UCD-4XX

User Manual

UCD Console SW Version 3.2

UNIGRAF

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Edition

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CE Mark

UCD-4XX Series products meet the essential health and safety requirements, is in conformity with and the CE marking has been applied according to the relevant EU Directives using the relevant section of the corresponding standards and other normative documents.

Table of Contents

1. ABOUT THIS MANUAL

Purpose

This guide is a User Manual of UCD-4XX test devices, that are USB-connected video interface test units for use with a PC with Windows® 11, Windows® 10, Windows® 8 or macOS operating system.

The purpose of this guide is to

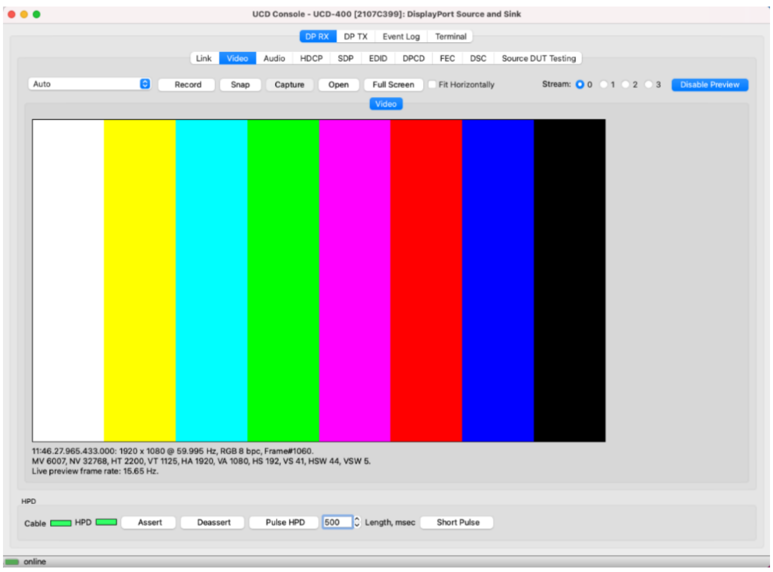
- Provide an overview of the product and its features.
- Provide instructions for the user on how to install the software and the drivers.
- Provide instructions for the user on how to update the FW of the unit.
- Introduce the HW features of the UCD-4XX units.
- Provide instructions for the user on how to use UCD Console SW.

Product and Software Version

This manual explains features found in UCD Console SW Bundle **3.2.** Please consult Unigraf for differences or upgrades of previous versions.

Please consult the Release Notes document in the installation package for details of the SW and FW versions and changes to previous releases.

Note:	This version of the User Manual describes features in UCD Console SW based on the functionality in Microsoft Windows and macOS operating systems.



Notes

On certain sections of the manual, when important information or notification is given, text is formatted as follows. Please read these notes carefully.

Note:	This text is an important note

Warning:	This is a warning about a direct risk for the functionality of the device

2. INTRODUCTION

Product Description

USB-Connected Test Equipment

UCD-4XX devices are high speed, USB 3.0 connected video interface test units. UCD-4XX units include the following models:

- UCD-400 DisplayPort 1.4a Analyzer and Generator
- UCD-411 DisplayPort 1.4a Generator
- UCD-412 HDMI 2.1 Generator
- UCD-422 HDMI 2.1 Analyzer and Generator
- UCD-424 USB-C DisplayPort Alt mode Analyzer and Generator

UCD Console SW is a common graphical user interface (GUI) for Unigraf's UCD test devices. The outlook and details of UCD Console SW will vary depending on the capabilities of the connected unit and will reflect the features enabled.

UCD-4XX units feature a high-level Software Development Kit (SDK) called Test Software Interface (TSI) for use in automated testing. TSI allows for an easy integration of Production and R&D testing routines into an automated test system environment. Please refer to TSI documentation found in additional Unigraf manuals for more details.

Stand-Alone Test Equipment

In stand-alone UCD models the test equipment is built inside a PC and the control interface is a PCI bus instead of a USB connection. Please find below a list of available units:

- UCD-451 Stand-alone DisplayPort 1.4a Generator
- UCD-452 Stand-alone HDMI 2.1 Generator

UCD-400 and UCD-411

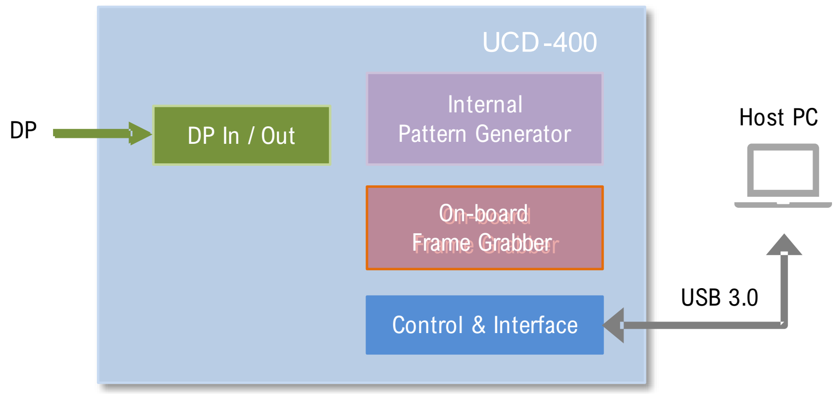
Product Features

- UCD-400: Reference Sink and Source for verifying DP connected devices.
- UCD-411: Reference Source for verifying DP connected sinks.
- DisplayPort 1.4a compliant with HBR3 support
- High resolution video up to 8K 30 Hz, 4K / UHD 120 Hz uncompressed and audio.
- Supports MST (4 streams), Adaptive-Sync, Forward Error Correction (FEC), Display Stream Compression (DSC) and Link Training Tunable PHY Repeater (LTTPR)
- Compatible with HDCP versions 1.3 and 2.3
- 2 GB on-board high-speed video frame buffer
- High speed USB 3.0 host PC interface

Please refer to *Product Specifications* in the appendix of this document for details.

Functional Description

UCD-400 units consist of a multimedia signal input stage with on-board frame buffer, an internal pattern generator, a control stage, and a PC interface stage. In the Input Stage the signal is conditioned and converted to desired format. The Interface and Control stages are either passing the captured data directly to the USB interface or storing it to the frame buffer. The internal pattern generator is able to source a signal for testing sink and branch units. The Interface & Control stages are receiving instructions from the host PC to configure and control the functionality of the unit.



Delivery Content

Product shipment contains:

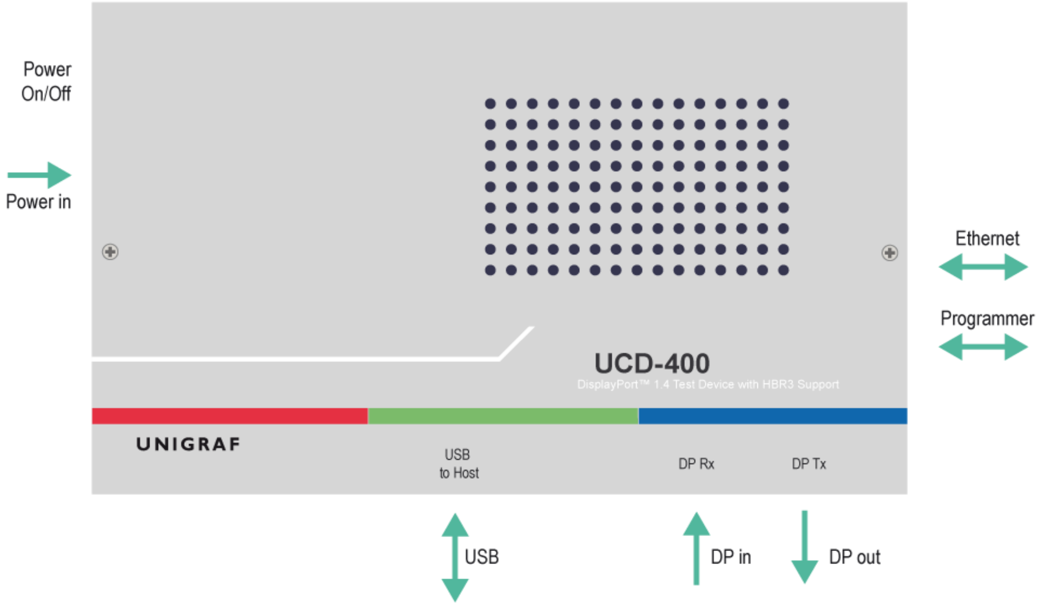
- The UCD-400 or UCD-411 unit
- AC/DC Power supply (100 to 240 Vac 50/60 Hz input, +12 Vdc output)
- USB 3.0 compliant cable for host PC connection
- Micro-USB type B compatible cable for FW programming
- USB-C to DP Bi-directional Cable for testing USB-C sinks or sources

USB Type-C Interface

UCD-400 and UCD-411 delivery package includes a “C to DP Bi-directional Cable” to enable testing of Sink or Source devices with USB-C interface.

Connections

The image below indicates the connections in **UCD-400** unit and their description.



Name	Description
DP in	DisplayPort™ 1.4a compliant input from the upstream Source (UCD-411 Not available)
DP out	DisplayPort™ 1.4a compliant output to the downstream Sink
Power in	+12 Vdc Power Supply Input
Power On/Off	Rocker power switch
USB	USB 3.0 connection to the host PC
Programmer	USB interface for configuring the device FW (behind a cover)
Ethernet	Ethernet interface for updating the device FW (behind a cover)

Note: Capturing and sourcing high resolution video modes, especially 4K video modes and the 120 Hz frame rate set stringent requirements on the video cables and connectors.

Warning: In order to avoid damage to the unit and the PC, please **always attach the power cord (Power In) to the unit first**, and after that connect the USB cable to the PC.

UCD-412 and UCD-422

Product Features

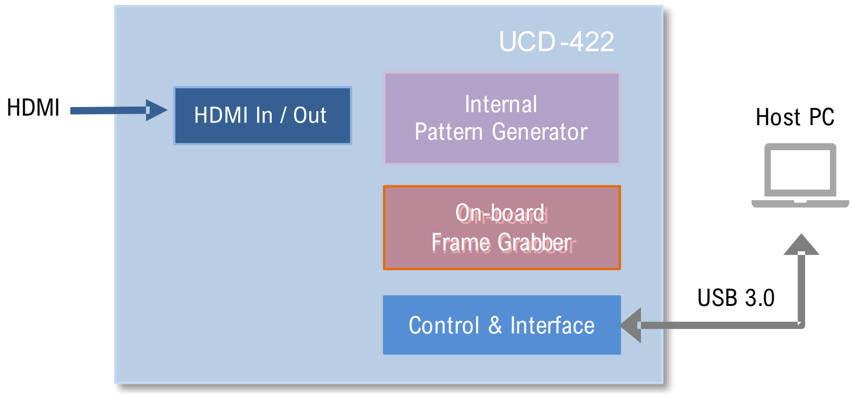
- UCD-422: Reference Sink and Source for verifying HDMI connected devices.
- UCD-412: Reference Source for verifying HDMI connected sinks.
- HDMI 2.1 compatible. Supports FRL and TMDS signaling.
- Supports HDMI video and audio up to 10K@30 Hz, 8K@60 Hz (YCbCr 4:2:0), 4K@120 Hz (YCbCr 4:2:0)
- Supports Display Stream Compression (DSC), and Enhanced Audio Return Channel (eARC)
- Compatible with HDCP versions 1.4 and 2.3
- 2 GB on-board high-speed video frame buffer
- High speed USB 3.0 host PC interface

Please refer to *Product Specifications* in the appendix of this document for details.

Functional Description

UCD-422 units consist of a multimedia signal input stage with on-board frame buffer, an internal pattern generator, a control stage, and a PC interface stage. In the Input Stage the signal is conditioned and converted to desired format. The Interface and Control stages are either passing the captured data directly to the USB interface or storing it to the frame buffer. The internal pattern generator is able to source a signal for testing sink and branch units. The Interface & Control stages are receiving instructions from the host PC to configure and control the functionality of the unit.

Please find below logical diagram of UCD-422 unit

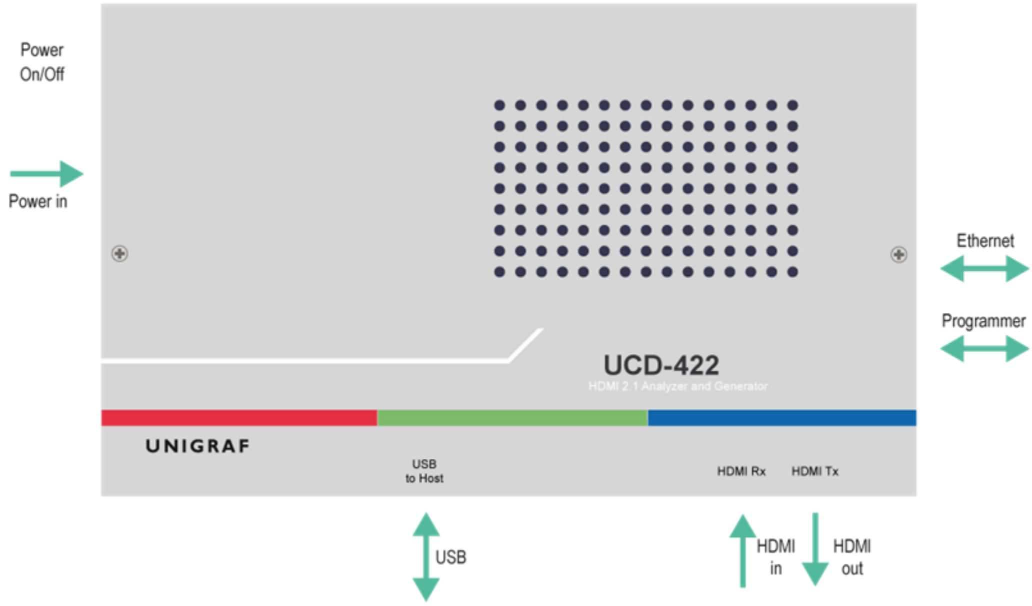


Delivery Content

- Product shipment contains:
- The UCD-422 or UCD-412 unit
- AC/DC Power supply (100 to 240 Vac 50/60 Hz input, +12 Vdc output)
- USB 3.0 compliant cable for host PC connection
- HDMI 2.1 grade HDMI cable
- Micro-USB type B compatible cable needed for FW programming.
- Ethernet cable needed for FW programming.

Connections

The image below indicates the connections in **UCD-422** unit and their description.



Name	Description
HDMI in	HDMI 2.1 compliant input from the upstream Source
HDMI out	HDMI 2.1 compliant output to the downstream Sink
Power in	+12 Vdc Power Supply Input
Power On/Off	Rocker power switch
USB	USB 3.0 connection to the host PC
Programmer	USB interface used in device FW update (behind a cover)
Ethernet	Ethernet interface used in device FW update (behind a cover)

Note: Capturing and sourcing high resolution video modes, especially 4K 8K and 10K video modes and the 120 Hz frame rate set stringent requirements on the video cables and connectors.

Warning: In order to avoid damage to the unit and the PC, please **always attach the power cord (Power In) to the unit first**, and after that connect the USB cable to the PC.

UCD-424

Product Features

- Reference Sink and Source for verifying DisplayPort™ Alt Mode over USB-C
- USB-C v1.3 input and output with Power Delivery 3.0
- DisplayPort 1.4a compliant with HBR3 support
- High resolution video up to 8K 30 Hz, 4K / UHD 120 Hz uncompressed and audio
- Supports MST (4 streams), Adaptive-Sync, Forward Error Correction (FEC), Display Stream Compression (DSC), and Link-Training Tunable PHY Repeater (LTTPR)
- Compatible with HDCP versions 1.3 and 2.3
- 2 GB on-board high-speed video buffer
- High speed USB 3.0 host PC interface

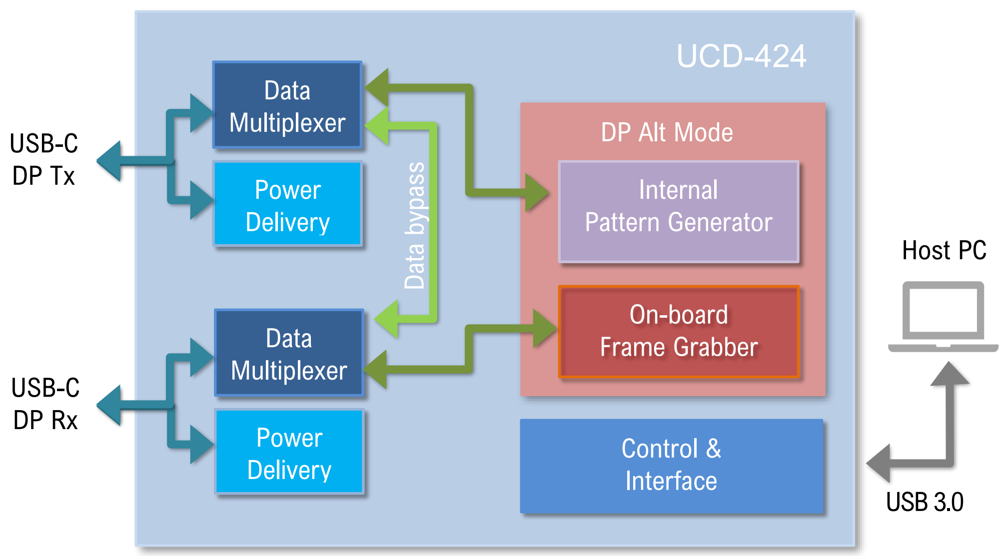
Please refer to *Product Specifications* in the appendix of this document for details.

Functional Description

UCD-424 units consist of a multimedia signal input stage with on-board frame buffer, an internal pattern generator, a control stage, and a PC interface stage. In the Input Stage the signal is conditioned and converted to desired format. The Interface and Control stages are either passing the captured data directly to the USB interface or storing it to the frame buffer. The internal pattern generator is able to source a signal for testing sink and branch units.

USB Data bypass can be enabled between the USB-C connector attached to the DUT to an external device connected to the vacant USB-C connector.

The Interface & Control stages are receiving instructions from the host PC to configure and control the functionality of the unit.



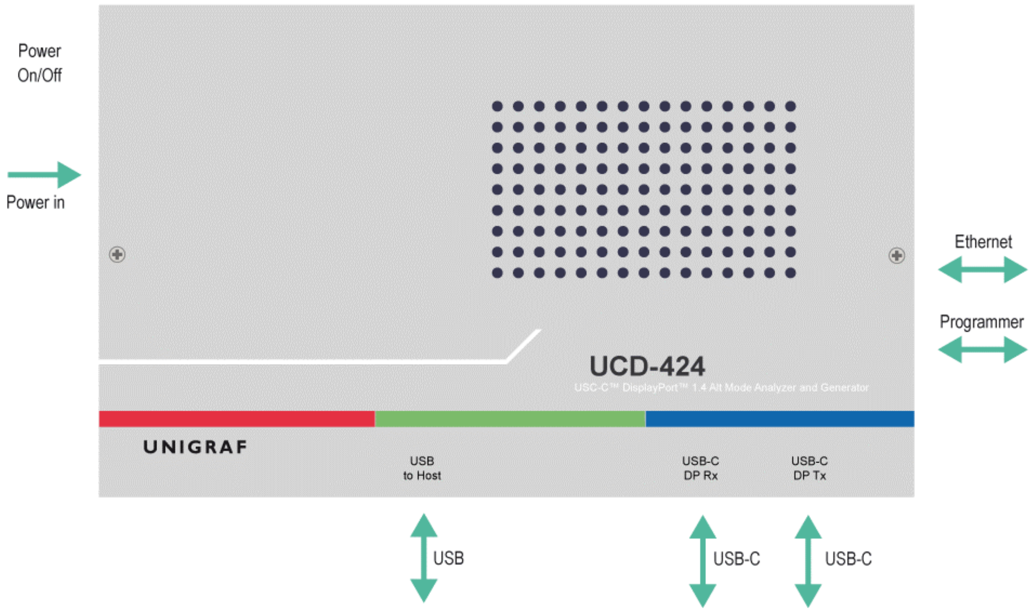
Delivery Content

Product shipment contains:

- The UCD-424 unit
- AC/DC Power supply (100 to 240 Vac 50/60 Hz input, +12 Vdc output)
- USB 3.0 compliant cable for host PC connection
- USB-C to USB-C USB 3.2 Gen2 e-marked cable
- USB-C to DP Bi-directional Cable for testing DP sinks or sources.

Connections

The image below indicates the connections in **UCD-424** unit and their description.



Name	Description
USB-C DP Tx	USB-C connection with DisplayPort™ 1.4a Alt Mode upstream Source capability
USB-C DP Rx	USB-C connection with DisplayPort™ 1.4a Alt Mode downstream Sink capability
USB	USB 3.0 connection to the host PC
Power in	+12 Vdc Power Supply Input
Power On/Off	Rocker power switch
Programmer	Optional USB interface for configuring the device FW (behind a cover) (Not used by default)
Ethernet	Optional Ethernet interface for updating the device FW (behind a cover) (Not used by default)

Note: Capturing and sourcing high resolution video modes, especially 4K, 8K and 10K video modes and the 120 Hz frame rate set stringent requirements on the video cables and connectors.

Warning: In order to avoid damage to the unit and the PC, please **always attach the power cord (Power In) to the unit first**, and after that connect the USB cable to the PC.

UCD-451

UCD-451 is a stand-alone DisplayPort interface test unit with full featured Generator functionality. UCD-451 contains a built-in PC, a DisplayPort reference source, and software for configuring the test interface and running tests.

UCD-451 is designed to specially facilitate Dolby Vision™ testing in DisplayPort interface.

Product Features

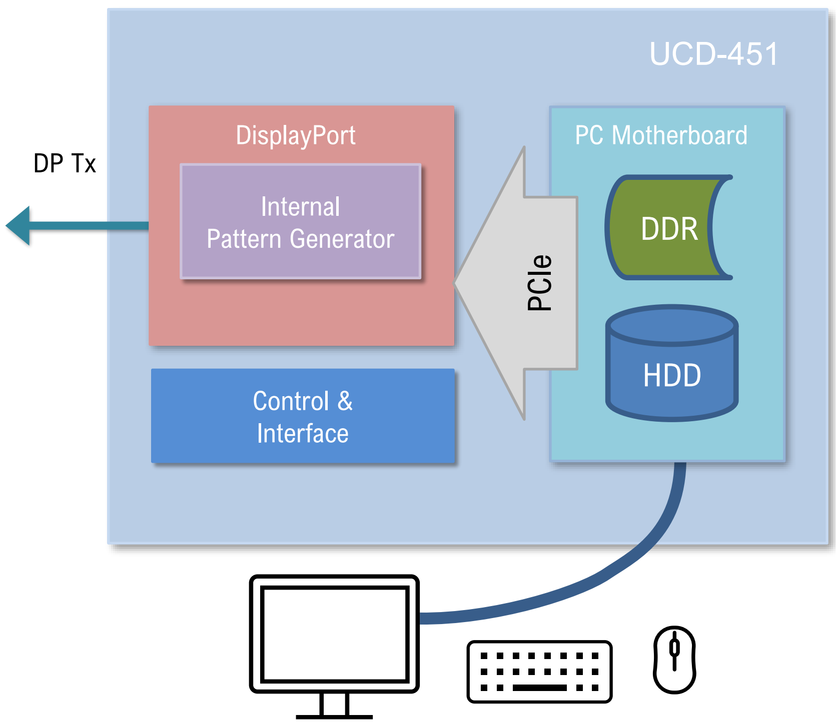
- DisplayPort 1.4a compliant with HBR3 support
- 8K Dolby Vision™ Test Tool
- High resolution video up to 8K 30 Hz, 4K / UHD 120 Hz uncompressed and audio.
- Supports MST (4 streams), Adaptive-Sync, Forward Error Correction (FEC), Display Stream Compression (DSC) and Link Training Tunable PHY Repeater (LTTPR)
- Compatible with HDCP versions 1.3 and 2.3
- Extended video memory up to 32 GBytes
- Embedded Windows PC

Please refer to *Product Specifications* in the appendix of this document for details.

Functional Description

Part of the DDR memory in the PC motherboard is locked and reserved for storing the playback content. During playback, content is first loaded from hard disk (HDD) to the RAM memory of the PC (DDR). Video frames are then sequentially transferred from PC RAM to pattern generator's internal playback memory via PCIe bus. Pattern Generator firmware triggers a PCIe transfer to request content when needed.

Please find below logical diagram of UCD-451 unit.



UCD-452

UCD-452 is a stand-alone HDMI interface test unit with full featured Generator functionality. UCD-452 contains a built-in PC, a HDMI reference source, and software for configuring the test interface and running tests.

UCD-452 is designed to specially facilitate Dolby Vision™ testing in HDMI interface.

Product Features

- HDMI 2.1 compatible Test Equipment. Supports FRL and TMDS signaling.
- 8K Dolby Vision™ Test Tool
- Supports HDMI video and audio up to 10K@30 Hz, 8K@60 Hz (YCbCr 4:2:0), 4K@120 Hz (YCbCr 4:2:0)
- Supports Display Stream Compression (DSC), and Enhanced Audio Return Channel (eARC)
- Compatible with HDCP versions 1.4 and 2.3
- Extended video memory up to 32 GBytes
- Embedded Windows PC

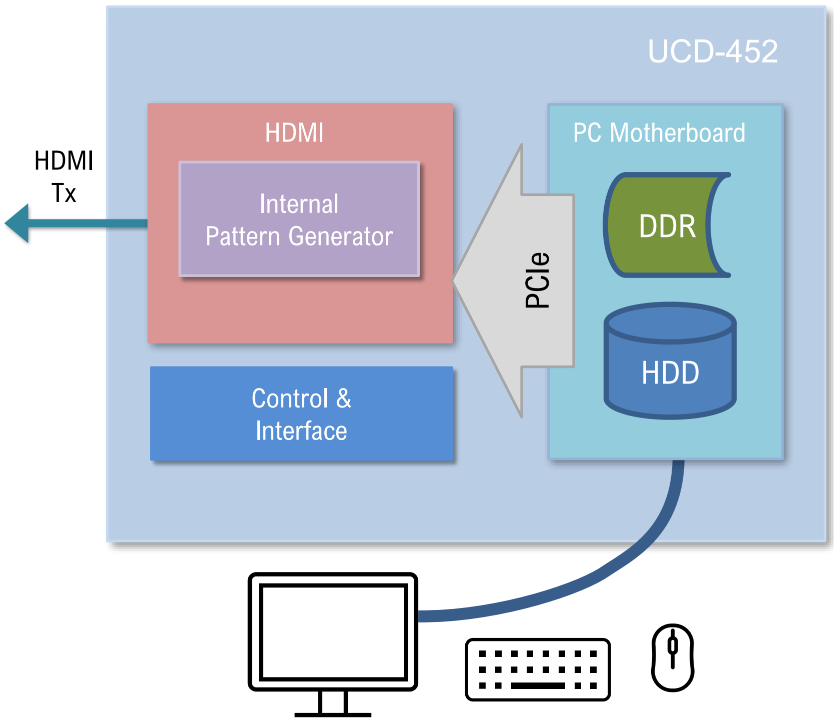
Note: Due to HW limitations, only 2 GBytes of video memory can be used with uncompressed deep color video at 3840x2160 p144 video timing. This allows for playing sequences containing up to 40 frames.

Please refer to *Product Specifications* in the appendix of this document for details.

Functional Description

Part of the DDR memory in the PC motherboard is locked and reserved for storing the playback content. During playback, content is first loaded from hard disk (HDD) to the RAM memory of the PC (DDR). Video frames are then sequentially transferred from PC RAM to pattern generator's internal playback memory via PCIe bus. Pattern Generator firmware triggers a PCIe transfer to request content when needed.

Please find below a logical diagram of UCD-452 unit.



Safety and Operational Precautions

Please find below the **Safety Precautions** for using the Unigraf UCD test instrument. Please also carefully read the **Notes and Warnings** within the text of this manual.

These **Precautions and Warnings** are provided to enable a safe use of the UCD test equipment. Therefore, Unigraf assumes no liability when the user fails to follow the expressed **Precautions and Warnings.**

- Use only Unigraf provided AC/DC Power Adapter. Please make sure that connectors and cabling to the Power Adapter are intact. In case there are any doubts about the condition of the Adapter or cabling, stop using it immediately.
- It is important to ensure that the used AC input voltage is within the specified range (100 to 240 Vac 50/60 Hz) and the fuses in the AC lines are of the specified type. If in doubt, do not connect the device.
- When installing the unit, connect the Power Adapter to the UCD device first, after that connect the AC plug. Please disconnect the USB cable to the controlling PC and remove cabling to DUT while connecting the power input cables.
- It is forbidden to open the housing of the UCD device without written permission from Unigraf. Failure to comply with this rule will void the warranty of the unit.
- UCD devices are intended for use as Electrical Test Instrument only. Use for other purposes is forbidden.
- Use UCD equipment only in its specified ambient temperature and humidity.
- In order to ensure that the UCD device and associated SW will operate properly, please ensure that the PC used for controlling the UCD device complies with the minimum requirement set by Unigraf.
- Please keep UCD software updated by regularly checking the updates on Unigraf download page (https://www.unigraf.fi/downloads/). Please update the device firmware to match the installed software.

3. INSTALLATION

Installation Package

The UCD software installation package can be obtained from Unigraf download page at https://www.unigraf.fi/downloads/. Please, note that there are separate packages for Windows and macOS.

The installation package is a bundle between the components needed for UCD Console SW and for TSI SDK. The bundle contains the following items:

- Windows/macOS drivers (installed during set up)
- UCD Console SW (installed during set up)
- License Manager (installed during set up)
- Device configuration utility (installed during set up)
- Packet Editor (installed during set up)
- TSI SDK
- User Manuals including this document.

In some cases, also the firmware of the unit needs to be updated. If in doubt, please contact Unigraf.

Note:	The software should be installed before connecting the UCD unit to the PC.

Note:	System administrator's privileges are required for performing the installation.

Software Installation

- For Windows users, install .exe file from the package.
- For MacOS users, install .pkg file from the package. MacOS is universal for ARM and Intel x86
- Start the installation by running application **SoftwareBundle_X.X.XXXX**

Once the installer has started, a welcome page is displayed. The welcome page shows the software package release version.

The user is also asked to confirm

- Creating a desktop shortcut
- Installation of Visual C++ redistributable (needs to be present in Windows)
- Installation of Unigraf USB drivers

- Next dialog confirms the selections made. If you are ready, click Install to start the installation.
- Click **Finish** to exit the installation dialog.

Firmware Update Procedure

UCD Configuration Utility is used to load an updated firmware to the device. As an option, UCD Configuration Utility can be used to select possible operation roles present in the UCD unit. A firmware set for the selected operation roles is created and the firmware set is programmed to the device. Please contact Unigraf for details.

Updating from Earlier FW Versions

UCD Firmware versions earlier than 1.8.52 (Pls see Help > About) do not support the procedure described here. Please follow instructions in *Appendix G Firmware Recovery Procedure with Quartus Prime* in this manual.

Note: Firmware update is a sensitive process. Please do not disconnect the device from the PC and do not power it off before the operation is completed unless specially requested. Avoid plugging and unplugging other USB devices when the firmware update is in progress.

To update the firmware or create a new configuration on a UCD-4XX device, please perform the following steps:

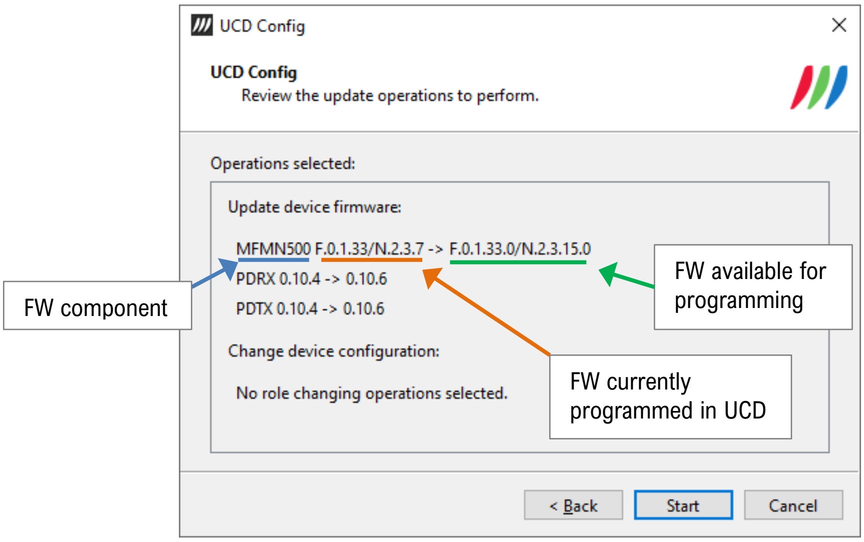
- Connect the UCD unit to a power supply and connect the USB cable.
- Open UCD Console SW. Select Tools > Open Config Utility update.

The first page of the utility indicates the firmware component versions present in the package. Please click **Next**.

From the list of connected UCD devices please select the one that you want to update. Click **Next**.

Updated Modules

The tool lists the FW components available in the UCD device, the currently programmed FW version, and the FW installed in the PC for programming.



- Click Start to **start** programming.

Power Cycle

When re-initiating the firmware of a UCD device the whole process cannot be done during one session. Therefore, on certain point, user is asked to power cycle the device (switch off power from UCD device > wait for 10 seconds > re-apply power to UCD device).

- Click **OK** button on the dialog.

Note: FW update procedure may take several minutes depending on the speed of the USB connection of the host PC.

Recovering Failures in FW Update Procedure

If FW Update procedure fails e.g., when updating from an earlier FW that does not support the procedure described here, please refer to Appendix G of this manual for instructions on *Firmware Recovery Procedure with Quartus Prime*.

Once FW Recovery procedure has been done and a FW version supporting UCD Firmware Configuration tool has been installed, all future updates can be done using this tool.

License Manager

Licensing

The features of UCD Console SW are divided into groups based on the target use of the device. Most basic features can be used by default, and more advanced feature groups are enabled by dedicated licenses. When the licenses are present, the related part of the GUI will be shown, or the related control will be enabled.

Unigraf licenses are provided as strings of characters, **License Keys**. Each License Key enables a dedicated function in one device. Each device has its dedicated **Seed Number**. Each **License Key** is tied to one **Seed Number**. License Keys can be freely used in any number of PCs

License keys are managed with **UCD License Manager**. The License Manager can be found in the **Tools** menu of UCD Console SW.

Note:	System administrator's privileges are required for accessing the licenses.

License Manager GUI

When run, License Manager will list the licensing enabled Unigraf devices. In the list of Devices please **Select** the device in question. The *serial number* and the *seed number* of your device are printed in a sticker attached to the bottom of the device.

The **Rescan…** button will re-scan the system for installed hardware.

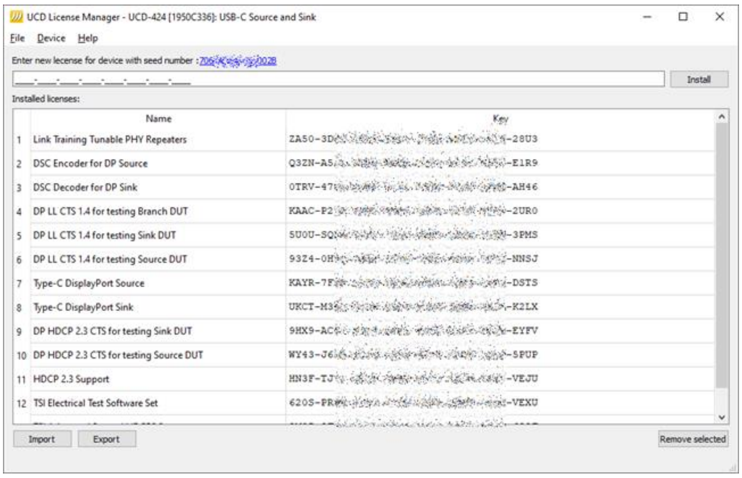
Managing Licenses

Seed Number

Each license is tied to a hardware unit with the help of the **Seed Number**. Each unit has a unique Seed Number. Seed Number of the selected unit can be found in the top of the dialog.

Seed Number of the selected device can be copied from dialog link for e.g., ordering Licenses.

Adding New License Keys



To add a new license key for a device, please enter the characters from the license sticker to the field for new licenses. The License Manager will automatically move the caret across the edit boxes during typing. If the key is given in text format, copy it and paste to the leftmost box.

Once the license key is fully entered, click Install. The license is authenticated and if it is valid, the license will appear in the list of installed licenses. If the key fails to authenticate, an error message is displayed. If this happens, please make sure that the key has been typed correctly and that the seed number on the license key sticker matches the seed number displayed in UCD License Manager.

Please note that to avoid confusion, some letters will never appear in a license key because they resemble numbers: For example, capital 'G' and number '6' are very similar when printed with small font. When in doubt, use numbers.

Also, please note, that characters that cannot be part of valid license key are not accepted as input. When appropriate, an automatic conversion is applied while typing: For example, lower case letters are converted to upper case automatically.

Managing Installed Licenses

The Installed licenses list shows all installed licenses for the selected device. The list shows the name of the license and the actual license key characters.

Import:	Install licenses from an INI file for the currently selected device.
Export:	Save installed licenses for the currently selected device into an INI file for backup and distribution to other PCs. To export license(s), select the license(s) to be exported and then click the Export button. Please note that licenses from multiple devices can be exported into the same INI file.
Remove Selected:	Uninstall selected licenses. To uninstall a license, click on the license and then click the Remove Selected button

UCD Console

UCD Console SW is graphical user interface (GUI) for UCD family test equipment for desktop use. UCD Console provides the user access to all features of the unit. UCD Console also includes powerful debugging and analysis tools enabling the user to monitor the status of the display interfaces and assist in problem detection.

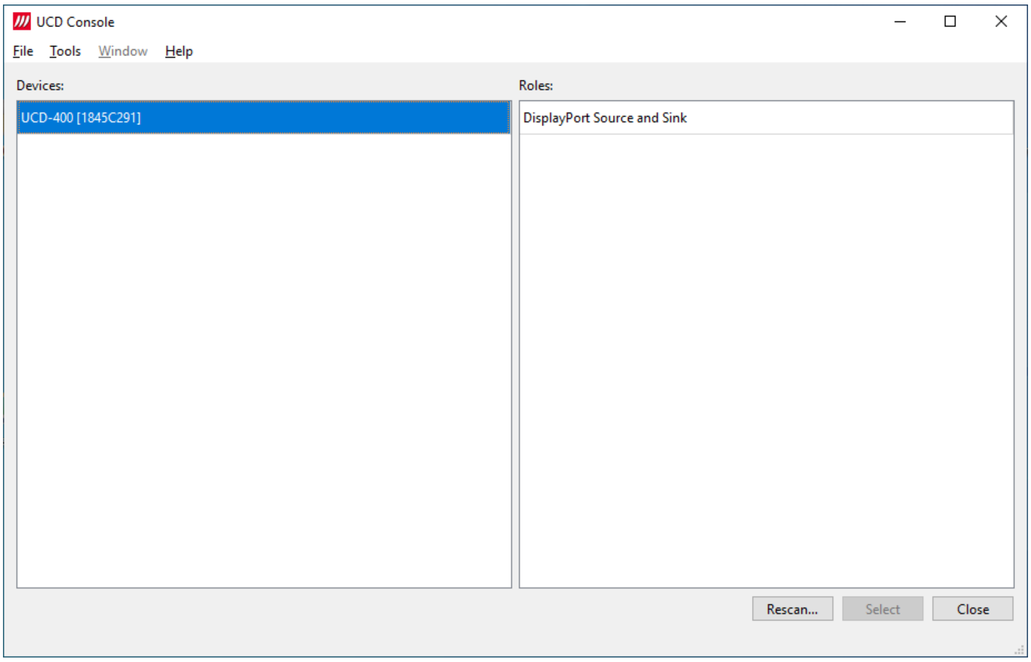
The various features of the UCD unit are divided into interface specific screens and tabs. Each tab contains data and controls for a specific feature.

Note: This version of the User Manual describes features in UCD Console based on the functionality in Microsoft Windows operating system.
UCD Console will be available also for macOS operating system to be used in iMac and MacBook computers and for Linux operating system. Detailed description of the macOS and Linux versions will be added later.

Device Selection

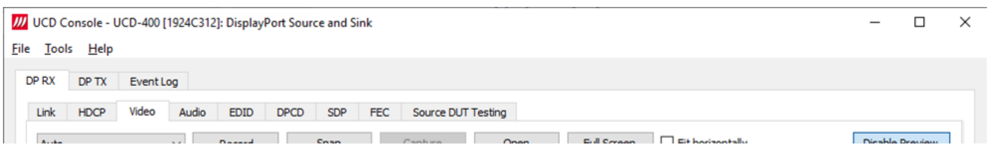
A shortcut of UCD Console can be found by default under Start Menu.

Once UCD Console is launched, the dialog provides a list of Unigraf UCD devices connected in the PC. Please select the target device by double clicking on the appropriate row. If your device cannot be found in the list, please confirm the power and USB connection to the device and click the **Rescan ...** button.



Analyzer and Generator Operation

Most UCD devices can be used with UCD Console as Analyzer (a Sink device) and as Generator (a Source device). The functionalities of the two operation modes can be found in separate tabs. This User Manual will explain both roles and all role functionalities.



Options

Options can be found in **Tools > Options**.

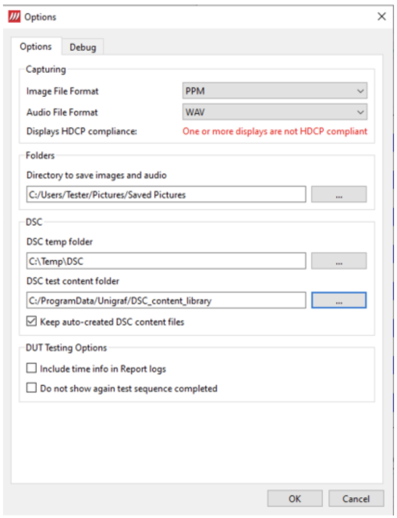


Image File Format

You can save the captured frames either in PPM, BMP, JPG or PNG bitmap file format. In PPM format the files are stored with the captured color depth, with other formats the color depth is truncated to 8 bits per color.

Audio File Format

Audio files are stored in WAV format.

Displays HDCP Compliance

Information if controlling PC is HDCP compliant, i.e. if preview of HDCP encrypted content can be enabled. If the display is non-HDCP compliant or when connected to the PC using RDP (Remote Desktop Protocol) then users will be presented with a blue background with a banner stating 'HDCP unauthorized'. HDCP is currently only supported on Windows OS and not supported on MacOS and Linux.

Folders

Please select the directories in the PC for saving the captured images and audio.

DSC

DSC temp folder:	Folder for DSC Work files.
DSC test content folder:	Folder where DSC source bitmap files, related configuration files and DSC conversion tools are stored.
Keep auto-created DSC content files:	By default, the DSC compressed content is deleted after use. If selected, the content is not deleted.

Warning

Keeping the automatically created DSC compressed content will shorten the time needed for running the DSC compliance tests.

Please note, that the space needed for storing the full library **can be very large** (appr. 400 GBytes). Please make sure that the content will be stored in a medium that has the required space available.

DUT Testing Options

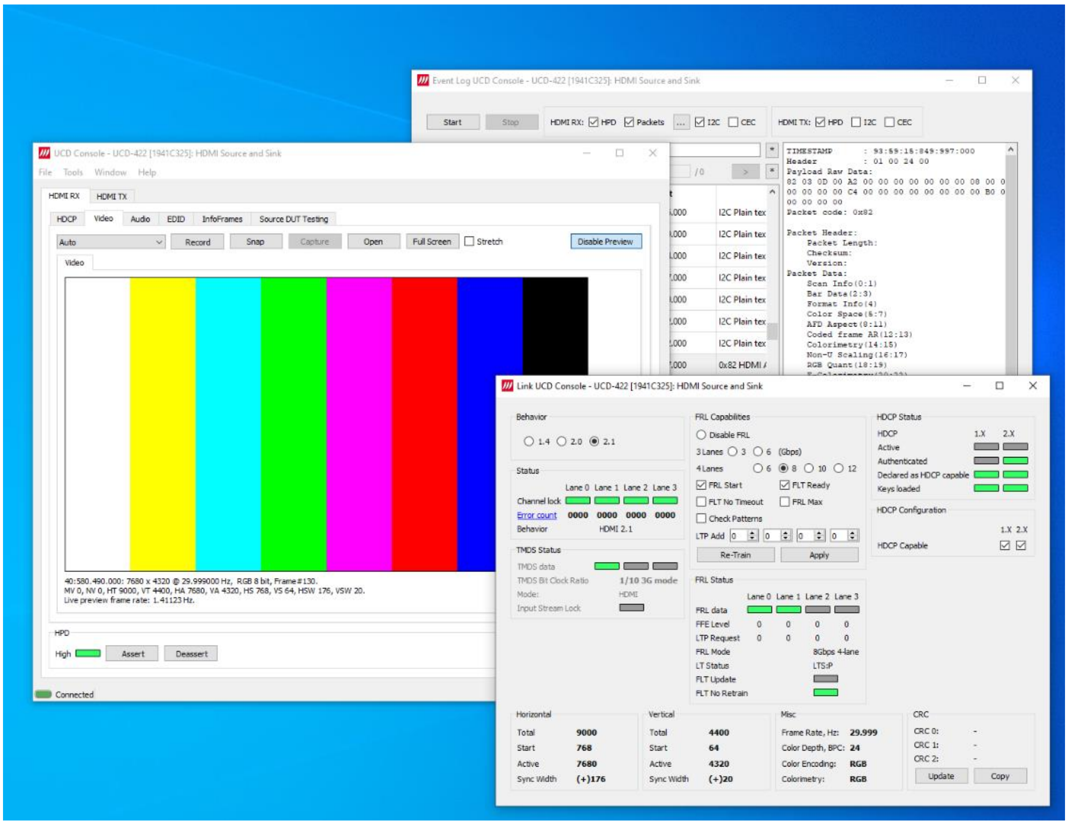
Configure DUT Testing reports.

Include time info in Report logs:	Include system date and time in the beginning of each event line in created reports.
Do not show again test sequence completed:	Include system date and time in the beginning of each event line in created reports.

Detaching and Cloning Tabs

Most of the UCD Console tabs can be detached into a separate window for monitoring and controlling separate features simultaneously. To detach a tab **Right-click** on a tab and select **Detach Window**. To glue the tab back to the main window, click on the red **Close button** in the top right-hand corner of the window or press **<Alt> + F4** on the keyboard.

Tabs can also be cloned (duplicated) in order to e.g., monitor various areas of DisplayPort DPCD simultaneously without swapping addresses. To clone a tab **Right-click** on a tab and select **Clone Tab** or **Clone and Detach** to the two actions simultaneously.



4. ANALYZER OPERATION

When used as an *Analyzer*, the UCD device acts as DisplayPort, HDMI or USB-C DisplayPort Alt Mode Sink or Receiver device.

Analyzer functionality related controls and dialogs can be used by selecting *DP RX* or *HDMI RX* tabs.

