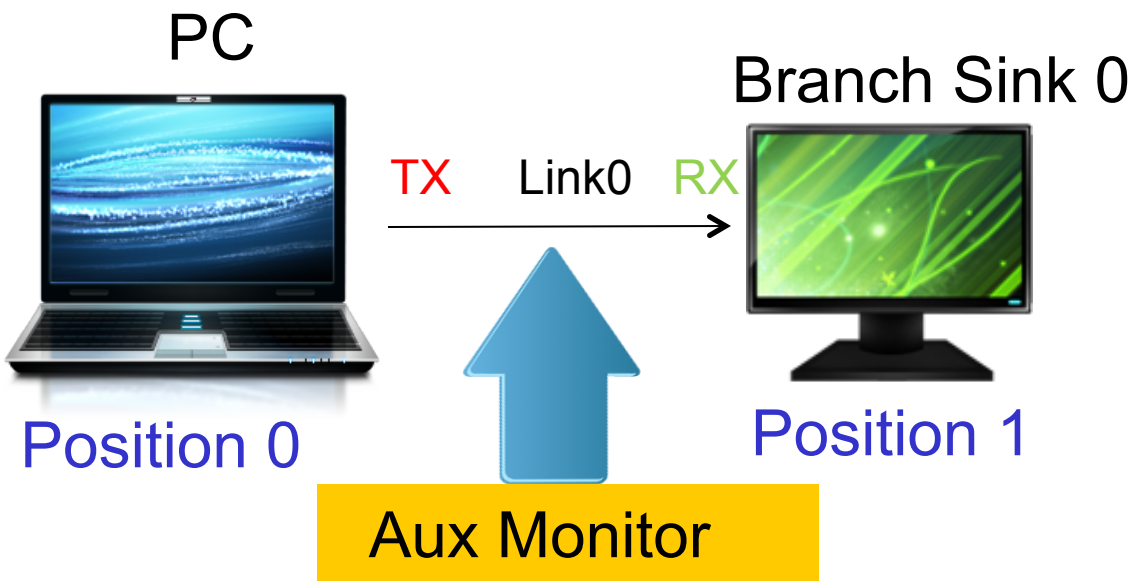
MST Compliance Test Introduction

- 5 Configurations for Protocol Test
  - Configuration A
  - Configuration B
  - Configuration C
  - Configuration D
  - Configuration E

MST Compliance Test Introduction

- Protocol Test
  - Configuration A



- ✓ Video
- ✓ Audio
- ✓ HBR2
- ✓ DPCD 1.2
- ✓ Payload Allocation
- ✓ GUID
- ✓ EDID

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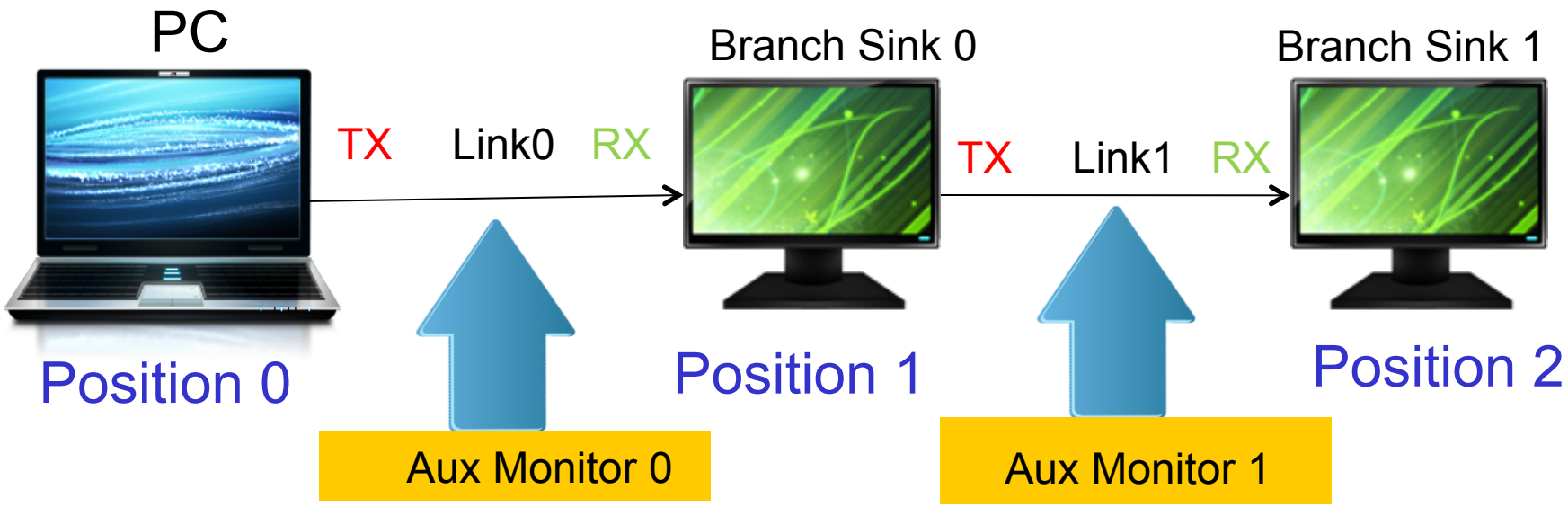
MST Compliance Test Introduction

