Using DisplayPort Passive Monitoring to Solve Real-World Interoperability Issues

White Paper

Summary

Resolve interoperability issues and improve performance with T.A.P.4™ passive monitoring

Introduction

Teledyne LeCroy's introduction of the quantumdata M42d, the industry's first DisplayPort 2.0 Video Analyzer/Generator, and the latest M42de Analyzer/Generator for DisplayPort 2.1, has redefined DisplayPort (DP) testing. Both systems incorporate Teledyne LeCroy's T.A.P.4™ proprietary technology for full passive monitoring of DP protocol bus. Often referred to as "sniffer" mode, it provides a non-intrusive tap to allow visibility to both Main Link and AUX Channel traffic for debug of interoperability issues between real DP 2.1 devices. This can provide developers with additional insight when compared to test systems that rely solely on the conventional "reference source" or "reference sink" approach. The ability to intelligently capture real responses can help resolve interoperability issues and improve performance with both legacy and next-generation DisplayPort devices.

Theory of Operation

Now that DisplayPort 2.1 chipsets and devices are more widely available, validation teams can benefit from additional interoperability testing with real devices. Designed to silently capture interaction between a real source and sink, the T.A.P.4™ passive analysis mode records the AUX transactions plus the actual video main, audio, metadata, and low-level symbol stream. This allows developers to instantly view an accurate picture of the device capabilities and timings; plus, real-world state changes and error recovery behaviors. By definition, the passive tap operates transparently and has minimal effect on the transmitted video stream and configuration messages. It operates at both HBR3 and UHBR lane rates allowing developers to verify all the new DP 2.1 mandates for both sources and sinks. Providing a debug path for unexpected interop problems such as video suddenly disappearing on the display after initialization or changing resolution can make the passive tap invaluable for delivering high quality DisplayPort products.

Example Test Setups

Passive monitoring is available on both the native DP connectors as well as Type-C links for devices that use DP Alt Mode. Typical test setups include capturing interaction between native DisplayPort source and sink; DP Alt-mode over USB-C links; and DP Alt mode over USB-C adapter or dock links.