Please note that in most UCD-4XX Series units, *Generator* functionality is available simultaneously with Analyzer. Please find the description of Generator functionality later in this manual.

Functionality Tabs

UCD Console features are presented in tabs. Standard tabs are similar in all functional roles, Interface Specific tabs present features and controls that are only available for a particular interface.

Some of the tabs are enabled by default, some only when an applicable license is included.

Standard Tabs

Analyzer role features six standard tabs:

- Video preview and saving (Video)
- Audio monitoring and saving (Audio)
- EDID editor (EDID)
- HDCP status monitor and control (HDCP)
- Source DUT Testing tab
- Event Log

Interface Specific Tabs

Depending on the connected UCD device, additional interface specific tabs will be available.

UCD-400 and UCD-424:
DP and USB-C DP Alt Mode Reference Sink

- Status information and control of the upstream link (Link)
- DPCD editor (DPCD)
- SDP sent by the Source device (SDP)
- Status and capabilities of the DSC feature (DSC)
- Forward Error Correction (FEC)

UCD-422: HDMI Reference Sink

- Status information and control of the upstream link (Link)
- Received InfoFrame packets (InfoFrame).

UCD-424: USB-C Reference Sink

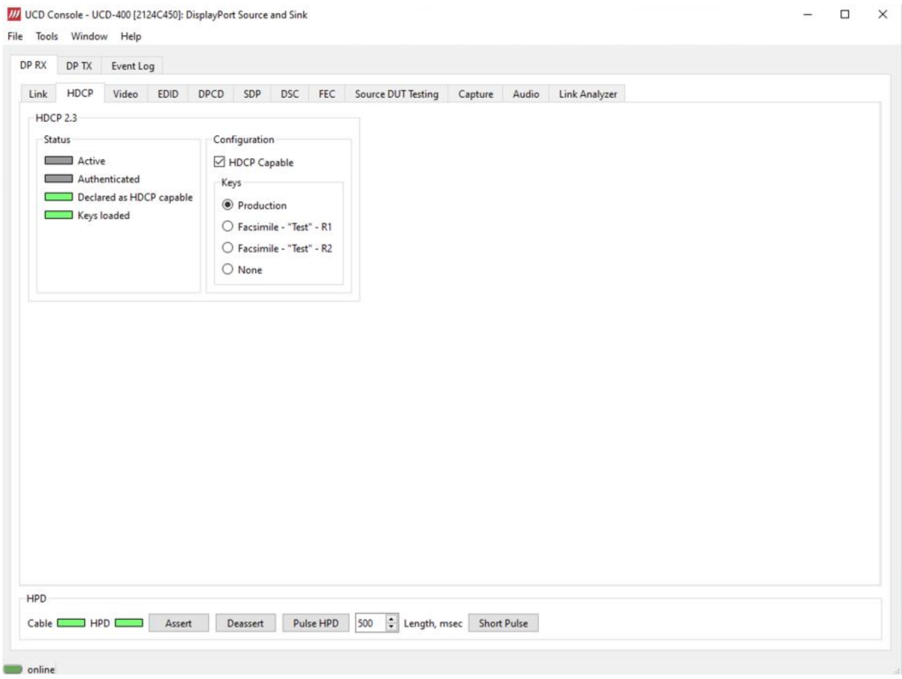
- USB-C Monitoring (PDC)

Note: Some of the tabs are enabled by default, some only when an applicable license is included. Please refer to Appendix B Licensing of this document for description of features and licensing.

Standard Tabs

HDCP Tab

HDCP tab is the dialog for monitoring the HDCP (for *High-Bandwith Digital Content Protection*) status and controlling the HDCP capabilities of the UCD device.



Status

The status field indicates the HDCP status of the UCD device.

Active:	The link between UCD and the upstream source has been encrypted.
Authenticated:	The HDCP handshake between the UCD and the sink unit has been completed successfully.
Declared as HDCP capable:	The UCD unit recognizes HDCP handshake messages.
Keys loaded:	The HDCP keys are loaded to the UCD unit.

Configuration

HDCP Capable:	To disable HDCP, uncheck the box.

Keys

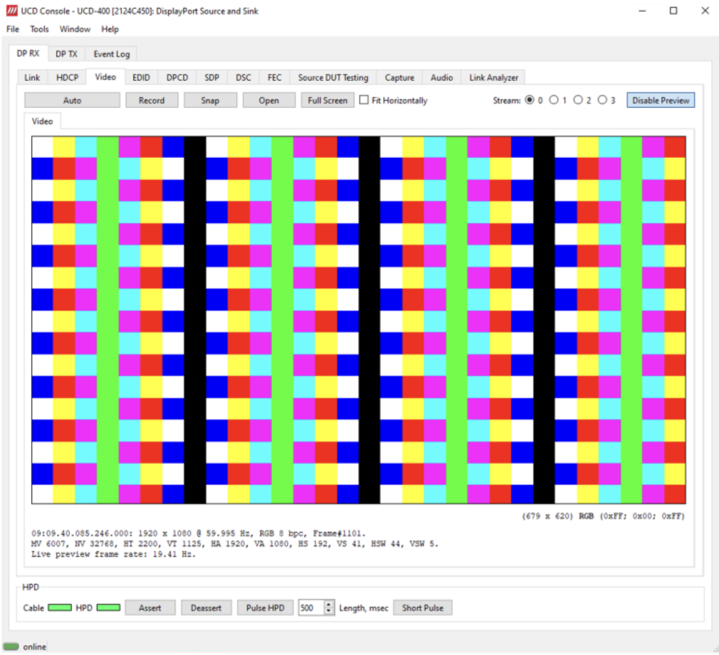
Select between *Production* or *Facsimile* HDCP keys. To remove the keys, select *None*.

HDCP 1.3 / 1.4 vs. HDCP 2.3

Currently, UCD-4XX DP and USB-C DP Alt Mode devices support only HDCP 2.3 standard. Currently, UCD-4XX HDMI devices do not support HDCP.

Video Tab

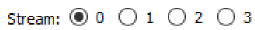
Video tab is the Preview window for the captured video stream.



Disable / Enable Preview

Click the button to start or stop capturing video frames.

Current Stream (UCD-400, UCD-424)



When Multistreaming (MST) is enabled, the monitored stream can be selected here.

Video Status

The details of the captured video are presented below the preview window.


(1427 x 915) RGB (0x00; 0x00; 0xFF)

09:19.30.975.164.000: 1920 x 1080 @ 59.995 Hz, RGB 8 bpc, Frame#12404.
MV 6007, NV 32768, HT 2200, VT 1125, HA 1920, VA 1080, HS 192, VS 41, HSW 44, VSW 5.
Live preview frame rate: 19.55 Hz.

First row:	Cursor location, pixel value at cursor location in YCbCr and RGB
Second row:	Time stamp, Color mode, color depth, frame counter.
Third row:	Mvid, Nvid, Horiz Total, Vert Total, Horiz Active, Vert Active, Horiz Start, Vert Start, Hor Sync Width, Vert Sync Width.
Fourth row:	Live preview frame rate.

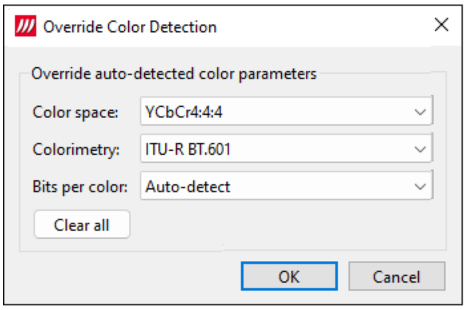
Note: HDCP preview is only available on UCD Console for Windows operating system.

Please note that UCD test equipment are able to capture video at full frame rate. *Live preview frame rate* indicates the rate of updating captured video on UCD Console preview screen. The rate is limited e.g by the USB communication between UCD test equipment and the PC.

Override Color Detection

The captured video will be by default automatically converted to RGB 8 bpc for preview and saving based on the information in video metadata.

By clicking Auto button, a dialog opens for overriding the automatic conversion. Captured image data will be interpreted based on the values set in the dialog.

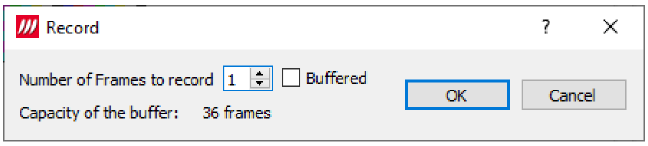


Color space:	Define as which format captured data will be interpreted. (Auto-detect, RGB, YCbCr4:4:4, YCbCr4:2:2, YCbCr4:2:0)
Colorimetry:	Define as which colorimetry captured data will be interpreted. (ITU-R BT.601, ITU-R BT.709, ITU-R BT.2020)
Bits per color	Define as which color depth captured data will be interpreted. (Auto-detect, 6, 8, 10, 12, 16)

Note: Please note that the color mode selection applies to the preview window only. All internal functions use the raw image data as captured from the input channel.

Frame recording

Clicking the button opens a dialog for definition of number of frames recorded. Buffered mode can also be enabled in this dialog.



Buffered	When checked, all input frames are captured non-drop until the on-board frame buffer will be full. When not checked, only one input frame is buffered at a time. Frames will be skipped if the transfer of the data to the PC is slower than the input data rate.
Capacity of the buffer	Capacity of the on board frame buffer with the selected video and color mode.

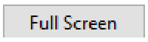
Note: Please note that buffered mode cannot be used when Audio preview is enabled.

Recorded frames are stored by default in C:/Users/<Current user>/Pictures. Please refer to Tools > Options where the location of this folder can be customized.

Open

Open folder where captured frames are stored. Double click or click **Open** to select a frame file for viewing. Please refer to Tools > Options where the location of this folder can be customized.

Full Screen

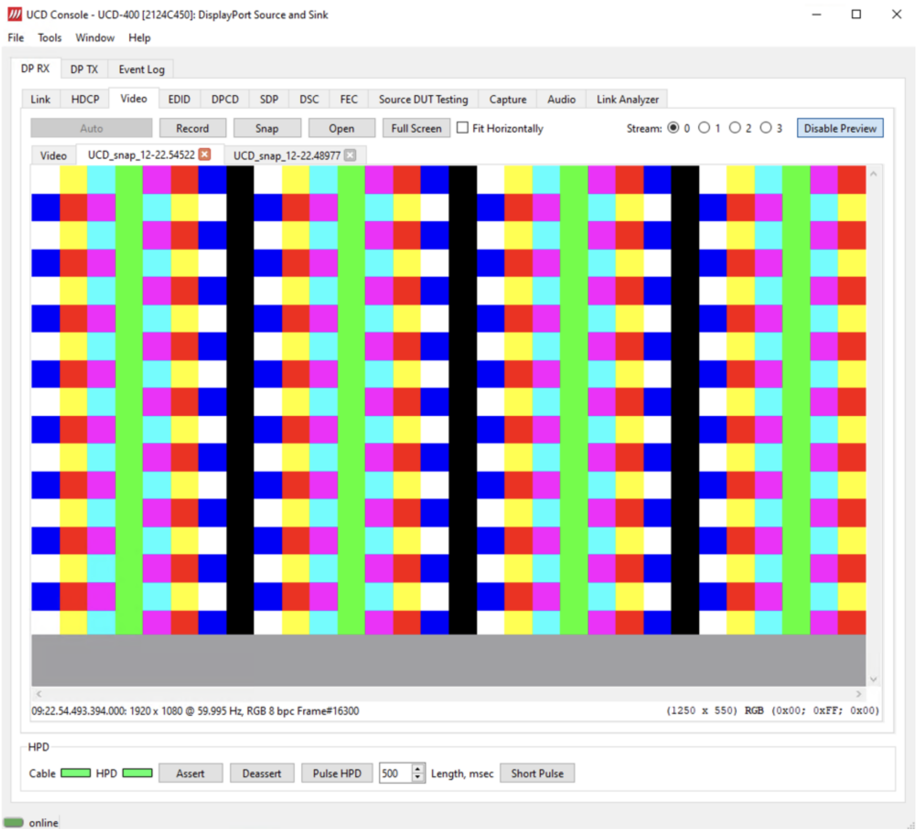


Preview captured video full screen, scaled to vertically fit the screen.

Double-click on the screen to exit full screen mode.

Snap Frame

When clicked, one frame of the incoming video is captured and shown in a new tab. Each click captures a new frame and opens a new tab.



Color Information of the captured frame can be evaluated by placing the mouse cursor on top of the preview image.

Info field in the lower right side of the bottom panel lists:

- Location of the cross cursor on the bitmap stating from the upper left corner
- The intensity of the Red, Green and Blue components of the pixel on the cursor location in decimal values
- The HTML HEX color code of the pixel on cursor location
- In case of YCbCr color mode the intensity of the Y, Cb and Cr components of the pixel on the cursor location in decimal values

Zoom

Zoom level of the captured frame can be altered by right clicking on top of the preview image and selecting between

- Fit Window
- Zoom 25%, 50%, 100%, 200%, and 500%

Save Frame

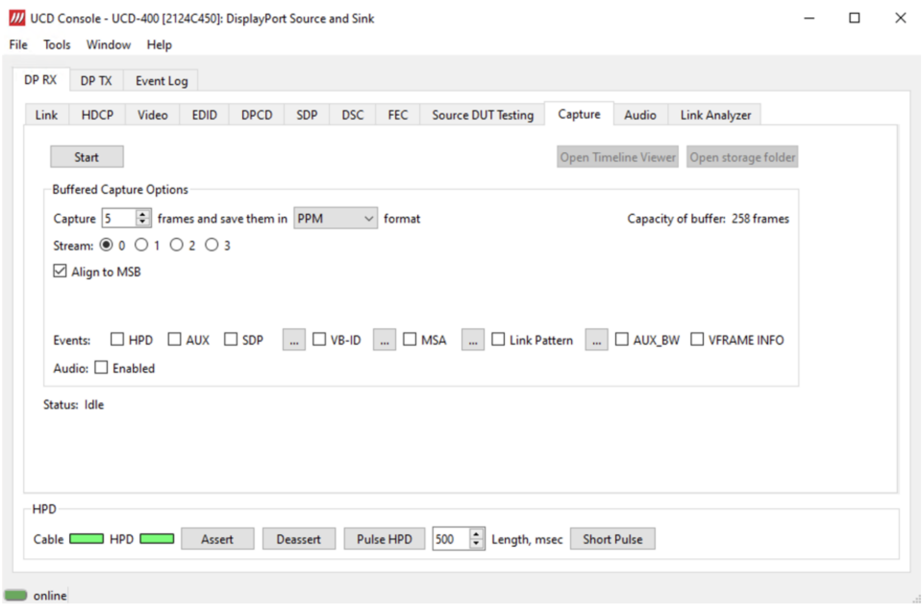
The captured frame current tab can be saved to a bitmap file in the PC by right clicking on top of the preview image and selecting **Save as…**. The format and storage location can be selected in the opening dialog. The available bitmap formats are BMP, JPG, PNG and PPM.

Note: In PPM format the files are stored with the captured color depth, with other formats the color depth is truncated to 8 bits per color.

The selections in Tools > Options menu define if the frame bitmap will be stored as captured from the display interface or if the color mode conversion selected for preview will be applied.

Capture (video, audio)

UCD device has an internal frame buffer that can be used for continuous capture of video data. In addition, audio and metadata can be captured and saved for later analysis. Video can be stored as RGB or RAW data.



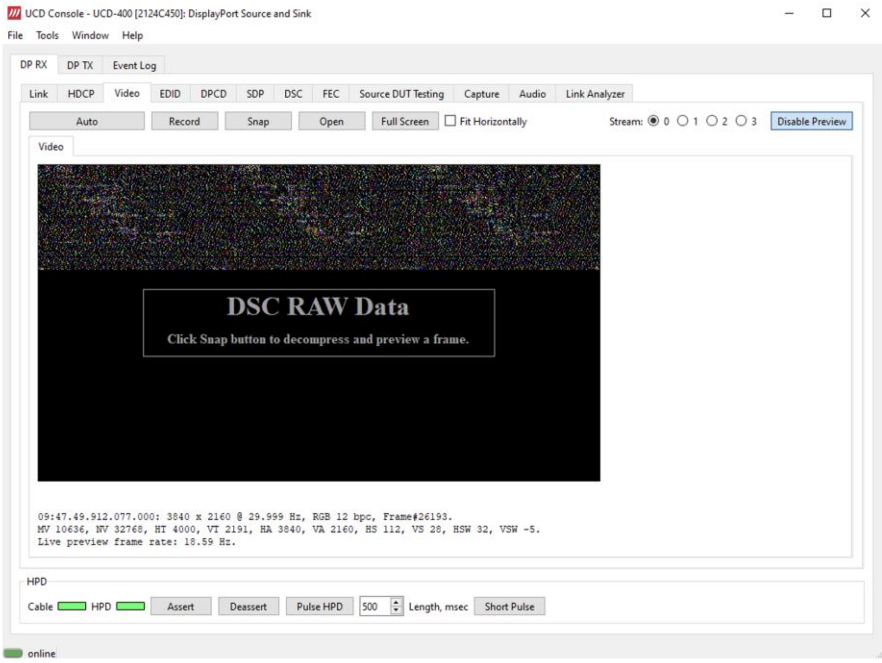
Capture N frames …:	The number of video frames captured.
Format:	Selection of the format of the saved video frame bitmaps. BIN, PPM, BMP, BIN + PPM, BIN + BMP.
Capacity of buffer:	The number of video frames that can be stored to UCD frame buffer using current video signal format
Align to MSB	Store binary data aligned to the Most Significant Bit (MSB). When this is left unchecked the binary data is aligned to the Least Significant Bit (LSB).
Events:	Please refer to chapter *Event Log* for details of the captured events
Status:	Status of the capture.
Open Timeline Viewer	Open Timeline Viewer to view the captured data.
Open storage folder:	Data save folder is defined in menu Tools > Options. Captured video, audio and data is saved in a subfolder of this folder. The name of the subfolder is “buffered_capture_yyyymmdd_hhmmss” (e.g., buffered_capture_20210301_130532).

Note: Video Preview needs to be disabled to use *Data Capture* functionality.

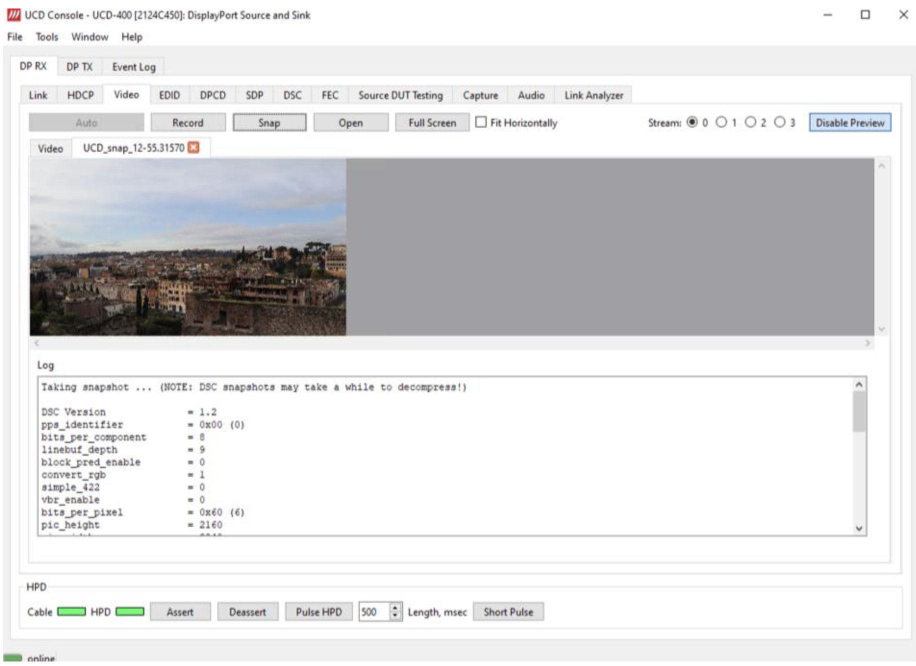
Previewing DSC Decompressed Stream (UCD-400, UCD-422, UCD-424)

In order to capture and preview DSC compressed video DSC must be enabled in *Link Capabilities* dialog in Link tab.

Select **Enable Preview** to verify that DSC compressed stream is received.

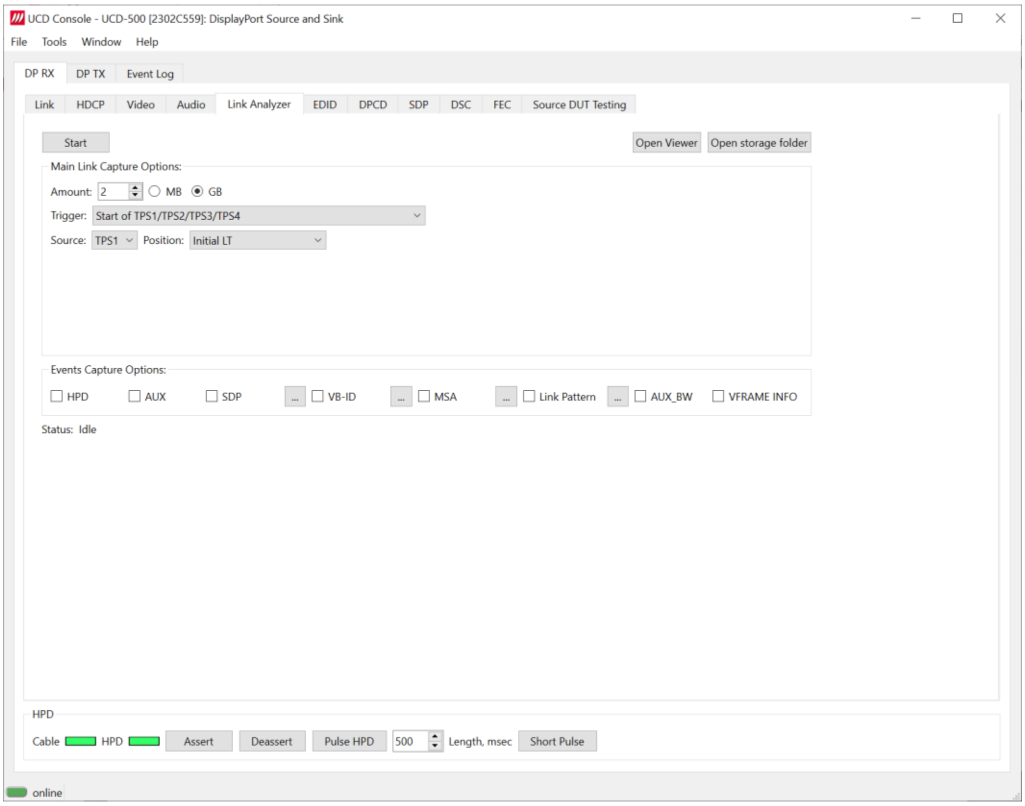


Click **Snap** button to capture one frame and start the decompressor (offline in the PC). Once the decompression is ready, the frame is shown, and *Log* lists the details of the compressed image.



Link Analyzer Tab

Capture of Main-link Data Events and AUX Transactions for evaluation with Timeline Viewer. Please refer for details to chapter Timeline Viewer later in this manual for more details.



Start	Start capturing main link data defined by *Main Link Capture Options*
Open Viewer	Open *TimelineViewer* dialog. For detailed description of TimeLine Viewer, please refer to chapter *Timeline Viewer*.
Open storage folder	Open folder in the PC where capture data is stored. Folder is the video storage folder defined in *Tools* > *Options*. Captured video, audio and data is saved in a subfolder of this folder. The name of the subfolder is “capture_yyyymmdd_hhmmss). (e.g. capture_20210215_093351).

Main Link Capture Options

Amount:	The amount of data logged to buffer. Buffer size 2 GBytes maximum.

Trigger Point Options

Start of data capture can occur without defined trigger of triggered by a predefined signal combination.

In the dialog, first select the event block from the upper drop-down list and from the appearing sub-menus select the detailed trigger.

Trigger	Source	Position
No active trigger	—	—
Start of TPS1 / TPS2 / TPS3 / TPS4	TPS1, TPS2, TPS3, TPS4	Initial LT, After ALPM, Initial LT or After ALPM
Exit of TPS1 / TPS2 / TPS3 / TPS4	TPS1, TPS2, TPS3, TPS4	Initial LT, After ALPM, Initial LT or After ALPM
Trigger	**Source**	**Mask (hex)**
VB-ID with the MASK – any change, match, selected bit transition	Any VB-ID change, VB-ID match with VB-ID mask, Change of any bit in VB-ID that is set in VB-ID mask	Set mask value in hex format
VB-ID on TYPE – BS/SR/CPBS/CPSR	BS, SR, CPBS, CPSR	—
Trigger	**Options**	**HB0 (hex), HB1 (hex)**
SDP Type received – HB0 and/or HB1 match	Match on HB0, HB1 can be any value; Match on HB1, HB0 can be any value; Match on HB0 and HB1	Set HB0/HB1 value in hex format
Trigger	**Source**	**Options**
MSA – any change, change by mask, match by mask	Any MSA change, Change of any MSA attribute set in mask, Match of any MSA attribute set in mask	MVid, NVid, HTotal, VTotal, HActive, VActive, HSyncW, VSyncW, HSyncP, VSyncP, HSyncS, VSyncS, MISC0, MISC1
Any AUX transition	—	Initial LT, After ALPM, Initial LT or After ALPM
Trigger	**Type**	**Address (hex)**
AUX read or write of specific address	AUX native, AUX natve read	Set address in hex format

Note: If you want to capture during link training and you have set the trigger accordingly, you can initiate link training by clicking *Pulse HPD* at the bottom of the window.

Events

The following events can be included in the captured data.

HPD

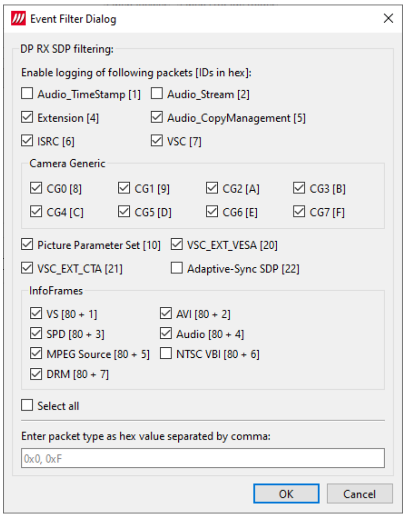
Status and status changes of Hot Plug Detect (HPD) signal

AUX

AUX Channel transactions.

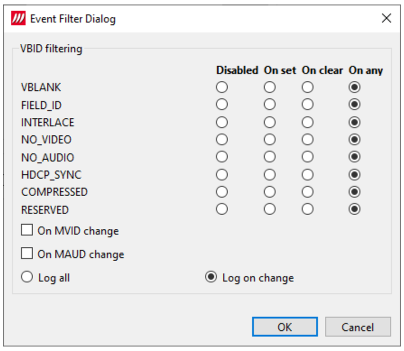
SDP

Secondary-data Packets received in the Main-Link. Click the ... button to open the *Event Filter Dialog.* The dialog enables filtering of SDP packets. In the dialog, the reference to Packet Type Value is indicated in square brackets "[ ]".



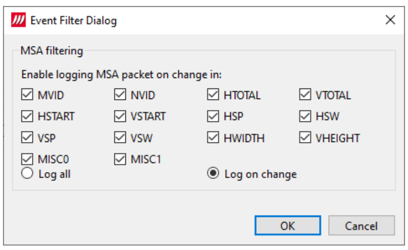
VB-ID

Vertical Blanking ID packets. Click the ... button to open the *Event Filter Dialog.* The dialog enables definition of which bit changes will be logged.



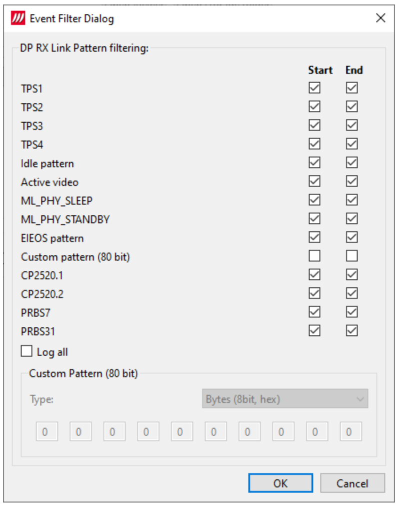
MSA

Log Main Stream Attributes. Click the ... button to open the *Event Filter Dialog.* The dialog enables definition of which events will be logged.



Link Pattern:

Detect link patterns. Click the ... button to open the *Event Filter Dialog.* The dialog enables definition of which patterns will be logged.



AUX_BW:

Capture AUX Channel signal details.

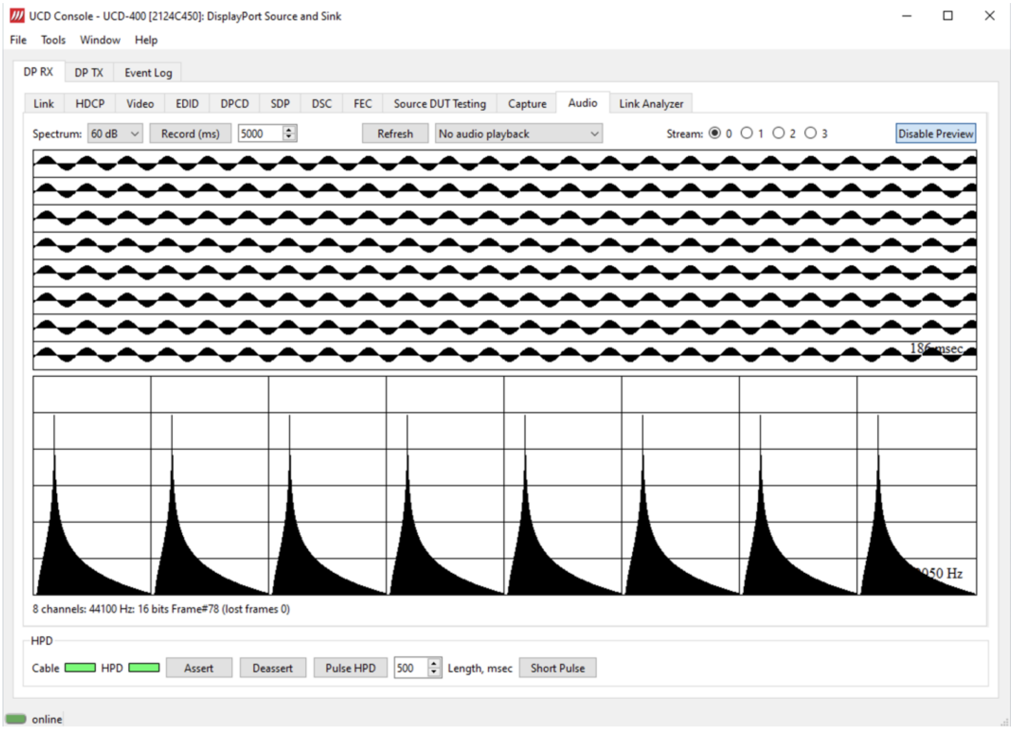
VFRAME INFO

Dimensions of the catured frame measured by the Sink

Audio Tab

Audio tab has a preview of the audio signal format and the controls for audio playback and recording. Up to eight channels will be shown based on the received audio stream.

The audio signal format is shown in three ways.



- The ‘oscilloscope’ panel displays the waveforms of the received audio channels.
- The frequency spectrum of the audio is shown in the lower panel. The range of the spectrum display is from 0 to 1/2 of the input sampling rate. The amplitude scale of the spectrum display can be selected between ‘Linear’ to 100 dB.
- The span of the oscilloscope preview window is defined with **Playback buffer** found in Tools > Options dialog. The value is given in ksamples (1024 samples). The relation between the preview window span in milliseconds (msec) and the value given in *Playback buffer* depends on the sampling frequency. Please do not exceed the *Main buffer* set in the same dialog. Please refer to description of the *Video Audio and Misc Options* earlier in this document.

Enable Preview / Disable Preview

This button controls capturing the audio data.

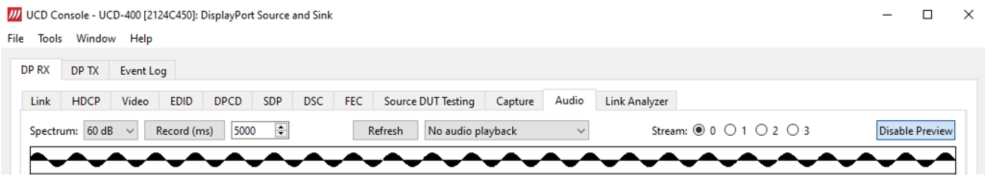
Select Monitored Stream

When Multistreaming (MST) is enabled, the monitored stream can be selected from **Current Stream** selection in the bottom of the dialog.

Note:	Please note that if the captured audio signal is constant, and audio signal frequency and audio sampling rate (e.g. 1000 Hz audio and 32 KHz sampling) match audio preview sampling rate, the ‘oscilloscope’ panel will seem static. Signal capture can be verified by ensuring that Frame # below the panels is increasing.

Playback device selection

The captured audio can be played back in the PC. The combo-box defines the audio device in the host PC through which the captured audio is played. By default, *No audio playback* is selected.



Note: Please note that the audio capabilities of the audio playback device of the PC are not automatically reflected in the audio capabilities description in UCD-4XX EDID. Since UCD-4XX is not performing any audio format conversion, it might occur that the source provides an audio format that the selected playback device is not supporting. In case a conflict occurs, please change manually the EDID content or disable audio playback to monitor the waveforms in UCD Console.

Refresh audio device list

Click here to re-read the list of audio devices after making changes to the host PC configuration.

Audio Buffer Size

The amount of buffering used in the data transfer between the UCD-4XX unit and the PC in Audio buffer size in Tools > Options dialog, Main buffer. Increased buffer size will ensure a smooth audio output but will also increase the delay between the capture of the audio stream and its playback.

Start audio recording

The captured audio can be recorded in the PC using Waveform Audio File Format, WAV (*.wav) format. Recording duration is defined in milliseconds (ms). The folder where the audio file will be saved can be selected in Tools > Options.

Input audio mode

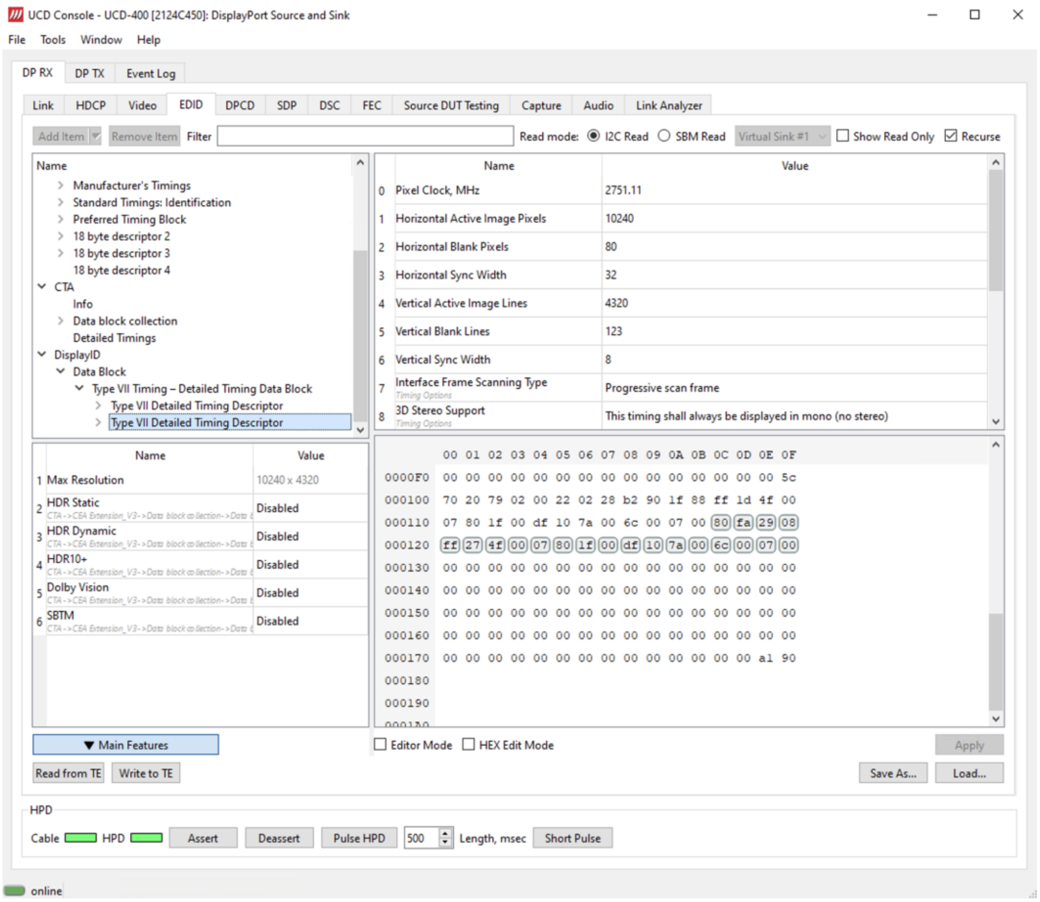
2 channels: 44100 Hz: 16 bits Frame#413 (lost frames 0)

This field (in the bottom of the dialog) indicates detected audio mode in the input stream and the number of audio packets captured.

EDID Tab

EDID Tab provides tools for accessing the EDID including DisplayID extension of the UCD Sink presented to the connected Source Device. There are three basic functions:

- Load and save EDID data files in the host PC.
- Edit the EDID contents either in EDID Editor or in hex format.
- Program and read the contents of the EDID memory for up to 4 virtual ports.



EDID Files

With **Load…** and **Save as…** a hex EDID file can be read and written from the PC. Please note that the program does not alter the contents of the EDID file or verify its integrity during load and save operation.

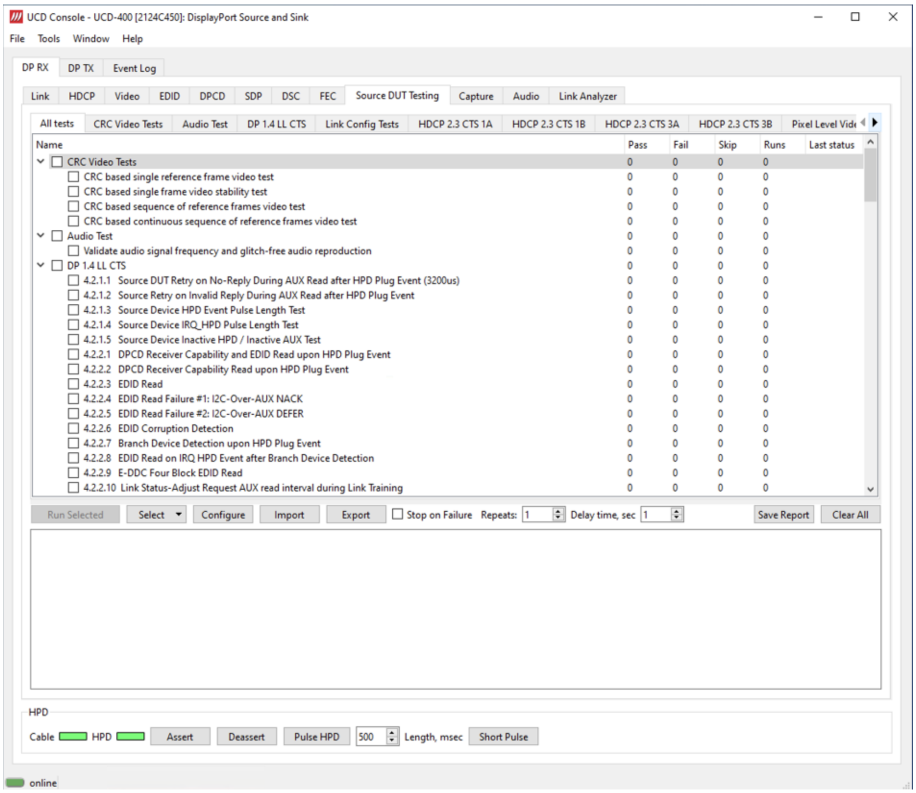
Note: Four blocks (512 bytes) of EDID code are read. If the device does not support all four blocks, the non-supported area is replaced with blanks.

EDID Editor

Please see the description of the EDID editor in Chapter EDID Editor later in this document.

Source DUT Testing Tab

Please refer to **Appendix E** later in this document for description of the tests available.



Select the tests for execution by selecting corresponding checkboxes or by highlighting them by left-clicking on the test name.

Run Selected:	Click to start selected tests. By clicking *Abort* the sequence is stopped.
Select:	Includes the following options for creating templates for tests execution: Select All, Clear All, Invert All, Save, Import and Export
Configure:	Clicking opens a dialog for defining the test parameters for the selected test set. Please refer to *Test Parameters* below for details.
Import:	Load saved test parameter files (*.td or *.json).
Export:	Save test parameters for later use or for use in test automation. For saving parameters for later use in UCD Console, either format can be used. For saving parameters for TSI scripting, please use *.td files. For use with Python applications, please use *.json files.
Stop on Failure:	Stops execution of the selected tests if one of the tests fail
Repeats:	Repeat the selected test several times
Delay time:	Delay in seconds between individual tests.

At the completion of each test the result of the test is indicated in the matrix on the right hand side of the test panel. For each test the matrix lists the number of occurrences of each result and the number of tries performed.

Save Report:	Click to generate a report file in HTML format for sharing the results with other parties for viewing without UCD Console.
Clear All:	Clear the test log and the results matrix

Test Parameters

Each test set has its dedicated set of test parameters. To open a dialog for defining the parameters click **Configure**.

Description of parameters for each test set can be found within the description of tests in Appendix E of this document.

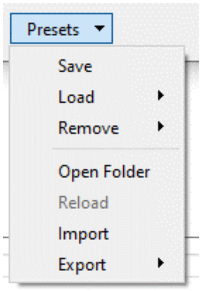
Saving Test Parameters

Test parameters can be saved in various ways.

- Export parameters in *Sink DUT Testing* tab to a *.td file for later use in UCD Console or with TSI scripting or sharing.
- Export parameters in *Sink DUT Testing* tab to a *.json file for later use in UCD Console or with Python applications or sharing.
- Save parameters in *Configure* dialog as Presets to be later used in UCD Console. Please find a description below.

Presets

In all *Configure* dialogs the selected parameters can be saved as Presets. Please click **Presets…** to save or recall a configuration. Click Save first to assign the configuration a name, and after that you can e.g. Export it to a file.



DP and DP Alt Mode Reference Sink

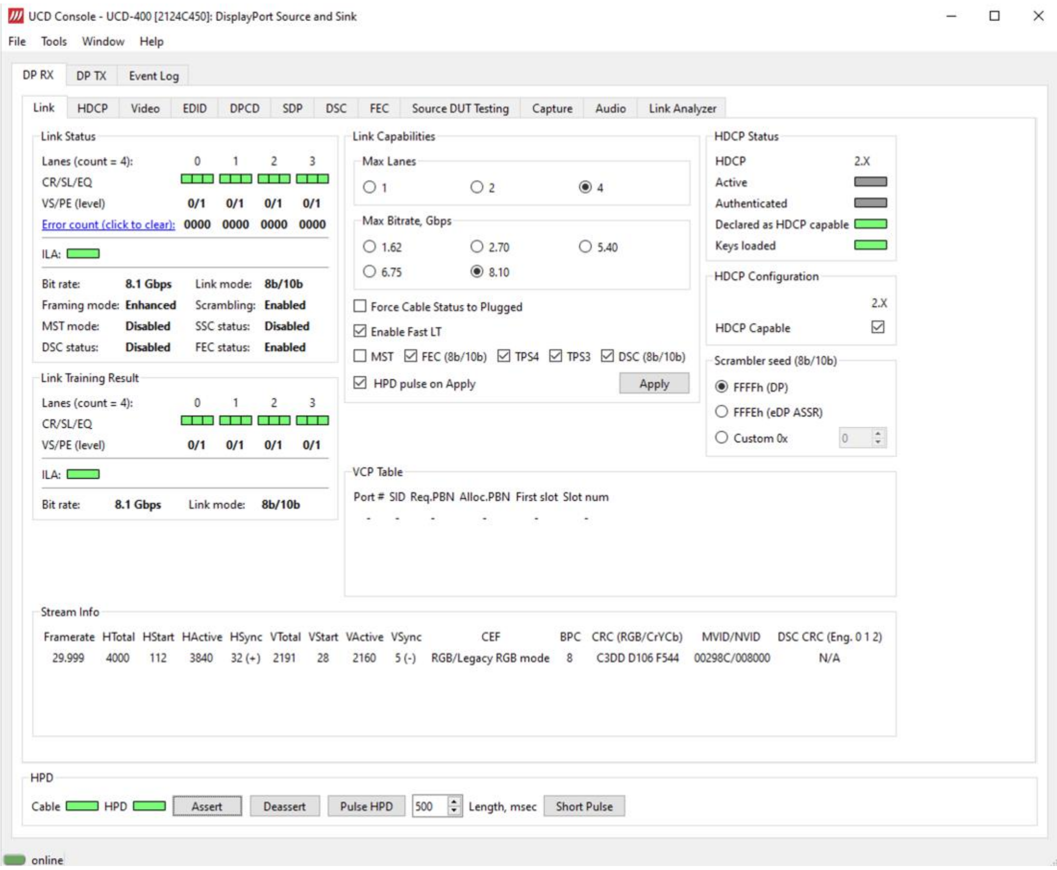
Role:	Product:
DP Reference Sink (DP RX)	UCD-400
USB-C DP Alt Mode Reference Sink (DP RX)	UCD-424

When *DP Reference Sink* or *USB-C DP Alt Mode Reference Sink* role is in use, the following interface specific tabs are available.

- Status information and control of the upstream link (Link)
- DPCD editor (DPCD)
- Analyze Secondary-data Packets received (SDP)
- Display Stream Compression status and configuration (DSC)
- Forward Error Correction (FEC)

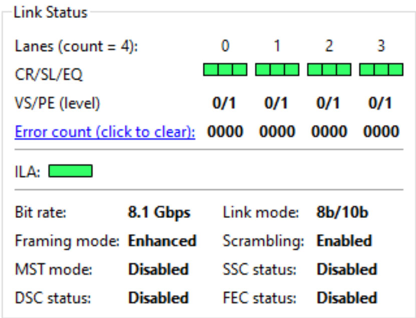
Link Tab

Link tab contains four panels: Cable / HPD, Link Status, Link Capabilities HDCP Status and Configuration, Video Status and HPD.



Link Status

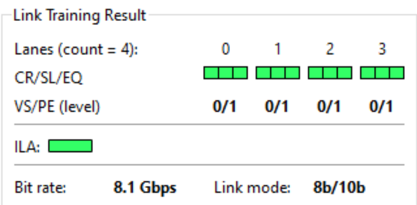
Link Status displays the status of the link training and the link parameters negotiated between UCD Sink and the Upstream Source. It also lists status of other link modes. The data is retrieved from the DPCD status registers of the UCD Sink. The status is updated automatically.