- Protocol Test
  - Configuration B



- ✓ Video/Audio/HBR2/DPCD 1.2
- ✓ Payload Allocation/GUID/EDID

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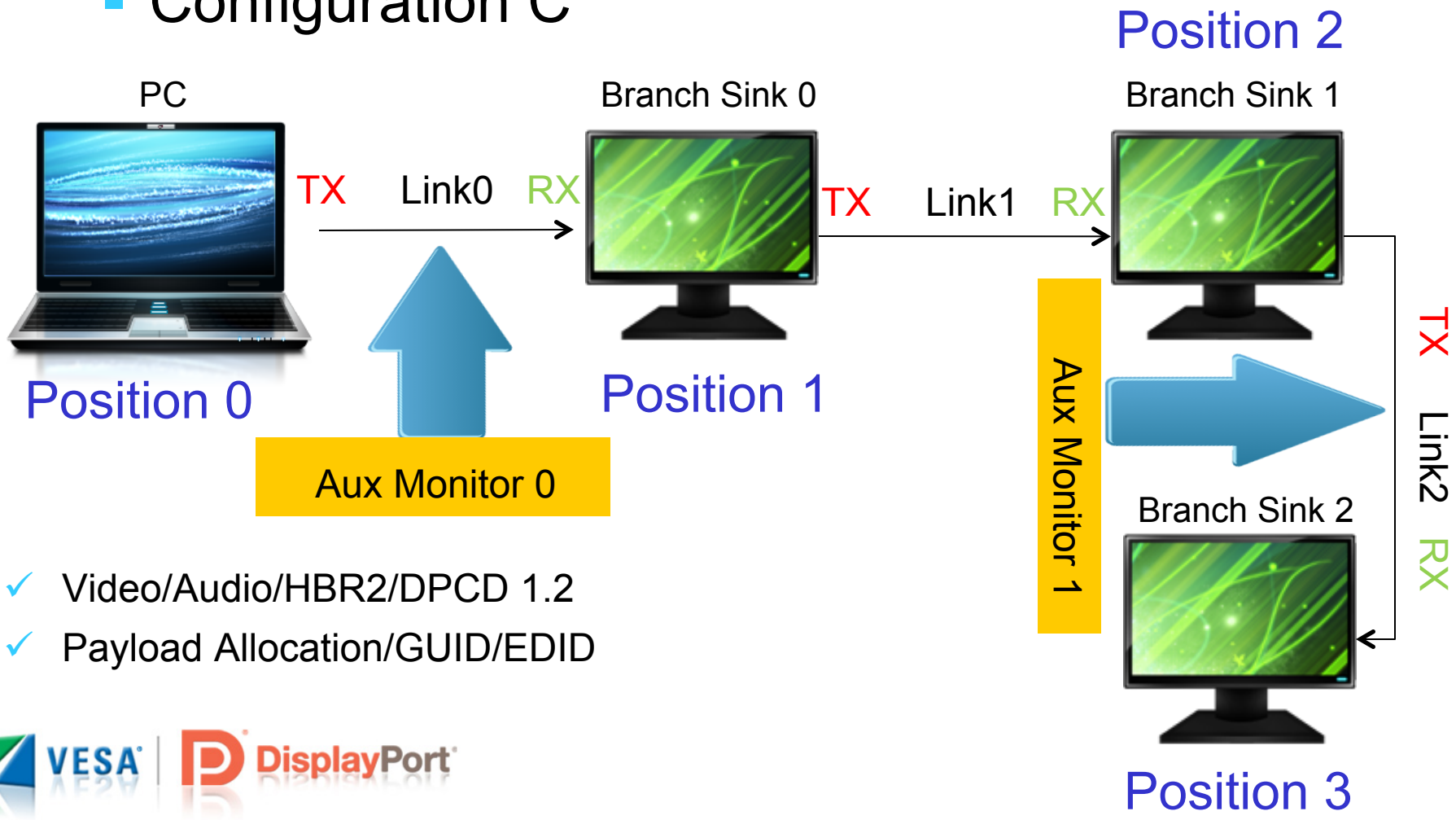
MST Compliance Test Introduction

- Protocol Test
  - Configuration C



- ✓ Video/Audio/HBR2/DPCD 1.2
- ✓ Payload Allocation/GUID/EDID

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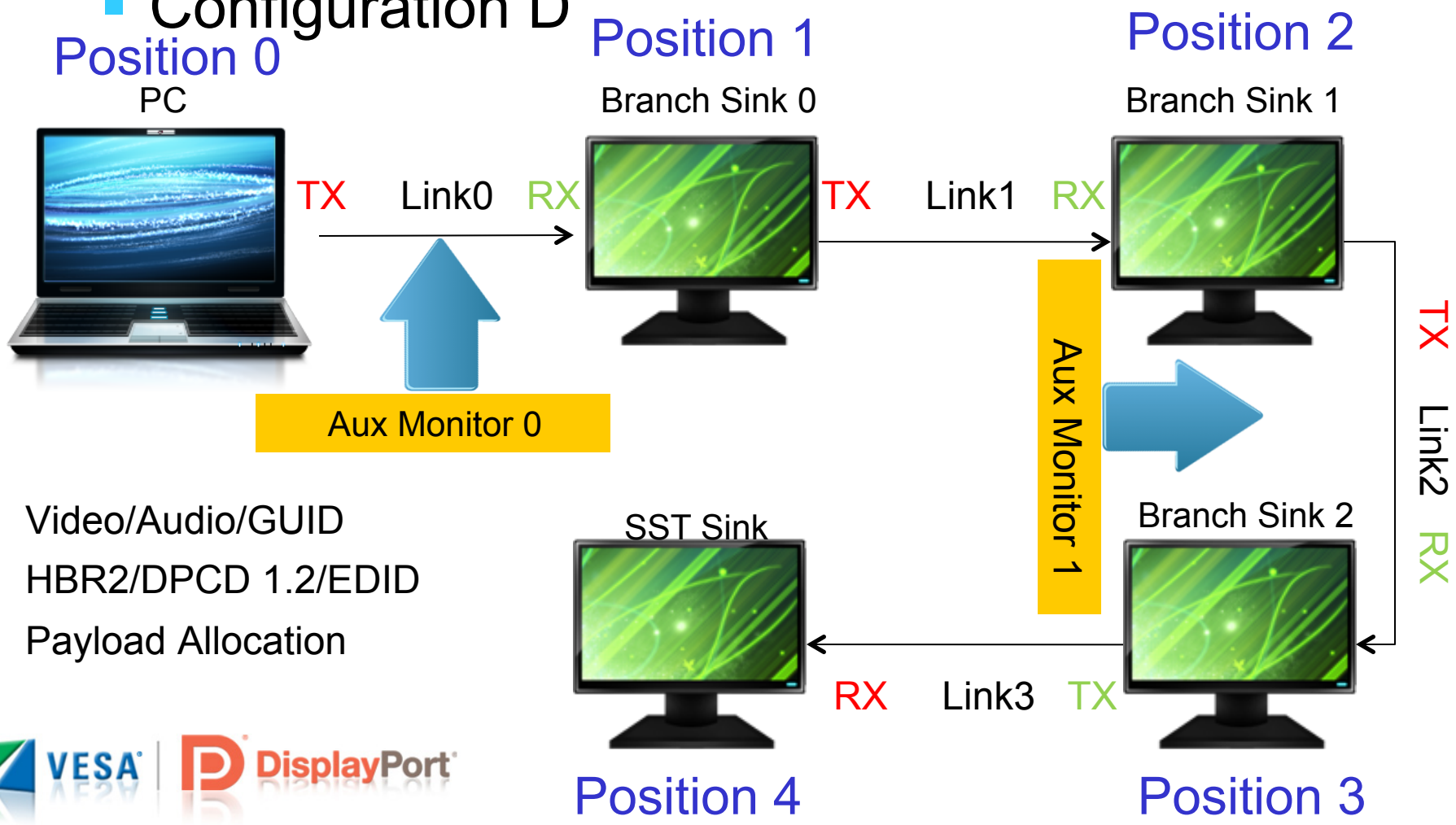
MST Compliance Test Introduction