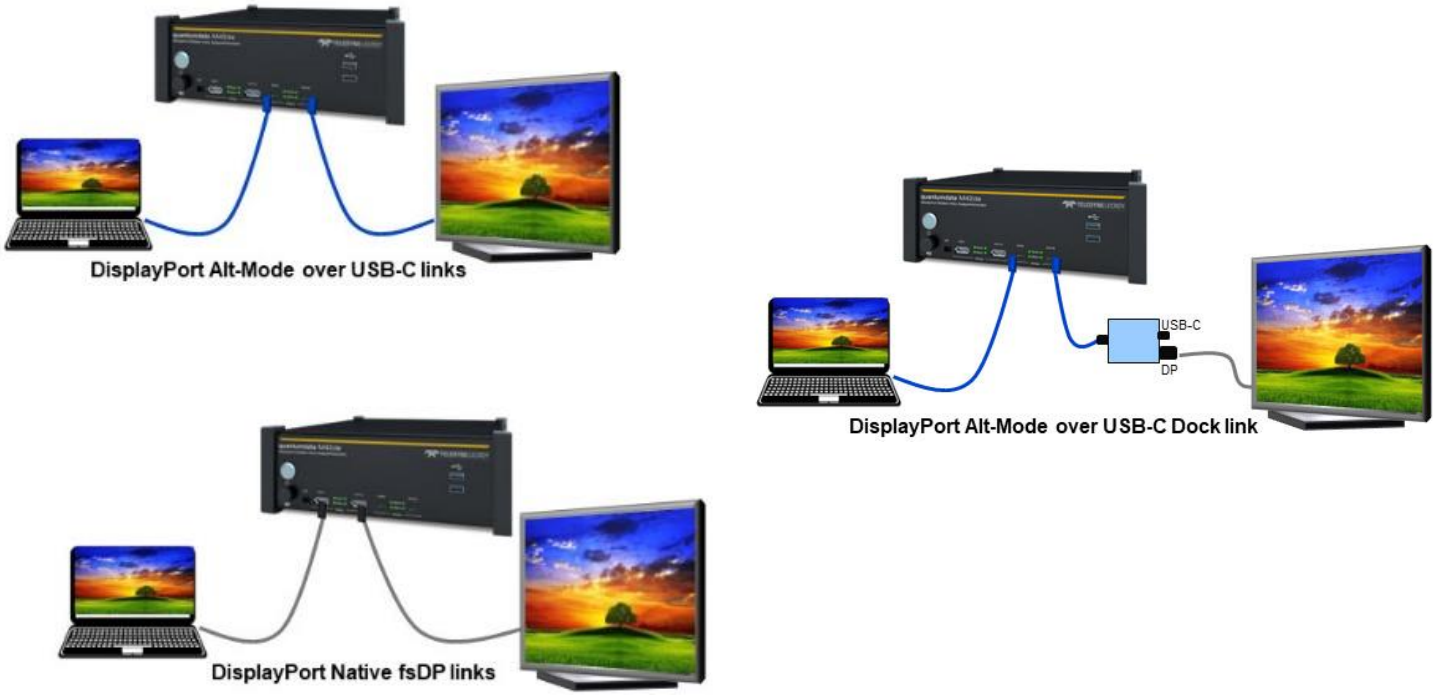


Image 1) Example test setups for “Passive Probing” option

Getting Started

The most common interoperability problem is simply encountering a new monitor does not show video when connected to a DisplayPort source. The essential first step is determining if the link trained successfully. This can be readily determined from the AUX Channel Analyzer (ACA) which operates concurrently with the passive analysis mode. The ACA can reveal when the initial link training fails and this typically is evident when a Tx - Rx pair fails to complete Equalization or Clock Data Switch (CDS) phase within the required 650 MS. Determining the root cause can take many paths; from signaling integrity to misbehaving monitor that issues continuous HPD Interrupts.

Less common but possible are cases where the link training does complete but the monitor still fails to show video. Here the passive tap comes to the rescue by allowing engineers to perform a protocol capture and show a pixel accurate rendering of the image transmitted by the source. This yields important debug clues including the actual video parameters used by the source which may be sending an incorrect geometry or format. The DP Sink could also be the root cause here by advertising incorrect settings in the EDID / DisplayID.