Lanes:	Indicates the number of lanes used for DisplayPort or DisplayPort Alt Mode.
CR/SL/EQ:	LED indicators for status of Clock Recovery / Symbol Lock / Channel Equalization for each of the four lanes
VS/PE (level):	Voltage Swing / Pre-emphasis level
Error count:	Content of DPCD Error Count registers
ILA:	LED indicator for 'Inter lane Alignment Done'
Bit rate:	Currently enabled link bit rate
Link mode:	Currently enabled channel coding (8b/10b only)
Framing mode:	Currently enabled Framing Mode (Normal or Enhanced)
Scrambling:	Status of link data scrambling (Enabled or Disabled)
MST mode:	Status of Multi-stream transport (Enabled or Disabled)
SSC Status:	Status of Spread-Spectrum Clock (Enabled or Disabled)
DSC Status:	Status of Display Stream Compression
FEC status:	Status of Forward Error Correction function (Enabled or Disabled)

Link Training Result

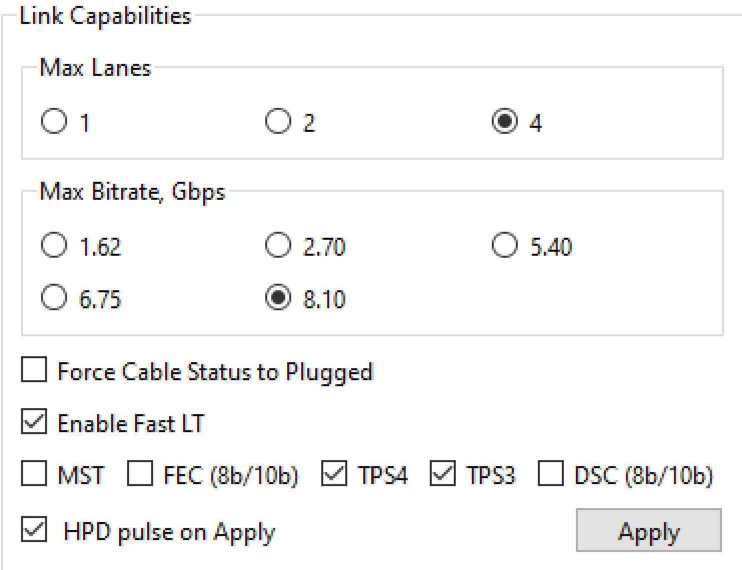
The result of the previous Link Training and values of some key parameters.



Lanes:	Indicates the number of lanes used for DisplayPort or DisplayPort Alt Mode.
CR/SL/EQ:	LED indicators for status of Clock Recovery / Symbol Lock / Channel Equalization for each of the four lanes
VS/PE (level):	Voltage Swing / Pre-emphasis level
ILA:	Status LED for Inter-Lane Alignment
Bit rate:	Currently enabled link bit rate
Link mode:	Currently enabled channel coding (8b/10b only)

Link Capabilities

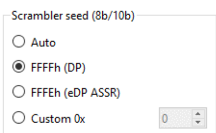
Link capabilities allows the user to change the way the Sink capabilities are announced in the DPCD capability registers of the UCD Sink. To update the new status to the DPCD registers click **Apply**.



Max lanes:	Maximum lane count used
Max Bitrate, Gbps	Maximum link rate used in LT
Force Cable Status to Plugged:	When checked, sink functionality is active regardless of a failure of upstream device detection e.g., due to incorrect AUX Channel electrical termination.
Enable Fast LT:	Indicate support for link training without AUX transactions.
MST:	Indicate support for MST mode and Sideband MSG handling.
FEC (8b/10b):	Indicate support for Forward Error Correction (FEC) feature.
TPS4, TPS3:	Indicate support for Link Training Pattern Sequence 4 and 3 correspondingly.
DSC (8b/10b):	Indicate support for Display Stream Compression (DSC) feature
HPD pulse on Apply:	Select to apply a Hot-Plug Detect (HPD) pulse automatically after updating the status. HPD pulse duration will be defined in the *Pulse HPD* field in *HPD* dialog in the bottom of the tab.

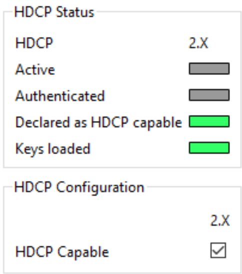
Scrambler Seed

Selection of the value to which the Linear Feedback Shift Register (LFSR) is reset during scrambler reset. Used only when 8b/10b link coding is enabled.



HDCP Status

Copy of the status from HDCP Tab. Please refer to chapter *HDCP Tab* later in this document for detailed description.



HDCP Configuration

Enable and disable HDCP capability of UCD Sink. Duplicates of the controls found in HDCP tab. Currently, UCD-4XX devices support only HDCP 2.3 standard.

Stream Info

Stream Info

Framerate	HTotal	HStart	HActive	HSync	VTotal	VStart	VActive	VSync	CEF	BPC	CRC (RGB/CrYCb)	MVID/NVID	DSC CRC (Eng. 0 1 2)
59.995	2200	192	1920	44 (+)	1125	41	1080	5 (+)	YCbCr4:2:2/ITU-R BT.601	8	E18E 0815 5A14	001777/008000	N/A
59.995	2200	192	1920	44 (+)	1125	41	1080	5 (+)	RGB/Legacy RGB mode	8	B69E B33E 1AB3	001777/008000	N/A
59.995	2200	192	1920	44 (+)	1125	41	1080	5 (+)	RGB/Legacy RGB mode	8	B69E B33E 1AB3	001777/008000	N/A
59.985	2200	192	1920	44 (+)	1125	41	1080	5 (+)	RGB/Legacy RGB mode	8	B69E B33E 1AB3	001776/008000	N/A

Stream Info is achieved from the Main-Stream Attributes (MSA) of the stream.

Note: Please note that the MSA information used for Video Timing Details is provided by the Upstream Source, it is not measured by the UCD Local Sink.

The content of *Stream Info* table can be copied by right-clicking on the table and selecting **Copy**.

Framerate:	Vertical refresh rate
HTotal:	Horizontal total of transmitted main video stream, measured in pixel count.
HStart:	Horizontal active start from leading edge of HSync, measured in pixel count.
HActive:	Horizontal active, number of active pixels in video line
HSync:	HSync width, measured in pixel count. (+)/(-) positive / negative sync.
VTotal:	Vertical total of transmitted main video stream, measured in line count.
VStart:	Vertical active start from leading edge of VSync, measured in line count.
VActive:	Vertical active, number of active lines in video frame
VSync:	VSync width, measured in line count. (+)/(-) positive v.s. negative sync.
CEF:	Used color mode: Color format + subsampling / colorimetry
BPC:	Color depth in bits per color (BPC)
CRC (RGB/CrYCb):	16-bit Cyclic redundancy check (CRC) value per color component calculated from active pixels. Value order in YCbCr color format: Cr, Y, Cb.
MVID/NVID:	Mvid and Nvid video time stamp values
DSC CRC:	16-bit Cyclic redundancy check (CRC) calculated from compressed pixel stream. Value order Engine 0, 1, 2.

VCP Table

VCP table shows allocation of Virtual Channel Payload for active virtual MST channels.

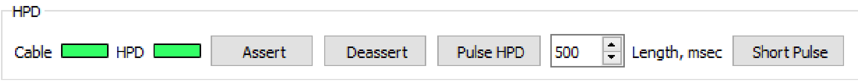
VCP Table

Port #	SID	Req.PBN	Alloc.PBN	First slot	Slot num
0	1	355	360	1	6
1	2	532	540	7	9
2	3	532	540	16	9
3	4	532	540	25	9

The content of *VCP Table* can be copied by right-clicking on the table and selecting **Copy**.

Port #:	Port number where the virtual channel is directed.
SID:	Stream identification number of the virtual channel
Req.PBN:	Requested PBN (payload bandwidth) value for the virtual channel
Alloc.PBN:	PBN value allocated for the virtual channel
First slot:	Time slot where the first VC Payload for the virtual channel is stored
Slot num:	Number of VC Payload slots reserved for the virtual channel.

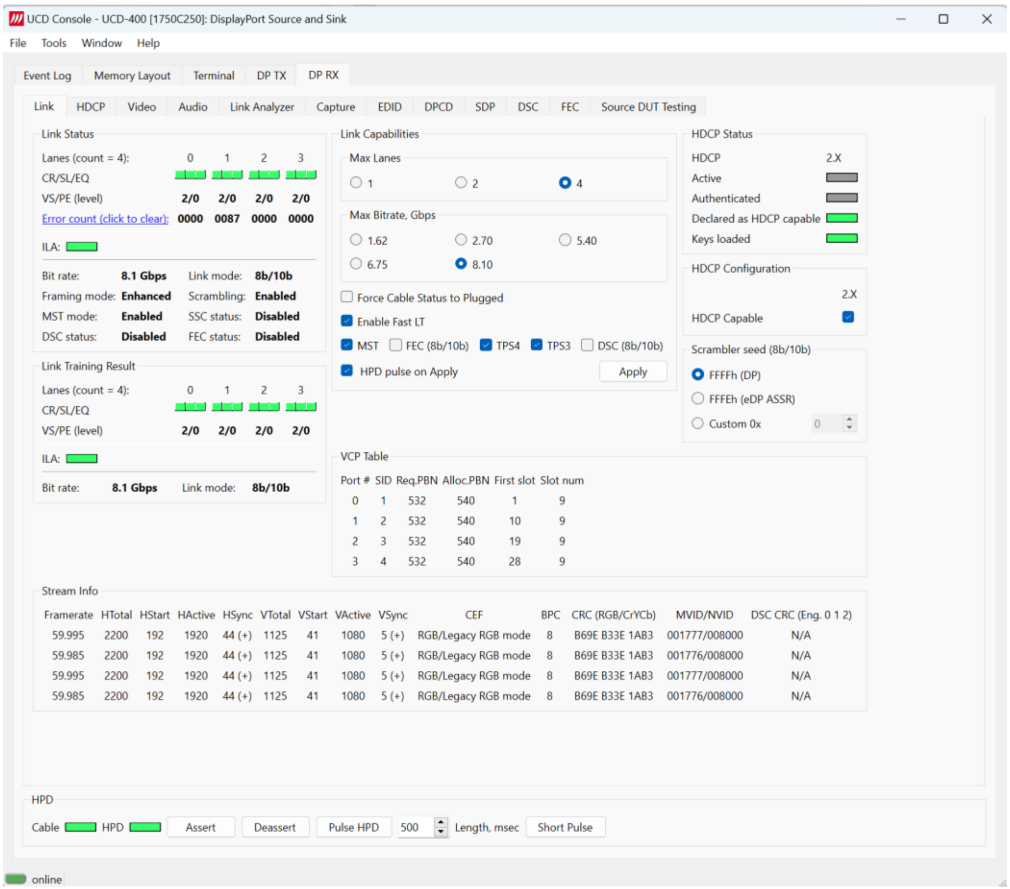
HPD



Cable LED:	Indicates that the hardware has detected an upstream cable.
HPD LED:	Indicates that the HPD signal is Asserted (logical "high").
Deassert:	Click button to set HPD line to logical "low" (de-asserted) and hence no HPD pulse can be generated.
Assert:	Click to re-activate the HPD line (set to logical "high").
Pulse HPD:	Click to apply an HPD Pulse with programmable duration. Duration will be defined in the provided field.
Short Pulse:	Click to apply a short pulse. Pulse duration is 1 ms.

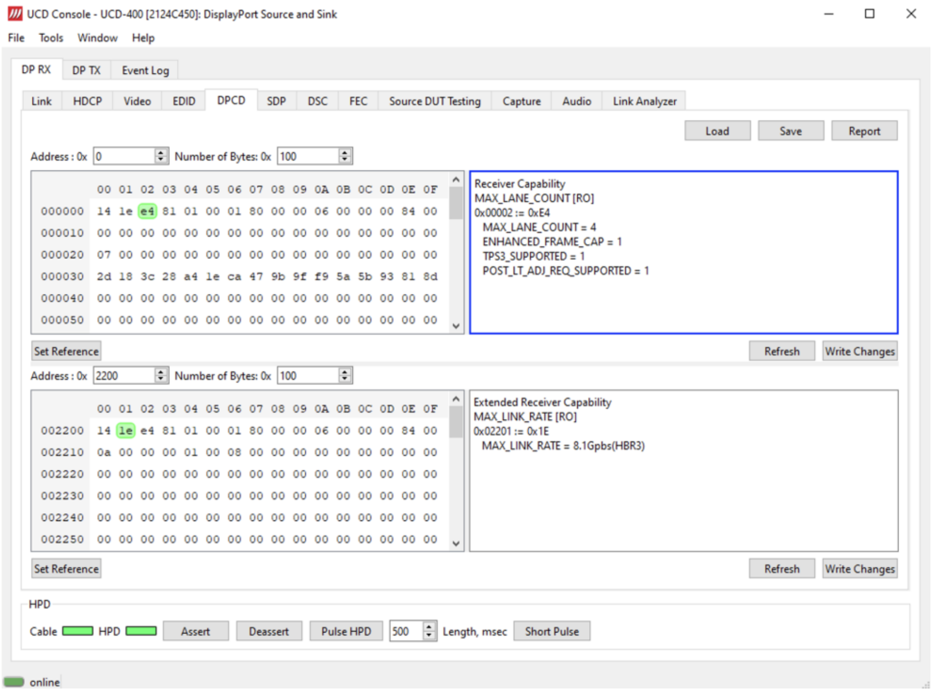
Multistreaming

When Multistreaming (MST) is enabled, the details of the received virtual channels is shown in *Stream Info* table and *VCP Table* .



DPCD Tab

DPCD tab is a tool for monitoring and editing the DPCD registers of the UCD Sink.



The *DPCD Decoder* panels on the right show the interpretation of the DPCD byte selected on the monitoring windows. The selected byte is shown with a green background.

Save:	Select DPCD content to the PC (please see below).
Load:	Retrieve previously saved DPCD data (please see below).
Report:	Save parsed content of selected DPCD register ranges as HTML file
Refresh:	Re-read the data from the DPCD registers to the window in question
Write Changes:	To program the data into the DPCD registers of UCD Local Sink
Set Reference:	Store currently shown data as a reference for comparison

When the data is *Refreshed* from the DPCD registers the changed bytes will be highlighted with **blue** color. The fields edited by the user will be highlighted with **red** color.

Saving and Loading DPCD Content

DPCD data in the selected address areas can be saved as a file in your PC. There are three alternative formats listed below. Please select the intended format when saving:

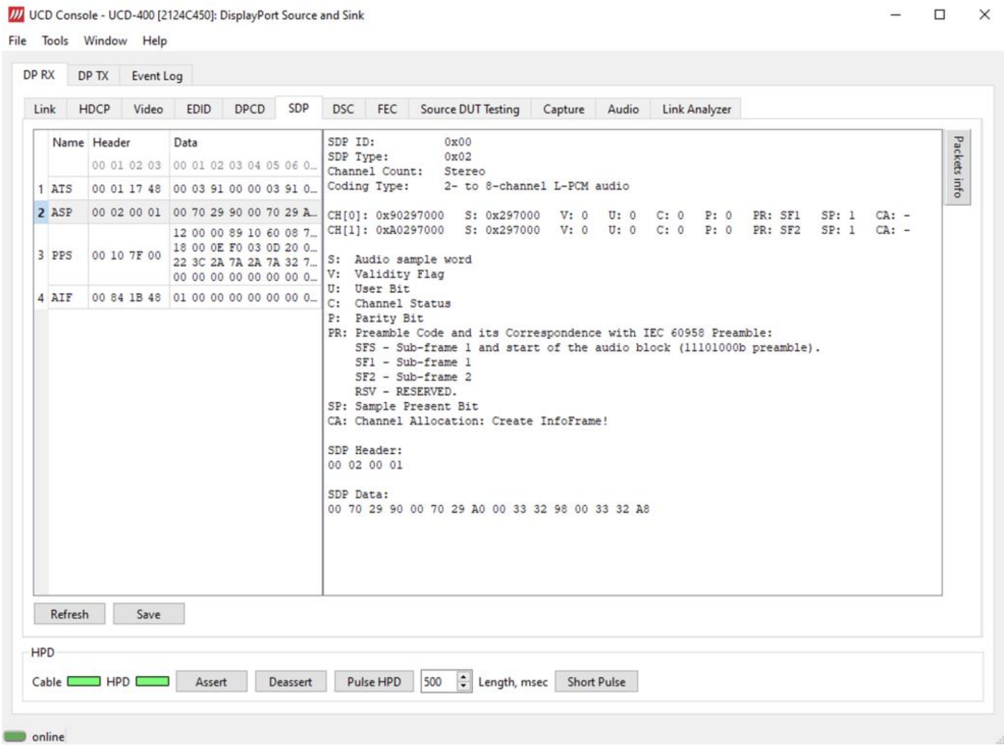
- Binary *DPCD Data File* format (*.DPD). This is Unigraf proprietary format. You can also load the DPCD content stored in this format.
- *Comma Separated Value* format (.CSV)
- *HEX Dump* (*.HEX) in a human readable text format.

Note:	- User controls like Link Training or mode changes will modify the content of the DPCD registers - During a reboot of UCD-4XX the DPCD registers will be returned to their default values

SDP Tab

In SDP Tab shows the *Secondary-Data Packets* sent by the Source device. Click **Refresh** to re-read the data. Show / hide the parsed data by clicking **Packets Info** in the divider bar.

The following packets are recognized:



- Audio_TimeStamp
- Audio_Stream
- Extension
- Audio_CopyManagement
- ISRC (International Standard Recording Code)
- Video Stream Configuration (VSC)
- Camera Generic 0 … 7
- Vendor-Specific Infoframe packet
- AVI InfoFrame packet
- Source Product Descriptor InfoFrame packet
- Audio InfoFrame packet
- MPEG Source InfoFrame packet
- Dynamic Range and Mastering InfoFrame
- Picture Parameter Set (PPS)

Saving SDP Packets

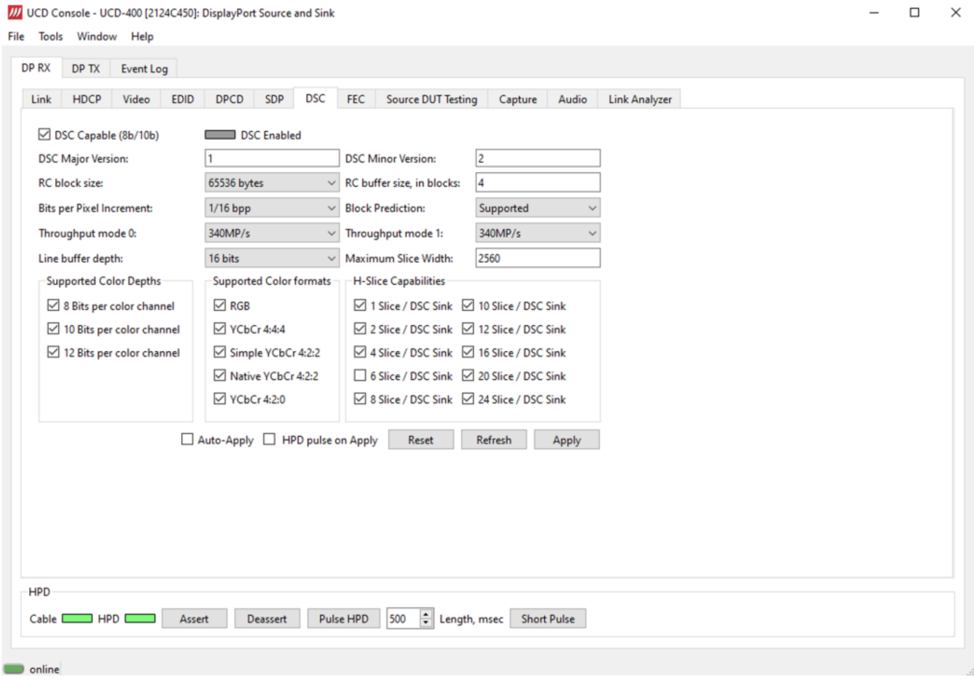
Packets can be saved in a file in binary format. Click *Save* and in the dialog select the packet types of choice. File name will be of format *ATS_2022-07-28T15_54_24.bin,* where *ATS* is the packet type and *2022-07-28T15_54_24* the time stamp.

Saved packets can be evaluated and edited using *Packet Editor*. Please see section *Packet Editor* later in this document

DSC Tab

DSC tab contains status of the Display Stream Compression (DSC) feature, and definition of DSC support capabilities that UCD defines in its DPCD register.

Enabling DSC

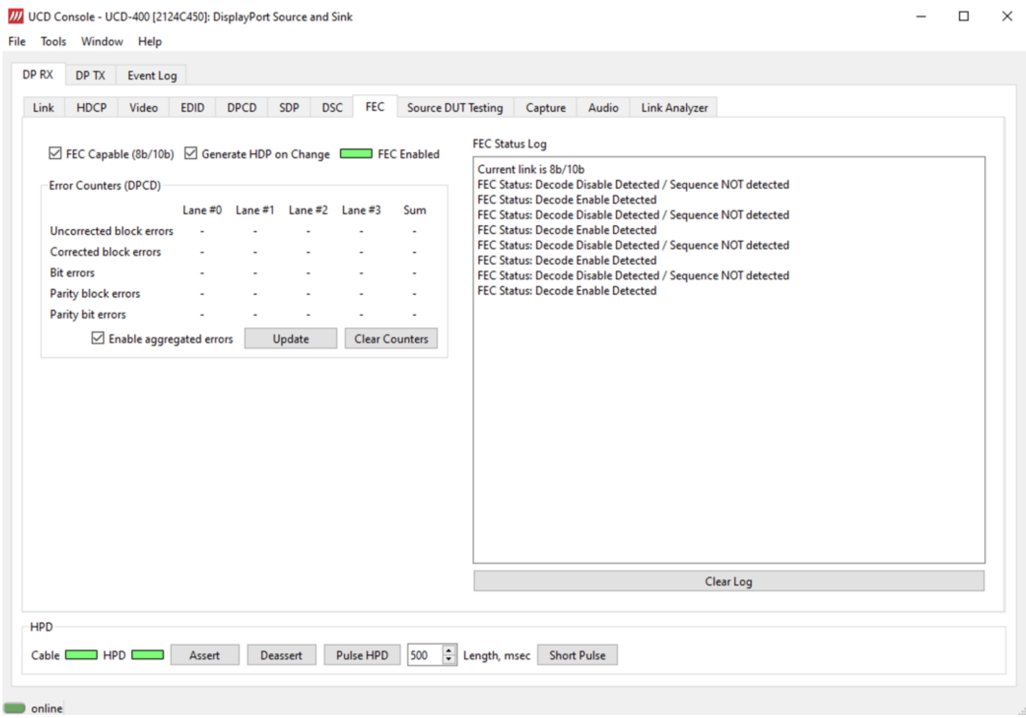


Enabling DSC feature is controlled by the connected source device. When connected, a source verifies corresponding registers in DPCD of UCD sink to find out if DSC capability is declared.

DSC Capable (8b/10b):	UCD is declared as DSC capable. Capability can be enabled or disabled in DP RX Link tab.
DSC Enabled:	LED indicating that the connected source has enabled DSC
Apply:	Write changes to UCD sink DPCD registers
Refresh:	Re-read the content of UCD sink DPCD and update the control status.
Reset:	Reset the content of UCD DSC related DPCD registers (0x00060 through 0x0006F) to the default values as defined in UCD firmware.

FEC Tab

FEC tab contains control of the FEC (Forward Error Correction) feature, Error Detection table and FEC Status Log.



Enabling FEC

Enabling FEC feature is controlled by the source device. When connected, source verifies corresponding registers in sink DPCD to find out if sink is FEC capable. This register in UCD-4XX sink can be controlled by **FEC Capable** checkbox.

Since source normally polls sink DPCD mainly after a new connection, selecting **Generate HPD on change** will force a new connection after the change of the FEC capability status.

Update:	Read FEC Error Counters from DPCD
Clear Counters:	Clear FEC Error Counters in DPCD.

FEC Status Log lists FEC events.

HDMI Reference Sink

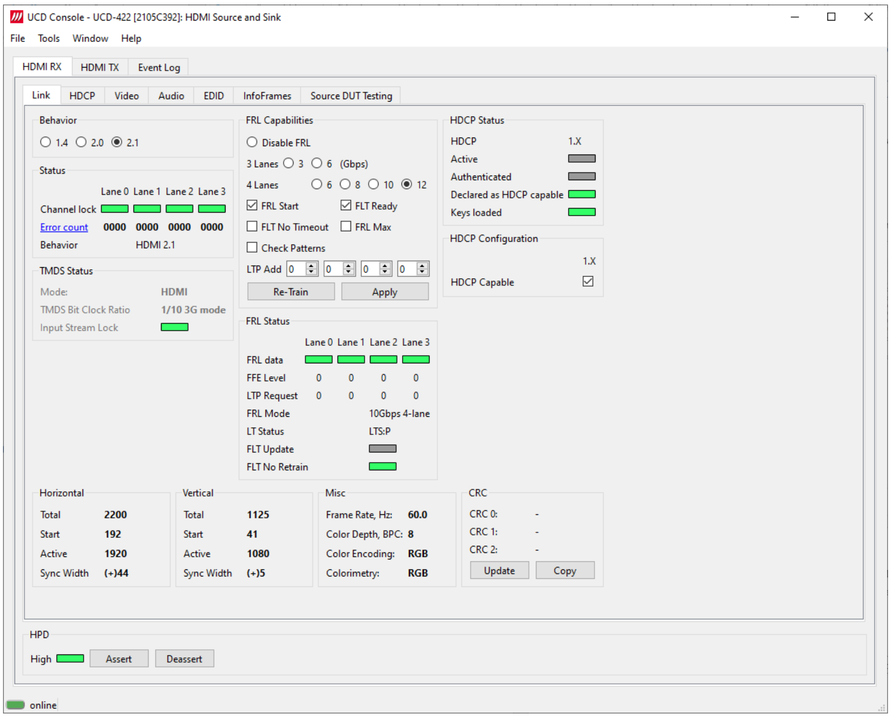
Role:	Product:
HDMI Reference Sink (HDMI RX)	UCD-422

When *HDMI Reference Sink* role is in use, the following interface specific tabs are available.

- Status information and control of the upstream link (Link)
- Received InfoFrame packets (InfoFrames).

Link Tab

Link tab contains four panels: Behavior, Status, TMDS Status, FRL Capabilities, FRL Status, Audio Return Channel, HDCP Status and Configuration, Video Status and HPD.



Behavior

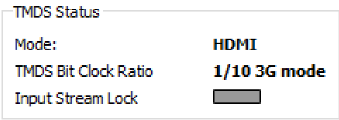
Selection of HDMI operation mode: HDMI 1.4, HDMI 2.0 or HDMI 2.1.

Please perform HPD **Deassert - Assert** after change of mode.

Status

Channel lock:	Status of Channel Lock in the four lanes and currently selected HDMI mode
Error count:	Contents of the SCDC Error counter registers of the UCD-422 Sink.
Behavior:	Assigned HDMI mode

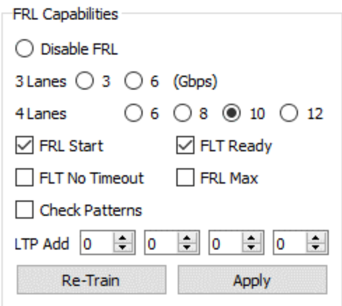
TMDS Status (Only in TMDS Mode)



Mode:	Indication of HDMI / DVI mode
TMDS Bit Clock Ratio:	TMDS Bit Period / TMDS Clock Period ratio (1/10 or 1/40)
Input Stream Lock:	Indication of TMDS character lock

FRL Capabilities (Only in FRL Mode)

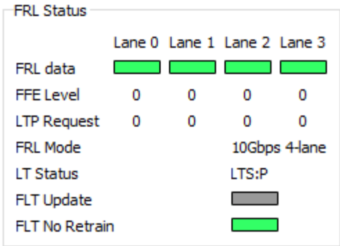
FRL Capabilities allows the user to change the way the Sink capabilities are announced in the SCDC capability registers of the UCD-422 Sink.



Disable FRL:	Disable FRL mode
Capability Radio Buttons:	Selection of the maximum link count and link rate capability of UCD-422 sink. Written to FLR_Rate configuration register of UCD_422 Sink. Please click **Re-train** to apply
FRL Start:	Control of the HDMI sink's FRL_start bit (1/0)
FLT Ready:	Control of the HDMI sink's FLT_ready bit (1/0).
FLT No Timeout:	Status of the HDMI sink's FLT_no_timeout bit (1/0)
FRL Max:	Status of the HDMI sink's FRL_Max bit (1/0)
Check Patterns:	If Check Patterns in unselected then there's no pattern verification during link training
LTP Add:	Additional Requested Link Training pattern in HDMI sink's LnX_LTP_req (X=0-3) register.
Re-Train:	Request a new link training
Apply:	Store new settings

FRL Status (Only in FRL Mode)

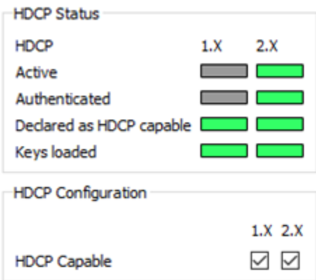
FRL Status displays the status of the link training and the link parameters negotiated between UCD-422 Sink and the Upstream Source. The status is updated automatically.



FRL Data 0/1/2/3:	Indication of data flow in FRL links 0 to 3
FFE Level:	Status of Feed Forward Equalizer Level that HDMI transmitter is using (only in FRL mode)
LTP Request:	Currently requested FRL link training pattern.
FRL Mode:	Lane count and link rate configuration used in FRL mode
LT Status:	Status of the FRL Link Training State
FLT Update:	Status of the UCD-422 sink's FLT_update bit (1/0) (only in FRL mode)
FLT No Retrain:	Status of UCD-422 Sink's FLT_no_retrain bit (1/0) (only in FRL mode)

HDCP Status

Copy of the status from HDCP Tab. Please refer to chapter *HDCP Tab* later in this document for detailed description.



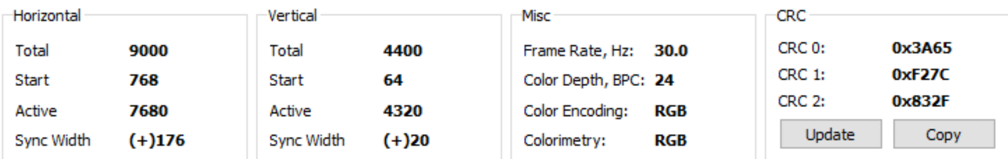
HDCP Configuration

Enable and disable HDCP 1.4 or HDCP 2.3 capability of UCD-422 Sink. Duplicates of the controls found in HDCP tab.

Note:	Currently HDCP is not supported

Video Status

Video Timing and Color Details as retrieved from stream metadata. Frame rate is measured by UCD-422 Local Sink.



CRC

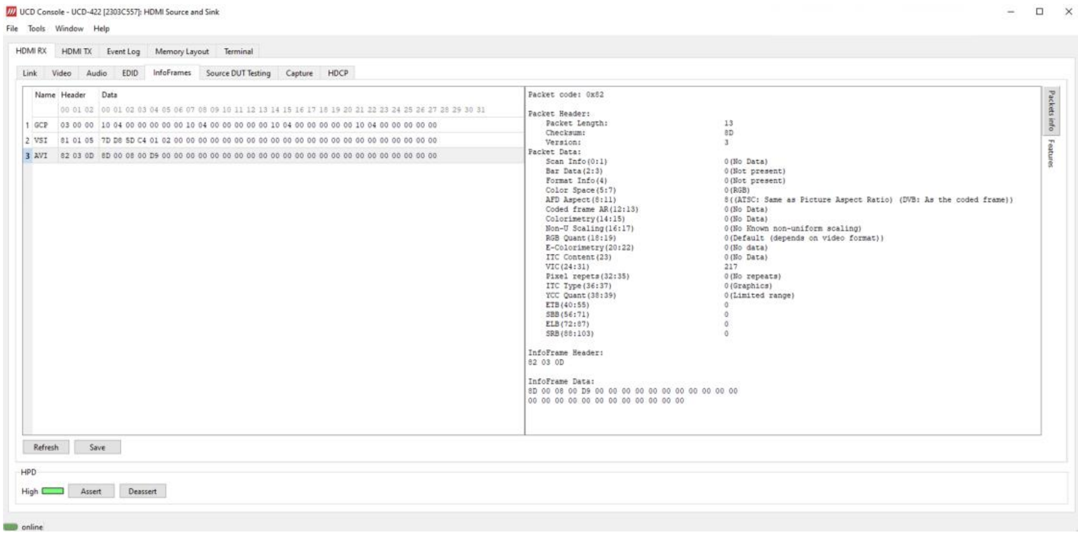
The 16-bit **CRC** (checksum, cyclic redundancy check) values of the three color components calculated by the Sink hardware. To re-calculate, click **Update**. Click **Copy** to store the information in Windows clipboard.

HPD

High:	LED indicates that the HPD signal is Asserted (logical “high”).
Deassert:	Click button to set HPD line to logical “low” (de-asserted) and hence no HPD pulse can be generated.
Assert:	Click to re-activate the HPD line (set to logical “high”).

InfoFrame Tab

InfoFrame Tab displays received InfoFrames. Click **Refresh** to update the list. Show / hide the parsed data by selecting **Packet Info**.



Received InfoFrames

InfoFrames tab displays in hexadecimal format the following received InfoFrames:

- ACR (Audio Clock Regeneration)
- ASP (Audio Sample Packet)
- GCP (General Control Packet)
- ACP (Audio Content Protection Packet)
- ISRC1 (International Standard Recording Code)
- ISRC2 (International Standard Recording Code)
- OBA (One Bit Audio sample packet)
- DTS (DTS Audio packet)
- HBR (High Bitrate Audio stream packet)
- GMP (Gamut Metadata packet)
- EMP (Extended Metadata Packet)
- 3D ASP (3D Audio Sample packet)
- 3D OBA (3D One Bit Audio sample packet)
- AMP (Audio Metadata Packet)
- MST_ASP (Multi-stream audio sample packet)
- MST_OBA (One Bit Multi-stream audio sample packet)
- VSI (Vendor Specific InfoFrame)
- AVI (Auxiliary Video Information)
- SPD (Source Product Descriptor)
- AIF (Audio InfoFrame)
- MPEG (MPEG Source InfoFrame)
- DRM (Dynamic Range and Mastering InfoFrame)

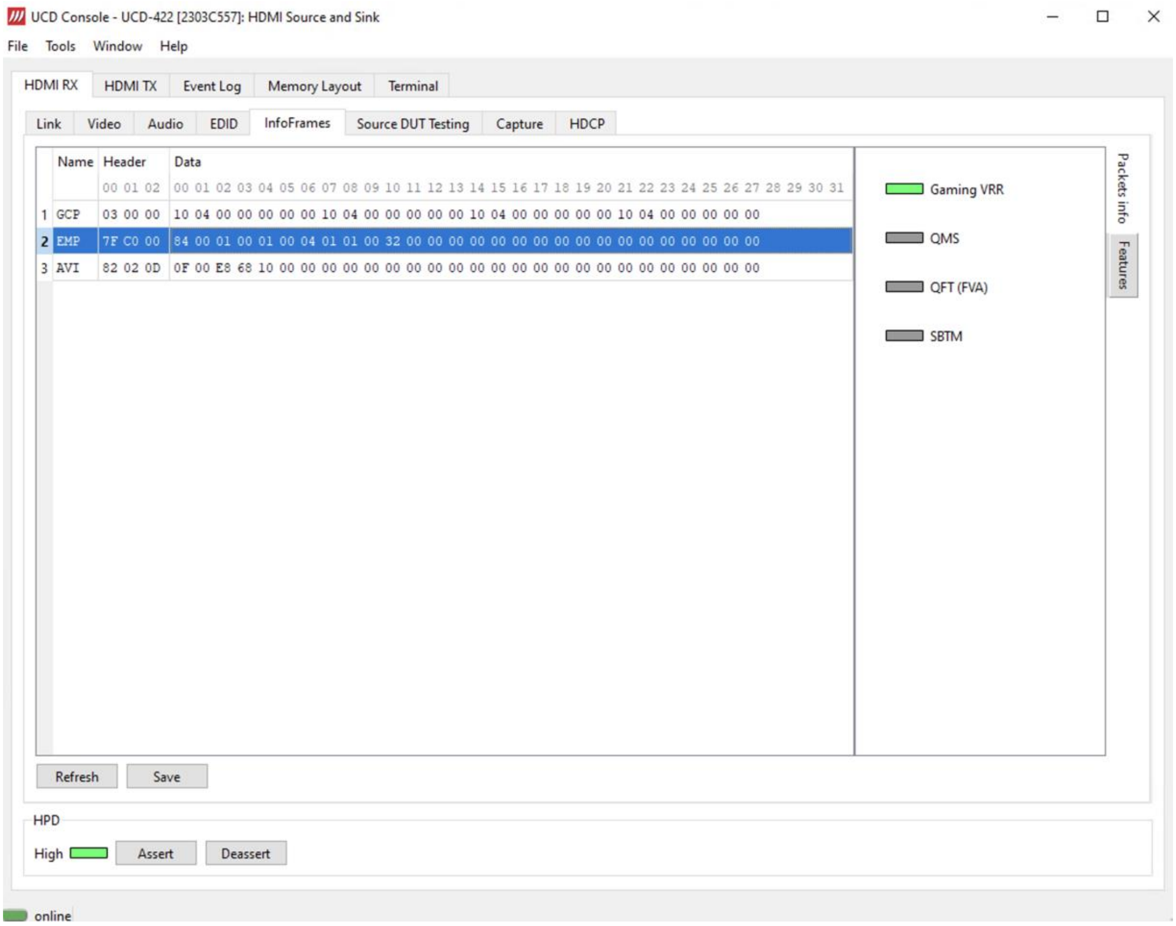
Saving Infoframes

Infoframe packets can be saved in a file in binary format. Click *Save* and in the dialog select the packet types of choise. File name will be of format *EMP_2022-07-28T15_54_24.bin,* where *EMP* is the packet type and *2022-07-28T15_54_24* the time stamp.

Saved packets can be evaluated and edited using *Packet Editor*. Please see section *Packet Editor* later in this document

Infoframe Features

Observe features found in infoframes by selecting **Features.**



USB-C Monitoring

Role:	Product:
USB-C DP Alt Mode Reference Source (USB-C TX) or USB-C DP Alt Mode Reference Sink (USB-C RX)	UCD-424

When *USB-C DP Alt Mode Reference Sink* or *Source* role is in use, the following interface specific tabs are available.

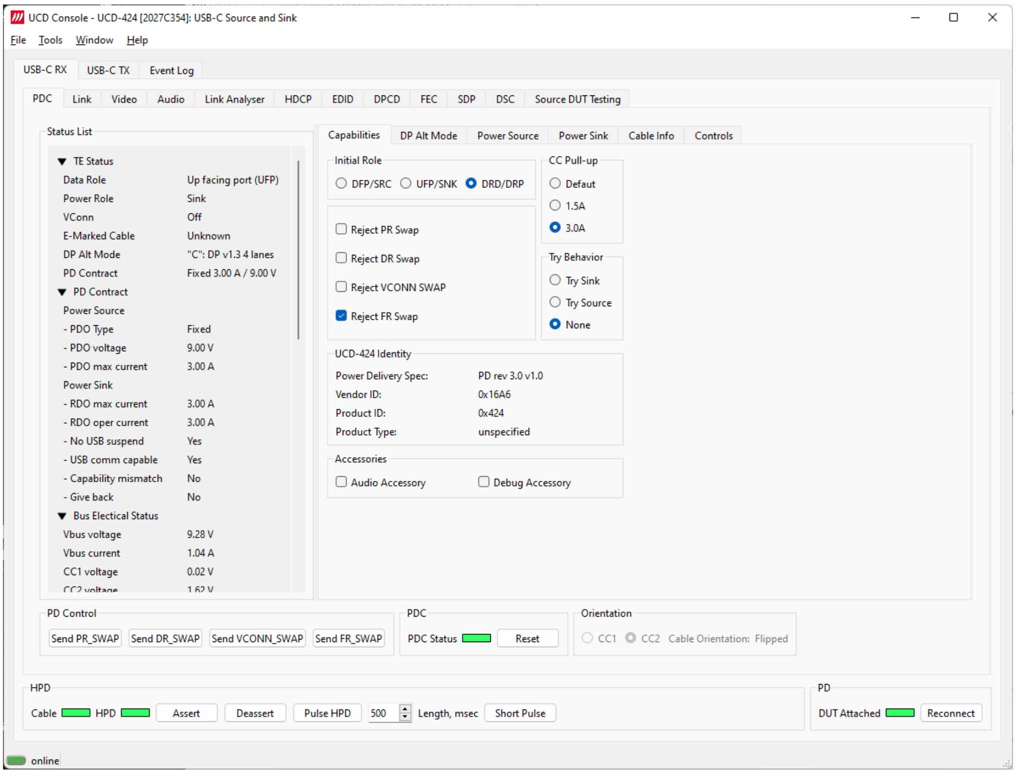
- USB-C Power Delivery (PDC)

In *USB-C Power Delivery* tab (PDC) operator can evaluate the status of the USB-C connection and USB Power Delivery Contract, the various roles adopted, and the configuration of the DP Alternate Mode. The user can set the initial roles for the UCD-424 test equipment and the optional capabilities for UCD-424 in the USB-C PD Contract. Controls allow user also to swap Power and Data roles.

USB-C Monitoring dialog is divided into four panels. The upper left panel is a Status List indicating statuses of both port partners, UCD-424 and the connected DUT.

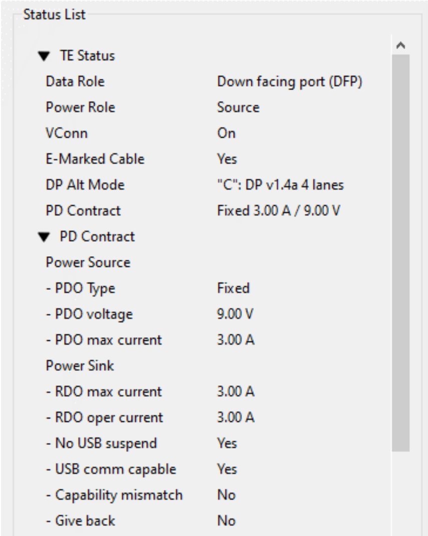
The tabs on the right panel configuration dialogs of various USB-C interface functions.

The bottom panel indicates status of the cable connection and PD Control controls for role swaps

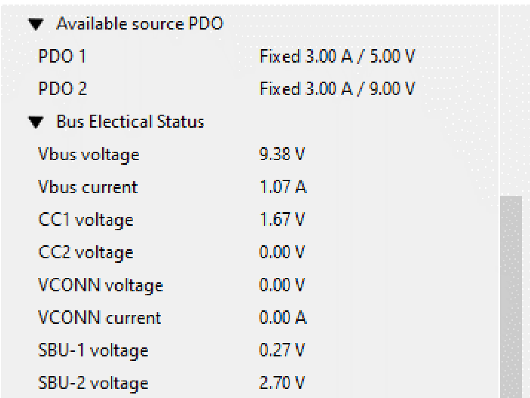


Status List

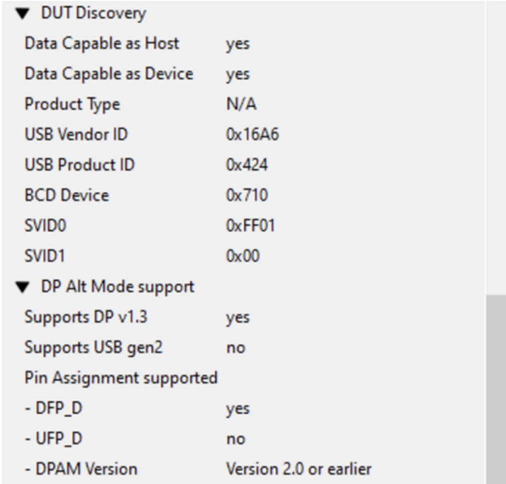
In Status List the information is presented in foldable sections. Each section contains information related to one feature of USB-C interface or PD protocol. The user can fold out the sections needed for the task in question.



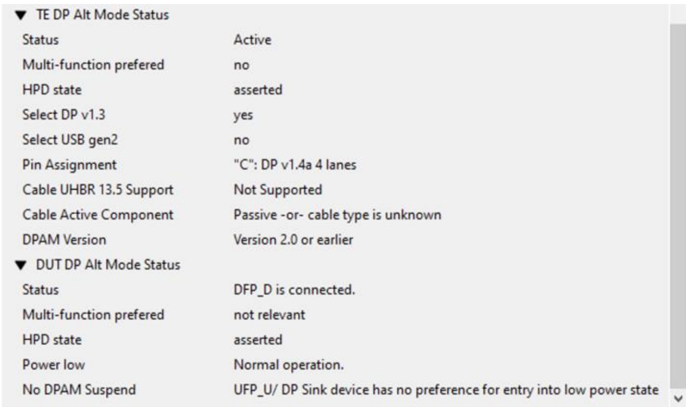
TE Status:	UCD-424 internal status (Data role, Power Role, VConn, E-marked cable, DP Alt Mode, PD Contract status)
PD Contract:	Details of the PD Contract (Power Source: PDO Type, PDO Voltage, PDO max current; Power Sink: RDO max current, RDO operating current, USB statuses)



Available source PDO:	(PDO 1, PDO 2)
BUS Electrical Status:	(Vbus voltage, Vbus current, CC1 voltage, CC2 voltage, VCONN voltage, VCONN current, SBU-1 voltage, SBU-2 voltage)

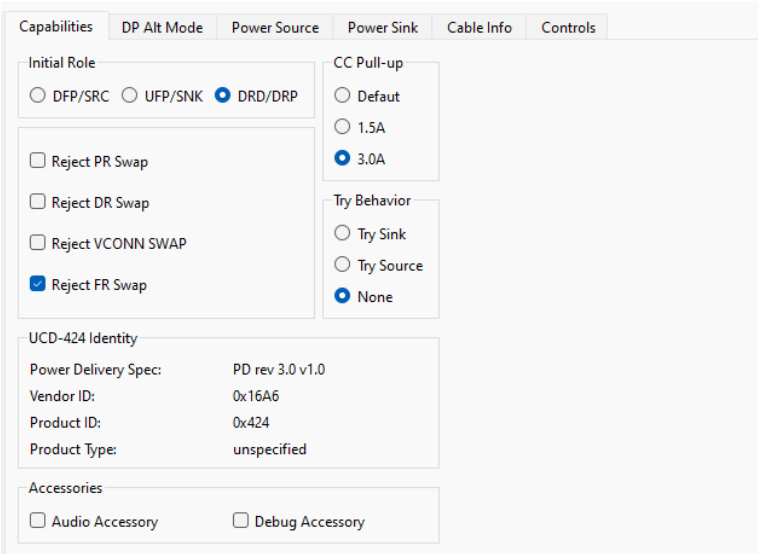


DUT Discovery:	DUT information (data capable as host, data capable as device, product type, USB vendor ID, USB product ID, BCD device, SVID0, SVID1)
DP Alt Mode support:	Supported DisplayPort Alt Mode features (Supports DP v 1.3, Supports USB gen2, Pin Assignments supported as DFP_D, UFP_D, and DPAM Version)

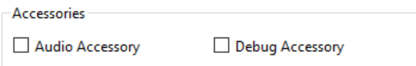


TE DP Alt Mode Status:	UCD-424 internal DP Alternate mode status (Status, Multi-function preferred, HPD state, Select DP v1.3, Select USB gen2, Pin Assignment, Cable UHBR 13.5 Support, Cable Active Component, DPAM Version)
DUT Alt Mode Status:	Status of the connected USB-C port partner gained from status update messages (Status, Multi-function preferred, HPD State, Power low, No DPAM Suspend)

Capabilities



Initial Role:	Defines the role which UCD-424 presents itself in the start PD communication (both power and data role).
Reject Swaps:	Allow or reject mode swap requests from the connected port partner.
CC Pull-up:	Control of Rp that Source uses to advertise the initial current source capability using USB-C Current method.
Try Behavior:	Control the USB-C PD role that UCD-424 initially takes in the connection handshake.
UCD-424 Identity:	Status information provided by UCD-424.