- Protocol Test
  - Configuration D



- ✓ Video/Audio/GUID
- ✓ HBR2/DPCD 1.2/EDID
- ✓ Payload Allocation

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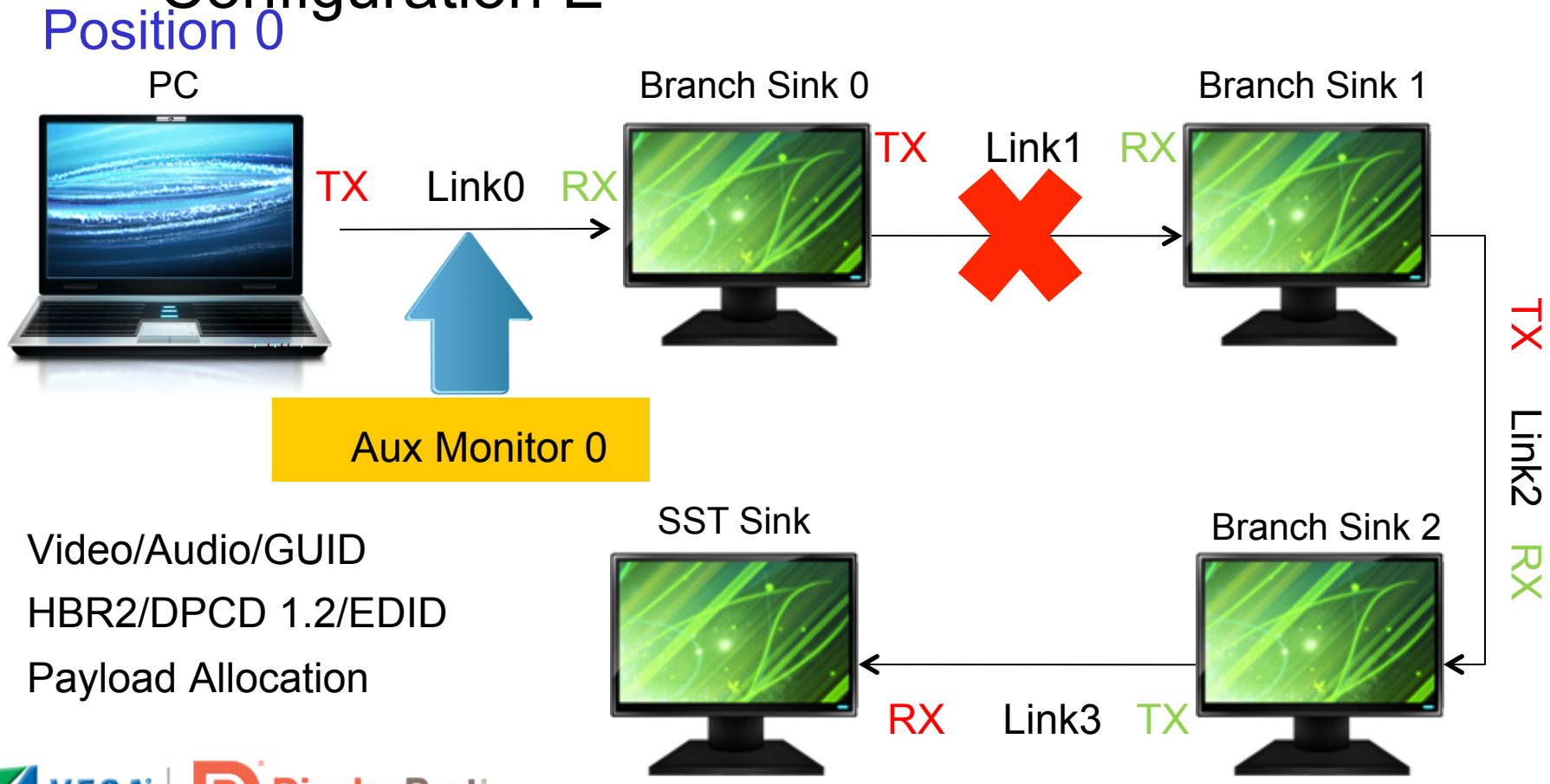
MST Compliance Test Introduction

- Protocol Test
  - Configuration E



- ✓ Video/Audio/GUID
- ✓ HBR2/DPCD 1.2/EDID
- ✓ Payload Allocation

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Interop Test Matrix

Branch Sink

Pos 0	Source	Source	Source	Source	Source	Source	Source	Source	Source	Source	Source	Source	Source
Pos 1	**DUT**	**DUT**	**DUT**	**DUT**	**DUT**	BS0	BS0	BS0	BS0	BS0	BS0	BS0	BS0
Pos 2		BS0	BS0	BS0	BS0	**DUT**	**DUT**	**DUT**	**DUT**	BS1	BS1	BS1	BS1
Pos 3			BS1	BS1	BS1		BS1	BS1	BS1	**DUT**	**DUT**	BS2	BS2
Pos 4				BS2	BS2			BS2	BS2	BS2	BS2	**DUT**	**DUT**
Pos 5					SST				SST		SST		SST

MST Compliance Test Introduction

Reference: DP 1.2a Standard

Table 2-75: Address Mapping for DPCD

DisplayPort Address	Definition	Read/Write over AUX CH
	Receiver Capability Field	
00000h	DPCD_REV : DPCD revision number Bits 3:0 = Minor revision number Bits 7:4 = Major revision number 10h for DPCD Rev.1.0 11h for DPCD Rev.1.1 12h for DPCD Rev 1.2 A DP device with uPacket RX with a DPCD Revision number of 1.2 and above must support GUID at DPCD Addresses 00030h ~ 0003Fh. Furthermore, a DP Sink device with DPCD Rev.1.2 with a stereo display capability support (as declared in EDID and Display ID) must support the handling of 3D Stereo in-band signaling using Video_Stream_Configuration (VSC) Packet. **Note:** The DPCD revision number does not necessarily match the DisplayPort version number.	Read Only
00001h	MAX_LINK_RATE : Maximum link rate of Main Link lanes = Value x 0.27Gbps	Read Only