Image 2) Link Training is successful but sink fails to display image

Example Usage Case: PPS Settings Verification

When DP links operate with Display Stream Compression (DSC), the Picture Parameter Set (PPS) SDP provides real-time information to the decoder about changes it wishes to make to the compression settings. A DSC source initially programs the bits_per_pixel parameter in a DSC Sink's DPCD (00067h and 00068h) by specifying the MAXIMUM bpp SUPPORTED BY THE DECOMPRESSOR. Both the encoder and decoder need to support the same PPS settings for correct operation.

This and other settings are transmitted in the PPS SDP on the high speed lines during the vBlank interval. The DP DSC Source can adjust the PPS SDP in increments of 1 bpp or smaller provided it's within the range supported by the sink. If the source tries to specify a bpp outside the range (defined in the INCREMENT field in the DSC_MAX_BPP_DELTA_AND_BPP_INCREMENT registers (DPCD 0006Fh[2:0] and DPCD 0226Fh[2:0]), this could result in image stuttering or freezing. Mismatches in these DSC settings would be evident by comparing the MAX_BPP programmed in the DPCD to the setting specified in the SDP which can be captured during the vBlank interval.

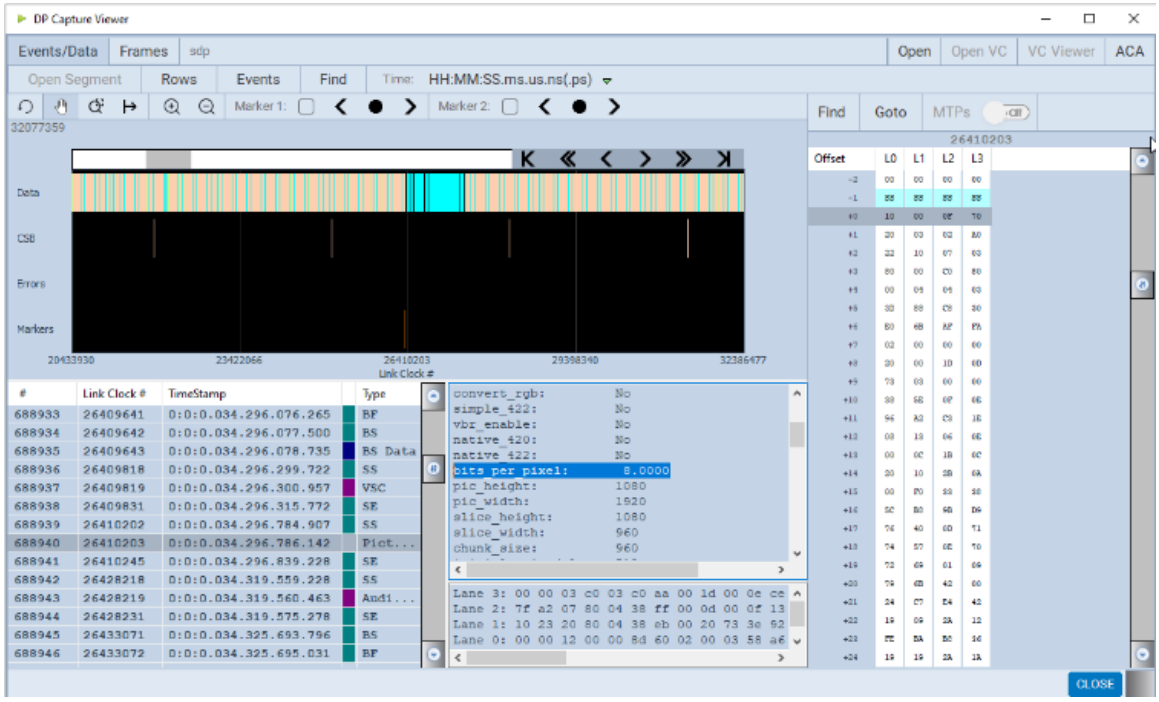
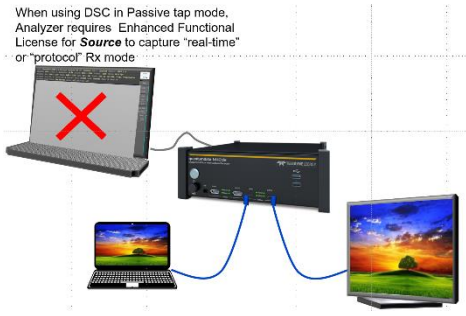