Accessories

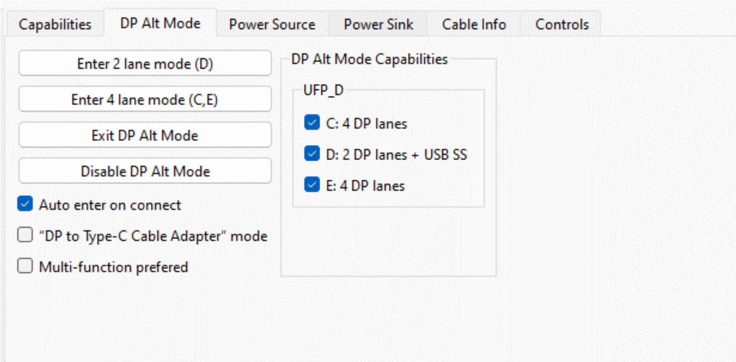
Audio Accessory:	Enable simulation of Audio Accessory support
Debug Accessory:	Enable simulation of Debug Accessory support

Enabling *Audio Accessory* and *Debug Accessory* extends USB Type-C Connection State Machine with *.Accessory states. (Please refer to USB Type-C specification for details).

Note:	Please note that UCD-424 does not support any physical connections for the Accessory functions. The selections enable only behavioral simulation.

DP Alt Mode

Controls and capability settings for DisplayPort Alternate Mode.



Enter 2 lane mode (D):	Restart mode discovery and advertise support for mode D (2 DP lanes + USB SS).
Enter 2 lane mode (C,E):	Restart mode discovery and advertise support for modes C and D (4 DP lanes).
Exit DP Alt Mode:	Exit DP Alternate mode.
Disable DP Alt Mode:	Exit DP Alternate mode and advertise no DP Alternate mode support.
Auto enter on connect:	Start mode discovery after connection and enter DP Alternate mode if suitable configuration is found.
"DP to Type-C Cable Adapter" mode:	Perform an automated procedure for connecting a DP to USB-C bidirectional cable. Please find an abstract of the issue below.
Multi-function preferred:	When entering DP Alternate Mode, select mode D.

DP to Type-C Cable Adapter

USB-C to DP Bi-directional Cable contains an active converter microchip that needs to be powered from USB-C interface. Therefore UCD-424 must be initially configured in power source role for USB Default Operation where it applies vSafe5V on Vbus to power up the microchip in the cable.

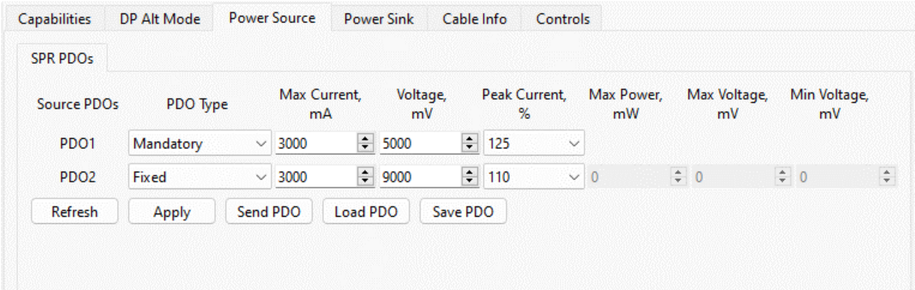
USB-C to DP Bi-directional Cable uses pin assignment E when acting as a source. In order to provide the "cable" a possibility to request the configuration it needs, UCD-424 has to initiate a Data Role Swap to be in UFP, Device, data mode.

DP Alt Mode Capabilities

Supported Pin Assignments declared in DisplayPort Capabilities discover message. Separate for UFP_D (DisplayPort sink) and DFP_D (DisplayPort source)

Power Source

Definition of Power Data Objects (PDO) for UCD-424 when acting as *Power Source Port*.



PDO Type: Definition of power source type (Mandatory, Disabled, Fixed, Variable or Battery)

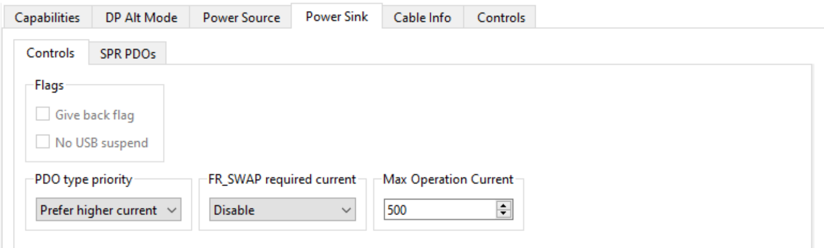
Note:	The requirement is that Sources shall supply at least one fixed supply capable of supplying vSafe5V

Note:	Please note that UCD-424 is not able to simulate as Source the electrical behavior of Variable and Battery source types.

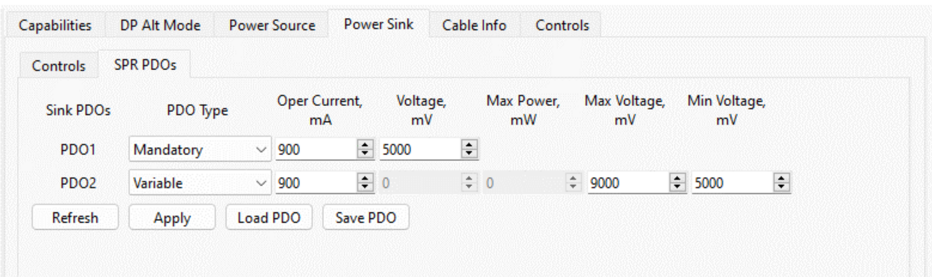
Refresh	Re-read status from UCD-424
Apply	Program new values to UCD-424
Send PDO	Send a Source Capabilities message
Load PDO	Load a stored Power Source PDO configuration from file.
Save PDO	Store current Power Source PDO configuration to a file

Power Sink

Controls and Definition of Power Data Objects (PDO) for UCD-424 when acting as *Power Sink Port*.



Give back flag:	UCD-424 sets *GiveBack* flag in its *Request Data Object*
No USB suspend:	UCD-424 sets No USB Suspend flag in its Request Data Object
PDO type priority:	Setting of the policy used for automatic selection from available PDOs advertised by Source Device. (Prefer higher current / Prefer higher voltage / Prefer higher power)
Max Operation Current	Setting the highest current UCD-424 will ever require when operating as a Power Sink.



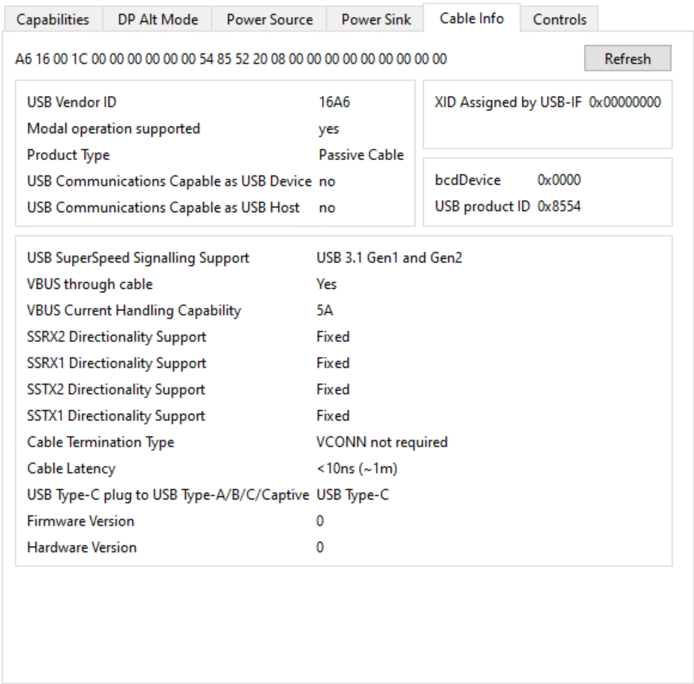
PDO Type: Definition of power source type (Disabled, Fixed, Variable or Battery)

Note: The requirement is that Sources shall supply at least one fixed supply capable of supplying vSafe5V

Refresh	Re-read status from UCD-424
Apply	Program new values to UCD-424
Load PDO	Load a stored Power Source PDO configuration from file.
Save PDO	Store current Power Source PDO configuration to a file

Cable Info

Cable Info tab displays the information received from the cable as a response to *Discover Identity* command sent to SOP'.



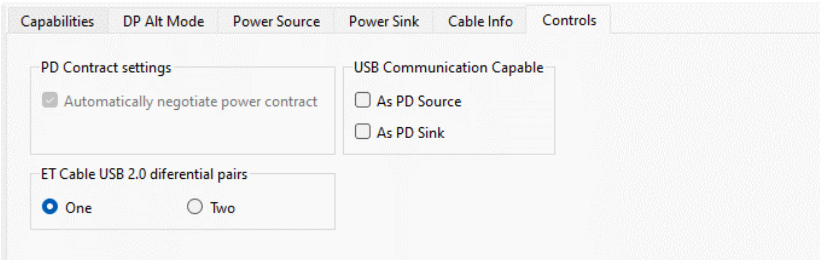
Note:	Please note that cable info can only be read when in DFP Data Role.

Controls

Control tab includes miscellaneous controls related to UCD-424 behavior as a USB-C PD Port Partner.

PD Contract Settings

Automatically negotiate power contract: When selected UCD-424 will start power contract negotiation if suitable configuration is found.



ET cable USB2.0 differential pairs

There are two versions for Unigraf Electrical Test Cable. The difference is the number of USB D+/- pairs included in the cable. The reasoning is that if an unused pair is not terminated, it is a receiver of EMI and disturbs the electrical circuitry.

Cable with P/N 546117 has two USB2.0 pairs (A6, A7 and B6, B7), while P/N 546114 has only one pair (A6, A7). Please update the control accordingly.

If DUT has shorted USB2.0 pins A6 to B6 and A7 to B7 at the receptacle then choose cable One: In order to minimize in-cable signal coupling only one USB D+/- pair is included in the cable

If DUT has shorted USB2.0 pins routed to mux or similar, then choose cable Two: In order to enable electrical cable flip in cases where USB D+ lines and USB D- lines correspondingly have not been shorted together on Device side, both USB D+/- pairs are included in the cable. This cable marked with a label "2xUSB 2.0 PAIRS".

USB Communication Capable

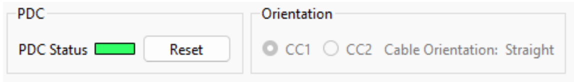
You can control the *USB Communication Capable* bit in its Request Data Object.

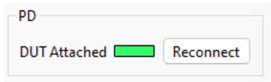
Note:	Please click *Apply* to enable changes.

Bottom Panel

Bottom panel includes statuses and controls for the USB-C connection

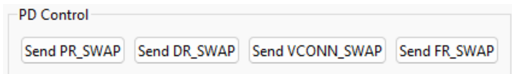
Status





PDC Status	LED for USB-C Power Delivery Control
Reset:	Reset the PD Controller in UCD-424 to overcome abnormal situations.
Orientation:	Straight (CC1 terminated) or Flipped (CC2 terminated).
DUT Attached:	Indication that *Attach* is detected by the Source port in one of its CC lines.
Reconnect:	Restart USB-C Source-to-Sink attach procedure.

PD Control



Send PR_SWAP:	Send *PR_Swap* message to request an exchange of power roles.
Send DR_SWAP:	Send *DR_Swap* message to request an exchange DFP and UFP operation between Port Partners while maintaining the direction of power flow over Vbus.
Send VCONN_SWAP:	Send *VCONN_Swap* message to request an exchange of Vconn Source.
Send FR_SWAP:	Send FR_Swap message to request a Fast Role Swap.

5. GENERATOR OPERATION

When used as a *Generator*, the UCD device acts as DisplayPort, HDMI or USB-C DisplayPort Alt Mode Source or Transmitter device. Generator functionality related controls and dialogs can be used by selecting *DP TX* or *HDMI TX* tabs.

Please note that in most UCD-4XX Series units *Analyzer* functionality is available simultaneously with Generator functionality. Please find description of Analyzer functionality earlier in this manual.

Functionality Tabs

UCD Console features are presented in tabs. Standard tabs are similar in all functional roles, Interface Specific tabs present features and controls that are only available for a particular interface.

Some of the tabs are enabled by default, some only when an applicable license is included.

Standard Tabs

Analyzer role features six standard tabs:

- Video pattern generator (Pattern Generator).
- Content Playback (Playback)
- EDID editor (EDID).
- HDCP status monitor and control (HDCP).
- Sink DUT Testing

Interface Specific Tabs

Depending on the connected UCD device, additional interface specific tabs will be available

UCD-400, UCD-411, UCD-451 and UCD-424:
DP and USB-C DP Alt Mode Reference Source

- Status information and control of the downstream link (Link).
- DPCD monitor (DPCD)
- Forward Error Correction (FEC)

UCD-422, UCD-452 and UCD-412: HDMI Reference Source

- Status information and control of the downstream link (Link).
- SCDC monitor (SCDC)

UCD-424: USB-C Reference Source

- USB-C Monitoring (PDC)

Note: Some of the tabs are enabled by default, some only when an applicable license is included. Please refer to Appendix B Licensing of this document for description of features and licensing

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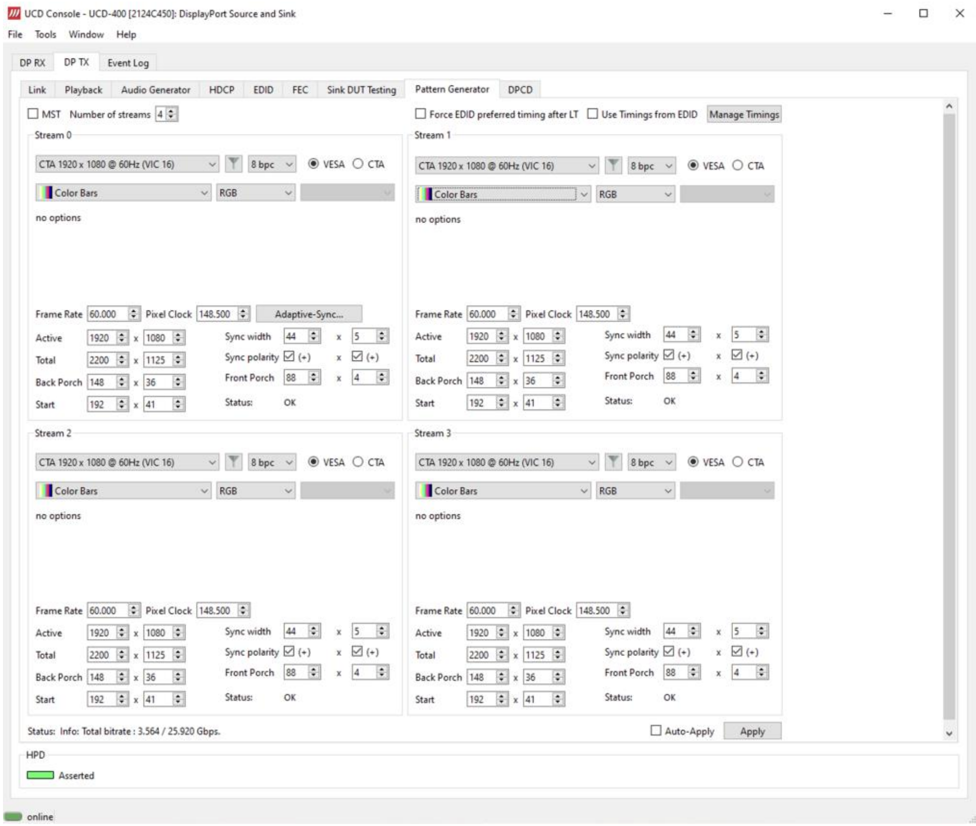
Standard Tabs

Pattern Generator Tab



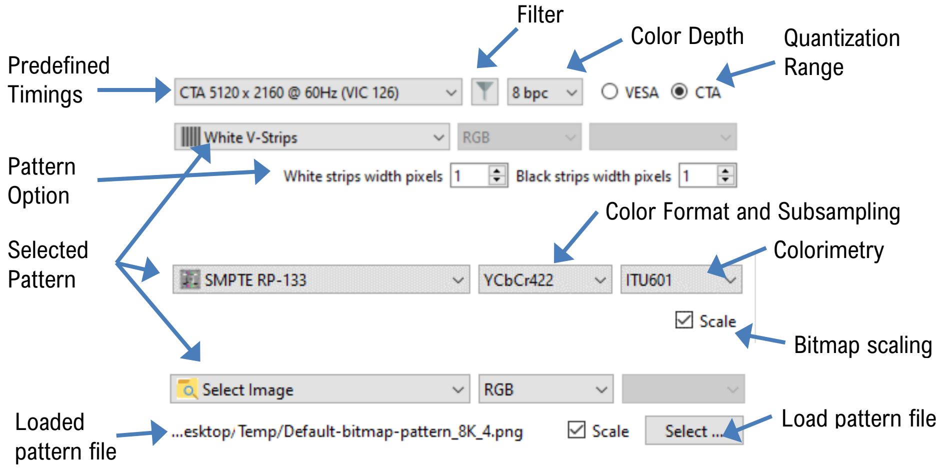
Note:	The video modes that can be used in MST streams are limited by the overall capability of the DisplayPort link and the capability of the connected DisplayPort Sink or Branch device.

Use timings from EDID	UCD reads the EDID of the connected Sink and lists only timings that are featured there.
Force EDID preferred timing after LT	UCD reads the EDID of the connected Sink and after next LT enables to Stream 0 the timing listed in 18 byte descriptor 1 in VESA block of the sink's EDID.
Manage Timings	Please see chapter *Manage Timings* later in this manual
Status:	Used link payload / Total link capability in Gbps (Pls see Note below)
Auto-Apply	In order to avoid sourcing invalid video mode combinations new settings are being validated when the user is clicking Apply. Automatic validation will be applied when *Auto-Apply* is checked.
Apply	Apply recent changes

Note:	A full description of Minimum link configuration combinations for UCD standard video modes is available. Please contact Unigraf for details.

Pattern

Configuration of the video sent in the corresponding stream
(Controls vary between selected pattern type)



Predefined Timings

The list includes a set of common fixed video timings. Please find a list of the timings with their major details in Appendix C of this document. With *Manage Timings* function the user can add timings in the list and select which timings are shown in the selection.

Color Depth

Available color depths are: 6, 8, 10, 12 and 16 bpc. Color depth 6 bpc is only available when using RGB color format in DisplayPort or DisplayPort Alt Mode.

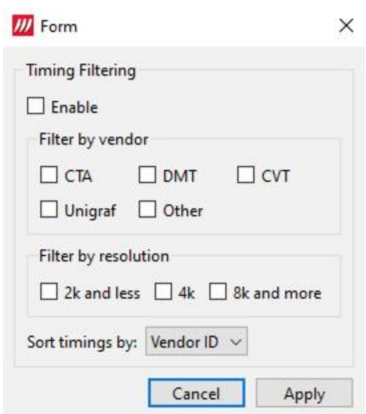
Video Pattern

The selection includes a set of predefined patterns and a possibility to load user defined custom patterns. Please find a description of the available predefined patterns in Appendix D of this document. By selecting **Disabled** you can have the links activated but no video data transferred.

Note: When MST mode is selected, full selection of test patterns is available only in stream 0

Filter

Filter timings by specific vendors and resolutions. Timings can be sorted by Vendor ID or width.



Custom Image Patterns

BMP, PNG, and JPG files can be loaded from the PC to be used as custom images.

Please refer to *Link Pattern* in description of *DP and DP Alt Mode Reference Source Link tab* later in this manual for sending special DisplayPort binary patterns in the link instead of video.

Bitmap Scaling

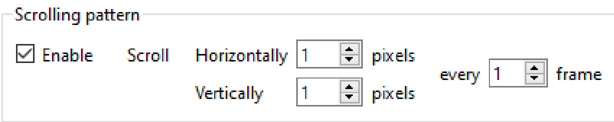
When bitmap patterns are used, they can be used either in their original resolution, aligned to left top corner (=un-check *Scale*), or upscaled or downscaled to match the selected video resolution (=check *Scale*).

Pattern Options

Some of the predefined patterns include additional configuration parameters. The controls for the parameters appear below the pattern selection when the pattern in question has been selected. Please find a description of patterns options in Appendix D of this document.

Pattern Scrolling

When Pattern Scrolling is enabled, the pattern is moved horizontally and vertically between display scans. The function is available for all patterns except the following: Color Bars, Chessboard, Solid Color, Solid colors (white, red, green, blue), White V-Strips, Motion Pattern, DSC Pattern.

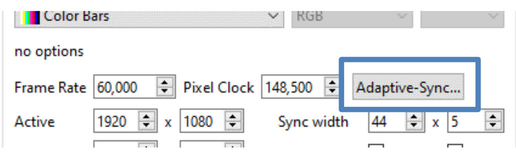


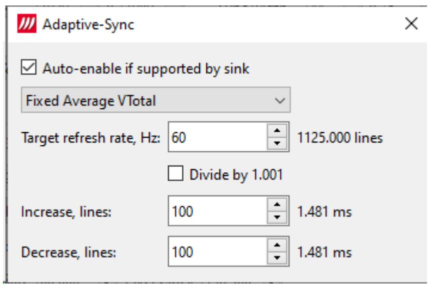
Enable:	Enable or disable pattern scrolling
Horizontally X pixels:	Horizontal step of the pattern movement in pixels (values in range -127…0…128, for YCbCr 4:2:2 even values). 0 = no movement, positive values = pattern moves to the right.
Vertically Y pixels:	Vertical step of the pattern movement in pixels (even values in range –127…0…128, for YCbCr 4:2:0 even values). 0 = no movement, positive values = pattern moves up.
Every N frame:	Delay of pattern movement in display frames (values in range 0… 255). 0 = no movement, 1 = move every frame, n = move every n:th frame.

Note: Please click Apply to enable changes or check Auto-Apply.

Adaptive-Sync Control (UCD-400, UCD-411, UCD-424)

Adaptive-Sync feature is available for Stream 0. Adaptive-Sync control dialog opens by clicking button *Adaptive-Sync…*.





Note: Adaptive-Sync is currently limited to SST mode.

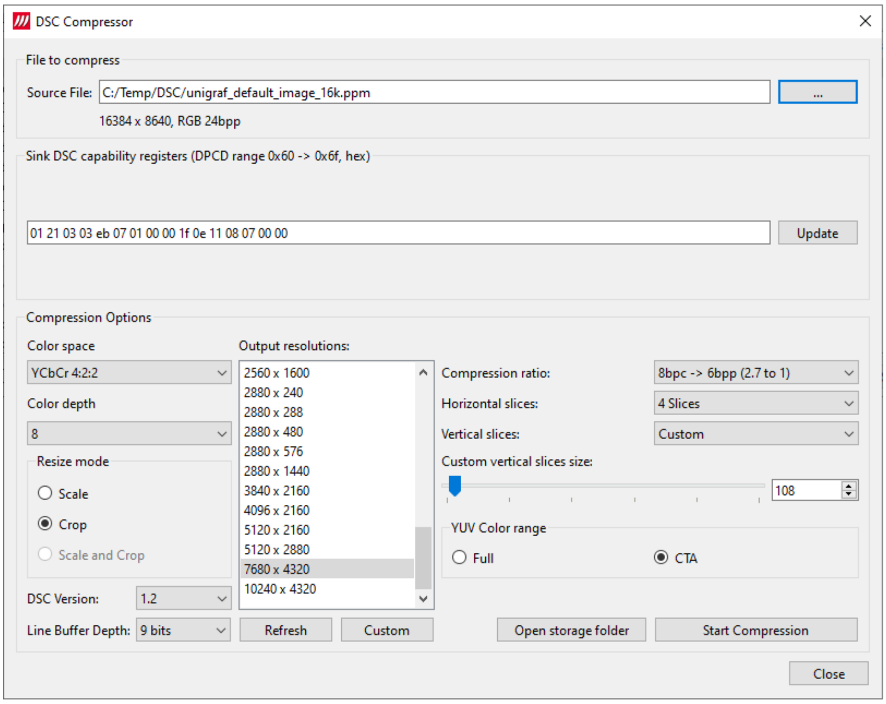
Auto enabled if supported by Sink:	The feature is enabled based on connected Sink status
Disabled:	Feature is disabled unless *Auto Enabled … box is checked. Please see the note below.*
Adaptive Total, constant refresh rate:	Added blank lines
Adaptive Total, Square pattern:	Added blank lines, min; Added blank lines, max; Period, frames.
Adaptive VTotal, Zigzag pattern:	Added blank lines, min; Added blank lines, max; Increase, lines; Decrease, lines.
Fixed Average VTotal:	Target refresh rate, Hz; Increase, lines; Decrease, lines

Note: Please note that in case *Auto enabled if supported by Sink* is selected and the connected Sink device supports Adaptive-Sync, but the selected mode is *Disabled, then* Adaptive-Sync is enabled in mode "*Adaptive Total, constant refresh rate*" with 0 (zero) added blank lines. Control dialog will be updated to indicate the status.

Sourcing DSC Compressed Patterns

UCD Pattern Generator function is able to source DSC content originating from pre-created DSC compressed files. DSC compressed pattern files can be created with a separate tool called *DSC Compressor*. It can be launched from Tools > DSC Compressor.

Select the source bitmap file in Source File field. Define the Output Resolution, the color depth, compression ratio and number of horizontal and vertical slices in the frame.

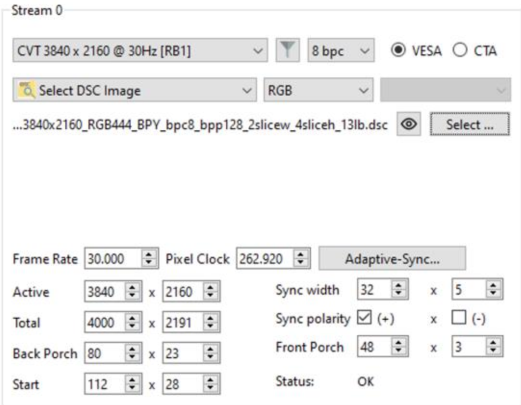


Source File:	Source bitmap file to be compressed (JPG, PNG, PPM)
Sink DSC capability registers:	Click *Update* to read DPCD registers 0x60 to 0x6f from the connected Sink device
Color Space:	Color space of the output compressed file (RGB, YCbCr 4:4:4, 4:2:2, 4:2:0, Simple 4:2:2)
Color depth:	Color space of the output compressed file (8, 10, 12, 16)
Output resolution:	Resolution of the output compressed file
Resize mode:	The way the DSC image is created from the Source file
Compression ratio:	Used compression ratio
Horizontal slices:	Nr. of slices horizontally (1 to 24 Slices)
Vertical slices:	Vertical slices (1 to 24 Slices, Custom) Custom vertical slices size: minimum 1, recommended 108
YUV Color range:	Selection of color range between Full range (Full) (0 to 255 at 8 bpc) and Limited Range (CTA) (16 to 235 at 8 bpc)
Refresh:	Refresh the list after adding a custom resolution
Custom:	Create a custom output resolution
DSC Version:	DSC version used (1.1, 1.2)
Line Buffer Depth:	Line buffer bit depth used to generate the bitstream. (8 to 16 bits, default 9 bits)
Open storage folder:	Open DSC temp folder defined in Tools > Options
Start Compression:	Start the compression process

Result of the compression process is saved in the same folder as the source file. The start of the file name is the same as the source bitmap file; resolution and color format are added to the end of the file name.

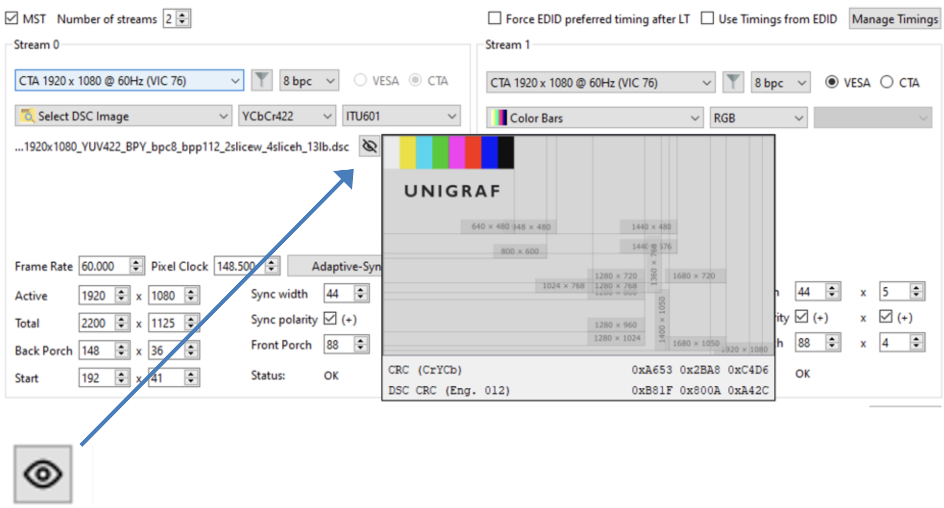
Example:
unigraf_default_image_16k.ppm >>
unigraf_default_image_16k_1920x1080_YUV422_FULL_bpc8_bpp6.dsc

To use the created DSC file in Pattern Generator, select pattern: *Select DSC Image* and click *Select …* to open file selection dialog.



When a DSC image is selected as the pattern, UCD Console will automatically enable DSC, provided that the connected Sink device declares support for DSC in its DPCD.

Preview DSC image

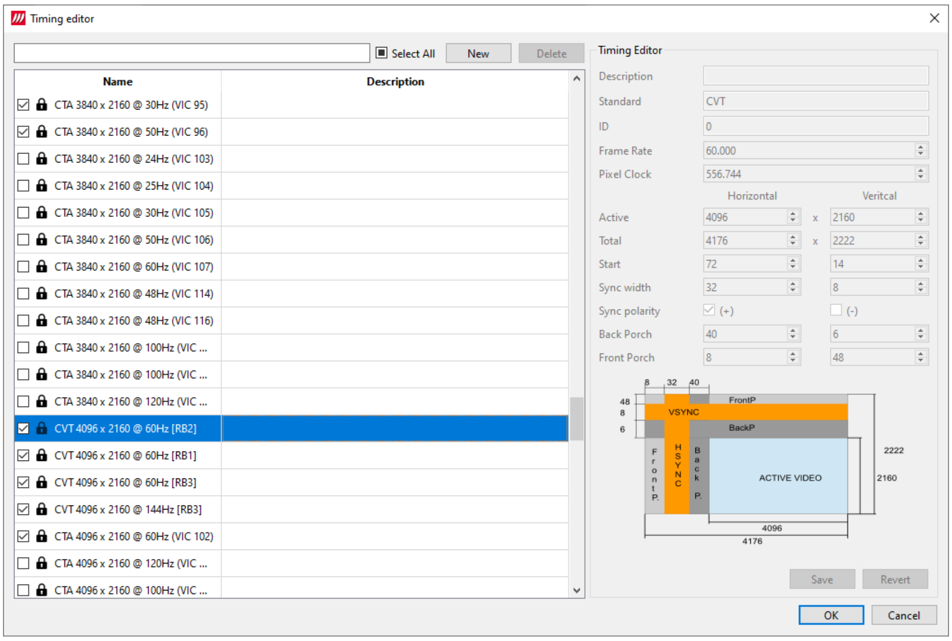


To preview an DSC image before it is applied to the pattern generator, select the eye icon. CRC and DSC CRC values will be indicated in the preview image.

Note:	Please note that the selected video mode has to match the used compressed DSC file.

Manage Timings

Custom timings can also be created and edited with pop-up *Timing Editor*. Launch the editor by clicking **Manage Timings**.



Customizing Timings List

The list of timings that are shown on the pull-down menu in Pattern Generator and Link tabs can be limited by un-checking the checkbox in the left edge of *Name* column. The timings will remain in the list and can be brought back to the pull-down menu, when needed.

Editing Timings

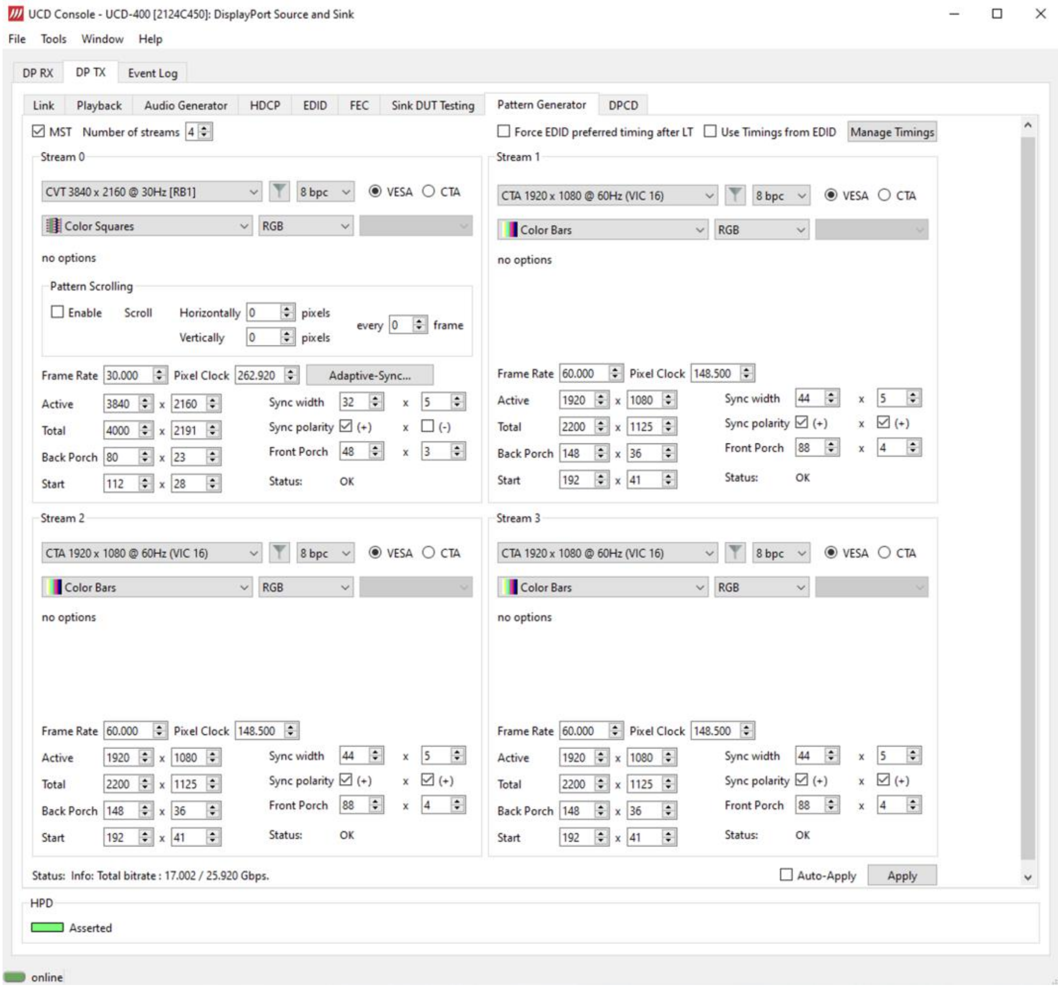
Video timing Name and Description are shown in the list. Lock icon indicates that a timing is a fixed timing which cannot be edited or deleted. Custom timings are indicated with a head icon .

New:	Create a new custom timing based on the selected fixed timing.
Delete:	Delete the selected custom timing
Save:	Save changes in the selected custom timing.
Revert:	Undo all changes

The dialog will make a sanity check for the values entered and will warn the user for any combinations that cannot be used.

MST Operation (UCD-400, UCD-411, UCD-424, UCD-451)

Multi-streaming can be enabled from **MST** check box and selecting the number of streams sourced.

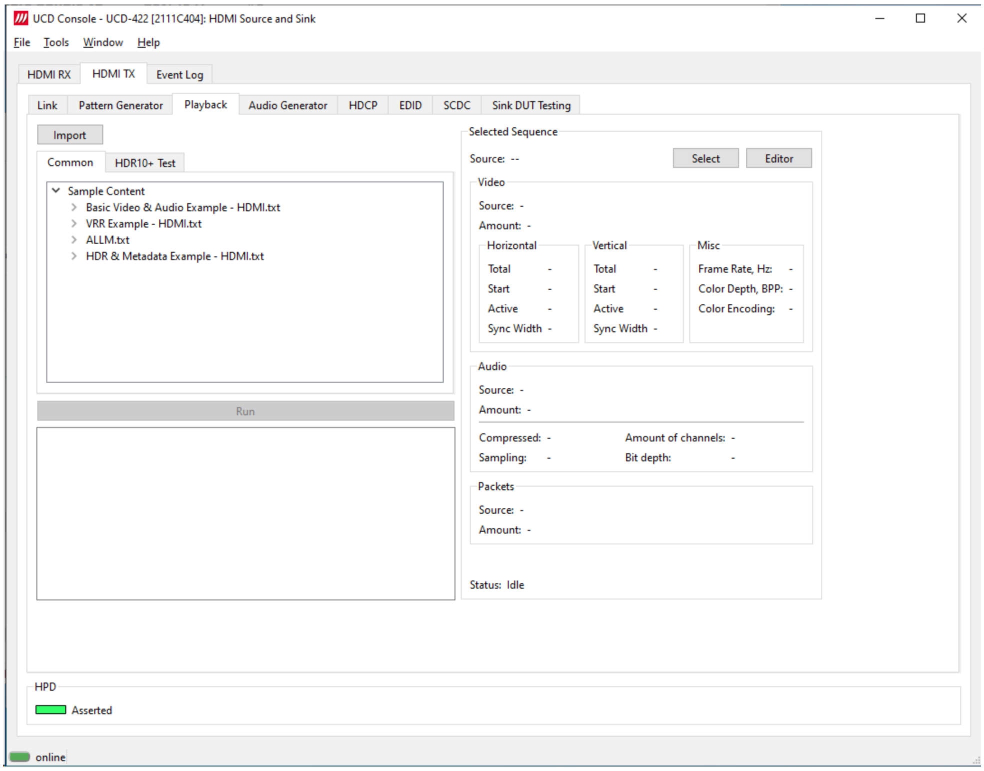


MST:	Checkbox for enabling Multi-stream transport (MST) mode. (UCD-400, UCD-411, UCD-424 and UCD-451)
Number of Streams:	When *MST* is enabled, select the number of streams sourced.

Playback Tab

Playback allows for running predefined *Playlist* files. Playlist contains a set of *Scenarios* with definitions of the timing, video pattern, audio content and related metadata packets and their duration.

Sample playlists are included in UCD Console by default. Content can be imported or edited.



Playlist

Playlist defines the UCD device and the output where the content is played. It lists the played Scenarios and their duration.

Scenario

Scenario is an operating structure that allows user to determine a specific sequence of video frames, metadata packets and audio that are going to be played in the defined order.

Playlists and Scenarios are stored as human readable text files. The files can be edited using any text-editor software.

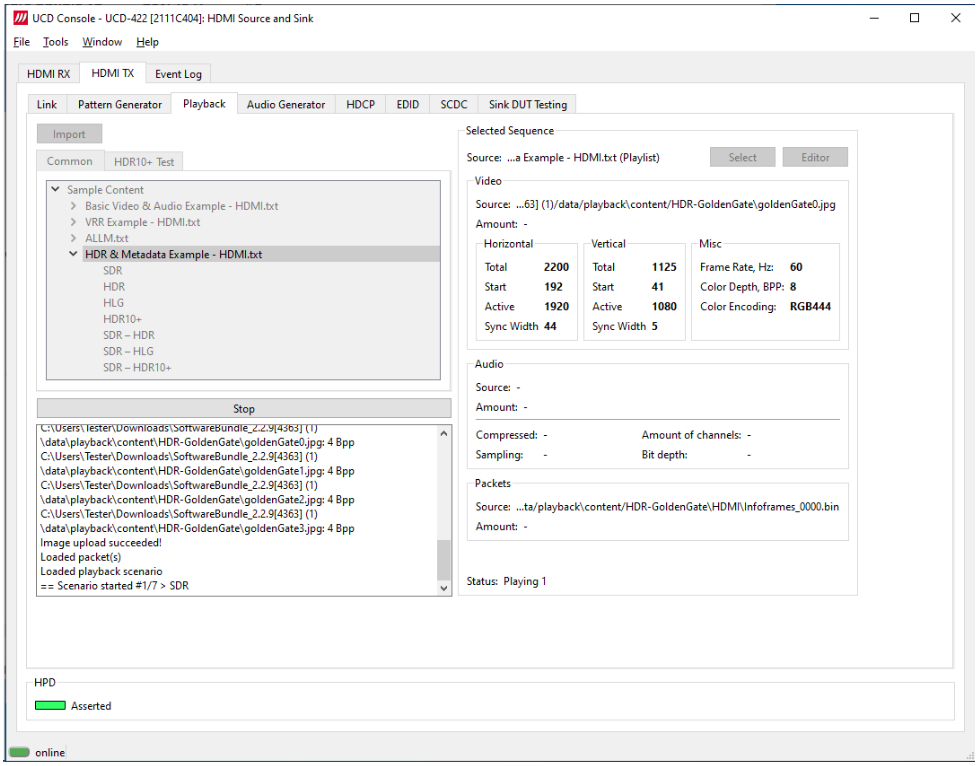
Advanced Playlists

Unigraf UCD devices can also be used as a compatibility test tool for dedicated standards like Dolby Vision™ and HDR10+. Please contact Unigraf for details.

Note: Please note that Playlists and Scenarios are interface technology dependent.
The provided examples are also somewhat different for HDMI and DisplayPort.

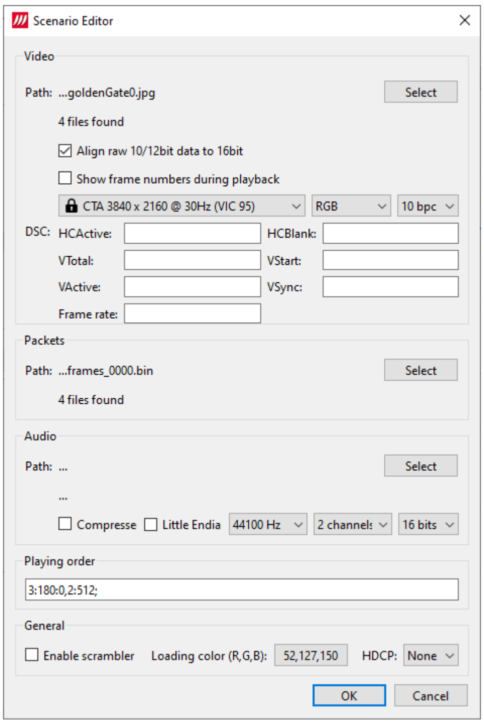
Selected Sequence

Currently run sequence and its details is indicated in *Selected Sequence* on the right. The executed steps of the scenario are listed in the *Status Log*.



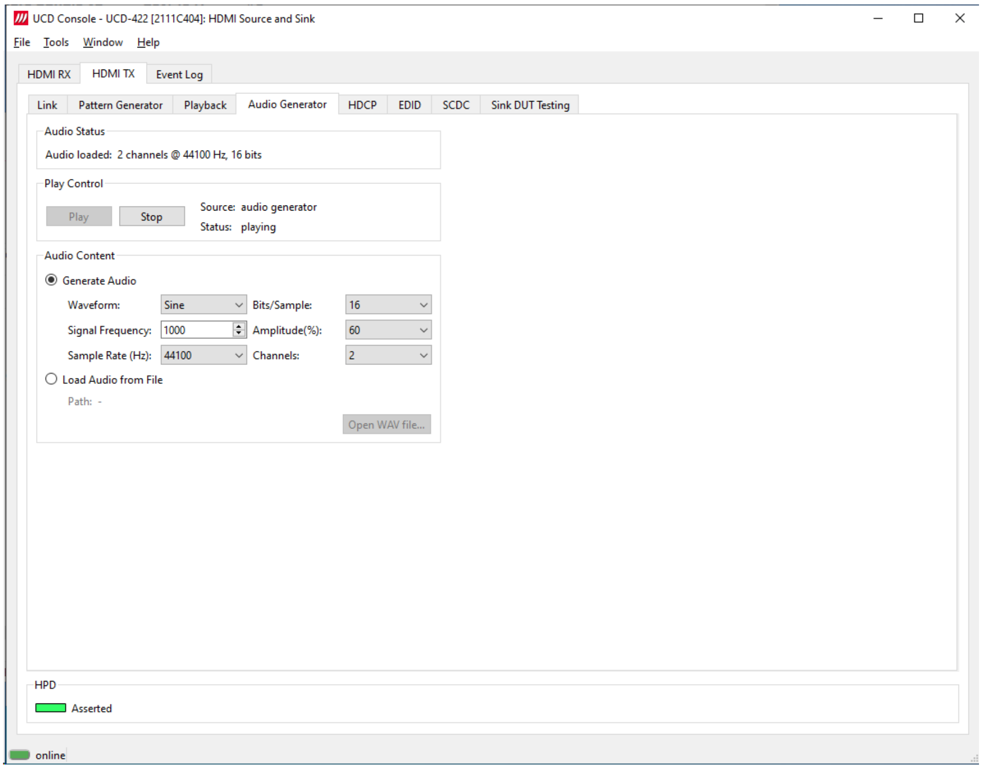
Scenario Editor

Details of a Scenario can be edited with *Scenario Editor*. Please refer to *Appendix H: Scenarios and Playlists* later in this manual for details of Scenarios.



Audio Generator Tab

Audio generator allows the user to play LPCM audio generated internally or from files in WAV format. Audio is played to all active ports.



To load internally generated audio, select **Generate audio**, and adjust the controls to the desired audio format.

To load an audio file from your PC, select **Load audio from file**, click the **Open WAV file…** button, browse and select the file and click **Open**

To play the selected audio content, click the **Play** button.

The content will be looped until the **Stop** button is clicked.

Audio Status in the top of the tab indicates the type of the currently played audio content.