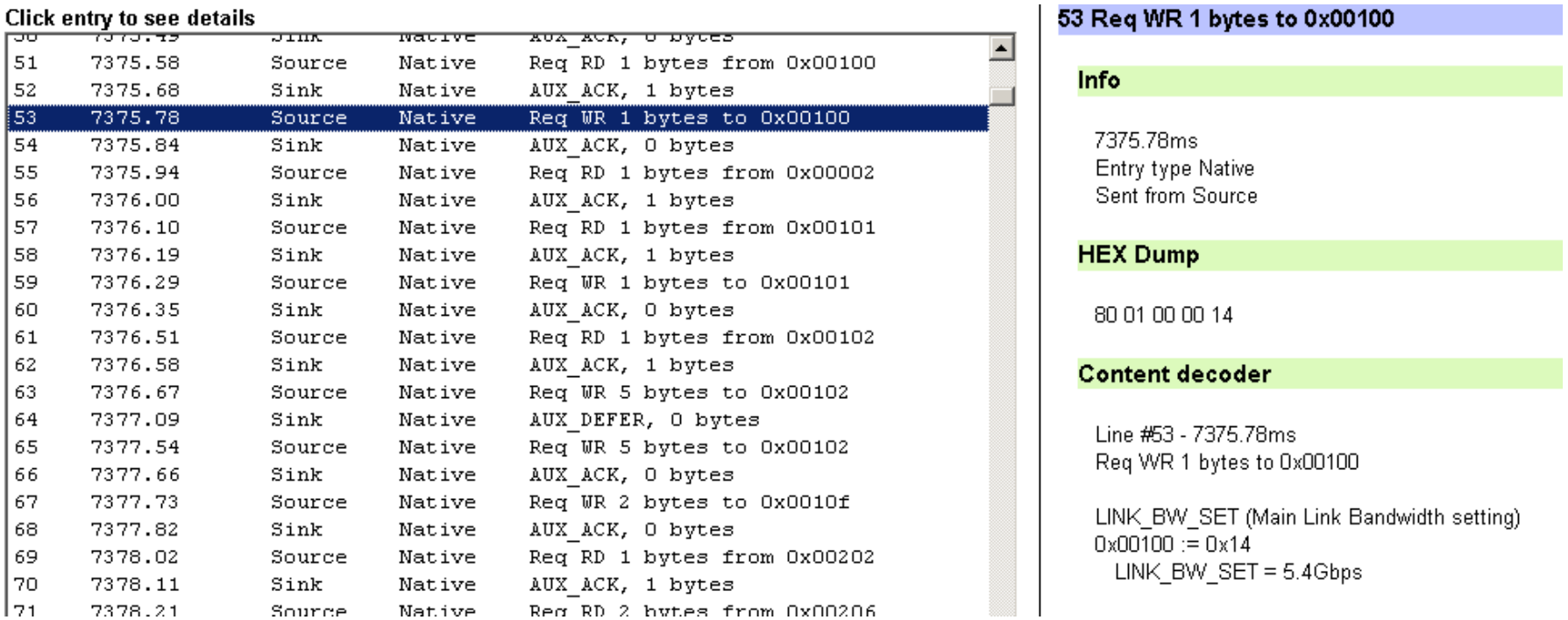
MST Compliance Test Introduction

Reference: DP 1.2a Standard

DisplayPort Address	Definition	Read/Write over AUX CH
	Link Configuration Field	
00100h	LINK_BW_SET : Main Link Bandwidth Setting=Value x 0.27Gbps per lane Bits 7:0 = LINK_BW_SET For DisplayPort Version 1, Revision 1a, only three values are supported. All other values are RESERVED. 06h = 1.62Gbps per lane 0Ah = 2.7Gbps per lane 14h = 5.4Gbps per lane The Source may choose any of the three link bandwidths as long as it does not exceed the capability of DisplayPort receiver as indicated in the receiver capability field.	Write/Read
00101h	LANE_COUNT_SET : Main Link Lane Count = Value Bits 4:0 = LANE_COUNT_SET For DisplayPort Version 1, Revision 1a, only the following three values are supported. All other values are RESERVED. 1h = 1-lane 2h = 2-lanes 4h = 4-lanes For 1-lane configuration, Lane 0 is used. For 2-lane configuration, Lane 0	Write/Read

MST Compliance Test Introduction

Check Link Training= HBR2



Click entry to see details

51	7375.58	Source	Native	Req RD 1 bytes from 0x00100
52	7375.68	Sink	Native	AUX_ACK, 1 bytes
53	7375.78	Source	Native	Req WR 1 bytes to 0x00100
54	7375.84	Sink	Native	AUX_ACK, 0 bytes
55	7375.94	Source	Native	Req RD 1 bytes from 0x00002
56	7376.00	Sink	Native	AUX_ACK, 1 bytes
57	7376.10	Source	Native	Req RD 1 bytes from 0x00101
58	7376.19	Sink	Native	AUX_ACK, 1 bytes
59	7376.29	Source	Native	Req WR 1 bytes to 0x00101
60	7376.35	Sink	Native	AUX_ACK, 0 bytes
61	7376.51	Source	Native	Req RD 1 bytes from 0x00102
62	7376.58	Sink	Native	AUX_ACK, 1 bytes
63	7376.67	Source	Native	Req WR 5 bytes to 0x00102
64	7377.09	Sink	Native	AUX_DEFER, 0 bytes
65	7377.54	Source	Native	Req WR 5 bytes to 0x00102
66	7377.66	Sink	Native	AUX_ACK, 0 bytes
67	7377.73	Source	Native	Req WR 2 bytes to 0x0010f
68	7377.82	Sink	Native	AUX_ACK, 0 bytes
69	7378.02	Source	Native	Req RD 1 bytes from 0x00202
70	7378.11	Sink	Native	AUX_ACK, 1 bytes