Image 3) Passive monitoring provides visibility to PPS parameters on DP_Tx making it easy to confirm the values are consistent with the DP_Rx capabilities.



Licensing Note: Sink developers that wish to use passive tap for "real-time" or "protocol capture" may find they have insufficient license because they purchased Generator (Tx) only. Sink developers may also need to add Enhanced Functional License for ***Source*** (Rx) on M42de to allow capture of DSC & Panel Replay. These modes are part of Enhanced license and is necessary to see the image in quantumdata VPS or ATP software.

Example Usage Case: Panel Replay Entry

A typical usage case could include critical steps such as the transition from Live Frame mode to Panel Replay. This occurs when the source transmits a VSC SDP with PR_State and Update RFB bits asserted (DB1[0] = 1 and DB1[3] = 1). Once panel replay is initiated, the sink can capture the active video image received into its RFB (remote frame buffer). In the very next frame, the DP Sink enters PR_State 2 (Active) and can display the video image received at the specified refresh rate. The specific VSC SDP that initiates PR mode needs to occur at least 50us before the video frame's first active pixel. This guard-band ensures the sink has time to process the SDP. Failure to wait the required 50us during this stage could appear as blocking or stuttering during Panel Replay transition.

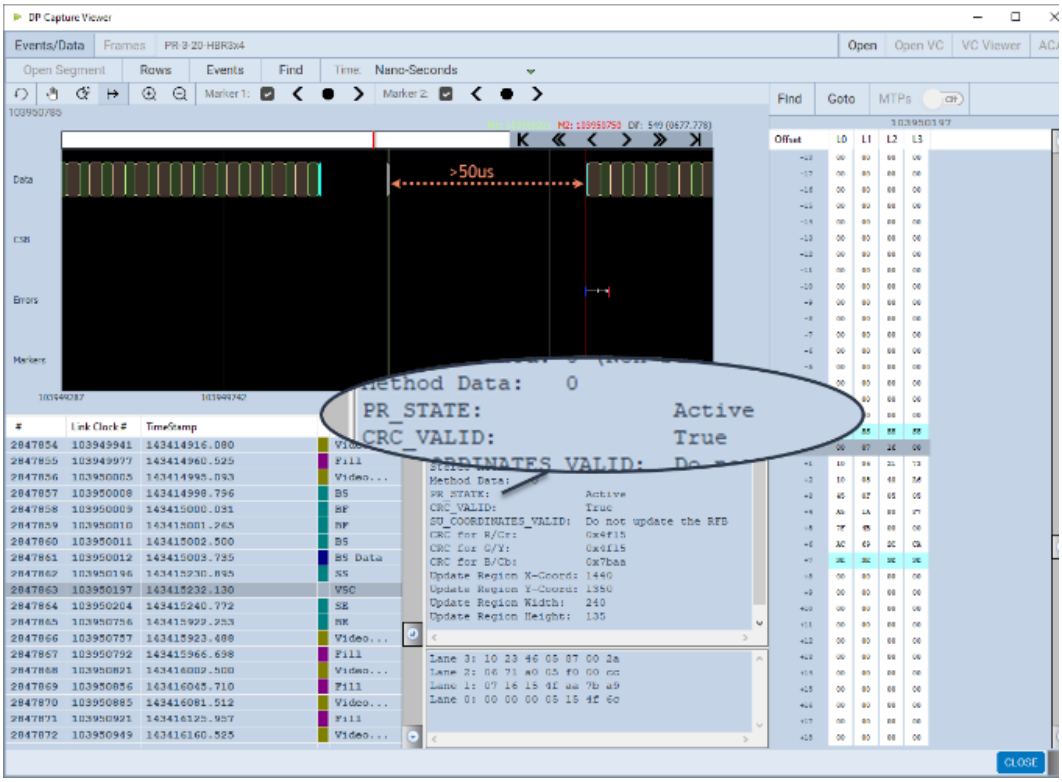


Image 4) Passive monitoring allows quick measurement of link state transitions including the point where the Sink device receives a VSC SDP with "PR Active" state asserted.

Example Usage Case: MSA Data Format

MSA data is transmitted by the DP Source once per frame during the main video stream's VBlank period and contains many important fields used by the sink to reproduce the video in the correct dimensions. These include the Active Video Width and Height (in pixels). Formatting problems in the SDP can be easily identified with the passive monitoring solution because it records all data including the MSA.
For example, when a source is operating in a single-lane configuration, it should repeat the same SDP data fields sequentially. The same source in a four-lane configuration would mux the data across all four lanes. Invalid formatting of these fields would include copying the same data fields sequentially across all four lanes. A compliant DP sink should detect corrupt or invalid data field location but finding the root cause would be easier with the passive monitoring mode.

4-lane Main-Link			
Lane 0	**Lane 1**	**Lane 2**	**Lane 3**
SS	SS	SS	SS
SS	SS	SS	SS
Mvid[23:16]	Mvid[23:16]	Mvid[23:16]	Mvid[23:16]
Mvid[15:8]	Mvid[15:8]	Mvid[15:8]	Mvid[15:8]
Mvid[7:0]	Mvid[7:0]	Mvid[7:0]	Mvid[7:0]
HTotal[15:8]	HStart[15:8]	HWidth[15:8]	Nvid[23:16]
HTotal[7:0]	HStart[7:0]	HWidth[7:0]	Nvid[15:8]
VTotal[15:8]	VStart[15:8]	VHeight[15:8]	Nvid[7:0]
VTotal[7:0]	VStart[7:0]	VHeight[7:0]	MISC0[7:0]
HSP|HSW[14:8]	VSP|VSW[14:8]	All 0s	MISC1[7:0]
HSW[7:0]	VSW[7:0]	All 0s	All 0s
SE	SE	SE	SE

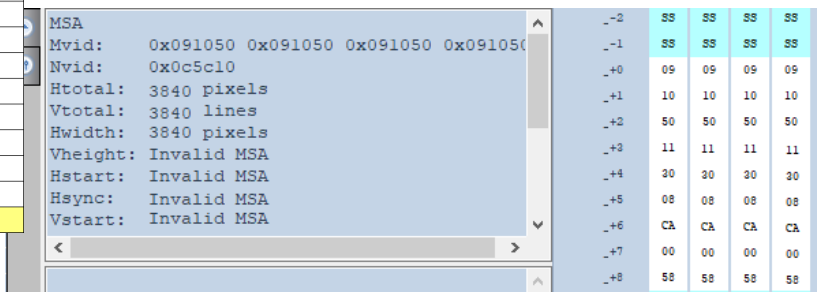


Image 5) The valid MSA data format (left) in the DP 2.1 specification illustrates the correct muxing of fields across all four lanes

MSA Fields can also be used to define the Color Encoding Format that the DP Source will transmit. Validating whether there is a mismatch between the source and sink colorimetry is another usage case for the passive probe option. The Source will read Extended Receiver Capability field (DPCD 02200h) to determine if the sink supports VSC (Video_Stream_Configuration) for colorimetry and pixel encoding. As long as the device supports this operation, the source can embed this information in the VSC SDP. The AUX channel analyzer alone would not provide visibility to these critical color encoding fields. Passive monitoring mode allows users to confirm the complete VSC exchange between a source and sink.

Summary

While the traditional "reference source/sink" test platforms are commendable for providing a consistent and repeatable method of testing a range of timings and resolutions, new techniques can now be used to quickly investigate interoperability issues. The quantumdata M42de Analyzer/Generator with Passive Monitoring option plays an important role in resolving unexpected interop problems between real devices as developers take their DisplayPort 2.1 products to production.