Audio Content

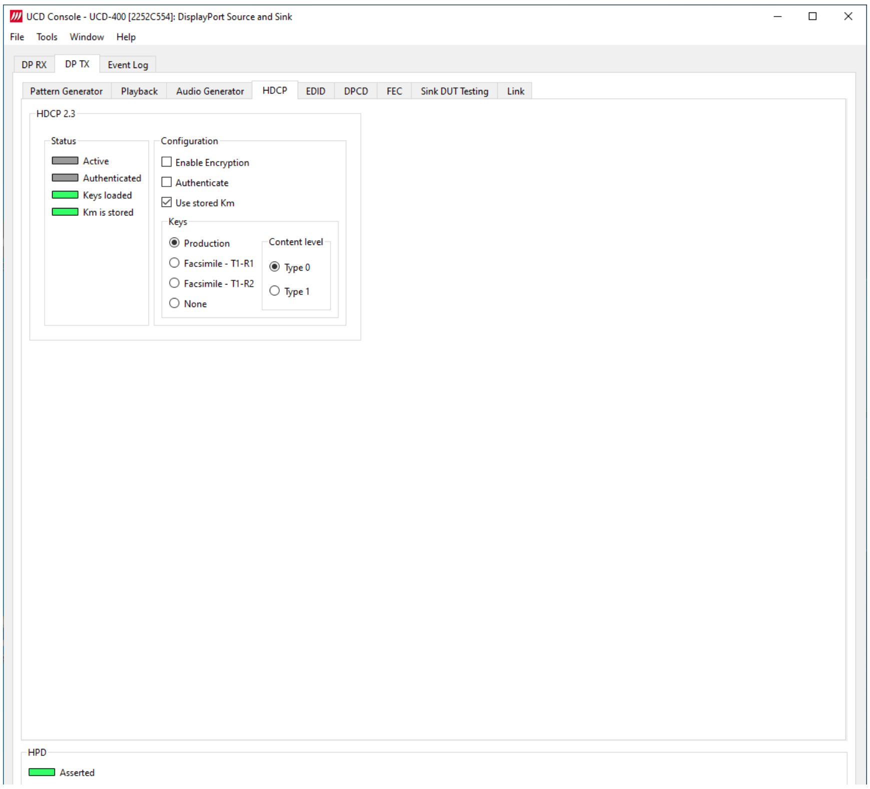
Sent audio can be generated internally or used a WAV file loaded from the PC.

In case of a WAV audio file, the parameters stored in the file will be used. When generating audio internally, the user sets the details of the LPCM Audio signal.

Waveform	Selection of audio waveform: Sine, Sawtooth, Square, or Incremental
Signal Frequency	Setting audio signal frequency in Hz
Sample Rate (Hz)	Selection of audio sampling rate: 32000, 44100 (default), 48000, 88200, 96000, 176400, 192000
Bits/Sample	Selection of sample bit depth: 16, 24
Amplitude(%)	Selection of audio amplitude: 10%, 20%, …, 90%, 100%
Channels	Selection of sent audio channels: 1, 2, …, 7, 8. When selecting 1 or 2 audio channels '1 and 2 channel LPCM Audio mode' is used and when 3 and more channels '3- to 8-channel LPCM Audio mode' is used.

HDCP Tab

HDCP tab is the dialog for monitoring the HDCP (for *High-Bandwith Digital Content Protection*) status and controlling the HDCP capabilities of the UCD device.



Status

The status fields indicate the HDCP status of the UCD device.

Active:	The stream between UCD and the downstream sink has been encrypted.
Authenticated:	HDCP handshake between the UCD and the sink unit has been completed successfully.
Keys loaded:	HDCP keys are loaded to the UCD unit.
Km is stored:	Master Key (Km) is stored

Configuration

Enable encryption:	Check to enable the encryption of the stream between UCD and the downstream sink.
Authenticate:	Perform the HDCP initiation handshake between the UCD and the sink unit.
Use stored Km:	Use stored Master key (Km)

Keys

Select between *Production* and *Facsimile* HDCP keys. To remove the keys, select *None*.

Content level

Selection of Type 1 content ensures that content encryption is done with HDCP version 2.2 or higher.

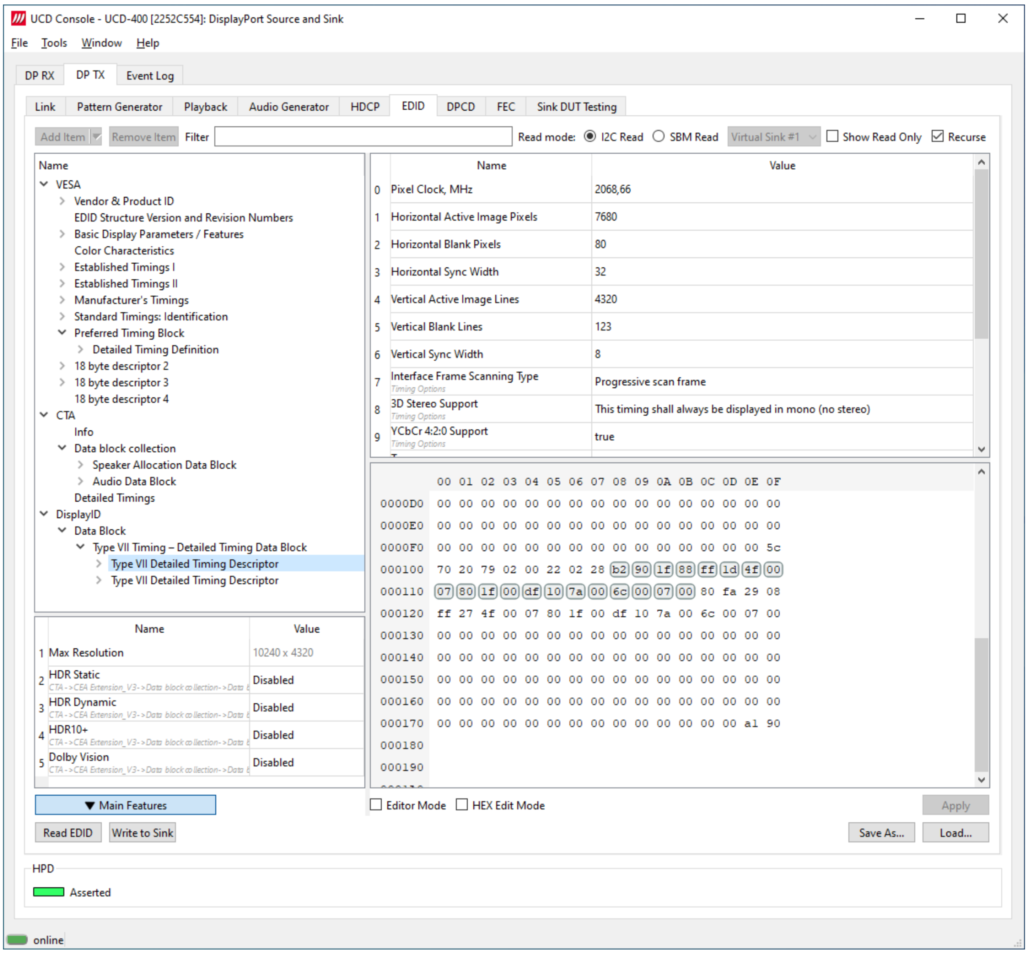
HDCP 1.3 / 1.4 vs. HDCP 2.3

Currently, UCD-4XX DP and USB-C DP Alt Mode devices support only HDCP 2.3 standard. Currently, UCD-4XX HDMI devices do not support HDCP.

EDID Tab

EDID Tab provides tools for accessing the EDID including DisplayID extension of the connected sink device. There are three basic functions:

- Load and save EDID data files in the host PC.
- Edit the EDID contents either in EDID Editor or in hex format.
- Program and read the contents of the EDID of the connected sink. Up to 4 virtual channels can be accessed.



EDID Files

With **Load…** and **Save as…** a hex EDID file can be read and written from the PC. Please note that the program does not alter the contents of the EDID file or verify its integrity during load and save operation.

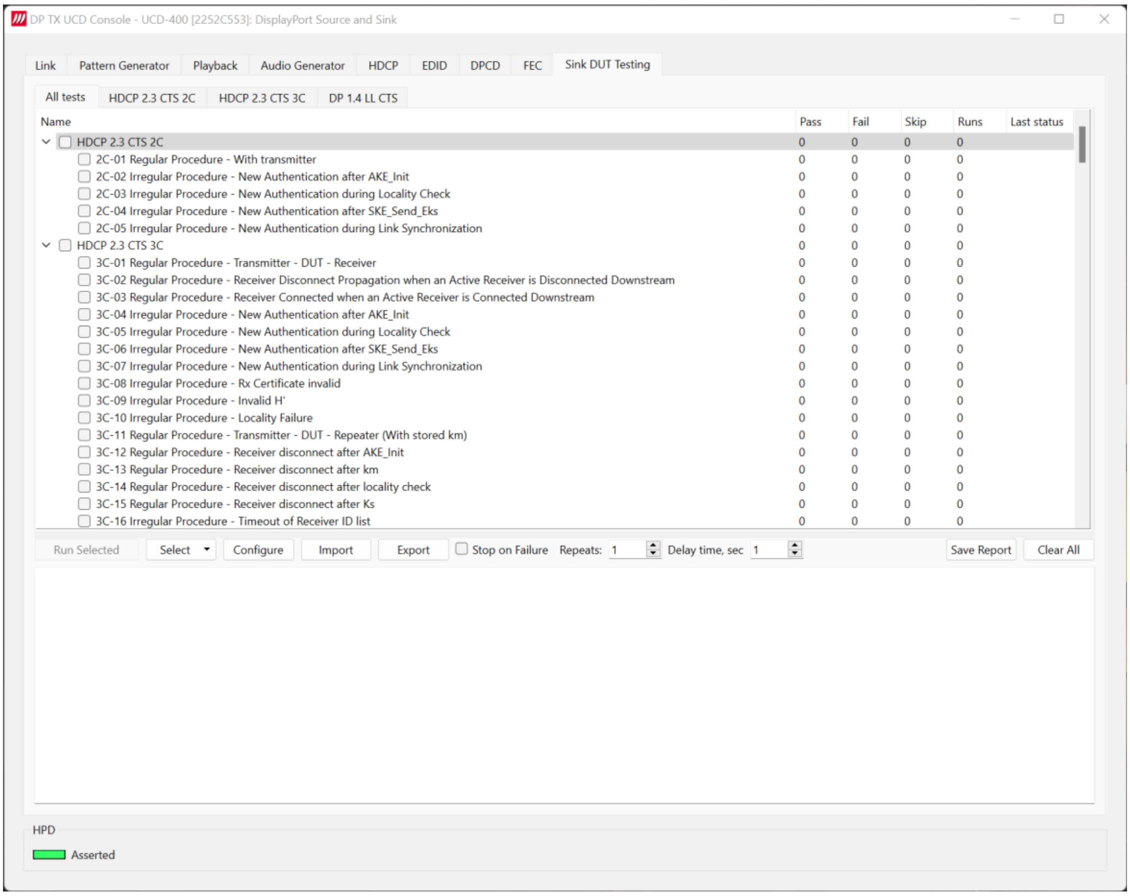
Note: Four blocks (512 bytes) of EDID code are read. If the device is not supporting all four blocks, the non-supported area is replaced with blanks.

EDID Editor

Please see the description of the EDID editor in Chapter EDID Editor later in this document.

Sink DUT Testing Tab

Please refer to **Appendix E** later in this document for description of the tests available.



Select the tests for execution by selecting corresponding checkboxes or by highlighting them by left-clicking on the test name.

Run Selected:	Click to start selected tests. By clicking *Abort* the sequence is stopped.
Select:	Includes the following options for creating templates for tests execution: Select All, Clear All, Invert All, Save, Import and Export
Configure:	Clicking opens a dialog for defining the test parameters for the selected test set. Please refer to *Test Parameters* below for details.
Import:	Load saved test parameter files (*.td or *.json).
Export:	Save test parameters for later use or for use in test automation. For saving parameters for later use in UCD Console, either format can be used. For saving parameters for TSI scripting, please use *.td files. For use with Python applications, please use *.json files.
Stop on Failure:	Stops execution of the selected tests if one of the tests fail
Repeats:	Repeat the selected test several times
Delay time:	Delay in seconds between individual tests.

At the completion of each test the result of the test is indicated in the matrix on the right hand side of the test panel. For each test the matrix lists the number of occurrences of each result and the number of tries performed.

Save Report:	Click to generate a report file in HTML format for sharing the results with other parties for viewing without UCD Console.
Clear All:	Clear the test log and the results matrix

Test Parameters

Each test set has its dedicated set of test parameters. To open a dialog for defining the parameters click **Configure**.

Description of parameters for each test set can be found within the description of tests in Appendix E of this document.

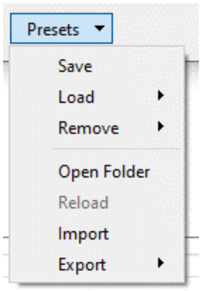
Saving Test Parameters

Test parameters can be saved in various ways.

- Export parameters in *Sink DUT Testing* tab to a *.td file for later use in UCD Console or with TSI scripting or sharing.
- Export parameters in *Sink DUT Testing* tab to a *.json file for later use in UCD Console or with Python applications or sharing.
- Save parameters in *Configure* dialog as Presets to be later used in UCD Console. Please find a description below.

Presets

In all *Configure* dialogs the selected parameters can be saved as Presets. Please click **Presets…** to save or recall a configuration. Click Save first to assign the configuration a name, and after that you can e.g. Export it to a file.



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DP and DP Alt Mode Reference Source

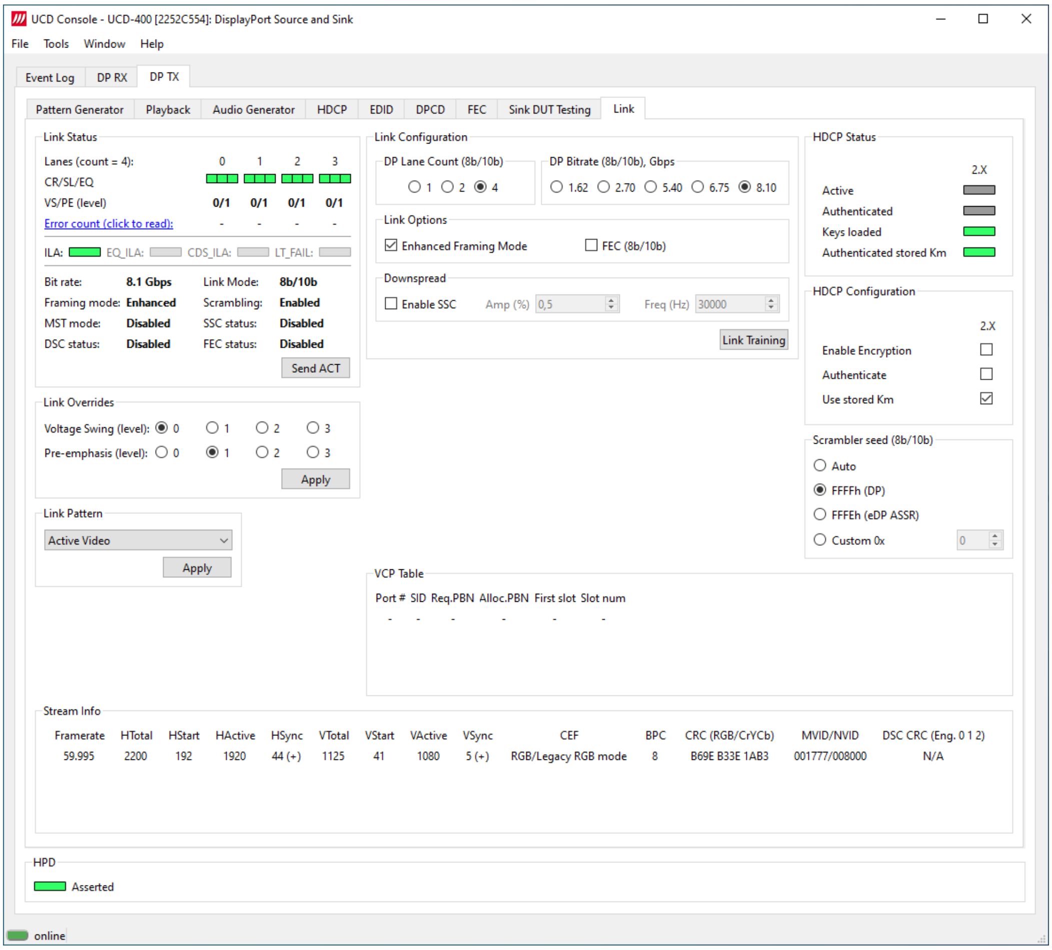
Role:	Product:
DP Reference Source (DP TX)	UCD-400, UCD-411, UCD-451
USB-C DP Alt Mode Reference Source (DP TX)	UCD-424

When roles *DP Reference Source* or *DP Alt Mode Reference Source* are in use, the following interface specific tabs are available.

- Status information and control of the downstream link (Link).
- DPCD monitor (DPCD)
- Forward Error Correction (FEC)

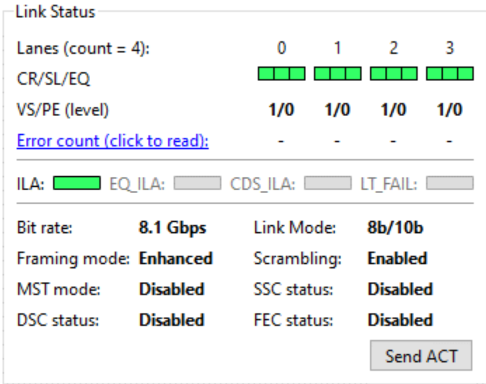
Link Tab

Link tab shows the status and control items for the DisplayPort link.



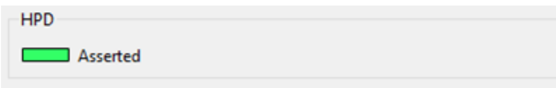
Link Status

Link Status displays the status of the link training and the link parameters negotiated between the connected Sink and UCD Source. It also lists status of other link modes. The data is retrieved from the DPCD status registers of the connected Sink. The status is updated automatically.



Lanes:	Indicates the number of lanes used for DisplayPort or DisplayPort Alt Mode.
CR/SL/EQ:	LED indicators for status of Clock Recovery / Symbol Lock / Channel Equalization
VS/PE (level):	Voltage Swing / Pre-emphasis level
Error count:	Content of DPCD Error Count registers
ILA:	Status LED for Inter-Lane Alignment
Bit rate:	Currently enabled link bit rate
Link mode:	Currently enabled channel coding (8b/10b only)
Framing mode:	Status of Enhanced Framing symbol sequence
Scrambling:	Status of link data scrambling (Enabled or Disabled)
MST mode:	Status of the Multistreaming (MST) mode
SSC status:	Status of down spreading of link frequency (SSC) function
DSC Status:	Status of Display Stream Compression (DSC) function
FEC status:	Status of Forward Error Correction (FEC) function.
Send ACT:	Force sending an Allocation Change Trigger (ACT) sequence over the Main-Link

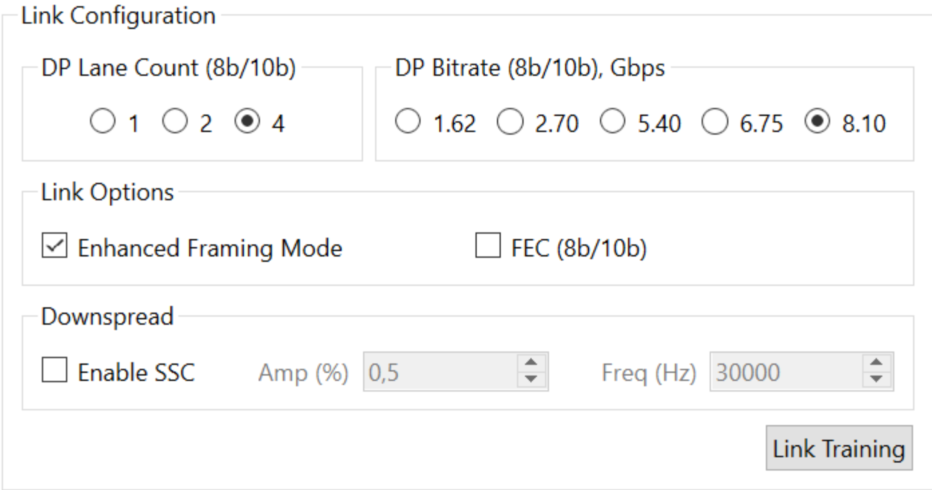
HPD



Asserted:	LED indicates status of Hot Plug Detect (HPD) signal

Link configuration

Set target capabilities for the link training. Click **Link Training** to apply.



DP1.4 Number of Lanes	Lane count used when 8b/10b link coding is selected in LT
DP1.4 Bitrate, Gbps	Link rate used when 8b/10b link coding is selected in LT
Enhanced Framing Mode	Enable Enhanced Framing Mode
FEC (8/10b)	Enable Forward Error Correction feature (only in 8b/10b coding)
Enable SSC	Enable Downspread of link frequency (SSC).
Amp (‰)	SSC Spreading Amplitude. Fixed 0.5% Downspread. Amplitude range setting will be supported in future versions of UCD-4XX.
Freq (Hz)	SSC Modulation frequency. Fixed 30 kHz frequency. Frequency range setting will be supported in future versions of UCD-4XX.

Link Overrides

Override Voltage Swing and Pre-emphasis levels selected during link training. Click **Apply** to validate changes.

Link Pattern

Select between Active video and audio, Idle pattern, or special bit patterns.

Active Video	Transmit Video Pattern, Audio and Metadata
Idle Pattern	Link is active but no stream data is being transmitted
Training Pattern 1	Send Link Training Pattern Sequence 1 (TPS1)
Training Pattern 2	Send Link Training Pattern Sequence 2 (TPS2)
Training Pattern 3	Send Link Training Pattern Sequence 3 (TPS3)
Training Pattern 4	Send Link Training Pattern Sequence 4 (TPS4)
PRBS7	Send PRBS7 Link Quality Test Pattern
HBR2 Compliance EYE pattern	Send HBR2 Compliance EYE pattern
SER (Symbol Error Rate)	Send Symbol Error Rate Measurement pattern
Force Video	Character error messages from sink will not interrupt video transmission.
Force Idle	Link Training and Active Video will not be initiated even after a re-plug

Note: Please note that except for *Active Video* and *Idle Pattern*, Link Training will NOT be initiated on such events as cable re-plug, Long HPD pulse and IRQ_HPD pulse due to link loss.

After using the special bit patterns, in order to return to the default operation mode, please select *Active Video* and click *Apply.*

Stream Info

Stream Info is achieved from the Main-Stream Attributes (MSA) of the stream.

Stream Info

Framerate	HTotal	HStart	HActive	HSync	VTotal	VStart	VActive	VSync	CEF	BPC	CRC (RGB/CrYCb)	MVID/NVID	DSC CRC (Eng. 0 1 2)
59.985	2200	192	1920	44 (+)	1125	41	1080	5 (+)	RGB/Legacy RGB mode	8	B69E B33E 1AB3	001776/008000	N/A
59.995	2200	192	1920	44 (+)	1125	41	1080	5 (+)	RGB/Legacy RGB mode	8	B69E B33E 1AB3	001777/008000	N/A

The content of *Stream Info* table can be copied by right-clicking on the table and selecting **Copy**.

Framerate	Vertical refresh rate
HTotal	Horizontal total of transmitted main video stream, measured in pixel count.
HStart	Horizontal active start from leading edge of HSync, measured in pixel count.
HActive	Horizontal active, number of active pixels in video line
HSync	HSync width, measured in pixel count. (+)/(-) positive / negative sync.
VTotal	Vertical total of transmitted main video stream, measured in line count.
VStart	Vertical active start from leading edge of VSync, measured in line count.
VActive	Vertical active, number of active lines in video frame
VSync	VSync width, measured in line count. (+)/(-) positive v.s. negative sync.
CEF	Used color mode: Color format + subsampling / colorimetry
BPC	Color depth in bits per color (BPC)
CRC (RGB/CrYCb)	16-bit Cyclic redundancy check (CRC) value per color component calculated from active pixels. Value order in YCbCr color format: Cr, Y, Cb.
MVID/NVID	Mvid and Nvid video time stamp values
DSC CRC	16-bit Cyclic redundancy check (CRC) calculated from compressed pixel stream. Value order Engine 0, 1, 2.

VCP Table

VCP table shows allocation of Virtual Channel Payload for active virtual MST channels.

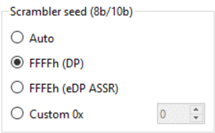
VCP Table

Port #	SID	Req.PBN	Alloc.PBN	First slot	Slot num
0	1	532	540	1	9
1	2	532	540	10	9
2	3	532	540	19	9
3	4	532	540	28	9

The content of *VCP Table* can be copied by right-clicking on the table and selecting **Copy**.

Port #:	Port number where the virtual channel is directed.
SID:	Stream identification number of the virtual channel
Req.PBN:	Requested PBN (payload bandwidth) value for the virtual channel
Alloc.PBN:	PBN value allocated for the virtual channel
First slot:	Time slot where the first VC Payload for the virtual channel is stored
Slot num:	Number of VC Payload slots reserved for the virtual channel.

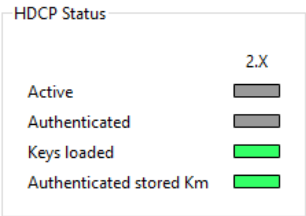
Scrambler Seed



Selection of the value to which the Linear Feedback Shift Register (LFSR) is reset during scrambler reset. Used only when 8b/10b link coding is enabled.

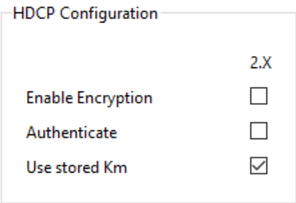
HDCP Status

Duplicate of the status in HDCP Tab. Please refer to chapter *HDCP Tab* earlier in this document for detailed description.



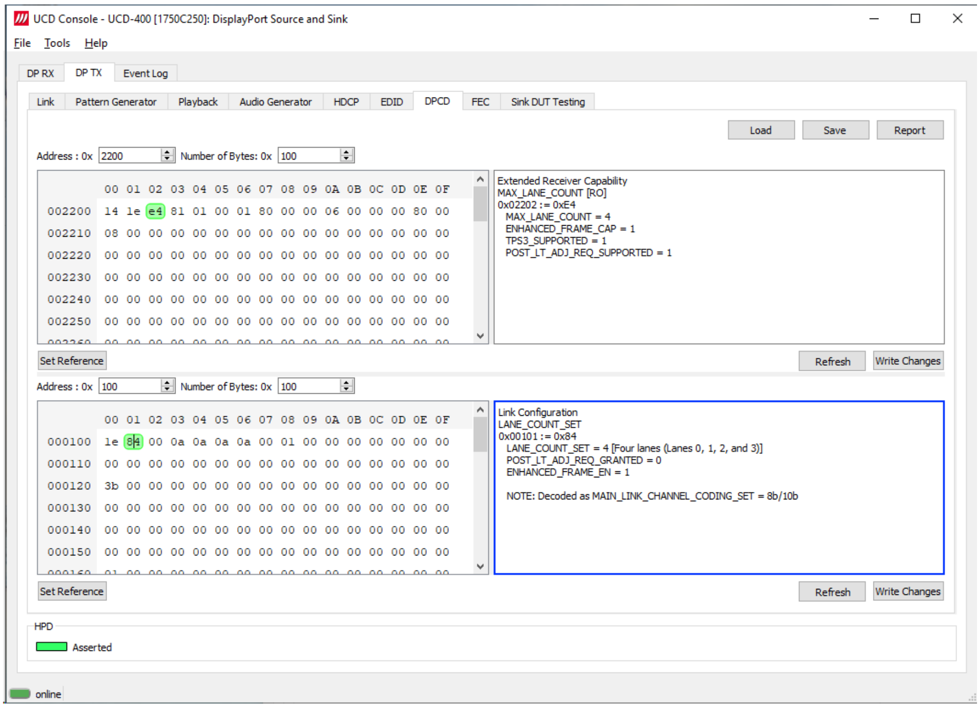
HDCP Configuration

Enable and disable HDCP 1.3 or HDCP 2.3 encryption. Duplicates of the controls found in HDCP tab.



DPCD Tab

DPCD tab is a tool for monitoring and editing the DPCD registers of the connected DisplayPort or DisplayPort Alt Mode Sink.



The *DPCD Decoder* panels on the right show the interpretation of the DPCD byte selected on the monitoring windows. The selected byte is shown with a green background.

Save:	Select DPCD content to the PC (please see below).
Load:	Retrieve previously saved DPCD data (please see below).
Report:	Save parsed content of selected DPCD register ranges as HTML file
Refresh:	Re-read the data from the DPCD registers to the window in question
Write Changes:	To program the data into the DPCD registers of the connected Sink
Set Reference:	Store currently shown data as a reference for comparison

When the data is *Refreshed* from the DPCD registers the changed bytes will be highlighted with **blue** color. The fields edited by the user will be highlighted with **red** color.

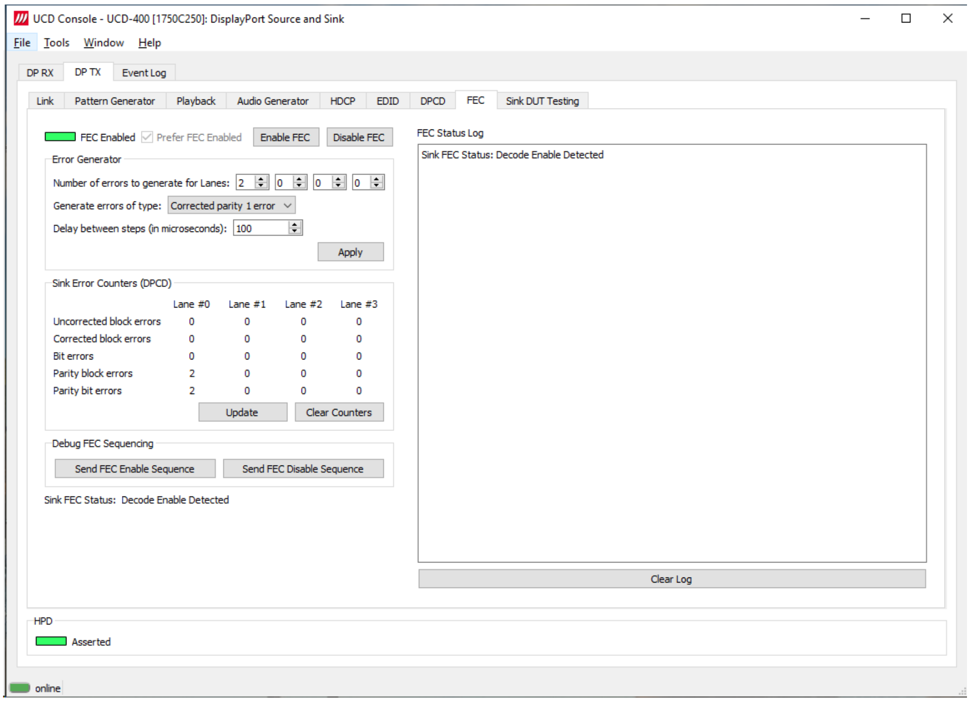
Saving and Loading DPCD Content

DPCD data in the selected address areas can be saved as a file in your PC. There are three alternative formats listed below. Please select the intended format when saving:

- Binary *DPCD Data File* format (*.DPD). This is Unigraf proprietary format. You can also load the DPCD content stored in this format.
- *Comma Separated Value* format (.CSV)
- *HEX Dump* (*.HEX) in a human readable text format.

FEC Tab

Forward Error Correction (FEC) can be enabled if connected sink supports it. For debug purposes, error injection to Main-link is possible. There is an error type for each standard sink DPCD error counter.



Enable FEC	UCD will verify if connected sink supports FEC and begins the handshake for enabling FEC.
Disable FEC	UCD will start the FEC disable handshake.
Prefer FEC Enabled	If selected, and the connected sink supports FEC, UCD will start the FEC Enable Sequence after a successful connection.

Error Generator

Selections will set how many errors will be inserted into one FEC block and to which link symbols. There are five options:

Uncorrected block	3 symbol errors with 3 error bits together
Corrected block	1 symbol errors with 1 error bits together
Corrected parity	1 parity byte errors with 1 error bits together
Corrected block 1 error	
Corrected parity 1 error	

Note: FEC must be enabled and running before errors can be added.
Link training will reset sink FEC error counters.

Each lane can have its individual error amount. When only one lane is enabled, errors can be injected to even and odd decoders by using **lane #0** and **lane #1** counters.

Apply	Start error injection
Update	Read sink DPCD FEC error counter registers
Clear counters	Clear sink DPCD FEC error counter registers
Send FEC Enable Sequence	UCD-4XX will start adding FEC Enable Sequence in its main link data.
Send FEC Disable Sequence	UCD-4XX will start adding FEC Disable Sequence in its main link data.

HDMI Reference Source

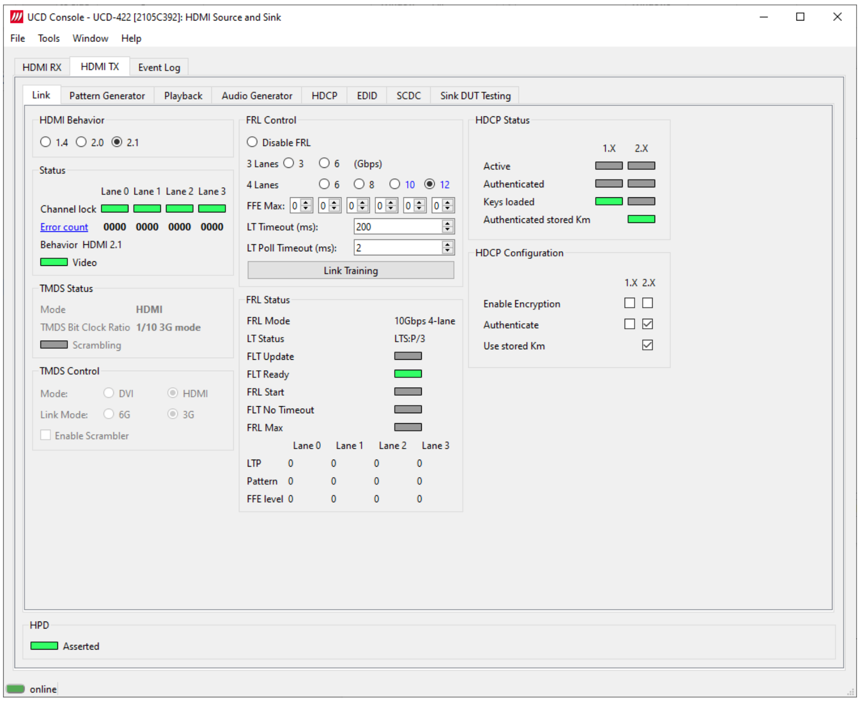
Role:	Product:
HDMI Reference Source (HDMI TX)	UCD-422, UCD-412, UCD-452

When roles *HDMI Reference Source* is in use, the following interface specific tabs are available.

- Status information and control of the downstream link (Link)
- SCDC monitor (SCDC)

Link Tab

Link tab shows the status and control items for the HDMI link.



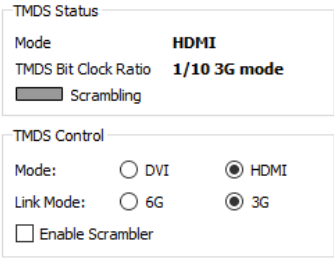
HDMI Behavior

Selection of the HDMI version to be used (HDMI 1.4 / HDMI 2.0 / HDMI 2.1).

Status

Channel lock:	Status of Channel Lock in the four lanes
Error count:	Contents of the SCDC Error counter registers of the connected Sink.
Behavior:	Assigned HDMI mode
Video	Video signal status

TMDS Status (only in TMDS mode)

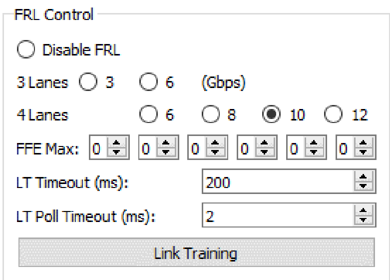


Mode:	Status of the HDMI/TMDS mode (HDMI/DVI)
TMDS Bit Clock Ratio:	Status of TMDS_Bit_Clock_Ratio bit in SCDC – TMDS Configuration (1/10 or 1/40)
Scrambling:	Status of TMDS_Scrambler_Status bit in SCDC – TMDS Scrambler Status (1=LED on; 0=LED off)

TMDS Control (only in TMDS mode)

Mode:	Selection of the HDMI/TMDS mode (HDMI/DVI)
Link Mode:	Selection of TMDS Bit Period / TMDS Clock Period ratio (1/10 or 1/40) (3G / 6G)
Enable Scrambler:	Control of Scrambling_Enable bit

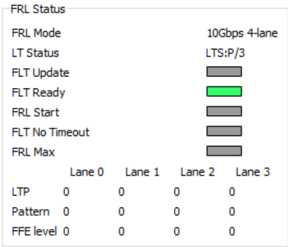
FRL Control



Disable FRL:	Disable FRL mode
Capability Radio Buttons:	Selection of the link mode used for FRL link training.
FFE Max:	Set the maximum FFE level (0 to 4) supported for each FRL rate
LT Timeout:	The time used for FLT Timer (default = 200 ms)
LT Poll Timeout:	Poll interval for FLT_update flag (default = 2 ms)

Please click **Link Training** to apply

FRL Status

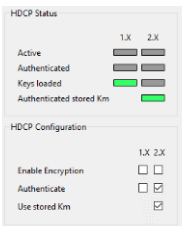


FRL Mode:	FRL Mode used by UCD-4XX HDMI source
LT Status:	FRL link training status of UCD-4XX HDMI source
FLT Update:	Status of FLT_update flag in SCDC Update Flags register of the connected HDMI sink.
FLT Ready:	Status of FLT_ready flag in SCDC Status Flags register of the connected HDMI sink.
FRL Start:	Status of FLT_start flag in SCDC Update Flags register of the connected HDMI sink.
FLT No Timeout:	Status of FLT_no_timeout flag in SCDC Source Test Configuration register of the connected HDMI sink.
FRL Max:	Status of FRL_Max flag in SCDC Source Test Configuration register of the connected HDMI sink.

Lane Status Matrix

LTP:	Status of Lnx_LTP_req (x = 0 to 3) fields in SCDC Status Flags register of the connected HDMI sink
Pattern:	Link Training Pattern used (0 to 8)
FFE Level:	FFE level used (0 to 3)

HDCP Status



Copy of the status from HDCP Tab. Please refer to chapter *HDCP Tab* later in this document for detailed description.

HDCP Configuration

Enable and disable HDCP 1.4 or HDCP 2.3 capability of UCD-422 and UCD-412 Sink. Duplicates of the controls found in HDCP tab.

Note:	Currently HDCP is not supported

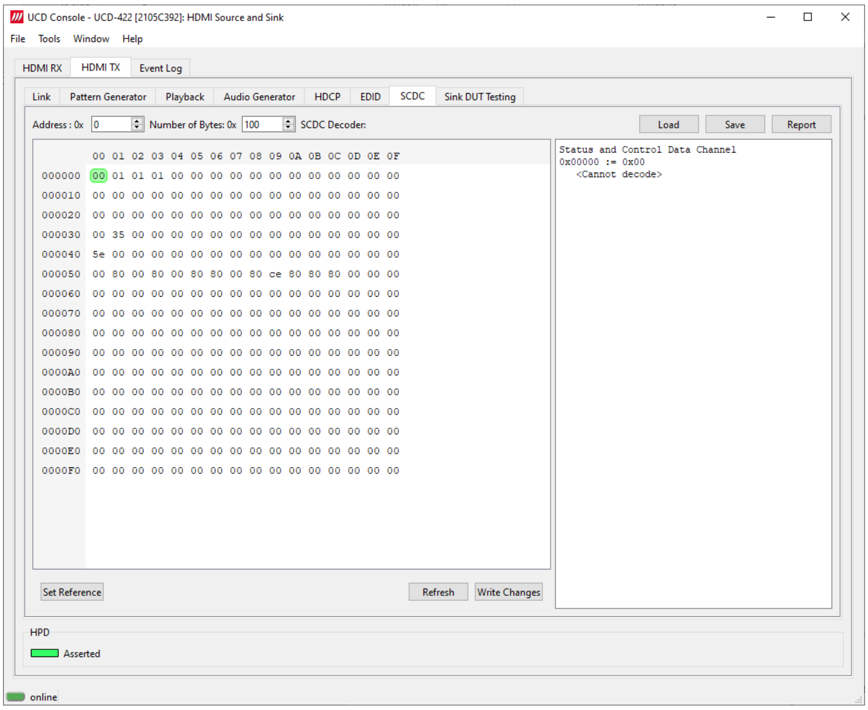
HPD (Bottom panel)

The status LED indicates the state of the HPD signal Asserted (logical "high") or De-asserted (logical "low").

SCDC Monitor

SCDC monitor presents content of HDMI Status and Control Data Channel (SCDC) structured by its address range.

The *SCDC Monitor* panel on the right hand side shows the interpretation of the SCDC byte selected



on the monitoring windows. The selected byte is shown with a green outline.

Save:	Select SCDC content to the PC (please see below).
Load:	Retrieve previously saved SCDC data (please see below).
Report:	Save parsed content of selected SCDC register ranges as HTML file
Refresh:	Re-read the data from the SCDC registers to the window in question
Write Changes:	To program the data into the SCDC registers of the connected Sink
Set Reference:	Store currently shown data as a reference for comparison

When the data is *Refreshed* from the DPCD registers the changed bytes will be highlighted with **blue** color. The fields edited by the user will be highlighted with **red** color.

Saving and Loading SCDC Content

SCDC data in the selected address areas can be saved as a file in your PC. There are three alternative formats listed below. Please select the intended format when saving:

- Binary *SCDC Data File* format (*.DPD). This is Unigraf proprietary format. You can also load the DPCD content stored in this format.
- *Comma Separated Value* format (.CSV)
- *HEX Dump* (*.HEX) in a human readable text format.

USB-C Monitoring

Role:	Product:
USB-C DP Alt Mode Reference Source (USB-C TX) or	UCD-424

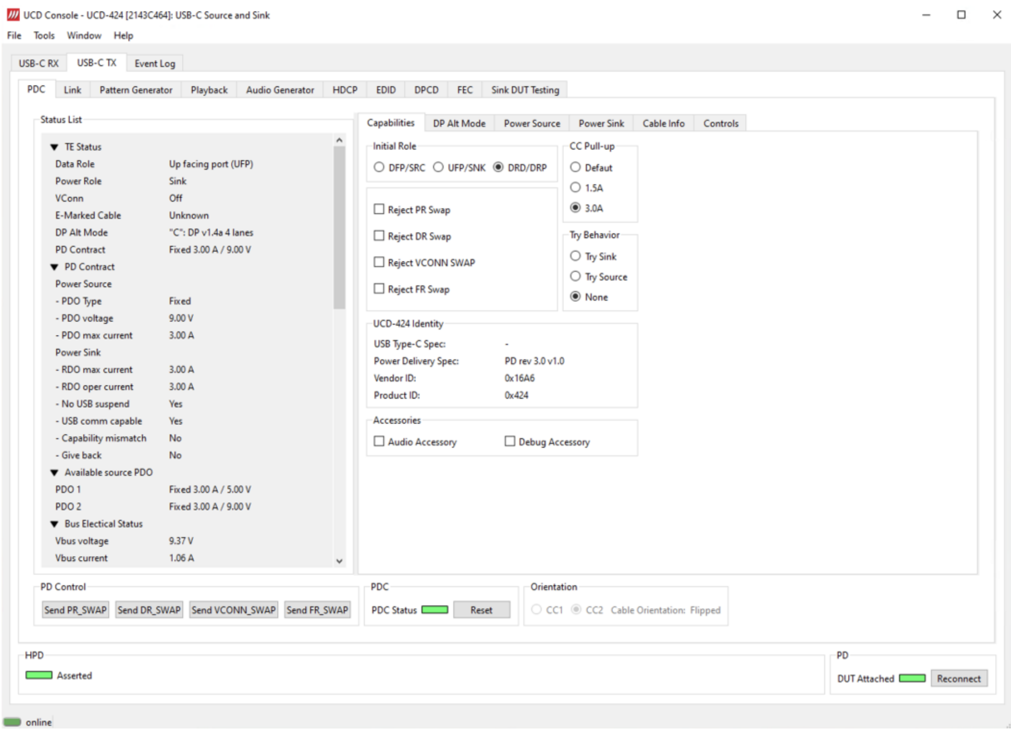
When *USB-C DP Alt Mode Reference Source* role is in use, the following interface specific tabs are available.

- USB-C Power Delivery (PDC)

USB-C Power Delivery Tab

When UCD-424 is used in *DP Alt Mode Reference Source* role, *USB-C Power Delivery* tab is available. The content of *USB-C Power Delivery* tab is similar to the tab available when in UCD-424 is used in *DP Alt Mode Reference Sink* role.

Please refer to chapter USB-C Monitoring in section 4. Analyzer Operation earlier in this document.

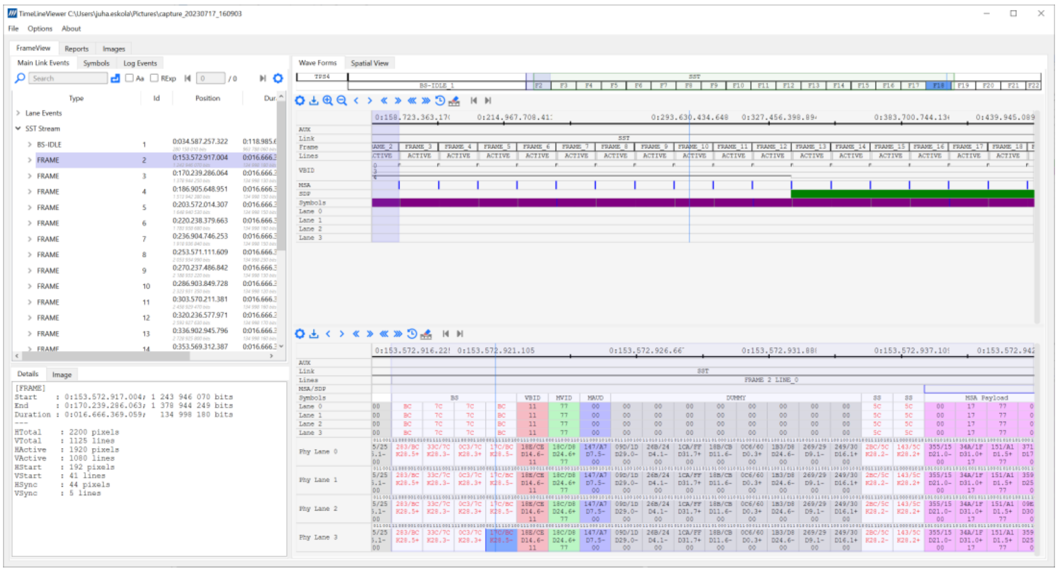


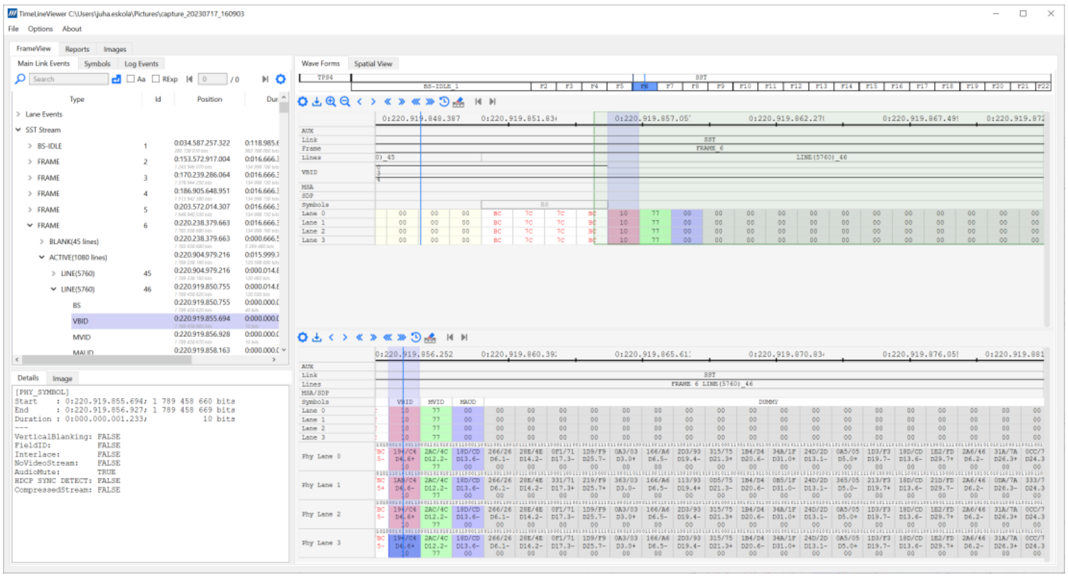
6. TIMELINE VIEWER

Timeline Viewer is a tool for evaluating the content and timing of data captured with *Link Analyzer* function of UCD Console. Timeline Viewer can be launched from UCD Console menu **Tools > Timeline Viewer**.