53 Req WR 1 bytes to 0x00100

Info

7375.78ms
Entry type Native
Sent from Source

HEX Dump

80 01 00 00 14

Content decoder

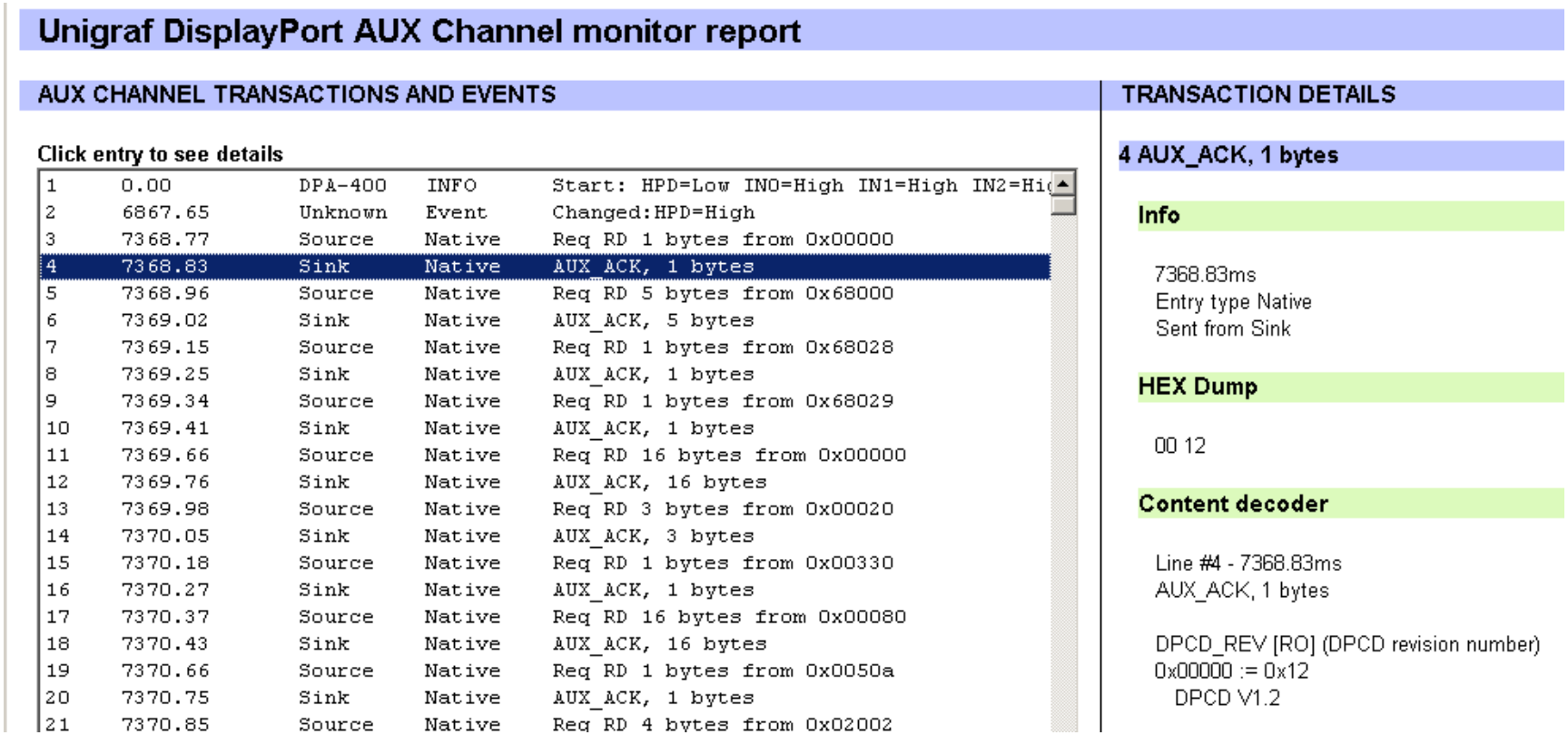
Line #53 - 7375.78ms
Req WR 1 bytes to 0x00100

LINK_BW_SET (Main Link Bandwidth setting)
0x00100 := 0x14
LINK_BW_SET = 5.4Gbps

Link may not train to HBR2 if bandwidth need is lower

MST Compliance Test Introduction

Check for DPCD Revision= 1.2



Unigraf DisplayPort AUX Channel monitor report

AUX CHANNEL TRANSACTIONS AND EVENTS

Click entry to see details

1	0.00	DPA-400	INFO	Start: HPD=Low IN0=High IN1=High IN2=Hi
2	6867.65	Unknown	Event	Changed:HPD=High
3	7368.77	Source	Native	Req RD 1 bytes from 0x00000
4	7368.83	Sink	Native	AUX_ACK, 1 bytes
5	7368.96	Source	Native	Req RD 5 bytes from 0x68000
6	7369.02	Sink	Native	AUX_ACK, 5 bytes
7	7369.15	Source	Native	Req RD 1 bytes from 0x68028
8	7369.25	Sink	Native	AUX_ACK, 1 bytes
9	7369.34	Source	Native	Req RD 1 bytes from 0x68029
10	7369.41	Sink	Native	AUX_ACK, 1 bytes
11	7369.66	Source	Native	Req RD 16 bytes from 0x00000
12	7369.76	Sink	Native	AUX_ACK, 16 bytes
13	7369.98	Source	Native	Req RD 3 bytes from 0x00020
14	7370.05	Sink	Native	AUX_ACK, 3 bytes
15	7370.18	Source	Native	Req RD 1 bytes from 0x00330
16	7370.27	Sink	Native	AUX_ACK, 1 bytes
17	7370.37	Source	Native	Req RD 16 bytes from 0x00080
18	7370.43	Sink	Native	AUX_ACK, 16 bytes
19	7370.66	Source	Native	Req RD 1 bytes from 0x0050a
20	7370.75	Sink	Native	AUX_ACK, 1 bytes
21	7370.85	Source	Native	Req RD 4 bytes from 0x02002