Timeline Viewer main panel contains two tabs:

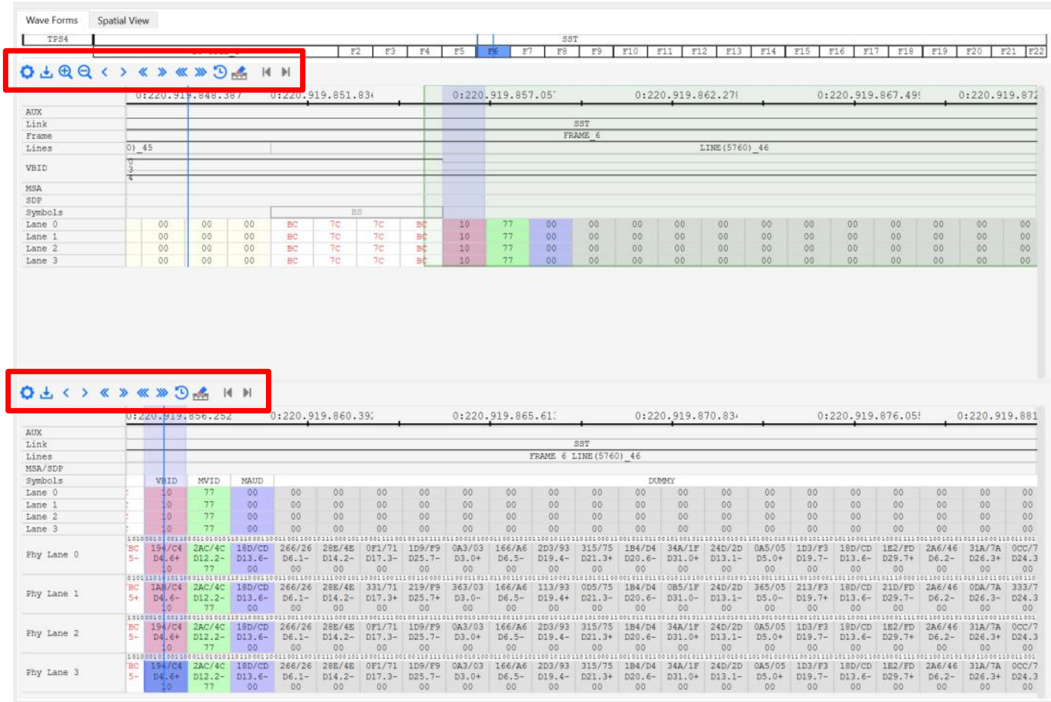
- *FrameView* provides the user ability to evaluate events within the captured data and their occurrence in time scale.
- *Images* lets the user view video frame images decoded from the captured data.



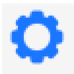


Note: When using TimeLine Viewer with MST, it's possible that all information for all streams are not fitted in the default window size. Below you can see how different streams are presented in ***Wave Form View*** and ***Symbol View.*** To make room for either of the view areas, please scale the areas from the area shown with the red box. You can also remove lines from both views to accommodate necessary information from all streams. Please refer to next chapter for detailed instructions.

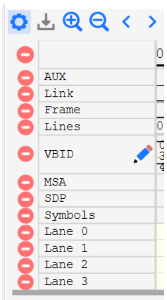
Wave Form and Symbol View Settings



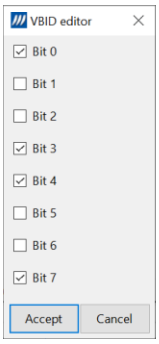
Gear Icon



The gear icon under the scroll bar allows users to select which events are shown in ***Wave Form and Symbol View***. Click the red circle to remove events. You can select which VBID events are shown by clicking the pen tool.

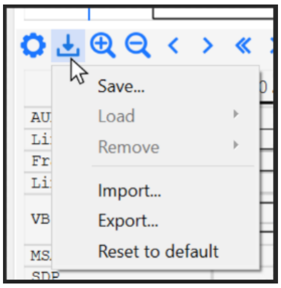


You can select which VBID bits are shown by clicking the pen tool.



Save Icon

By clicking the Save icon you can save, load and remove settings selected with the gear icon. You can also import and export .json files and reset settings to default.



Zooming

You can zoom in/out with the magnifying glass icons. The zooming in/out option applies to ***Wave Form View*** only.

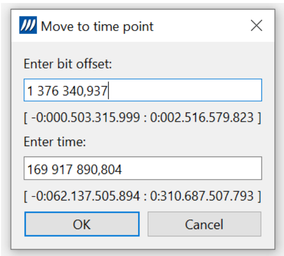
Scrolling

You can use the arrow keys to move in the timeline. One arrow moves the timeline one interval, two arros move it 10 intervals and three arrows move it 100 intervals.

Alternatively, you can scroll by clicking, holding and dragging.

Clock icon

With the clock icon you can move to a time point. Enter the values and press OK.



Eraser

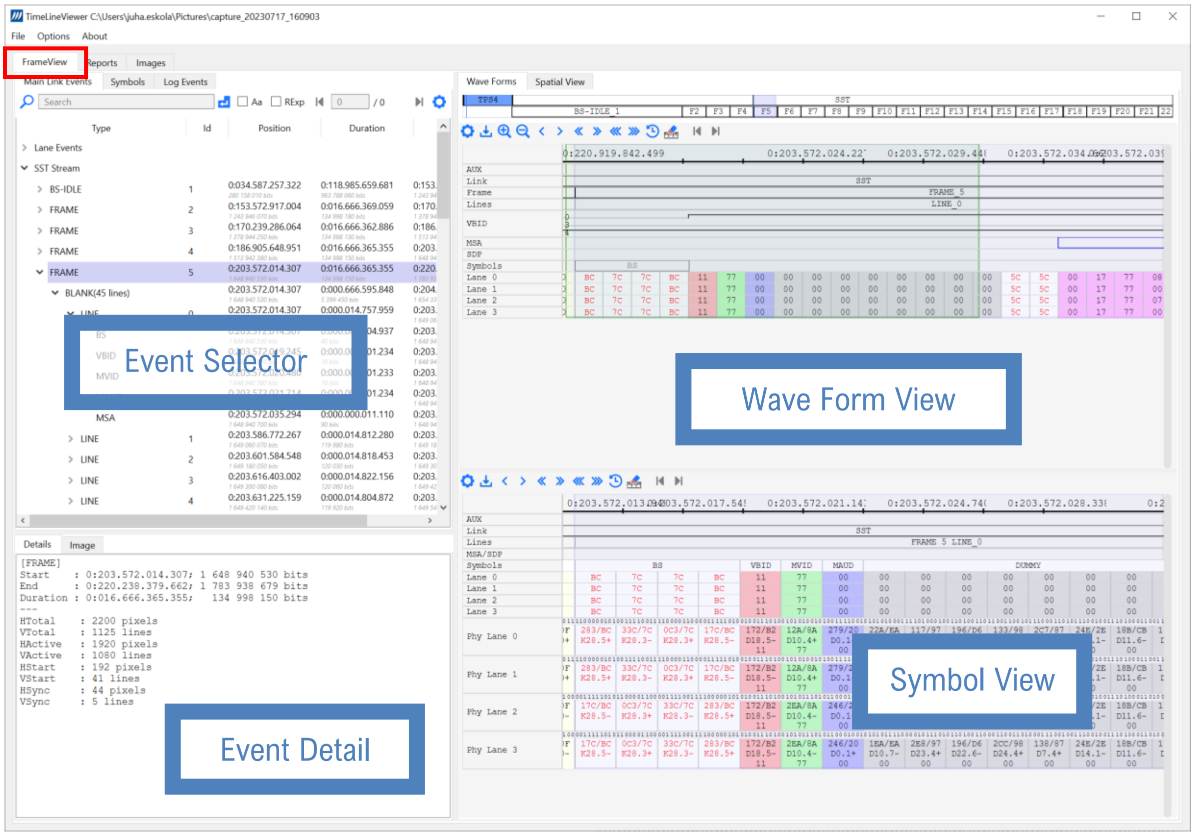
The eraser icon deletes all made measurements on the timeline.

FrameView Tab

FrameView tab consists of four areas shown in the image below.

- Event Selector
- Event Detail
- Wave Form View
- Symbol View

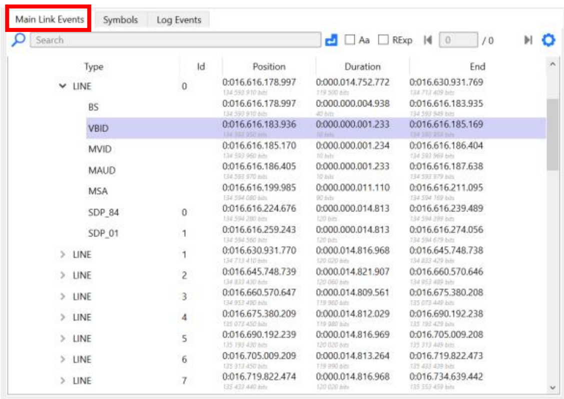
Each of these areas will be described in detail in the upcoming chapters. However, it is worth noting that all these areas are interconnected and actions in one area will affect the information shown in other areas.



Event Selector

Main Link Events

Main Link Events lists events, packets and symbols occurring during the time span of the captured data. By selecting items in *Main Link Events*, the user can easily locate the items of interest and get the ***Wave Form View*** and ***Symbol View*** panels focused for evaluating the item. In Event Selector the events are presented as a folding list of detected items. When opened, each frame lists video lines detected, and further the events detected during each of the lines.

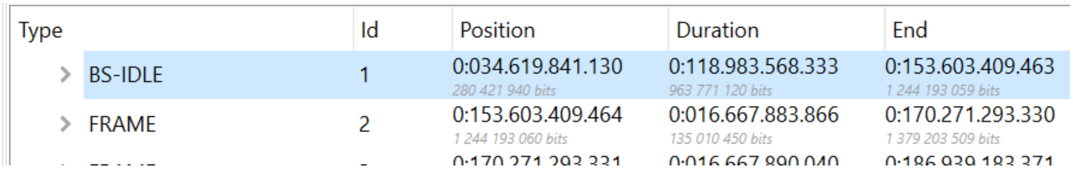


The timing format used in TimeLine Viewer consists of two timings based on *time* and *bits*.

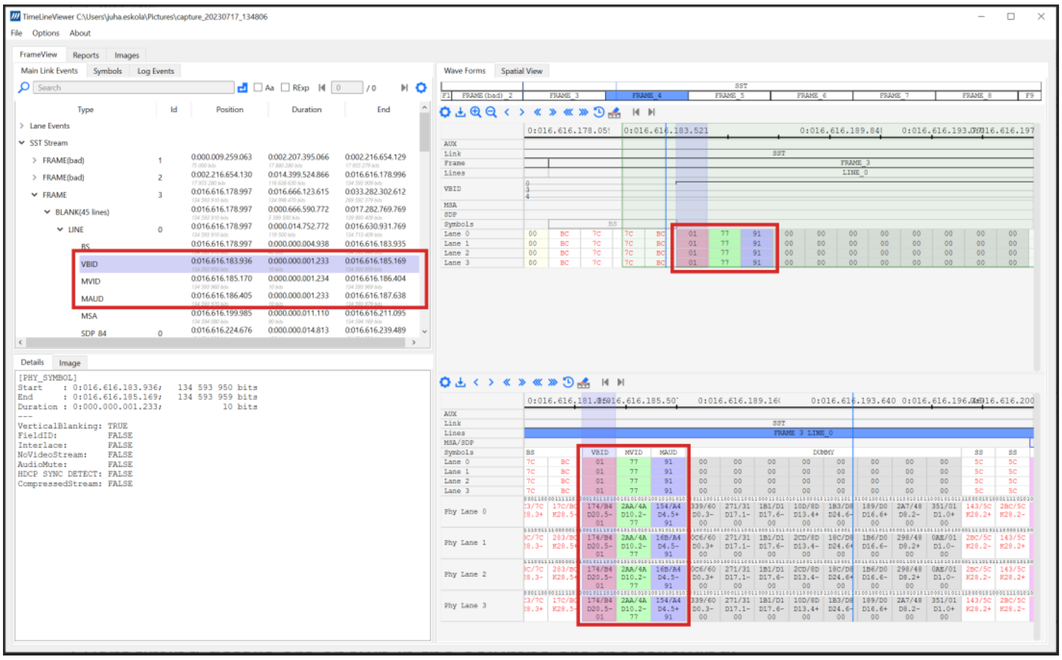
The time format is shown as follows:

seconds:milliseconds.microseconds.nanoseconds.picoseconds

The timing format is demonstrated in the image below where you can see the time format on top and the bit format under it with a smaller grey font.



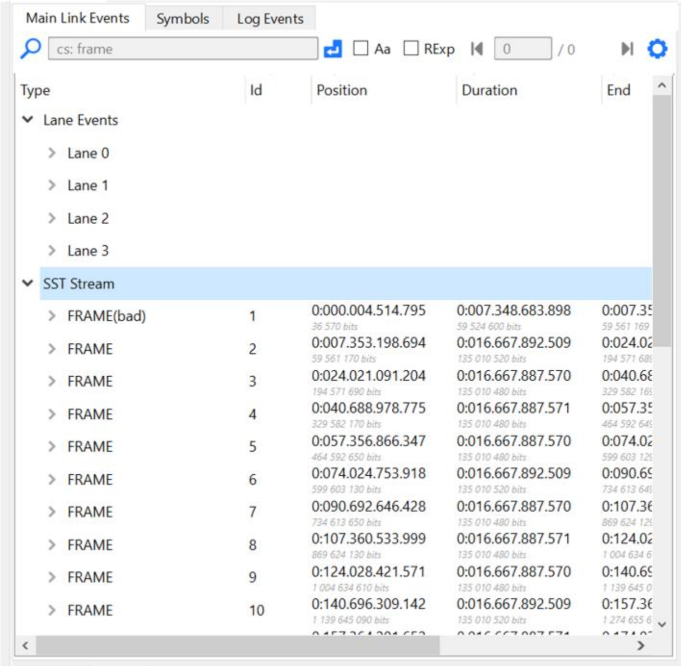
When clicking on a Frame, a Line, an Event, or a Symbol, both ***Wave Form View*** and ***Symbol View*** are focused on the item, and the time stamp of the item is indicated with light blue color highlighting as shown in the image below.



Event timing details are shown in the columns are the following:

Type:	Type of item. FRAME, LINE, or name of Event
Id:	Event's occurrence number
Position:	Start of the event from start of the captured data
Duration:	Duration of the event
End:	End of the event from start of the captured data

Under *Main Link Events*, there are two types of event categories: **Lane events** and **SST/MST Stream**.

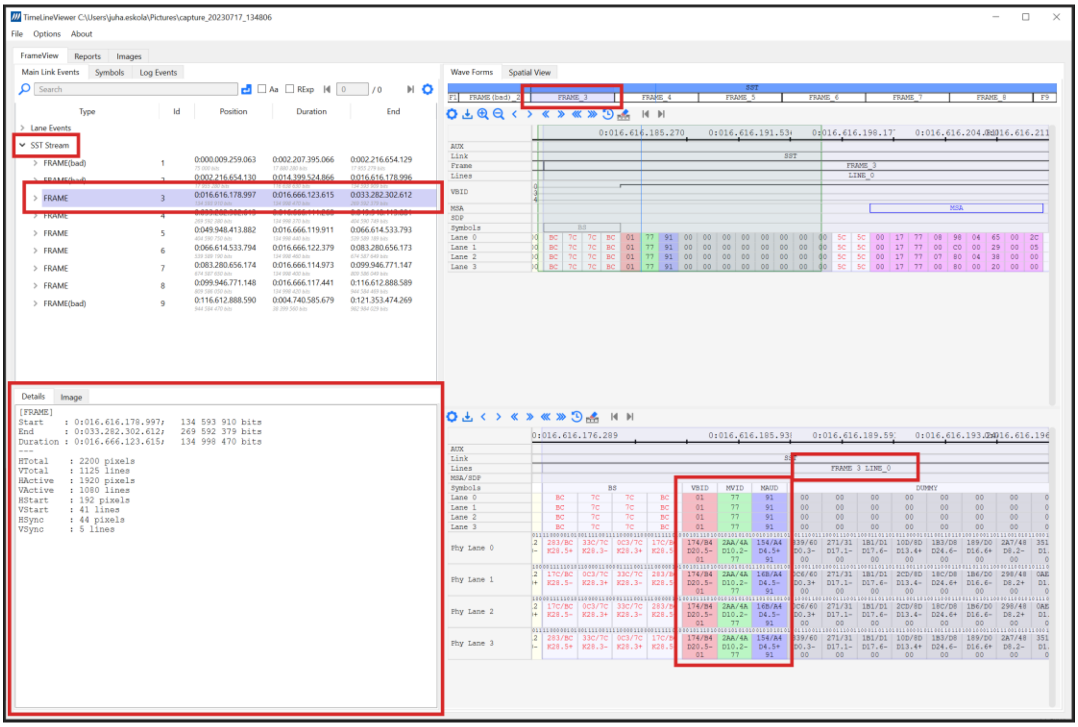


Lane Events

Lane events shows events such as SST, TPS1, TPS3 and TPS4 for each lane.

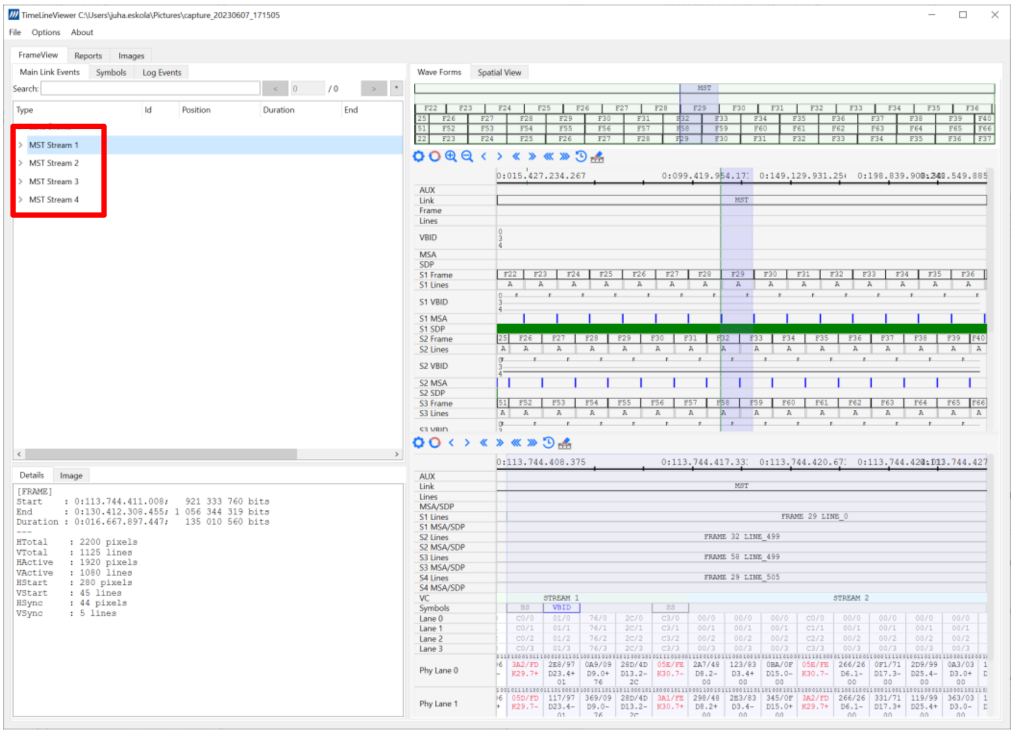
SST Stream

You can find all the captured frames under “SST Stream”. When clicking on a frame in the Event selector, the frame is highlighted and shown in ***Wave Form View*** and ***Symbol View*** as shown in the image below. Event details are shown in ***Event Details*** in the lower left corner.



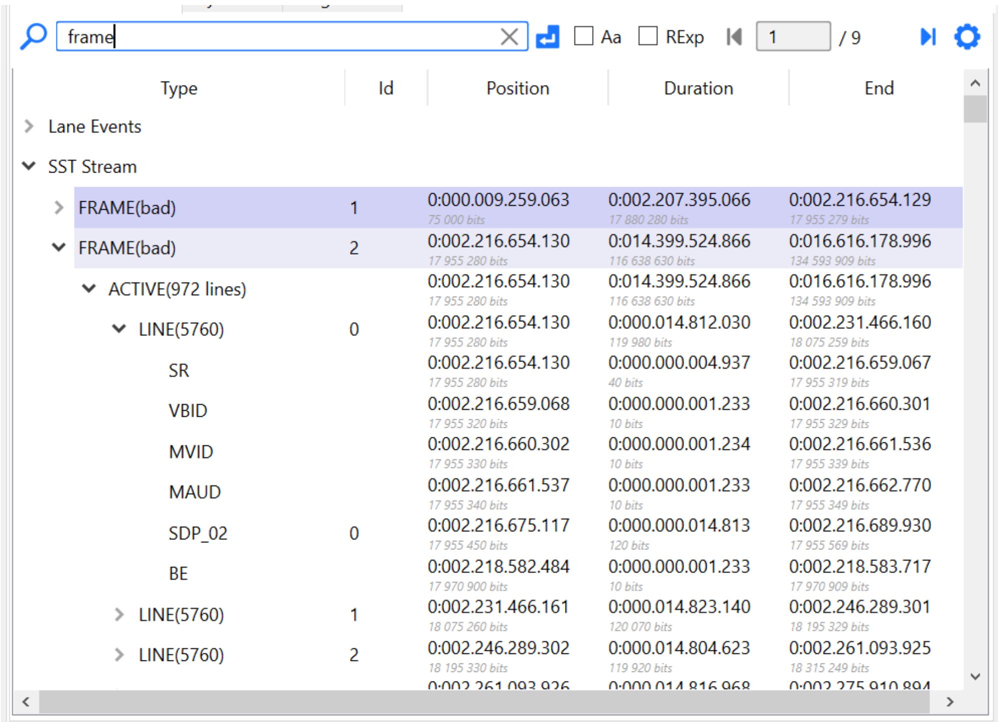
MST Stream

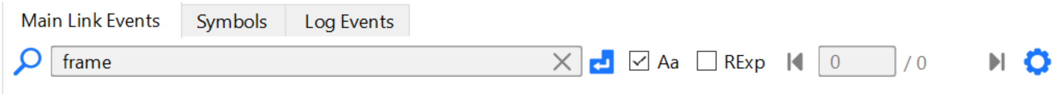
When using TimeLine Viewer in MST mode, the streams are shown in the event selector as in the image below. Click on each stream to inspect its events. All aspects of the events found under different streams include the same aspects as in the SST mode described in the chapter above.



Search

You can search events by typing its name in the Search bar and pressing enter. The found events are highlighted and shown in ***Wave Form View*** and ***Symbol View.***

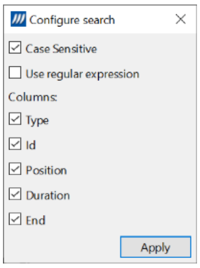




Aa:	Makes search function case sensitive.
RExp:	Use regular expressions.

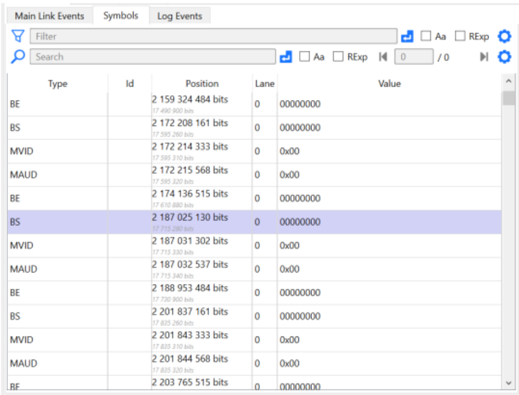
Click the enter icon to apply filters.

The gear icon opens *Configure search* window. In addition to settings described above, you can select which colums are shown in *Main Link Events* window.



Symbols

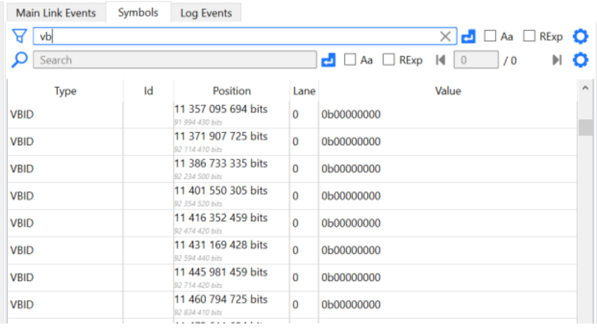
Symbols view lists all the PHY level events found in the capture made. Wheres *Main Link Events* is structured in a tree format, *Symbols* view is presented in a list format containing all symbols from the capture.



Type:	Type of item. FRAME, LINE, or name of Event
Id:	Event's occurrence number
Position:	Start of the event from start of the captured data
Lane:	The main link lane where the Symbol was found
Value:	

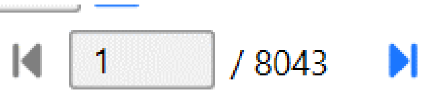
Filter

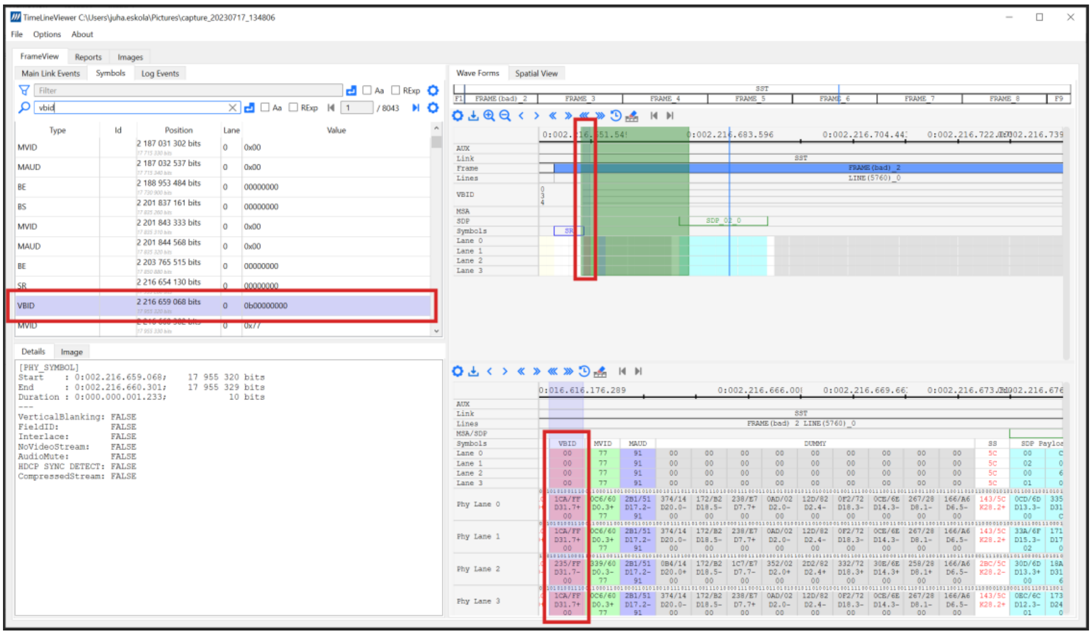
You can filter symbols by typing the event name in the Filter bar. The screenshot below shows an example of VBID event search.



Search

Whereas filtering simply lists all the symbols matching the search word, **Search** will find all searched symbols and when selected, shows them on ***Wave Form View*** and ***Symbol View*.** You can browse through the found symbols by using the arrow keys:





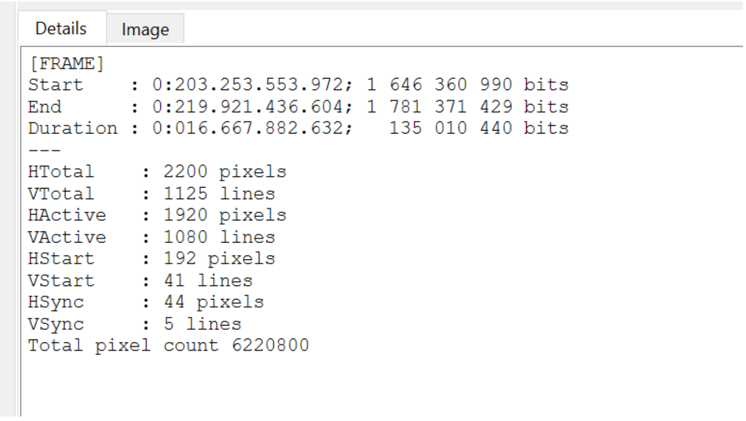
Event Details

The event details are shown in the window in the lower left corner. The event details consists of two tabs: **Image tab** and **Details tab.**

Details tab

The information shown in the **Details** tab depends on the event selected.

Frame



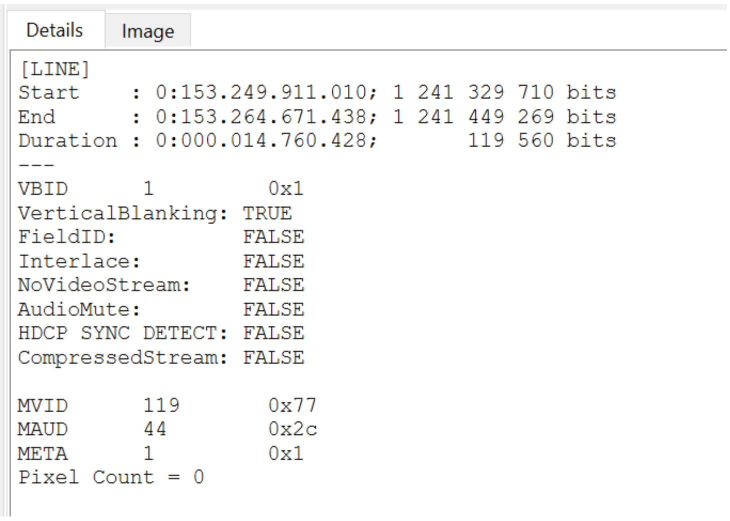
For frames the details include the following parameters:

- Start, End and duration
- HTotal and VTotal
- HActive and VActive
- HStart and VStart
- HSync and VSync
- Total pixel count

The above mentioned parameters can be set for the transferred pattern in the pattern generator tab. For detailed information, please refer to UCD-4XX/UCD-5XX user manual.

Line

For example, in the image below we can see that the line is part of blanking as the value for VerticalBlanking is set as TRUE. Also, AudioMute is set as FALSE so audio is being transferred.



MSA

```
Details  Image
[MSA]
Start    : 0:153.249.931.998; 1 241 329 880 bits
End      : 0:153.249.943.108; 1 241 329 969 bits
Duration : 0:000.000.011.110;            90 bits
---
FIELD     DEC       HEX       BITS
---------------------------------------
MVid      6007      0x1777
NVid      32768     0x8000
HActive   1920      0x780
VActive   1080      0x438
HTotal    2200      0x898
VTotal    1125      0x465
HStart    192       0xC0
VStart    41        0x29
VSynWidth 5         0x5
HSynWidth 44        0x2C
MISC0     32        0x20      00100000
MISC1     0         0x0       00000000

MISC0.Synchronous Clock: Link clock and main video stream clock are asynchronous.
MISC1.Interlaced Vertical Total Even: Number of lines per interlaced frame (consisting of two fields) is an
odd number
MISC1.Stereo Video Attribute: No 3D stereo video in-band signaling

MISC.Colorimetry Format Value: 1         0x1       00000001
MISC.Colorimetry Format: RGB unspecified color space (Legacy RGB mode), 8 bpc, 8bpc


----------------------------
00 00 00 00 17 17 17 17 77 77 77 77 08 00 07 00
98 C0 80 80 04 00 04 00 65 29 38 20 00 00 00 00
2C 05 00 00
```

SDP

SDP events contain several different kinds of events all with individual details shown. The image below shows an audio stamp event.

```
Details  Image
[SDP]
Start    : 0:034.894.928.816;   282 650 160 bits
End      : 0:034.894.943.629;   282 650 279 bits
Duration : 0:000.000.014.813;           120 bits
---
Secondary-data Packet
HB0 (ID)     0x00
HB1 (Type)   0x01 Audio_TimeStamp
HB2          0x17
HB3          0x48
PB0          0x00
PB1          0x67
PB2          0x35
PB3          0xD1
Header checksum OK

Data checksum OK

Maud         0x0000012C 300
Naud         0x00008000 32768

PB4          0xB4
PB5          0xB4
PB6          0xB4
PB7          0xB4
PB8          0x7F
PB9          0x7F
PB10         0x7F
PB11         0x7F
```

PHY Symbol

Events such as BS, VBID and MVID will be shown under [PHY _SYMBOL] title. For example, in the image below we see the event details for VBID event.

Details | Image

```
[PHY_SYMBOL]
Start    : 0:170.271.298.270; 1 379 203 550 bits
End      : 0:170.271.299.503; 1 379 203 559 bits
Duration : 0:000.000.001.233;            10 bits
---
VerticalBlanking: TRUE
FieldID:          FALSE
Interlace:        FALSE
NoVideoStream:    FALSE
AudioMute:        FALSE
HDCP SYNC DETECT: FALSE
CompressedStream: FALSE
```

PHY Area

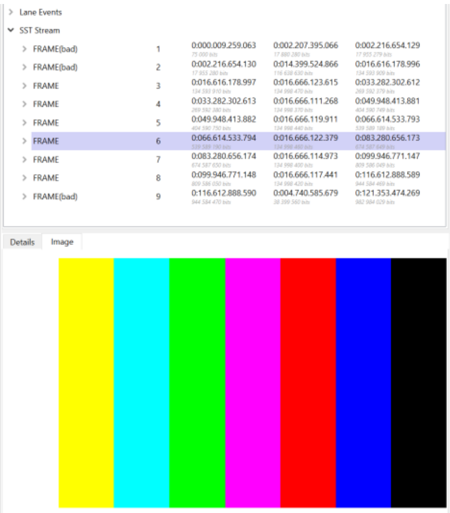
PHY Area events shows TPS events. In the image below you can see a TPS1 event and its start, end and duration.

Details | Image

```
[PHY_AREA]
Start    : 0:000.000.000.000;         0 bits
End      : 0:000.854.703.667; 6 923 129 bits
Duration : 0:000.854.703.667; 6 923 130 bits
---
TPS1
```

Image tab

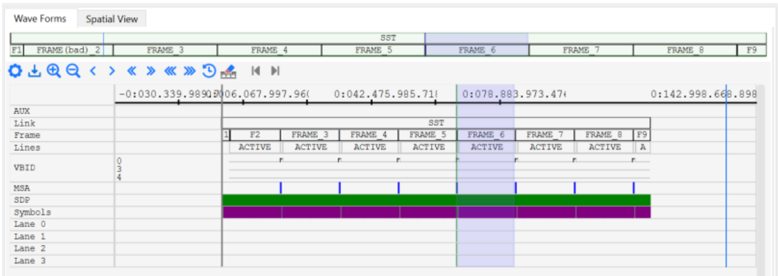
Image tab shows the frame captured with active area. Please note that Images are shown only shown when a frame is selected.



Wave Forms View

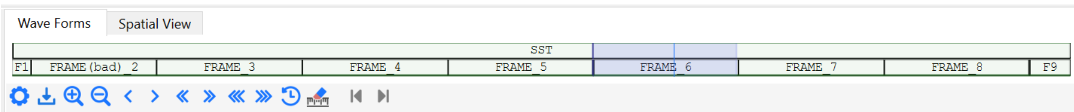
Wave Forms View consists of two tabs: *Wave Forms and Spatial View.*

Wave Forms

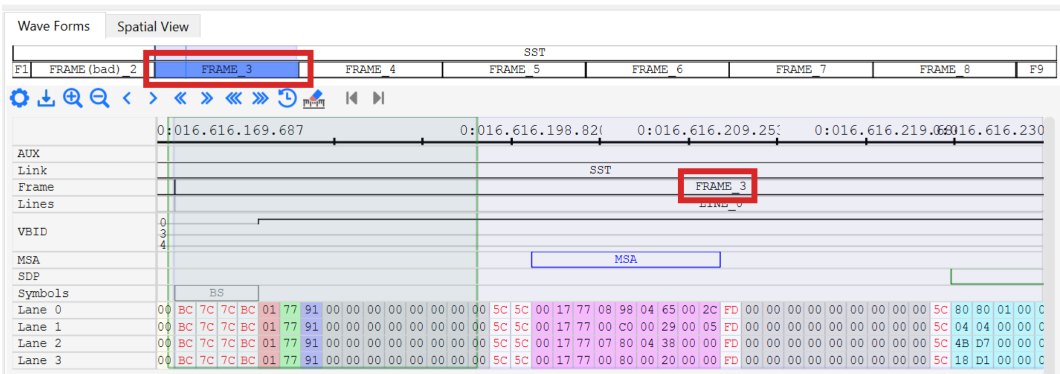


AUX:	Events of the AUX channel.
Link:	Link state (TPS1, TPS2, TPS3, TPS4, SST, MST etc.)
Lines:	Frame and line number
VBID:	Location of VBID events
MSA/SDP:	Location of MSA and SDP events
Symbols:	Control and special symbols
Lanes (0-3):	Decoded data and control symbols

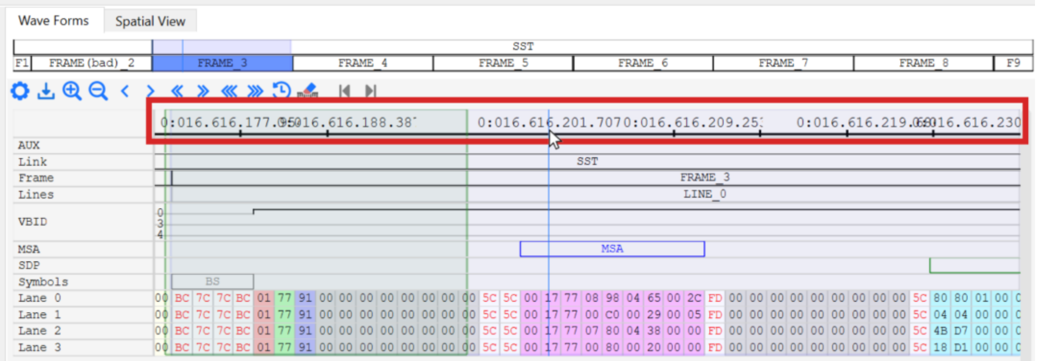
The scroll bar on the top of the panels shows all captured frames of the bulk. As no triggers were set on the example capture shown in the image below, the first frame is not captured fully. Please, note that this view cannot be zoomed in.



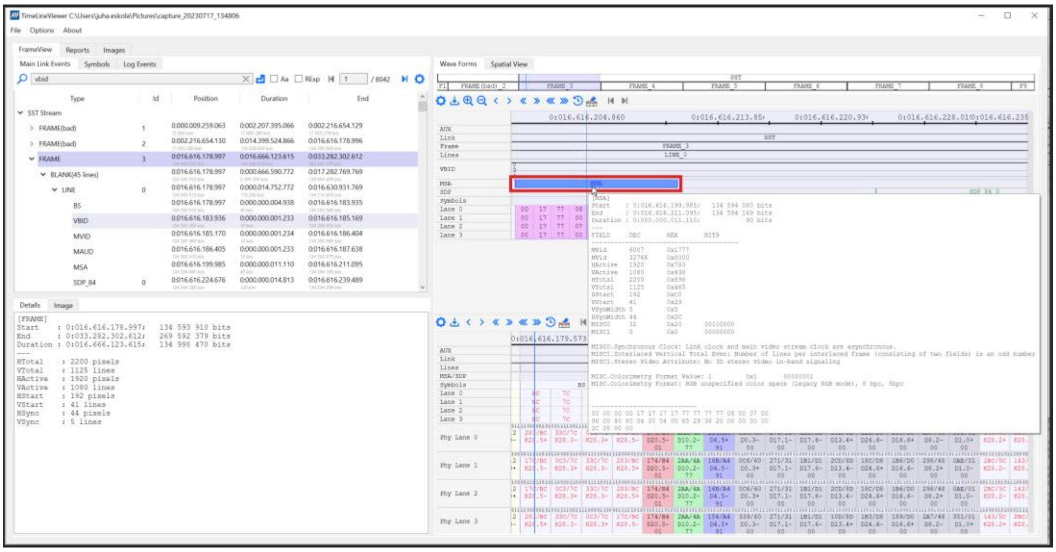
You can select a frame by double-clicking on it. After a frame is selected, it turns into light purple and ***Wave Form View*** will be focused to view this frame.



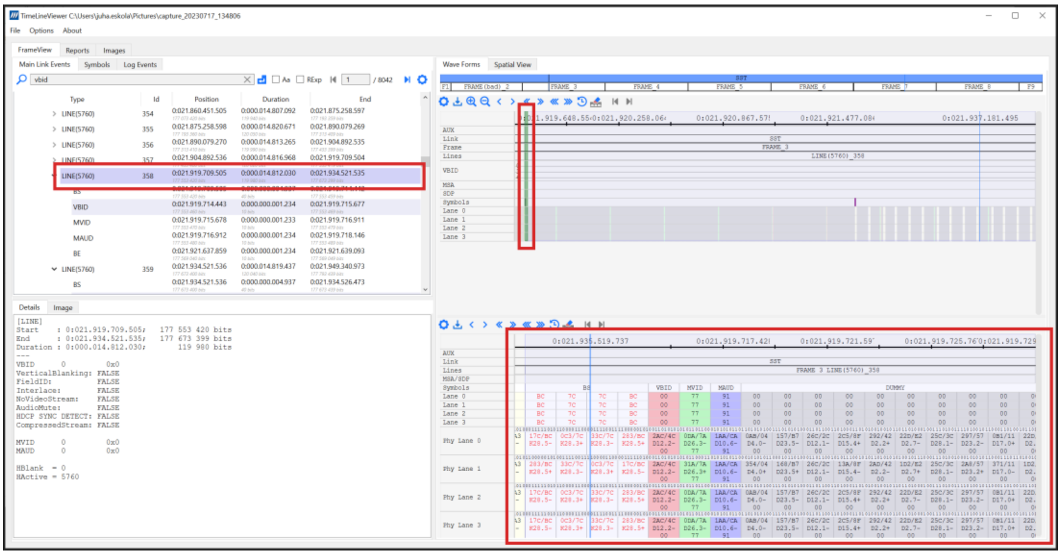
When you hover the cursor over the timeline, the timestamp of that position on the timeline is shown as illustrated in the image below.



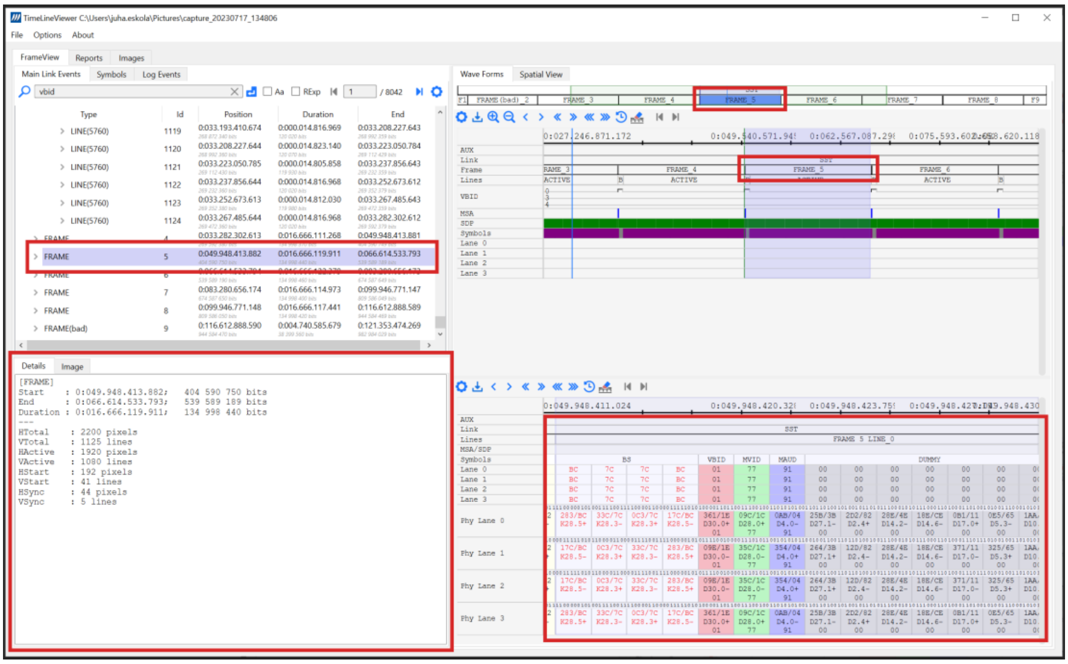
When you hover mouse cursor over an event in ***Wave Form View***, a popup windows shows details of the event.



When doble-clicking on timeline or within the perimeters of ***Wave Forms View***, ***Symbol View*** is focused on the location, and the event is selected in ***Event Selector*** as shown in the image below. The green vertical line in ***Wave Form View*** shows the position of the selected event.

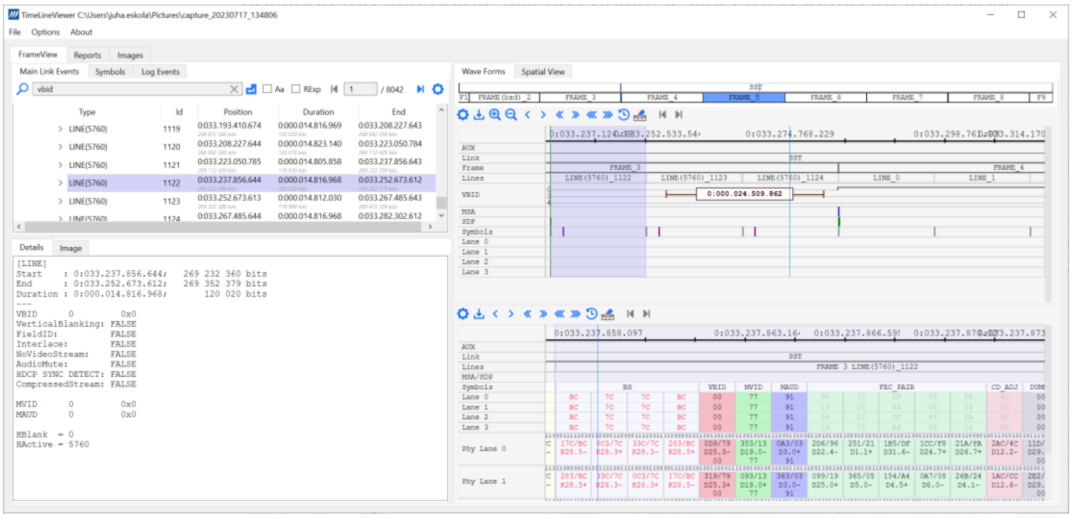


The image below further shows you how the different areas of the TimeLine Viewer align when you double click on a frame in ***Wave Form View.***



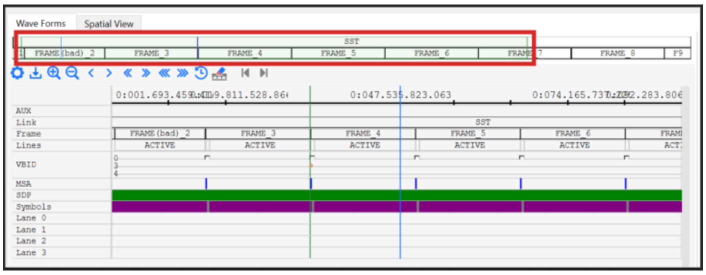
Measuring

The ruler tool allows users to measure the distance between two points on the timeline. When you right click on the timeline, a point willl appear. Right click again on the timeline and the distance between the two points will be shown as illustarted in the image below.

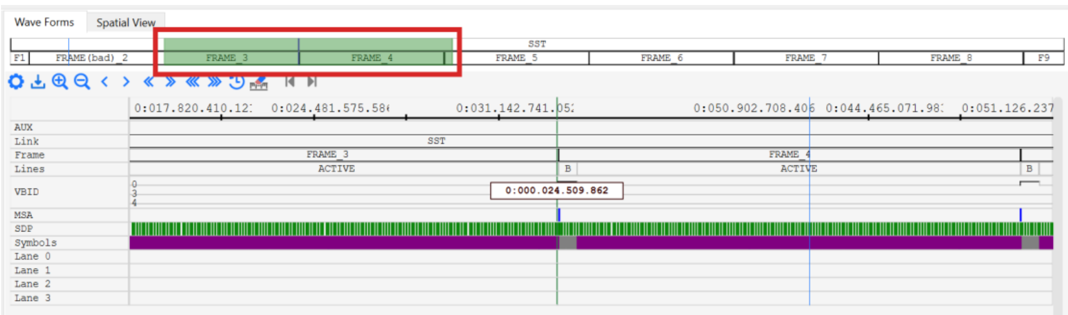


Zooming In

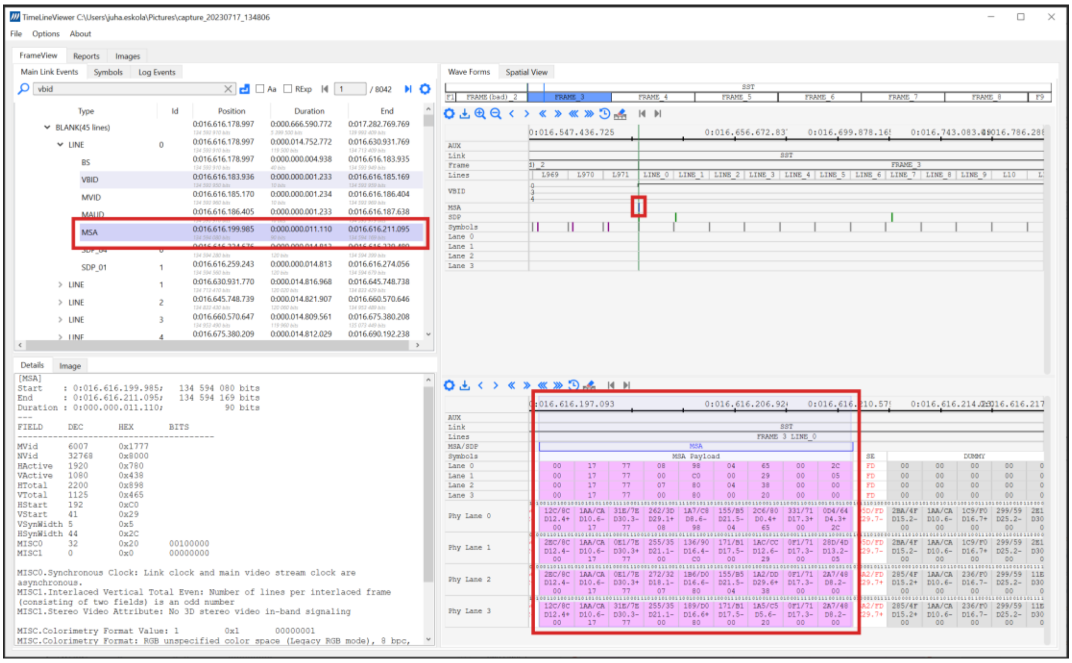
When you zoom in a little, the area shown in ***Wave Form View*** is highlighted with light green color as illustrated in the image below.



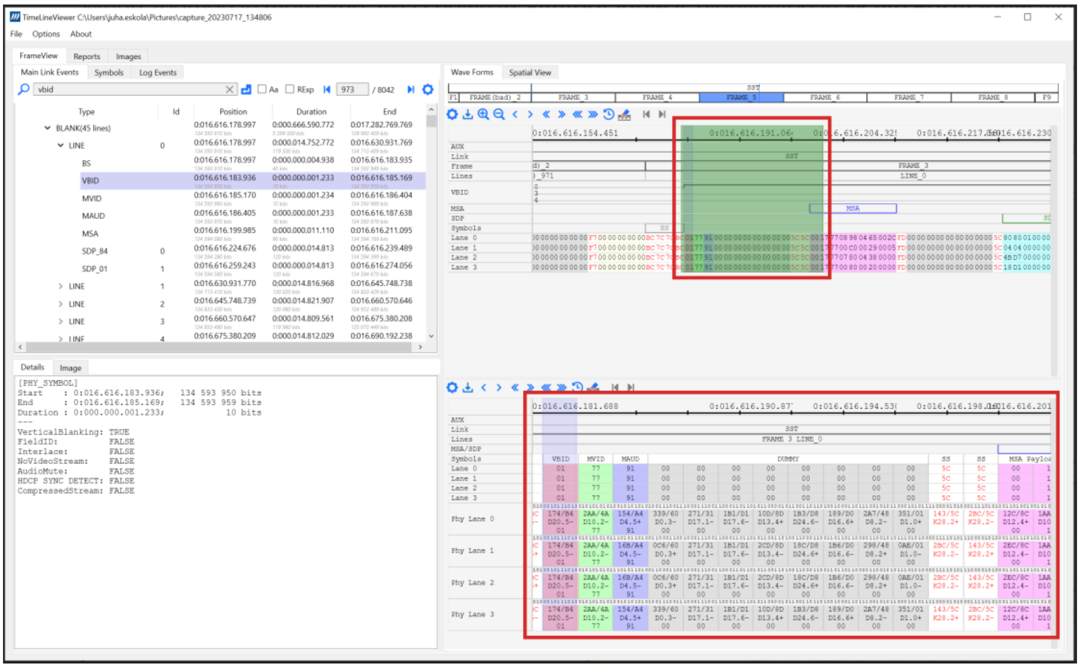
When you zoom in more, the frames shown in ***Wave Form View***, are highlighted in green in the scroll bar as shown in the image below.



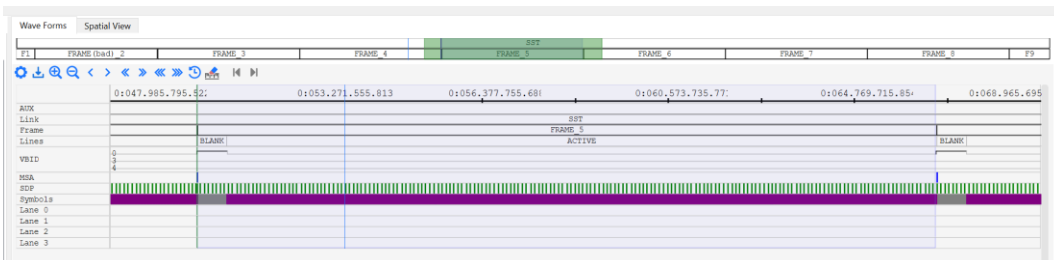
When zoomed in more, ***Wave Form View*** shows the events in small vertical lines as shown in the image below. When you want to zoom into a certain event, make sure to keep the cursor on top of the event you want to inspect more in detail.



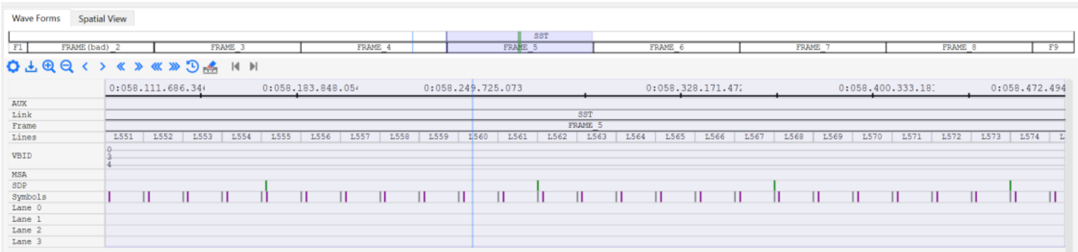
When zoomed in more, the area shown in ***Symbol View*** is highlighted in ***Wave Form View*** with green color as shown in the image below.



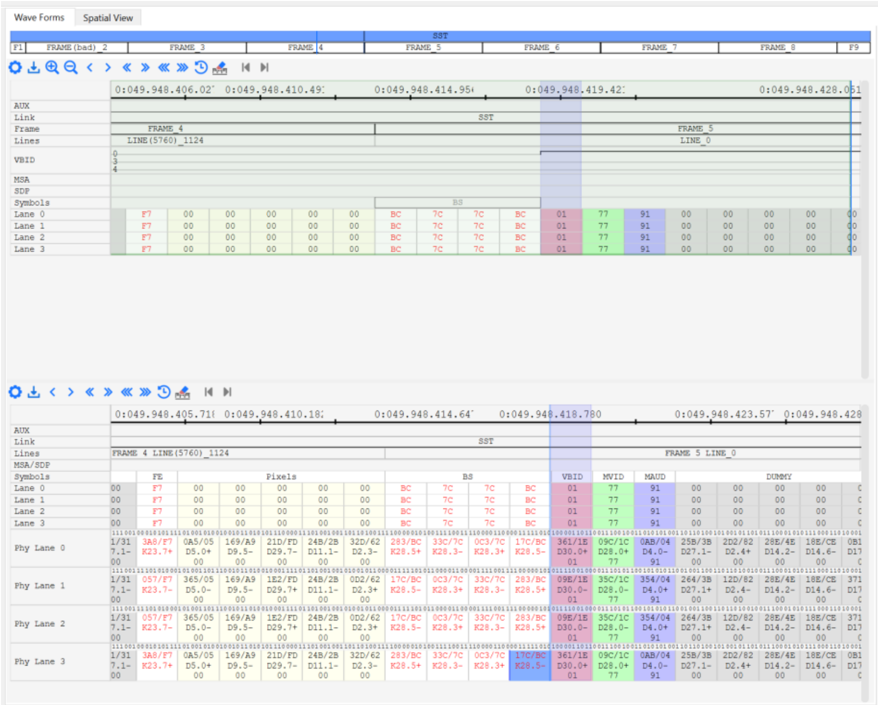
The image below shows a view of one frame in ***Wave Form View*** when zoomed in on a frame level. You can see the blank area and active in this view.



If you zoom in closer, into a line level view, you begin to see the lines the frame consists of.

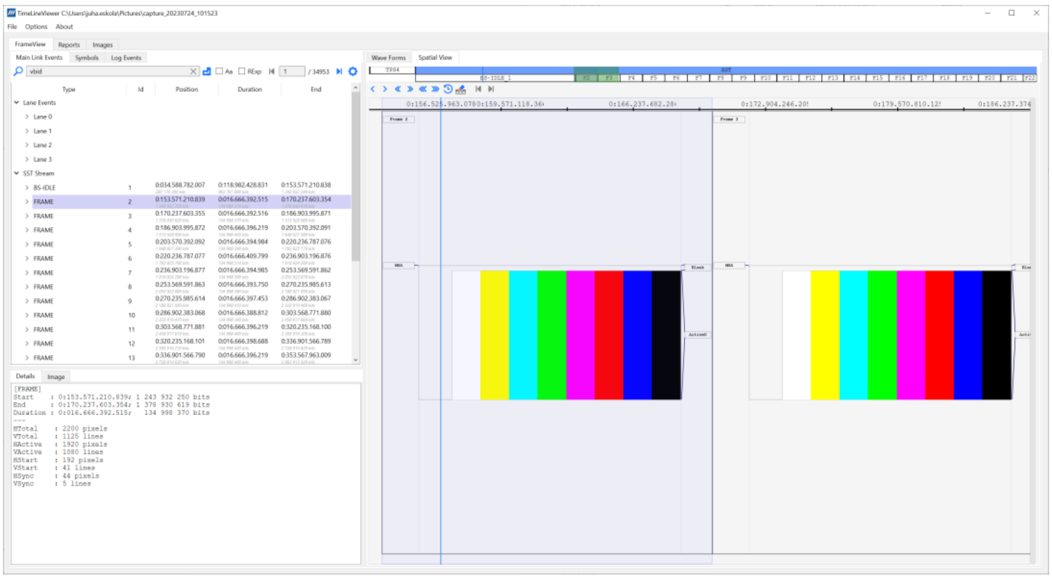


The lines shown in ***Wave Form View*** are symbols that match the ones shown in ***Symbol View***. When you zoom in close enough, you can see the symbols in both views as shown in the image below.

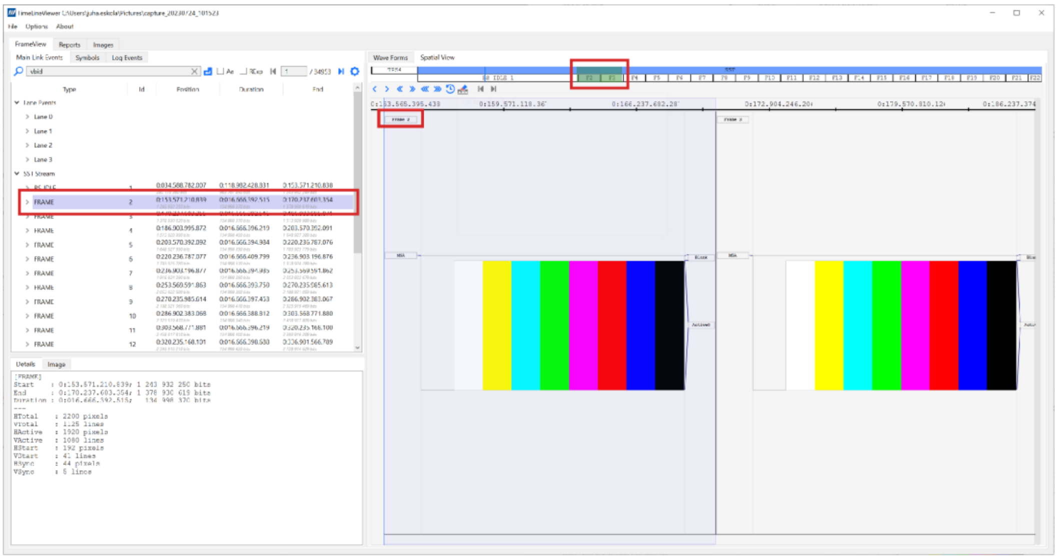


Spatial View

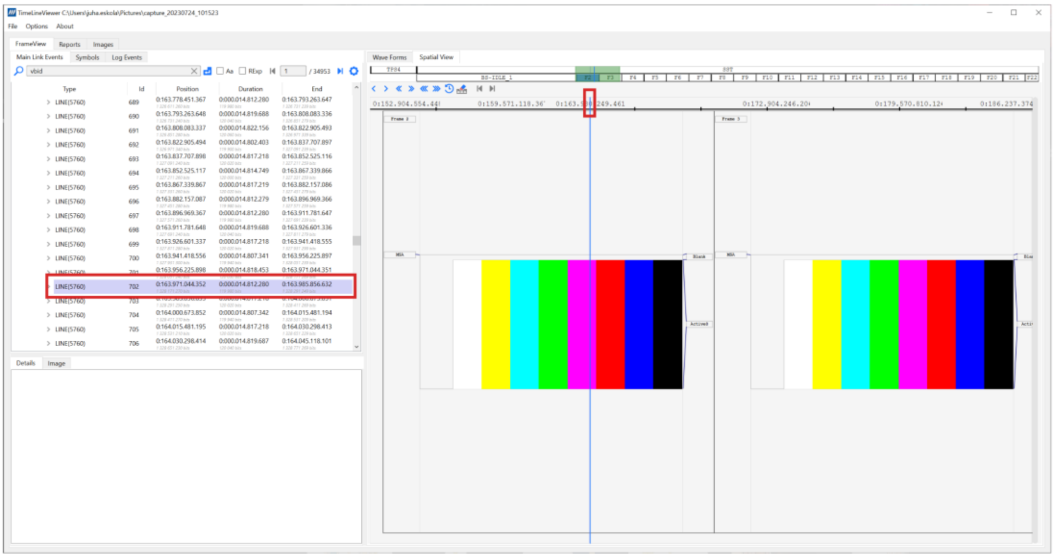
Spatial view shows the geometry of the frame.



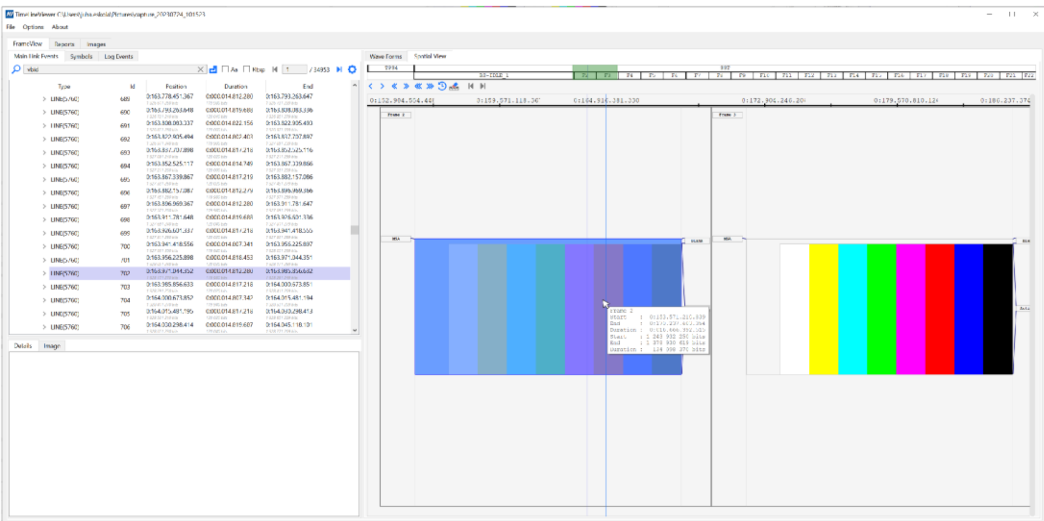
If you select a frame in ***Event Selector*** the frame will be shown in ***Spatial View*** as shown in the image below.



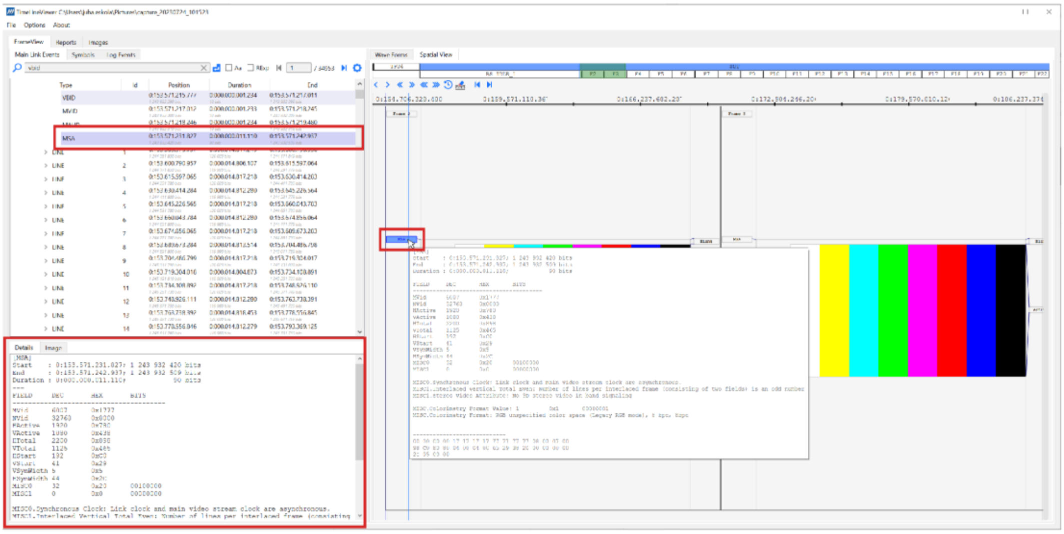
If you double-click on the timeline, the line on that time stamp will be selected in the ***Event Selector*** as illustrated in the image below.



When you hover a cursor on top of the frame, frame details will be shown. Frame details include the start, end and duration of the frame.

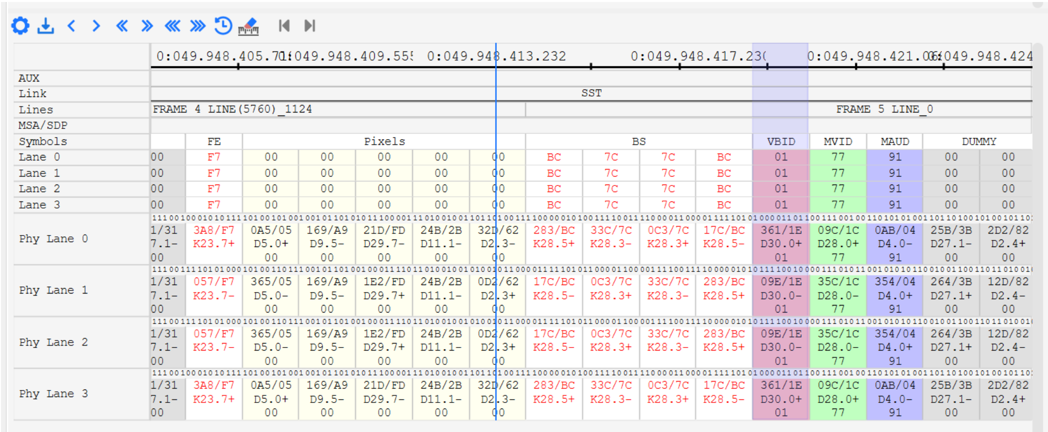


When you hover your mouse over an event shown next the frame, details of that event will be show in a popup window. If you double-click on the event, it will be selected in the ***Event Selector*** and its details will be shown in the ***Event Details.***



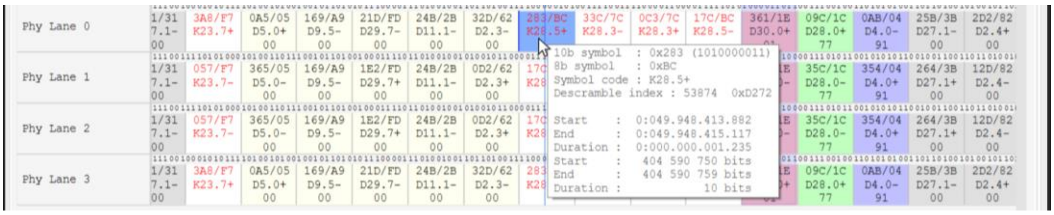
Symbol View

In addition to ***Wave Form View***, ***Symbol View*** shows symbols from the PHY lanes. Identically to ***Wave Form View*** you can scroll the ***Symbol View*** by clicking it, holding and dragging or by using the arrow keys.



AUX:	Events of the AUX channel.
Link:	Link state (TPS1, TPS2, TPS3, TPS4, SST, MST etc.)
Lines:	Frame and line number
MSA/SDP:	Location of MSA and SDP events
Symbols:	Control and special symbols
Lanes (0-3):	Decoded data and control symbols
PHY Lanes (0-3):	Binary bit stream, 10b/8b scrambled symbols, symbol code and descrambled values

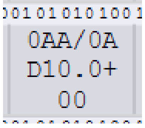
Link Symbols



The lower part of the ***Symbol View*** describes the distribution of link symbols in the physical link lanes. You can see the individual bits above the symbol blocks. When you hover your mouse over a symbol, a window appears presenting details of the selected symbol. The details include:

10b symbol:	Link symbol as sent (in this case 8b/10b link coding)
8b symbol:	Link symbol after conversion to 8 bits
Symbol code:	Link symbol K or D code
Descrambled:	Link symbol value after de-scrambling
Start:	Start of the item from start of the captured data
End:	End of the item from start of the captured data
Duration:	Length of the symbols

For clarity, the position of control symbols and and payload of link events is marked with a gray bar on top of the corresponding link symbols.

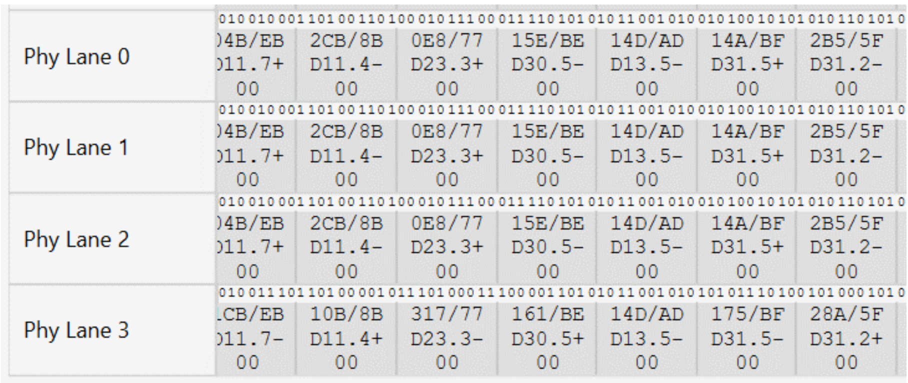


Each individual block contains the following information

First row:	10b/8b link symbol in HEX format
Second row:	Link symbol K or D code. K symbols are highlighted with red color.
Third row:	Descrambled value if available

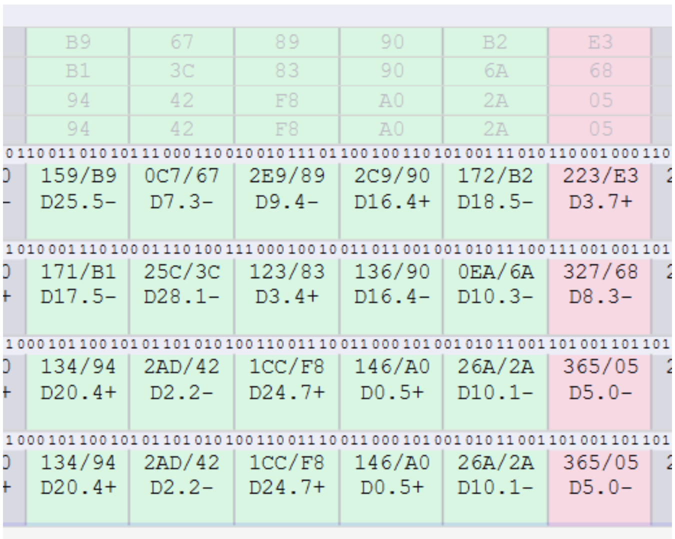
Scrambling

You can see the result of scrambling in ***Symbol View.*** As you can see in the image below, all blocks have value of 00. However, the first row of each block reads a different 10b/8b link symbols.



Forward Error Correction (FEC)

FEC parity codes are highlighted in ***Symbol View*** with a light green color. CD_ADJ symbols are highlighted with light red color.



SDP

SDPs are highlighted with turquoise color. You can see the start of the SDP event marked as SS and the end of the SDP event marked as SE.

	SST												
	BS-IDLE 1 LINE_3												
	SDP_01_7												
SS													SE
5C	00	60	00	01	2C	00	B4	00	80	00	00	7F	FD
5C	01	07	00	01	2C	00	B4	00	80	00	00	7F	FD
5C	47	D5	00	01	2C	00	B4	00	80	00	00	7F	FD
5C	18	31	00	01	2C	00	B4	00	80	00	00	7F	FD
143/5C K28.2+	0E3/63 D3.3- 00	2DA/9A D26.4- 60	29A/5A D26.2- 00	19C/DC D28.6- 01	1D2/E2 D2.7+ 2C	2E2/9D D29.4+ 00	231/F1 D17.7+ B4	29B/5B D27.2- 00	1A3/C3 D3.6- 80	34A/1F D31.0+ 00	165/A5 D5.5- 00	15A/BA D26.5- 7F	3A2/FD K29.7+
143/5C K28.2+	32D/62 D2.3- 01	1E2/FD D29.7+ 07	29A/5A D26.2- 00	19C/DC D28.6- 01	1D2/E2 D2.7+ 2C	2E2/9D D29.4+ 00	231/F1 D17.7+ B4	29B/5B D27.2- 00	1A3/C3 D3.6- 80	34A/1F D31.0+ 00	165/A5 D5.5- 00	15A/BA D26.5- 7F	3A2/FD K29.7+
143/5C K28.2+	26B/24 D4.1- 47	245/2F D15.1+ D5	29A/5A D26.2- 00	19C/DC D28.6- 01	22D/E2 D2.7- 2C	11D/9D D29.4- 00	3B1/F1 D17.7- B4	2A4/5B D27.2+ 00	1A3/C3 D3.6- 80	0B5/1F D31.0- 00	165/A5 D5.5- 00	15A/BA D26.5- 7F	05D/FD K29.7-
2BC/5C K28.2-	0E4/7B D27.3+ 18	18B/CB D11.6- 31	29A/5A D26.2- 00	19C/DC D28.6- 01	22D/E2 D2.7- 2C	11D/9D D29.4- 00	3B1/F1 D17.7- B4	2A4/5B D27.2+ 00	1A3/C3 D3.6- 80	0B5/1F D31.0- 00	165/A5 D5.5- 00	15A/BA D26.5- 7F	05D/FD K29.7-

Pixel data

Grey area is fill symbols (scrambled 00). Light yellow area is actual pixels (surrounded by fill end symbol and fill start symbol). K30.7 is fill start and K23.7 is fill end.

	FE	Pixels									FS	
00	F7	00	00	00	00	00	00	00	00	00	FE	00
00	F7	00	00	00	00	00	00	00	00	00	FE	00
00	F7	00	00	00	00	00	00	00	00	00	FE	00
00	F7	00	00	00	00	00	00	00	00	00	FE	00
36A/0A D10.0- 00	3A8/F7 K23.7+	223/E3 D3.7+ 00	25C/3C D28.1- 00	296/56 D22.2- 00	269/29 D9.1- 00	163/A3 D3.5- 00	0C7/67 D7.3- 00	0B6/10 D16.0- 00	1CE/EE D14.7- 00	2A3/43 D3.2- 00	3A1/FE K30.7+	162/BD D29.5+ 00
0AA/0A D10.0+ 00	057/F7 K23.7-	1E3/E3 D3.7- 00	25C/3C D28.1- 00	296/56 D22.2- 00	269/29 D9.1- 00	163/A3 D3.5- 00	338/67 D7.3+ 00	349/10 D16.0+ 00	04E/EE D14.7+ 00	2A3/43 D3.2- 00	05E/FE K30.7-	15D/BD D29.5- 00
0AA/0A D10.0+ 00	057/F7 K23.7-	1E3/E3 D3.7- 00	25C/3C D28.1- 00	296/56 D22.2- 00	269/29 D9.1- 00	163/A3 D3.5- 00	338/67 D7.3+ 00	349/10 D16.0+ 00	04E/EE D14.7+ 00	2A3/43 D3.2- 00	05E/FE K30.7-	15D/BD D29.5- 00
36A/0A D10.0- 00	3A8/F7 K23.7+	223/E3 D3.7+ 00	25C/3C D28.1- 00	296/56 D22.2- 00	269/29 D9.1- 00	163/A3 D3.5- 00	0C7/67 D7.3- 00	0B6/10 D16.0- 00	1CE/EE D14.7- 00	2A3/43 D3.2- 00	3A1/FE K30.7+	162/BD D29.5+ 00

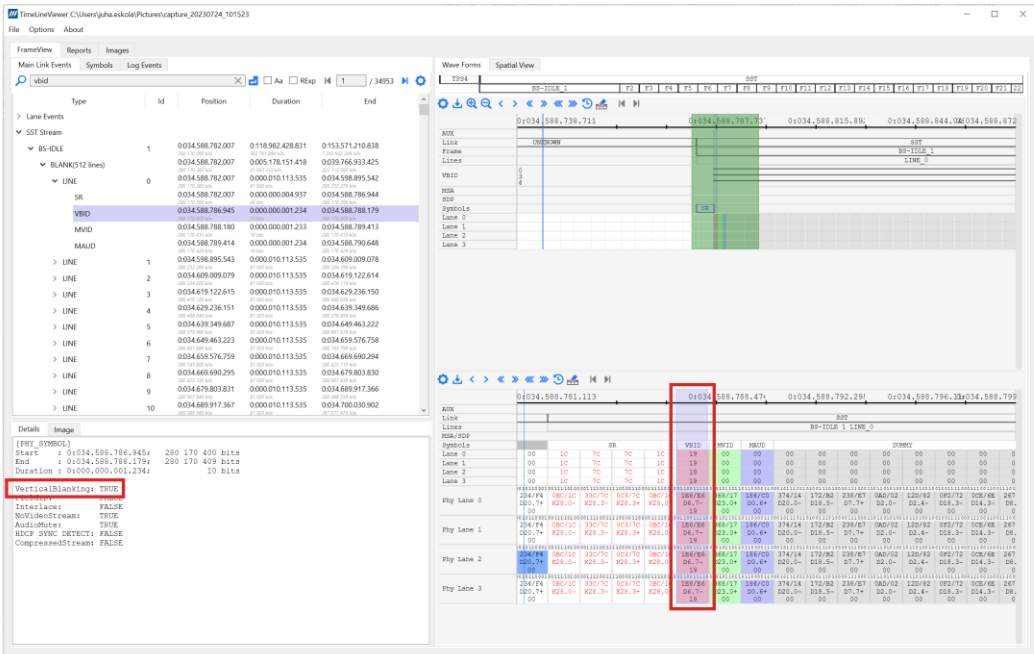
MSA

MSA symbols are highlighted in purple color.

			SST										
FRAME 4 LINE_0													
			MSA										
	SS	SS										SE	
00	5C	5C	00	17	77	08	98	04	65	00	2C	FD	00
00	5C	5C	00	17	77	00	C0	00	29	00	05	FD	00
00	5C	5C	00	17	77	07	80	04	38	00	00	FD	00
00	5C	5C	00	17	77	00	80	00	20	00	00	FD	00
147/A7 D7.5- 00	2BC/5C K28.2-	143/5C K28.2+	235/FF D31.7- 00	19C/DC D28.6- 17	097/17 D23.0- 77	1B6/D0 D16.6- 08	171/B1 D17.5- 98	274/34 D20.1- 04	1AA/CA D10.6- 65	29C/5C D28.2- 00	259/39 D25.1- 2C	3A2/FD K29.7+	196/D6 D22.6- 00
178/A7 D7.5+ 00	143/5C K28.2+	2BC/5C K28.2-	1CA/FF D31.7+ 00	19C/DC D28.6- 17	368/17 D23.0+ 77	18C/D8 D24.6+ 00	1E9/E9 D9.7- C0	249/30 D16.1+ 00	2E6/86 D6.4- 29	29C/5C D28.2- 00	349/10 D16.0+ 05	3A2/FD K29.7+	196/D6 D22.6- 00
178/A7 D7.5+ 00	143/5C K28.2+	2BC/5C K28.2-	1CA/FF D31.7+ 00	19C/DC D28.6- 17	368/17 D23.0+ 77	18A/DF D31.6+ 07	169/A9 D9.5- 80	274/34 D20.1- 04	117/97 D23.4- 38	29C/5C D28.2- 00	355/15 D21.0- 00	3A2/FD K29.7+	196/D6 D22.6- 00
178/A7 D7.5+ 00	143/5C K28.2+	2BC/5C K28.2-	1CA/FF D31.7+ 00	19C/DC D28.6- 17	368/17 D23.0+ 77	18C/D8 D24.6+ 00	169/A9 D9.5- 80	276/30 D16.1- 00	2C5/8F D15.4+ 20	29C/5C D28.2- 00	095/15 D21.0+ 00	05D/FD K29.7-	196/D6 D22.6- 00

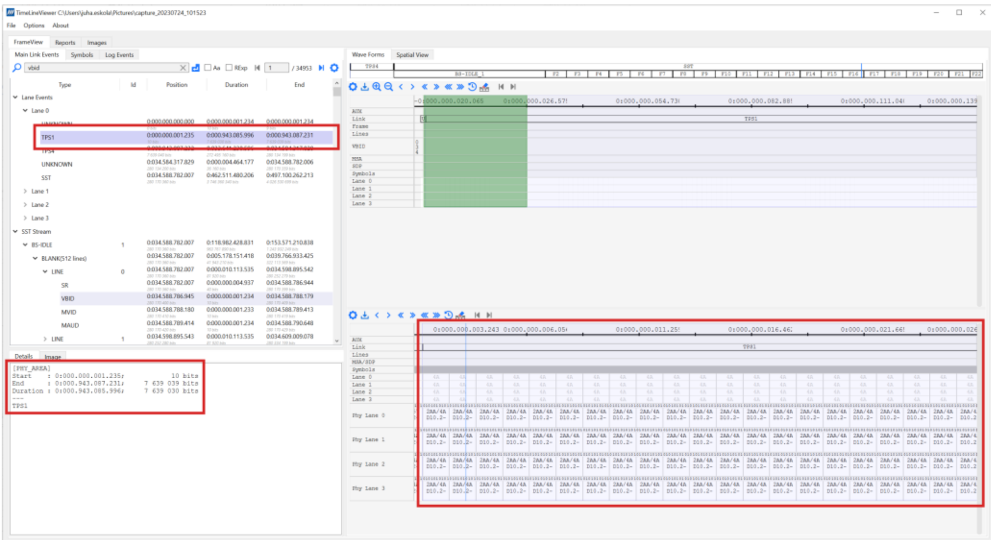
VBID

The ***Event Details*** will show information of what the line will contain. In the image below you can see that the line is vertical blanking without pixel data.

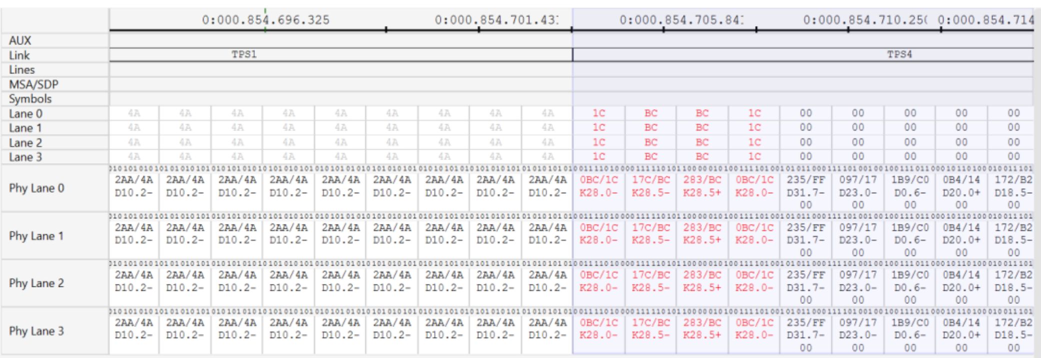


TPS Events

The image below shows how the events are shown for each lane in ***Event Selector***, ***Symbol View*** and ***Event details.*** The image below shows a TPS1 event.



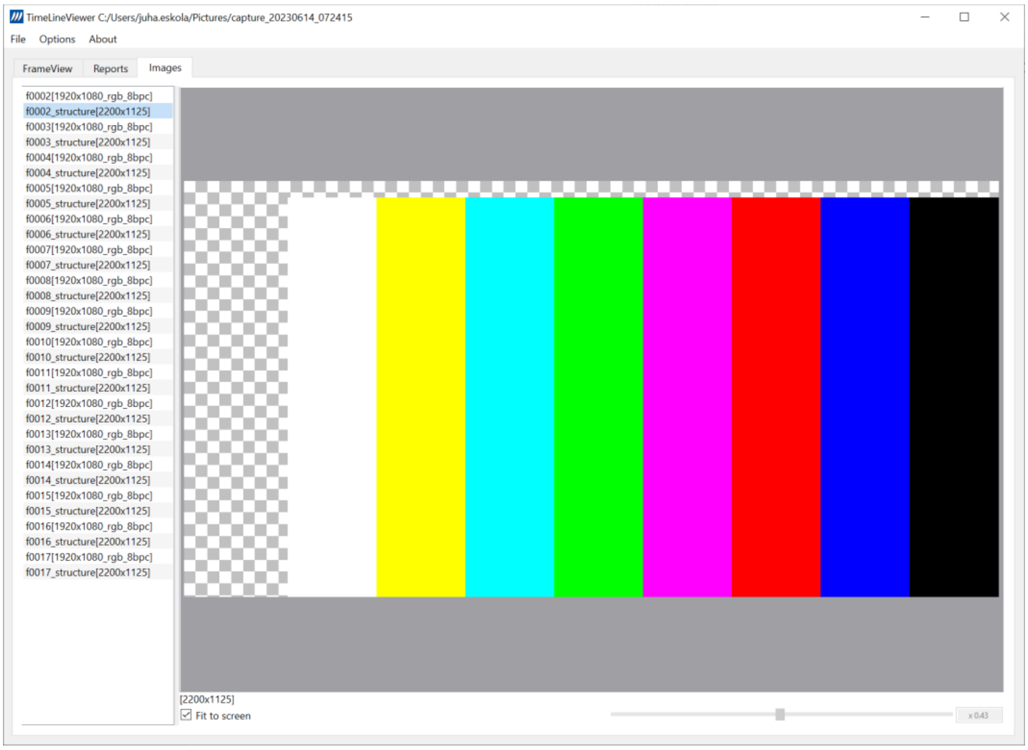
The image below illustrates the transition from TPS1 to TPS4.



Images Tab

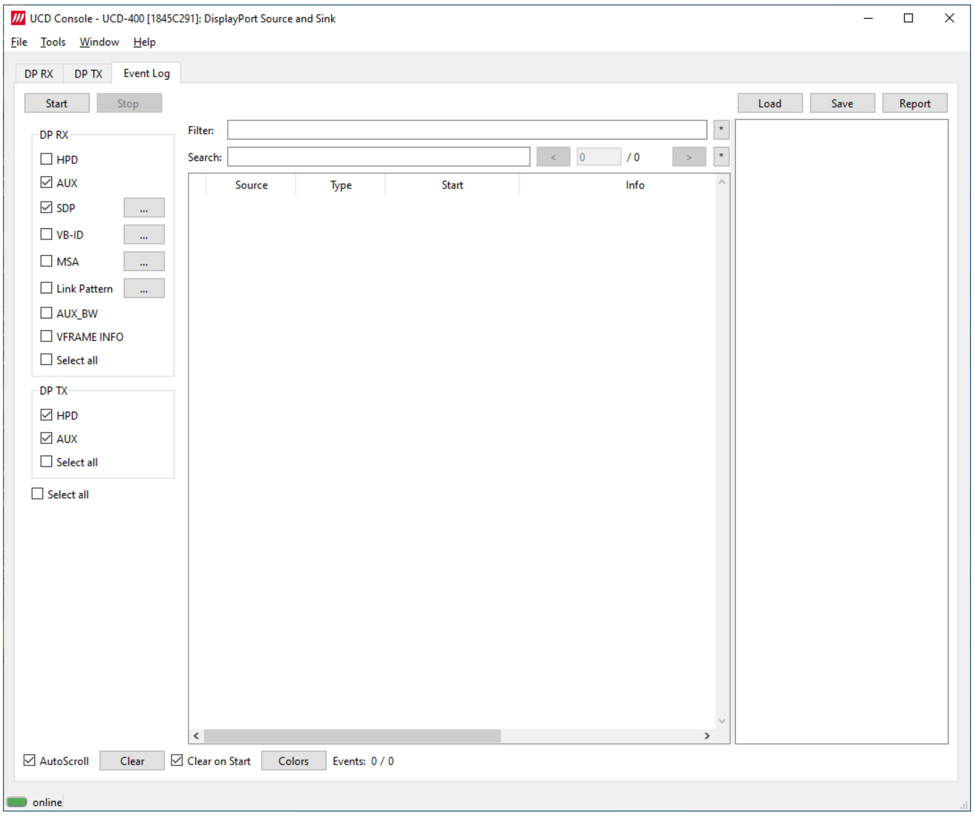
Video frames decoded from Main Link Data Capture can be previewed in Images tab. Frames are listed on the left-hand side of the window. Each frame has two lines. The first line shows the frame with its active area only.

The second line is a structure frame, which shows total and active area.



7. EVENT LOG

Event Log dialog is divided into two panels: the left panel lists all transactions, and the right panel shows the parsed transaction data for the line selected in the list on the left.



Role	Logged Events
DP Sink (UCD-400) DP Alt Mode Sink (UCD-424)	HPD, AUX, SDP, VB-ID, MSA, Link Pattern, AUX_BW, VFRAME INFO
HDMI Sink (UCD-422)	HPD, Packets, I2C, CEC
DP Source (UCD-400, UCD-411, 451) DP Alt Mode Source (UCD-424)	HPD, AUX
HDMI Source (UCD-422, UCD-412, 452)	HPD, I2C, CEC
DP Alt Mode Sink (UCD-424) DP Alt Mode Source (UCD-424)	PD, LSE

Start:	Starts event logging and stop it by clicking *Stop*.
Save:	Save transactions as Event Log data.
Load:	Load saved Event Log data
Report:	Store event logs as reports in HTML format to be shared and viewed with any web browser.
AutoScroll:	When selected, transaction list is scrolled vertically, and the latest transaction is shown as the last item of the list. When not selected, the items shown before clicking Start will be shown.
Events	Number of events detected
Colors:	Open configure colors dialog
Clear:	Click to clear transaction list. When *Clear on Start* is selected, the list is cleared when clicking Start.