TRANSACTION DETAILS

4 AUX_ACK, 1 bytes

Info

7368.83ms
Entry type Native
Sent from Sink

HEX Dump

00 12

Content decoder

Line #4 - 7368.83ms
AUX_ACK, 1 bytes

DPCD_REV [RO] (DPCD revision number)
0x00000 := 0x12
DPCD V1.2

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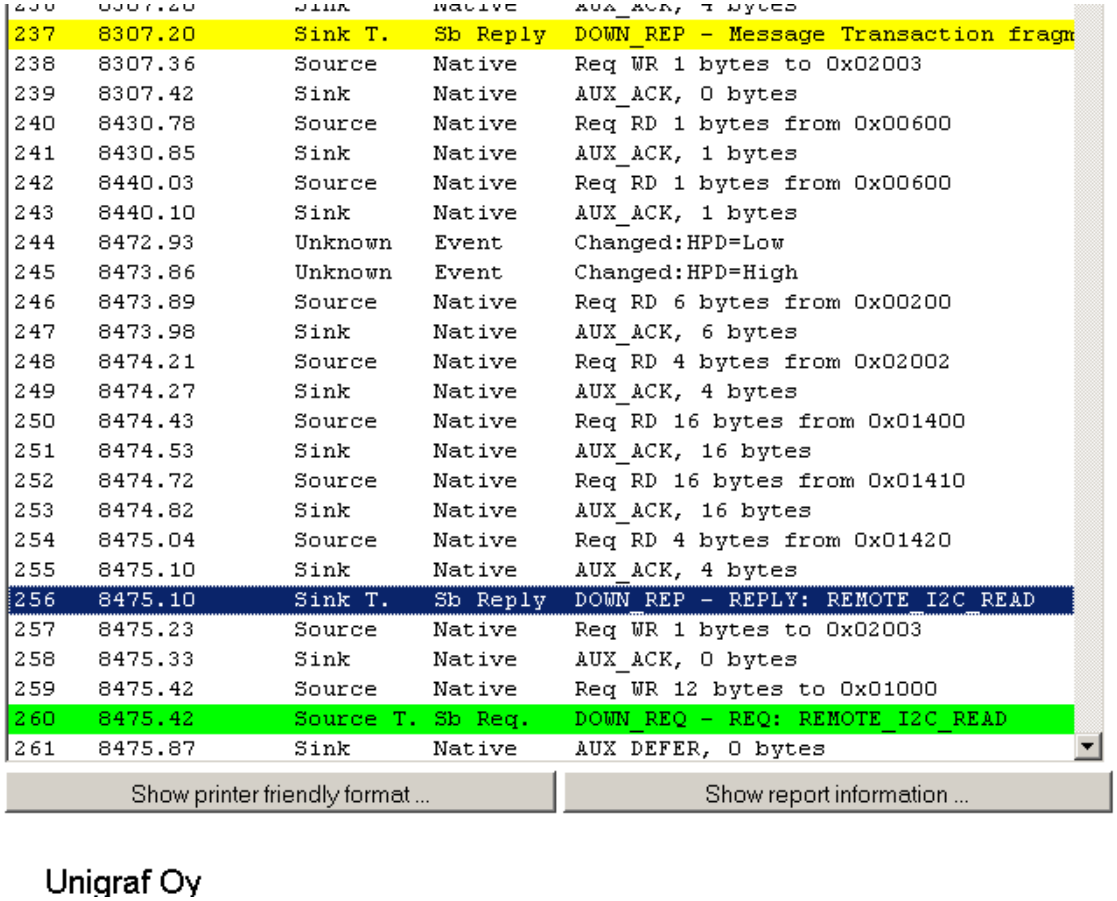
MST Compliance Test Introduction

Check for EDID from Sideband Messages



237	8307.20	Sink T.	Sb Reply	DOWN_REP - Message Transaction fragm
238	8307.36	Source	Native	Req WR 1 bytes to 0x02003
239	8307.42	Sink	Native	AUX_ACK, 0 bytes
240	8430.78	Source	Native	Req RD 1 bytes from 0x00600
241	8430.85	Sink	Native	AUX_ACK, 1 bytes
242	8440.03	Source	Native	Req RD 1 bytes from 0x00600
243	8440.10	Sink	Native	AUX_ACK, 1 bytes
244	8472.93	Unknown	Event	Changed:HPD=Low
245	8473.86	Unknown	Event	Changed:HPD=High
246	8473.89	Source	Native	Req RD 6 bytes from 0x00200
247	8473.98	Sink	Native	AUX_ACK, 6 bytes
248	8474.21	Source	Native	Req RD 4 bytes from 0x02002
249	8474.27	Sink	Native	AUX_ACK, 4 bytes
250	8474.43	Source	Native	Req RD 16 bytes from 0x01400
251	8474.53	Sink	Native	AUX_ACK, 16 bytes
252	8474.72	Source	Native	Req RD 16 bytes from 0x01410
253	8474.82	Sink	Native	AUX_ACK, 16 bytes
254	8475.04	Source	Native	Req RD 4 bytes from 0x01420
255	8475.10	Sink	Native	AUX_ACK, 4 bytes
256	8475.10	Sink T.	Sb Reply	DOWN_REP - REPLY: REMOTE_I2C_READ
257	8475.23	Source	Native	Req WR 1 bytes to 0x02003
258	8475.33	Sink	Native	AUX_ACK, 0 bytes
259	8475.42	Source	Native	Req WR 12 bytes to 0x01000
260	8475.42	Source T.	Sb Req.	DOWN_REQ - REQ: REMOTE_I2C_READ
261	8475.87	Sink	Native	AUX DEFER, 0 bytes

Show printer friendly format ... Show report information ...

Line #256 - 8475.10ms
DOWN_REP - REPLY: REMOTE_I2C_READ

-- Sideband message header --
Link_Count_Total = 1
Link_Count_Remaining = 0
Broadcast_Message = 0
Path_Message = 0
MSG_Body_Length = 33
Start_Of_MT = 0
End_Of_MT = 1
Message_Sequence_No = 0

-- Sideband message validity check --
MSG_Header_CRC = 2 [Good]
MSG_Body_CRC = 182 [Good]
Header Reserved (Zero) fields = Good

-- Full Message Transaction body --
0x00 : 22 08 80 00 ff ff ff ff ff ff 00 10 ac 46 f0 4c
0x10 : 30 38 43 31 16 01 04 b5 34 20 78 3a 1d f5 ae 4f
0x20 : 35 b3 25 0d 50 54 a5 4b 00 81 80 a9 40 d1 00 71
0x30 : 4f 01 01 01 01 01 01 01 01 28 3c 80 a0 70 b0 23
0x40 : 40 30 20 36 00 06 44 21 00 00 1a 00 00 00 ff 00
0x50 : 46 4e 38 46 59 32 43 37 43 38 30 4c 0a 00 00 00
0x60 : fc 00 44 45 4c 4c 20 55 32 34 31 33 0a 20 20 00
0x70 : 00 00 fd 00 38 4c 1e 51 11 00 0a 20 20 20 20 20
0x80 : 20 01 3b

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MST Compliance Test Introduction

Check Allocate Payload

918	10244.99	Source	Native	Req WR 10 bytes to 0x01000
919	10244.99	Source T.	Sb Req.	DOWN_REQ - REQ: ALLOCATE_PAYLOAD
920	10245.44	Sink	Native	AUX_DEFER, 0 bytes
921	10245.92	Source	Native	Req WR 10 bytes to 0x01000
922	10245.92	Source T.	Sb Req.	DOWN_REQ - REQ: ALLOCATE_PAYLOAD
923	10246.08	Sink	Native	AUX_ACK, 0 bytes
924	10246.18	Source	Native	Req RD 4 bytes from 0x02002
925	10246.24	Sink	Native	AUX_ACK, 4 bytes
926	10246.59	Source	Native	Req RD 4 bytes from 0x02002
927	10246.66	Sink	Native	AUX_ACK, 4 bytes
928	10247.01	Unknown	Event	Changed:HPD=Low
929	10247.58	Source	Native	Req RD 4 bytes from 0x02002
930	10247.68	Sink	Native	AUX_ACK, 4 bytes
931	10247.81	Source	Native	Req RD 16 bytes from 0x01400
932	10247.90	Sink	Native	AUX_ACK, 16 bytes
933	10247.90	Sink T.	Sb Reply	DOWN_REP - REPLY: ALLOCATE_PAYLOAD
934	10247.90	DPA-400	ERROR	AUX Transaction start error
935	10247.94	Unknown	Event	Changed:HPD=High
936	10248.10	Source	Native	Req RD 6 bytes from 0x00200
937	10248.16	Sink	Native	AUX_ACK, 6 bytes
938	10248.42	Source	Native	Req WR 1 bytes to 0x02003
939	10248.51	Sink	Native	AUX_ACK, 0 bytes
940	10250.53	Source	Native	Req RD 4 bytes from 0x02002
941	10250.59	Sink	Native	AUX_ACK, 4 bytes
942	10250.85	Source	Native	Req RD 1 bytes from 0x68029
943	10250.91	Sink	Native	AUX_ACK, 1 bytes
944	10251.07	Source	Native	Req WR 1 bytes to 0x02003
945	10251.14	Sink	Native	AUX_ACK, 0 bytes

Content decoder

Line #933 - 10247.90ms
DOWN_REP - REPLY: ALLOCATE_PAYLOAD

-- Sideband message header --
Link_Count_Total = 1
Link_Count_Remaining = 0
Broadcast_Message = 0
Path_Message = 1
MSG_Body_Length = 6
Start_Of_MT = 1
End_Of_MT = 1
Message_Sequence_No = 0

-- Sideband message validity check --
MSG_Header_CRC = 5 [Good]
MSG_Body_CRC = 7 [Good]
Header Reserved (Zero) fields = Good

-- Message Transaction decoded --
ACK
Request_Identifier = 0x11 [ALLOCATE_PAYLOAD]
Port_Number = 8
Virtual_Channel_Payload_ID = 2
Payload_Bandwitdh_Number = 689

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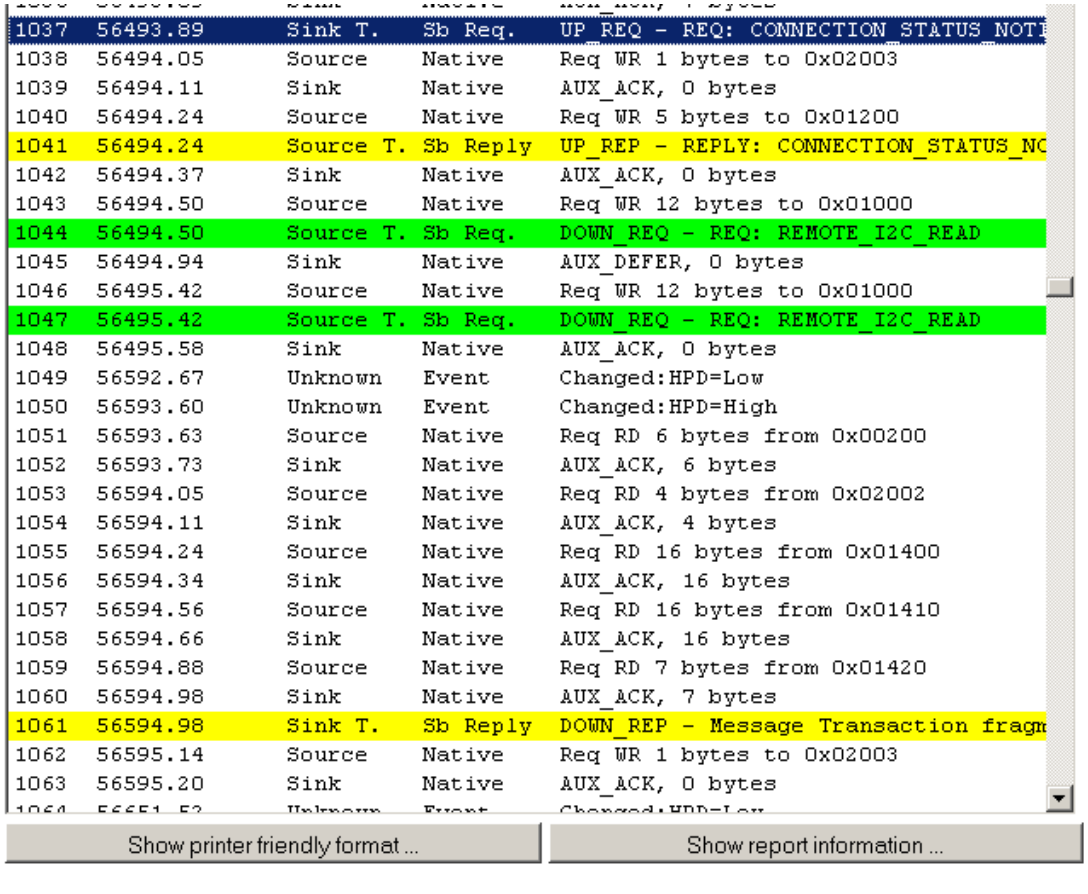
Graphics driver may allocate all remaining bandwidth to the last device in the chain

MST Compliance Test Introduction

Check GUID



1037	56493.89	Sink T.	Sb Req.	UP_REQ - REQ: CONNECTION_STATUS_NOTI
1038	56494.05	Source	Native	Req WR 1 bytes to 0x02003
1039	56494.11	Sink	Native	AUX_ACK, 0 bytes
1040	56494.24	Source	Native	Req WR 5 bytes to 0x01200
1041	56494.24	Source T.	Sb Reply	UP_REP - REPLY: CONNECTION_STATUS_NC
1042	56494.37	Sink	Native	AUX_ACK, 0 bytes
1043	56494.50	Source	Native	Req WR 12 bytes to 0x01000
1044	56494.50	Source T.	Sb Req.	DOWN_REQ - REQ: REMOTE_I2C_READ
1045	56494.94	Sink	Native	AUX_DEFER, 0 bytes
1046	56495.42	Source	Native	Req WR 12 bytes to 0x01000
1047	56495.42	Source T.	Sb Req.	DOWN_REQ - REQ: REMOTE_I2C_READ
1048	56495.58	Sink	Native	AUX_ACK, 0 bytes
1049	56592.67	Unknown	Event	Changed:HPD=Low
1050	56593.60	Unknown	Event	Changed:HPD=High
1051	56593.63	Source	Native	Req RD 6 bytes from 0x00200
1052	56593.73	Sink	Native	AUX_ACK, 6 bytes
1053	56594.05	Source	Native	Req RD 4 bytes from 0x02002
1054	56594.11	Sink	Native	AUX_ACK, 4 bytes
1055	56594.24	Source	Native	Req RD 16 bytes from 0x01400
1056	56594.34	Sink	Native	AUX_ACK, 16 bytes
1057	56594.56	Source	Native	Req RD 16 bytes from 0x01410
1058	56594.66	Sink	Native	AUX_ACK, 16 bytes
1059	56594.88	Source	Native	Req RD 7 bytes from 0x01420
1060	56594.98	Sink	Native	AUX_ACK, 7 bytes
1061	56594.98	Sink T.	Sb Reply	DOWN_REP - Message Transaction fragm
1062	56595.14	Source	Native	Req WR 1 bytes to 0x02003
1063	56595.20	Sink	Native	AUX_ACK, 0 bytes

Show printer friendly format ... | Show report information ...

Content decoder

Line #1037 - 56493.89ms
UP_REQ - REQ: CONNECTION_STATUS_NOTIFY

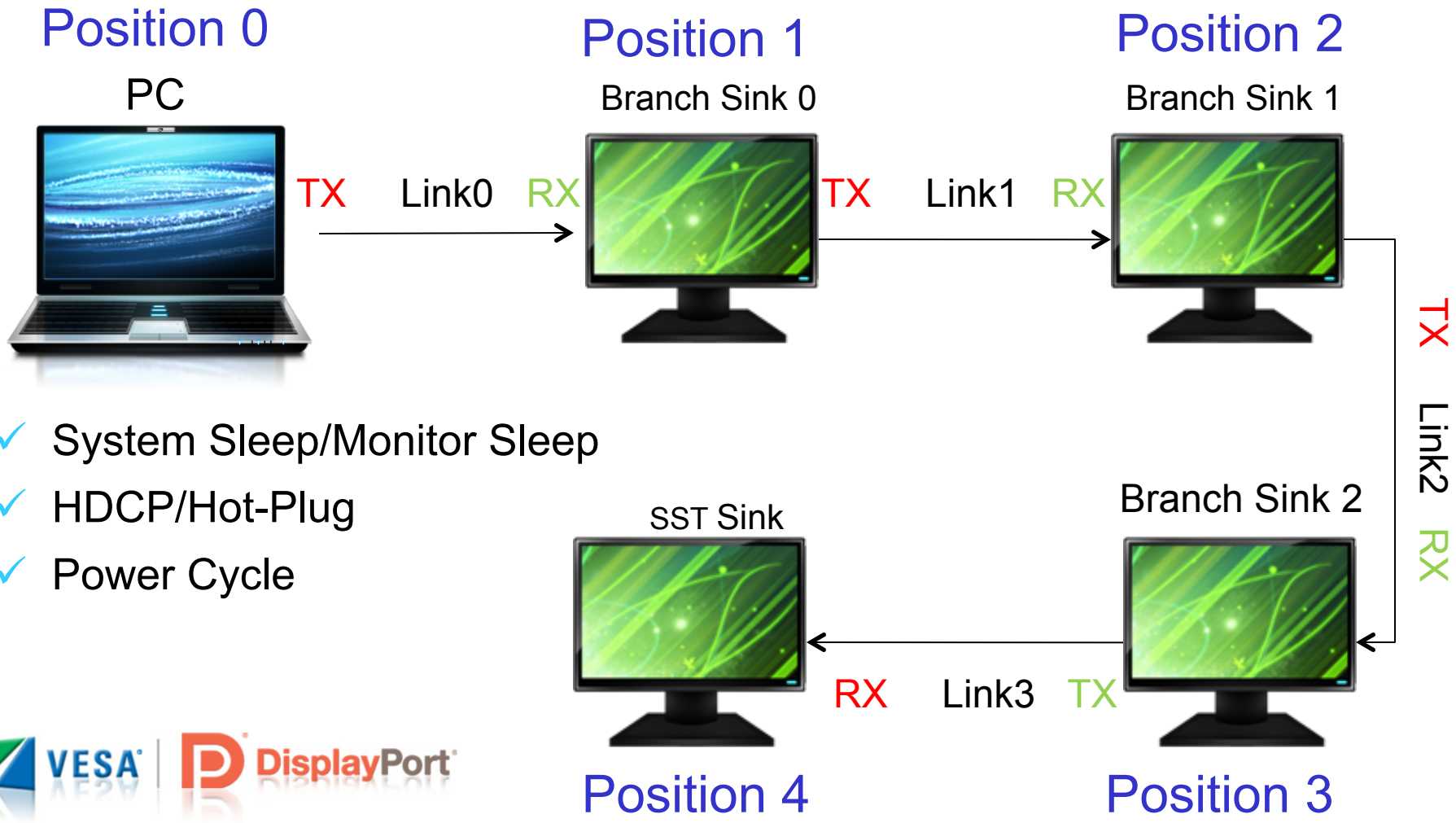
-- Sideband message header --
Link_Count_Total = 1
Link_Count_Remaining = 7
Broadcast_Message = 1
Path_Message = 0
MSG_Body_Length = 20
Start_Of_MT = 1
End_Of_MT = 1
Message_Sequence_No = 0

-- Sideband message validity check --
MSG_Header_CRC = 6 [Good]
MSG_Body_CRC = 193 [Good]
Header Reserved (Zero) fields = Good

-- Message Transaction decoded --
CONNECTION_STATUS_NOTIFY (0x02):
Port_Number = 1
Global_Unique_Identifier = 0x10de90700000000217ed235500000096
Legacy_Device_Plug_Status = 0
DisplayPort_Device_Plug_Status = 1
Messaging_Capability_Status = 0
Input_Port = 0
Peer_Device_Type = 3

MST Compliance Test Introduction

- Interoperability Test



- ✓ System Sleep/Monitor Sleep
- ✓ HDCP/Hot-Plug
- ✓ Power Cycle

VESA | DisplayPort

Live Demo about MST Compliance Test

Test Equipment for Demo

MST Source

Aux Monitor

Branch Sink

Let’s GO

Branch Sink

VESA | DisplayPort

Live Demo about MST Compliance Test

Test Configuration A for Demo

MST Source

Aux Monitor

Branch Sink

Let’s GO

VESA | DisplayPort

Live Demo about MST Compliance Test

Test Configuration B for Demo

MST Source

Aux Monitor

Branch Sink

Branch Sink

Let’s GO

VESA | DisplayPort

One Stop Logo Solution at Allion

Bus Interface

Radio Frequency

OS, Content & Storages

Live Demo about MST Compliance Test

Thank you!