Selecting Logged Events

HPD

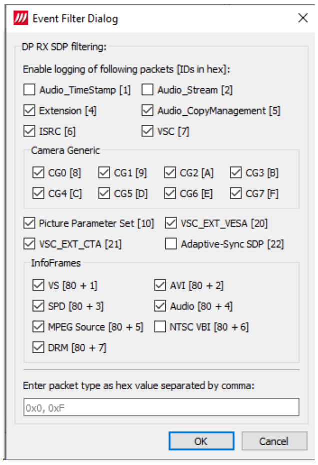
Status and status changes of Hot Plug Detect (HPD) signal, power detection status and cable connection status.

AUX

Log DP AUX Channel transactions and Sideband Messaging.

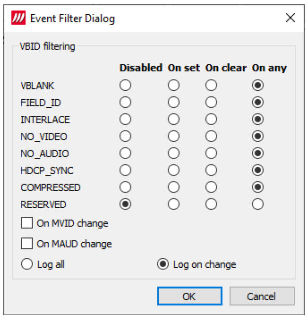
SDP

Log DP Secondary-data Packets. Click the ... button to open the *Event Filter Dialog.* The dialog enables filtering of SDP packets. In the dialog, the reference to Packet Type Value is indicated in square brackets "[ ]".



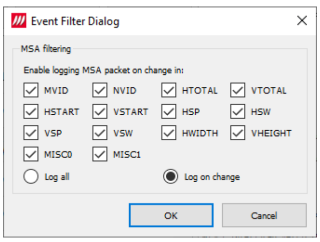
VB-ID

Log Vertical Blanking ID packets sent in DP stream. Click the ... button to open the *Event Filter Dialog.* The dialog enables definition of which events will be logged.



MSA

Log Main Stream Attributes sent in DP stream. Click the ... button to open the *Event Filter Dialog.* The dialog enables logging of all MSA:s of just changes on selected parameter.

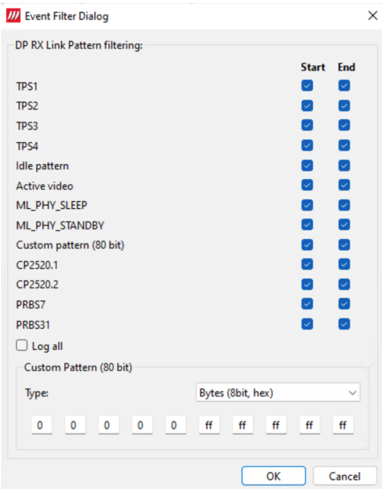


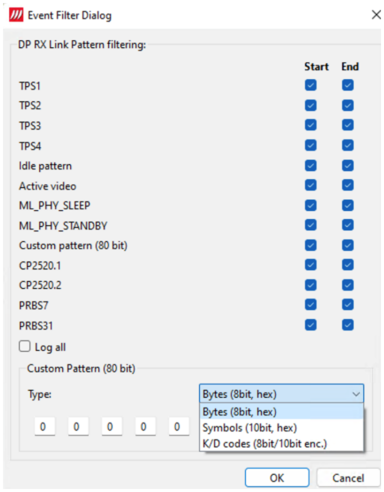
Link Pattern

Click the button to open the *Event Filter Dialog.*

Log link patterns. Event filter dialog sets the type of link patterns that will be captured.

Custom Pattern (80 bit) is a squence that either splits into 10 bytes or 8b/10b encoded symbols. For 10b symbols, either K/D codes or hex values must be provided. For bytes, hex values must be provided.





AUX_BW

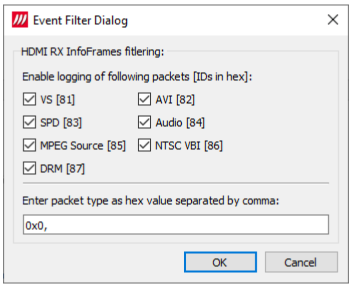
Log AUX_Bitwise transactions as a series of Manchester II codes.

VFRAME INFO

Dimensions of the catured frame measured by the Sink

Packets

Log metadata sent by Source device in HDMI stream



I2C

Log data sent over I2C communication lines of HDMI interface

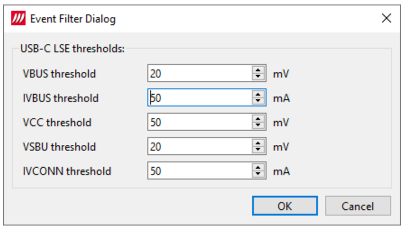
PD

Log USB-C PD communication messages

CEC

Log CEC communication messages

LSE

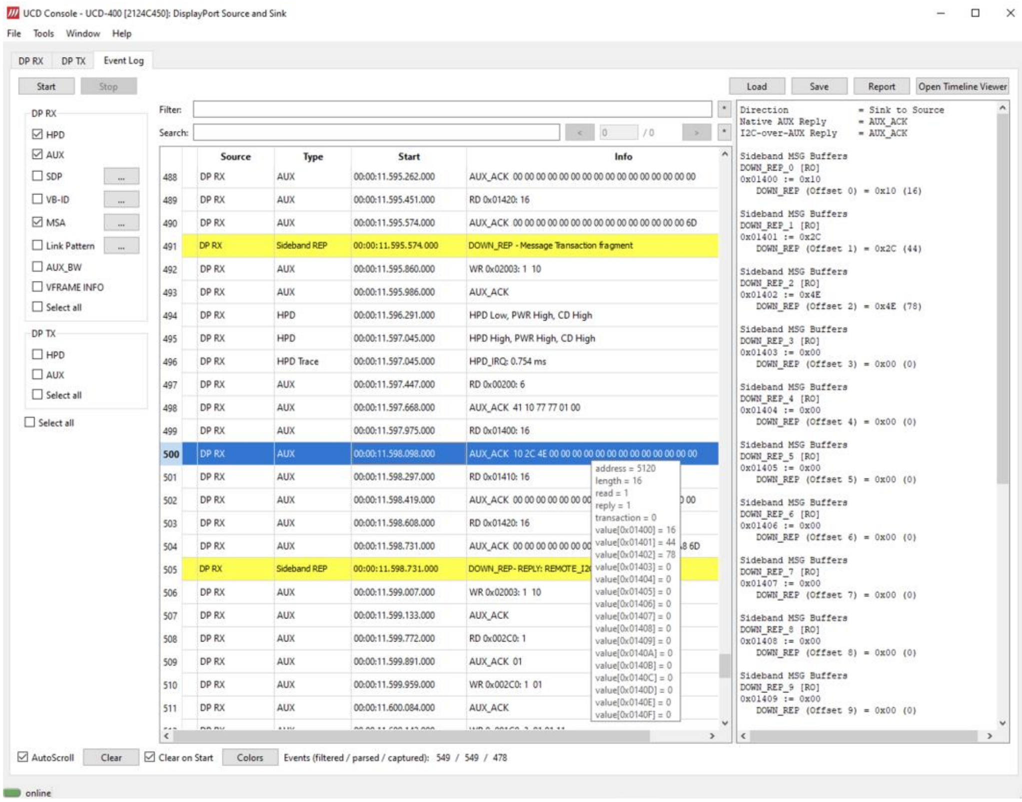


Low Speed Electrical logger captures the Voltage and Current on the low speed lanes of the USB-C connector including CC, VBUS, VCONN, and SBU.

Event Filter Dialog sets the threshold values for capturing the changes. Parsed transaction data shows the captured data with indication of the changed values.

Event Transaction List

Transaction data in Transaction List is ordered in columns. Each column provides additional information about the data line, facilitating its viewing and interpretation.



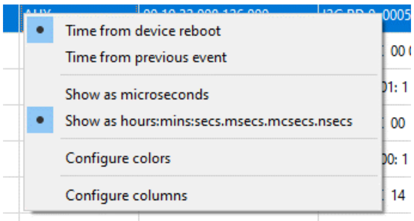
Source:	The communication port: DP RX, DP TX, HDMI RX, HDMI TX or HDCP 1.X, HDCP 2.3
Type:	The logged item: HPD, AUX, SDP, VB-ID, MSA, Link Pattern, AUX_BW, VFRAME INFO (DP or DP Alt Mode) HPD, Packets, I2C, CEC (HDMI)
Start:	Each line is identified by its timestamp, marking the instant when an event or error was detected, or when a data transaction got started. The timestamp can be displayed as a time delay from the start of the acquisition (absolute) or from the previous line (relative). The timestamp can be displayed in milliseconds or in minutes, seconds, and microseconds.
Info:	This column provides a short description of the message content

When hovering the mouse over the transaction list, a mouse-over window will open. It provides a brief list of the content in the transaction under the mouse.

Customizing Transaction List

User Can change what data is shown in the transaction list by adding and removing columns or limiting the transaction types in the list. User can also color highlight various types of transactions for better readability.

Right-click on the list to open the menu.



Configure Start

The time indicated in column *Start* can be either:

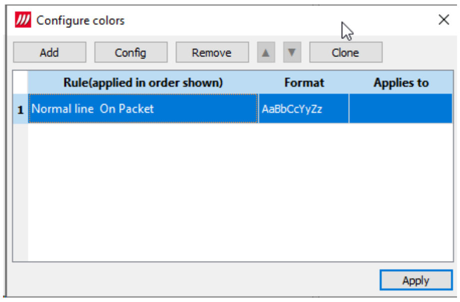
- Time from device reboot
- Time from previous event

The time can be expressed either:

- In microseconds (1/1 000 000 Second)
- Hours : minutes : seconds : milliseconds : nanoseconds

Configure Colors

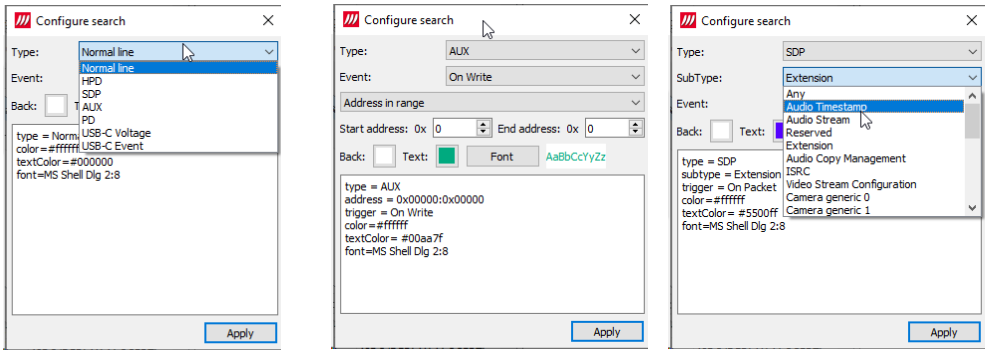
Configure colors dialog allows the user to highlight various types of transactions in the list by changing character color and background color of the transaction line.



Add:	Add a new color highlight rule
Config:	Modify the selected rule
Remove:	Delete the selected rule
Clone:	Duplicate the selected rule
▲ ▼:	Change order where rules are applied. The rules are applied from the bottom to the top of the list.

Adding Rules

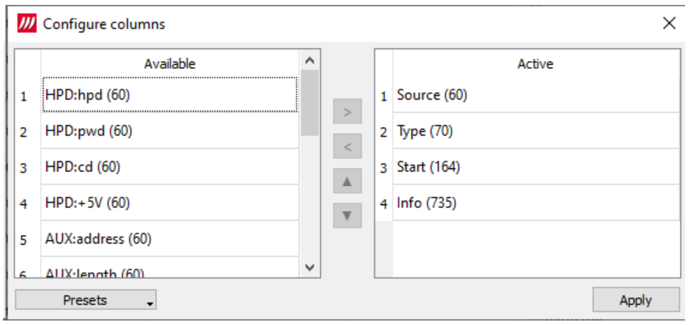
The color highlight rules are set by transaction type. The content of *Add rules* dialog is dependent on the type of item selected.



Configure Columns

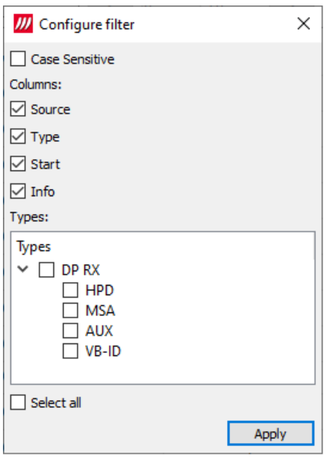
In the dialog there are two columns: *Available* and *Active*. An item from Available list can be included in Active columns by selecting it and clicking on the right arrow [>] in the middle of the two columns.

The order of Active items can be changed by selecting an item and moving its position in the list with up ▲and down ▼ arrows.



Type Filter

Type filter dialog lists the types of transactions found in the list and allows the user to select which



transaction lines are currently shown.

Quick Filter

By entering a DPCD address in the Quick Filter field on top of the transaction line, the user can limit the list to show only the reads or writes to this DPCD address.

Event Details

HPD

HPD transactions include the following statuses:

Hot-Plug-Detect Level:	Status of HPD signal: HIGH (Asserted), LOW (De-asserted)
PWD Level:	Status of source device detection: High (DP Tx detected), LOW (DP Tx not detected)
Cable Detect Level:	Status of cable detection HIGH (Cable connection detected) LOW (Cable connection not detected)

```
Device ID              = 01 [DP RX]
Hot-Plug-Detect Level = HIGH
PWD Level              = HIGH (DP Tx is connected to Rx and has power applied to AUX pull-up resistor)
Cable Detect Level     = HIGH
```

AUX (UCD-400, UCD-411, UCD-424, UCD-451)

Transaction list includes the following DP AUX Channel transactions. Parsed transactions panel provides details for each transaction.

RD:	Native AUX Request Transaction for read
WR:	Native AUX Request Transaction for write
I2C RD:	I2C-over-AUX Request Transaction for read
I2C WR:	I2C-over-AUX Request Transaction for write
AUX_ACK:	AUX Reply Transaction (Request accepted)
AUX_NACK:	AUX Reply Transaction (Request not accepted)
AUX_DEFER:	AUX Reply Transaction (Delayed, new request needed)
Sideband REQ:	Sideband down request message (DOWN_REQ_MSG)
Sideband REP:	Sideband down reply message (DOWN_REP_MSG)
HDCP Trace 1.X or HDCP Trace 2.3:	HDCP Transmitter and HDCP Receiver communicate DPCD values over AUX Channel. Transactions are listed as DPCD Address Range Traces where HDCP Port name is indicated.

Native AUX Transaction Example

```
Direction                = Source to Sink
Native AUX Request       = Read
Length                   = 6
Address                  = 0x00200

Link/Sink Device Status
SINK_COUNT [RO]
0x00200

Link/Sink Device Status
DEVICE_SERVICE_IRQ_VECTOR
0x00201

Link/Sink Device Status
LANE0_1_STATUS [RO]
0x00202

Link/Sink Device Status
LANE2_3 STATUS [RO]
0x00203

Link/Sink Device Status
LANE_ALIGN_STATUS_UPDATED [RO]
0x00204

Link/Sink Device Status
SINK_STATUS [RO]
0x00205
```

```
Direction                = Sink to Source
Native AUX Reply         = AUX_ACK
I2C-over-AUX Reply       = AUX_ACK

Link/Sink Device Status
SINK_COUNT [RO]
0x00200 := 0x01
   SINK_COUNT = 1
   CP_READY = 0

Link/Sink Device Status
DEVICE_SERVICE_IRQ_VECTOR
0x00201 := 0x10
   REMOTE_CONTROL_COMMAND_PENDING = 0
   AUTOMATED_TEST_REQUEST = 0
   CP_IRQ = 0
   MCCS_IRQ = 0
   DOWN_REP_MSG_RDY = 1
   UP_REQ_MSG_RDY = 0
   SINK_SPECIFIC_IRQ = 0

Link/Sink Device Status
LANE0_1_STATUS [RO]
0x00202 := 0x77
   LANE0_CR_DONE = 1
   LANE0_CHANNEL_EQ_DONE = 1
   LANE0_SYMBOL_LOCKED = 1
   LANE1_CR_DONE = 1
   LANE1_CHANNEL_EQ_DONE = 1
   LANE1_SYMBOL_LOCKED = 1

Link/Sink Device Status
```

Sideband Message Example

```
Sideband message header
   Link_Count_Total                          1
   Link_Count_Remaining                      0
   Broadcast_Message                         0
   Path_Message                              1
   MSG_Body_Length                           3
   Start_Of_MT                               1
   End_Of_MT                                 1
   Message_Sequence_No                       0

Sideband message validity check
   MSG_Header_CRC                            7 [Good]
   MSG_Body_CRC                              95 [Good]
   Header Reserved (Zero) fields             [Good]

Message Transaction decode
   Request_Identifier                        0x10 [ENUM_PATH
   Port_Number                               8
```

```
Sideband message header
   Link_Count_Total                              1
   Link_Count_Remaining                          0
   Broadcast_Message                             0
   Path_Message                                  1
   MSG_Body_Length                               7
   Start_Of_MT                                   1
   End_Of_MT                                     1
   Message_Sequence_No                           0

Sideband message validity check
   MSG_Header_CRC                                0 [Good]
   MSG_Body_CRC                                  20 [Good]
   Header Reserved (Zero) fields                 [Good]

Message Transaction decode
   Reply_Type                                    ACK
   Request_Identifier                            0x10 [ENUM_PATH_
   Port_Number                                   8
   Full_Payload_Bandwidth_Number_Available       7737
   Payload_Bandwidth_Number                      7737
```

HDCP Trace Example

```
E(kpub)_k(m)- DPCD Address range trace

0x69220 - 0x6929F
   No extended trace decoding available.
Block dump:
CD C7 90 67 D8 D9 9A BD 43 56 64 18 52 A5 73 BB
41 56 E1 FD 82 F8 3A 24 9A BB 0C FD 42 98 3B 17
D8 E6 07 14 D6 E9 CA 25 19 10 3D 26 38 F6 15 B7
5E 4F BE 8B 25 B3 CC 62 0E 1D 00 21 41 E2 DD 09
50 A2 26 E5 8F 9D A0 2F F2 18 AA 98 48 C6 6D 49
AB D8 92 7E B3 A7 F2 CC 85 55 F7 51 53 31 41 FC
68 C2 6D BF 06 5A 8B D7 B9 17 87 53 8E 16 DE 74
00 E3 96 1C 4E A8 81 30 BA 68 B8 3D D6 EE C9 F7
```

SDP (UCD-400, UCD-424)

DP Secondary-data Packets.

```
SDP ID:          0x00
SDP Type:        0x84
SDP Length:      0x01B  (27)
SDP Version:     0x12   (18)

Data Byte 1:
 CC[2-0]:        0x1    Channel Count                2
 CT[7-4]:        0x0    Refer to Stream Header

Data Byte 2:
 SS[1-0]:        0x0    Sample Size                  Refer to Stream Header
 SF[4-2]:        0x0    Sampling Frequency           Refer to Stream Header

Data Byte 3:
 CXT[4-0]:       0x00   Refer to CT (Data Byte 1)

Data Byte 4:
 CA[7-0]:        0x00   Channel Allocation           1     2     3     4     5     6
                                                     FL    FR    -     -     -     -
Data Byte 5:
 LFEPBL[1-0]:    0x0    LFE Playback Level           Unknown or refer to other inform
 LSV[6-3]:       0x0    Level Shift Value            0dB
 DM_INH[7]:      0x0    Down-mix Inhibit Flag        Permitted or no information abou

Raw Data:
 Head: 00 84 1B 48 (PB: 00 84 D7 D1)
 Body: 01 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 (PB: 98 00 00 00)
       00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 (PB: 00 00 00 00)
```

VB-ID (UCD-400, UCD-424)

Vertical Blanking ID packets sent in DP stream.

```
Device ID         = 00
Stream ID         = 00
Data length       = 3
VerticalBlanking_Flag = 1[bit 0]
FieldID_Flag          = 0[bit 1]
Interlace_Flag        = 0[bit 2]
NoVideoStream_Flag    = 0[bit 3]
AudioMute_Flag        = 1[bit 4]
HDCP SYNC DETECT      = 0[bit 5]
CompressedStream_Flag = 0[bit 6]
Reserved              = 0[bit 7]
Mvid              = 0x33
Maud              = 0x00
```

MSA (UCD-400, UCD-424)

Main Stream Attributes sent in DP stream.

```
Device ID         = 01
Stream ID         = 03
Data length       = 28
Mvid              = 0x2333
Nvid              = 0x8000
H-Total           = 2200
V-Total           = 1125
H-Active          = 1920
V-Active          = 1080
H-Sync Width      = 44
V-Sync Width      = 5
H-Sync Start      = 192
V-Sync Start      = 41

MISC0             = 0x20
MISC0.Clock       = Asynchronous
MISC1             = 0x00
MISC1.Interlaced Vertical Total Even: Number of lines per interlaced frame (consist
MISC1.Interlaced Vertical Total Even: No 3D stereo video in-band signaling
```

Link Pattern (UCD-400, UCD-424)

Status of link pattern detected in which lane.

```
Device ID = 01
Lane 0 []
Lane 1 []
Lane 2 []
Lane 3 [TPS1; Detected; ]
```

AUX_BW (UCD-400, UCD-424)

Status of captured binary Manchester II codes. The duration of the preamble and postamble will be presented.

```
Packet content type   = 0x00 [Data message]
Packet size           = 24 [bytes]
Direction             = Source to Sink
Native AUX Request    = Write
Length                = 2
Data                  = 08 08
Address               = 0x00103

Link Configuration
TRAINING_LANE0_SET
0x00103 := 0x08
   VOLTAGE_SWING_SET = level 0
   MAX_SWING_REACHED = level 0
   PRE_EMPHASIS_SET = level 1
   MAX_PRE-EMPHASIS_REACHED = 0
   NOTE: Decoded as MAIN_LINK_CHANNEL_CODING_SET = 8b/10b

   TX_FFE_PRESET_VALUE = 8
   NOTE: Decoded as MAIN_LINK_CHANNEL_CODING_SET = 128b/132b

Link Configuration
TRAINING_LANE1_SET
0x00104 := 0x08
   VOLTAGE_SWING_SET = level 0
   MAX_SWING_REACHED = level 0
   PRE_EMPHASIS_SET = level 1
   MAX_PRE-EMPHASIS_REACHED = 0
   NOTE: Decoded as MAIN_LINK_CHANNEL_CODING_SET = 8b/10b

   TX_FFE_PRESET_VALUE = 8
   NOTE: Decoded as MAIN_LINK_CHANNEL_CODING_SET = 128b/132b

Transaction Data
80 01 03 01 08 08

Manchester II codes:
 preamble:  L 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 H H L L
 command:   1 0 0 0 [0x8]
 address:   0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 1 1 [0x00103]
 length:    0 0 0 0 0 0 0 1 [0x01]
 data:      0 0 0 0 1 0 0 0 [0x08]
            0 0 0 0 1 0 0 0 [0x08]
 postamble: H H L L
```

VFAME INFO (UCD-400, UCD-424)

Measure dimensions of capture video frame.

```
Stream ID              = 0

VFRECORD 1
 VFA TYPE              VIDEO_DP_MEAS
 VFA LENGTH            2
 Vtotal                1125
 Hactive               1920
 Vactive               1080
```

PD (UCD-424)

USB-C PD communication messages

```
Start of packet: SOP (S1 S1 S1 S2)
--------------------------------------------------------------------------------
Header                                  0x21A1                  Data Message
    Extended(15)                            0
    Data Objs(14..12)                       2
    Message ID(11..9)                       0
    Port Power Role(8)                      Source(0x1)
    Spec Rev(7..6)                          v3.0(0x2)
    Port Data Role(5)                       DFP(0x1)
    Message Type(4..0)                      Source_Capabilities(0x01)
--------------------------------------------------------------------------------
Fixed PDO - Source                      0x2A01912C
    Fixed supply(31..30)                    0x0
    Dual-Role Power(29)                     True(0x1)
    USB Suspend Supported(28)               False(0x0)
    Unconstrained Power(27)                 True(0x1)
    USB Comm Capable(26)                    False(0x0)
    Dual-Role Data(25)                      True(0x1)
    Unchunked Ext Messages Sup(24)          False(0x0)
    EPR Mode Capable(23)                    False(0x0)
    Reserved(22)                            0x0
    Peak Current(21..20)                    Peak current equals Ioc(0x0)
    Voltage(19..10)                         5000mV(0x064)
    Maximum Current(9..0)                   3000mA(0x12C)
--------------------------------------------------------------------------------
Fixed PDO - Source                      0x2A02D12C
    Fixed supply(31..30)                    0x0
    Dual-Role Power(29)                     True(0x1)
    USB Suspend Supported(28)               False(0x0)
    Unconstrained Power(27)                 True(0x1)
    USB Comm Capable(26)                    False(0x0)
    Dual-Role Data(25)                      True(0x1)
    Unchunked Ext Messages Sup(24)          False(0x0)
    EPR Mode Capable(23)                    False(0x0)
    Reserved(22)                            0x0
    Peak Current(21..20)                    Peak current equals Ioc(0x0)
    Voltage(19..10)                         9000mV(0x0B4)
    Maximum Current(9..0)                   3000mA(0x12C)
--------------------------------------------------------------------------------
CRC                                     0x18F3953D
--------------------------------------------------------------------------------
End of packet
--------------------------------------------------------------------------------
```

LSE (UCD-424)

Status of USB-C Low Speed Electrical signals

```
Device ID               = 01
Packet size             = 40 [bytes]
Data length             = 40
Vbus TimeStamp          = 02:53:20.750.932.000

Vbus voltage            = 5420 mV [updated]
Vbus currens            = 88 mA
Vcc 1                   = 5337 mV [updated]
Vcc 2                   = 1680 mV [updated]
Vsbu 1                  = 234 mV
Vsbu 2                  = 2865 mV
Ivconn                  = 5337 mA [updated]
```

Packets (UCD-422, UCD-452)

Log metadata sent by Source device in HDMI stream

```
Packet code: 0x82

Packet Header:
    Packet Length:                            13
    Checksum:                                 57
    Version:                                  2
Packet Data:
    Scan Info(0:1)                            0(No Data)
    Bar Data(2:3)                             0(Not present)
    Format Info(4)                            0(Not present)
    Color Space(5:7)                          0(RGB)
    AFD Aspect(8:11)                          8((ATSC: Same as Picture Aspect Ratio) (I
    Coded frame AR(12:13)                     0(No Data)
    Colorimetry(14:15)                        0(No Data)
    Non-U Scaling(16:17)                      0(No Known non-uniform scaling)
    RGB Quant(18:19)                          0(Default (depends on video format))
    E-Colorimetry(20:22)                      0(No data)
    ITC Content(23)                           0(No Data)
    VIC(24:31)                                16
    Pixel repets(32:35)                       0(No repeats)
    ITC Type(36:37)                           0(Graphics)
    YCC Quant(38:39)                          0(Limited range)
    ETB(40:55)                                0
    SBB(56:71)                                0
    ELB(72:87)                                0
    SRB(88:103)                               0

Transformed HDMI Data:
82 02 0D 57 00 08 00 10 00 00 00 00 00 00 00 00
00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 38
00 00 00
```

I2C (UCD-422, UCD-452)

Log data sent over I2C communication lines of HDMI interface

```
Message:
HDRX SCDC: RD 0x10:UPDATE[0] 0x0
```

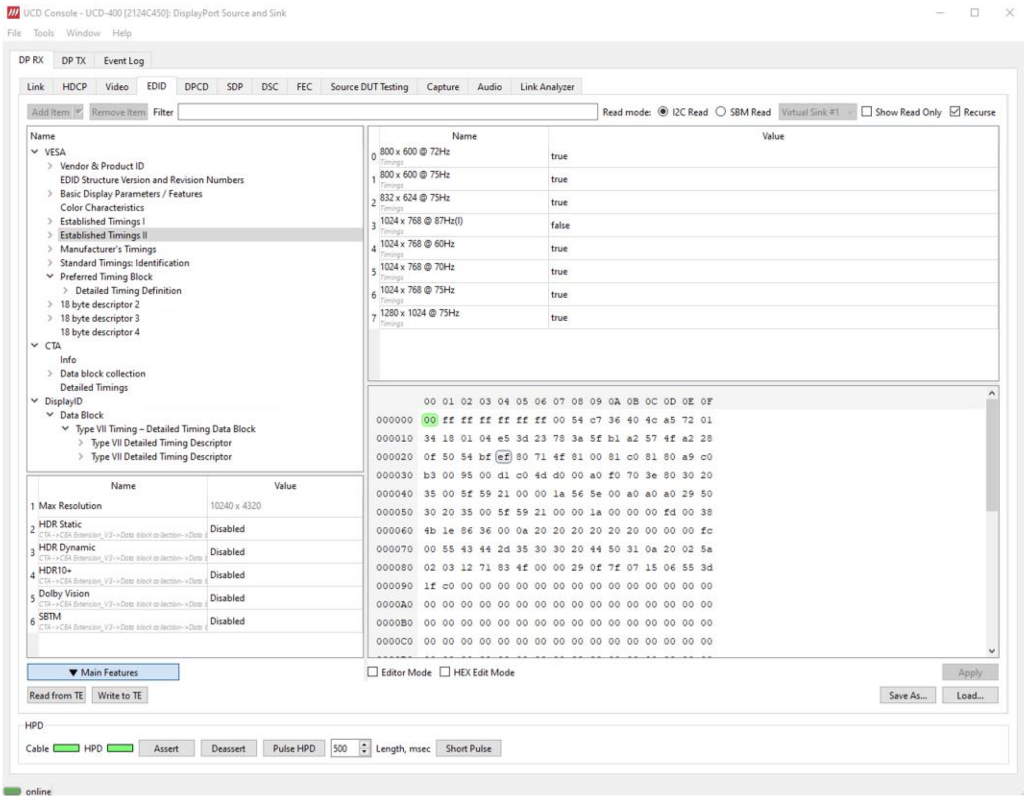
CEC (UCD-422, UCD-452)

CEC messages

```
Device ID: 00
Flags: 00
Data length: 7
Ackonledges vector:    0x001F
--------------------------------------------------------------------------------
Header:
   Initiator address:                              0x00
   Destination address:                            0x0F
--------------------------------------------------------------------------------
Opcode Block:
   Opcode:                                         <Report Physical Address>(0x84)
--------------------------------------------------------------------------------
[Physical Address]                                 0.0.0.0
[Device Type]                                      TV(0x00)
--------------------------------------------------------------------------------
```

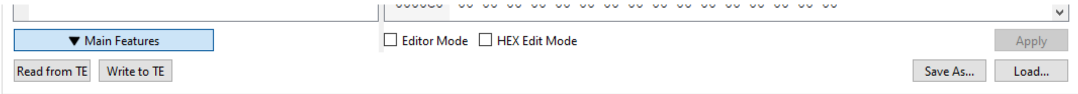
8. EDID EDITOR

The *EDID Editor* main window is divided into three logical areas. The bottom part additionally contains the command buttons. The top-left portion shows the currently edited E-EDID blocks in a tree-form, and the top-right portion shows an edit control for the currently selected item, possibly a list of sub-keys and their names (The list is not shown for all values) and the HEX-view of the block collection.



Add Item:	Add a new EDID or DisplayID block
Remove Item:	Delete the selected EDID or DisplayID block.
Filter:	Show only items having indicated the string in the field name
Read mode:	Select EDID data reading mode: I2C: local EDID read using I2C protocol SBM (MST mode only): virtual channels read with SBM protocol
Show Read Only:	When selected, also automatically created fields are shown
Recurse:	When selected, the whole logical tree of the selected item is parsed on the right hand side list.

The buttons in the bottom of the dialog differ based on the role selected, i.e., is the subject the local EDID or EDID of a connected device.



Main Features:	Toggle open and close the Main Features panel.
Read from TE (Analyzer):	Read UCD-4XX local EDID.
Write to TE (Analyzer):	Program UCD-4XX local EDID. Please see the Note below.
Download from Sink (Generator):	Read EDID of a connected sink device.
Upload to Sink (Generator):	Program EDID of a connected sink device.
Editor Mode:	Enable editing EDID content in parsed logical fields.
HEX Edit Mode:	Enable editing EDID content in HEX mode table
Save As…:	Save the current block collection to a disk file.
Load …:	Load an EDID block collection file from disk.

Note: Please note that a Source device is always able to read EDID of the connected Sink device. However, it is dependent on the design of the connected Sink device if modifying its EDID content is enabled.

EDID Editor Features

A practically unlimited number of extension blocks may exist in a single collection. The number of blocks is limited by VESA Specifications and possibly by available system resources. Most EDID blocks contain a structure that is very similar to a tree-structure. The EDID Editor decodes each block into a tree-view of the block. The tree-view then contains all values contained within the EDID block. The contents can then be easily browsed, using only a few mouse clicks. The EDID Editor has a support for automatic variables, such as the block checksum. When the user changes a value in an EDID block, the tool will update the checksum accordingly. The automatic variables appear as read only values for the user. A log print will be made when an automatic variable is updated by the editor.

Editing Tips

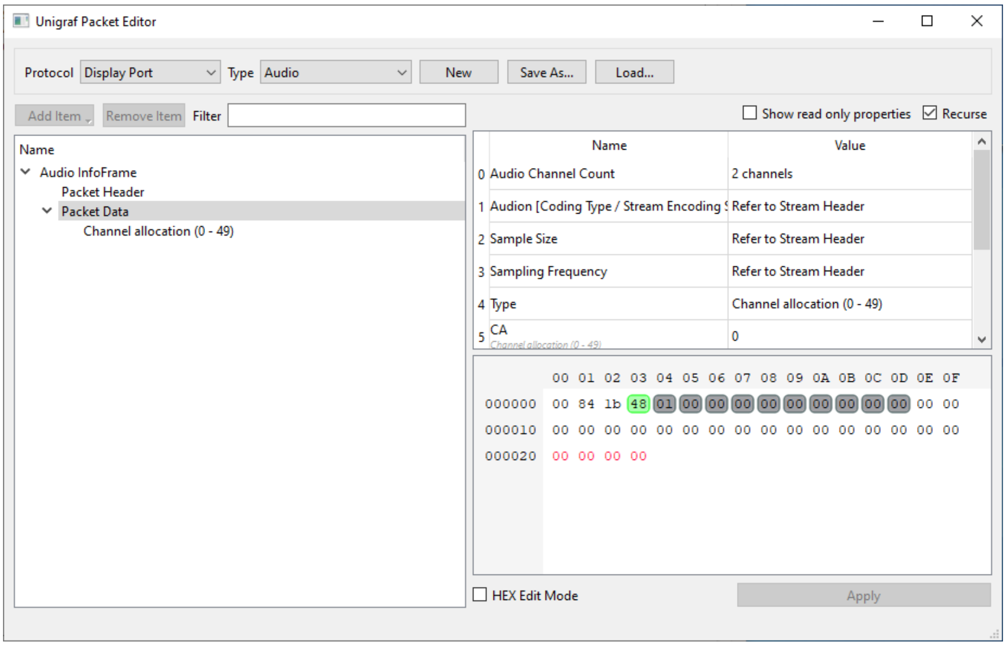
Editing an EDID block is very straightforward, but there are some special cases where the user must know how to accomplish certain types of tasks.

- Double-click the property field to edit.
- Red values in the HEX view indicate a changed value.
- **Enter** key will apply text-edit values and combo-box selection.
- In CTA-861 blocks, you can add and remove 18-byte descriptors and CEA data blocks by setting the values “18-byte Descriptors in this block” and “CEA Data block count”.
- Enter hex values with prefix “**0x**” or “**$**”, no prefix means a decimal value.
- You can always enter HEX or DEC, even if the value is presented as HEX, and/or value range is given in HEX.
- Floating point values must be given with period “**.**” as decimal separator, even if your localization setting defines decimal separator as comma (or other).
- Remember to click **Set** after changing a bit-value presented as a single checkbox if you want the new value applied.

Note: EDID Editor does not have an *Undo* function. Therefore, it is highly recommended that you back up un-edited EDID contents to a file before editing it.

9. PACKET EDITOR

Packet Editor enables creation and editing metadata packets.



The types of supported packets are:

- Audio InfoFrame (Audio)
- AVI InfoFrame (AVI)
- Custom InfoFrame (Custom) (HDMI)
- Custom Packet (Custom) (DP)
- DR&M InfoFrame (DR&M) (HDMI)
- DR&M Packet (DR&M) (DP)
- EMP-VRR (EMP-VRR)
- GCP InfoFrame (GCP)
- SPD InfoFrame (SPD)
- Vendor-Specific InfoFrame (VS) (HDMI)*
- Vendor-Specific SDP (VS) (DP)*

*) Please select from available VS packet types in field “4: Type” in the packet editor.

10. PATTERN EDITOR

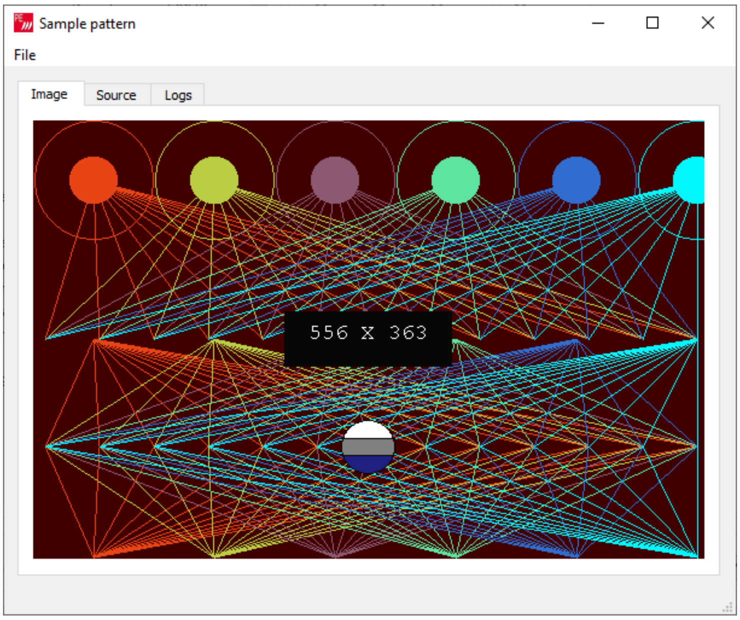
Pattern Editor is a tool for editing and debugging Unigraf Custom VTP Pattern scripts.

Please refer to APPENDIX F: VTP PATTERN LANGUAGE later in this document for description of the VTP Pattern Language syntax.

Pattern Editor consists of three tabs:

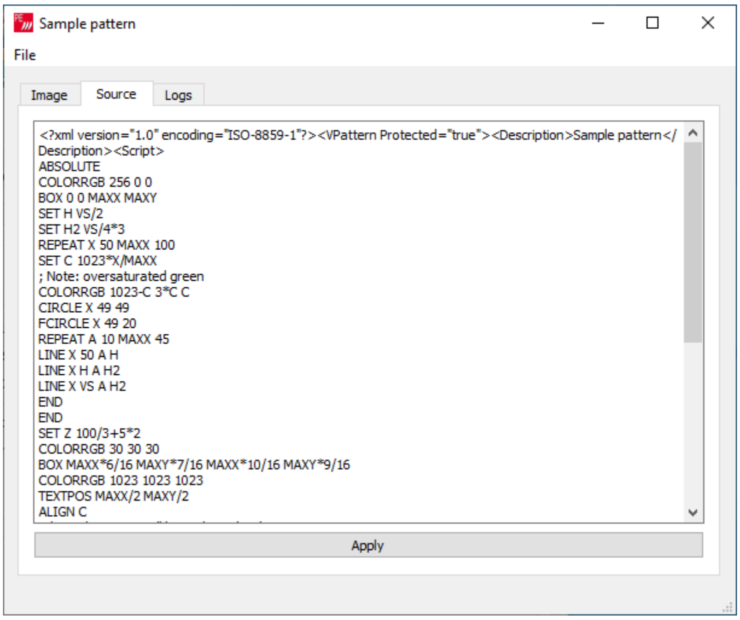
Image Tab

Monitoring the rendering of the VTP pattern script.



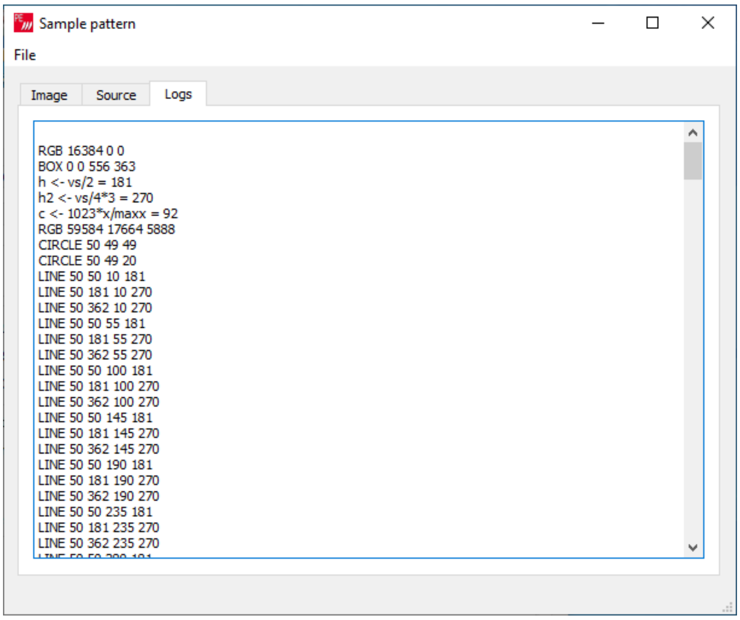
Source Tab

Tool for editing VTP Pattern Language script. Click Apply to render the code in the resolution of the preview image in *Image* tab.



Logs Tab

Log of the pattern code parsing indicating the values assigned to logical variables and the actual parameter values used for render instructions.



Saving and Recalling the Script

In File pull-down menu the user can save his work.

Open: Open a VTP language script from PC

Save Script: Save the script currently in Source tab to PC

Save Image: Save a rendered pattern in PNG, BMP, JPG or PPM format

Select Save Resolution: Select from six common resolutions the size in which the pattern script will be rendered when saved.

11. IMAGE CONVERTER

Image Converter is a tool for converting images from one color format to another. This kind of conversion is typically needed when creating YCbCr test images from RGB bitmaps.

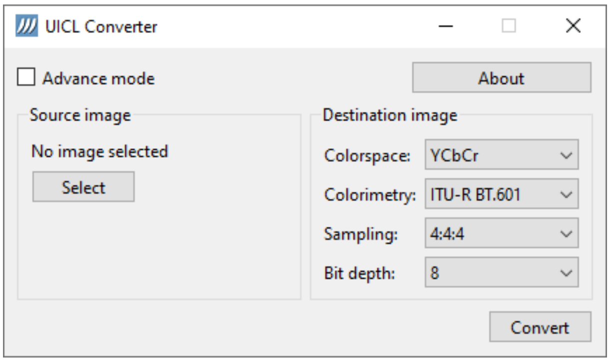
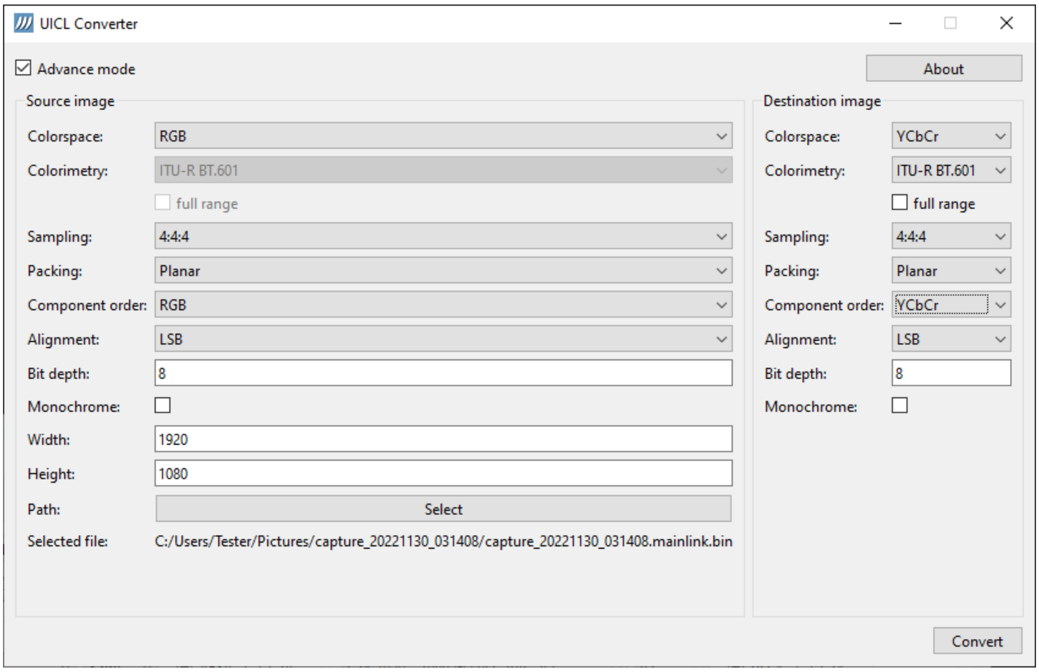


Image Converter has two operating modes: Standard mode and Advanced mode. In Standard mode typical Windows image file formats are used as Source image and the user sets basic color formats for the Destination image. In Advanced mode, the user is able to define the Source and Destination image parameters in detail.

Click **Select** to load the Source image. Click **Convert** to store the Destination image. File name for



the Destination image is of form:

```
Source_image_1920x1080_8bits_yuv444_lsb.bin
```

Source_image	Name of the image file used as Source image
1920x1080	Resolution of the Source Image
8bits	Bit depth of the Destination image
yuv444	Color space and sampling of the Destination image
lsb	Data alignment of the Destination image

APPENDIX A: PRODUCT SPECIFICATION

UCD-400 and UCD-411

Input	DisplayPort™ 1.4a compliant (DP Rx) *(UCD-400 only)*
Output	DisplayPort™ 1.4a compliant (DP Tx)
Max video mode	7680 × 4320 p30 input and output 3840 × 2160 p120 input and output
Audio	LPCM, 2 – 8 channels, 44.1 to 192 kHz
Content Protection	HDCP 2.3, HDCP 1.3
DSC Capability	DSC Sink with off-line decompression DSC Source using pre-compressed content
Additional features	FEC, LTTPR, DSC DP 1.4a LL CTS, DP DSC CTS HDCP 2.3 CTS
Computer interface	USB 3.0
Software	Windows 11, 10 and 8 compatible software drivers, UCD Console for Windows. Compatible with Unigraf TSI SDK.
Power supply	AC/DC Power supply (100 to 240 Vac 50/60 Hz input, +12 Vdc output)
Environmental	Operating temperature: 15 to 35 deg C Storage temperature: 0 to 50 deg C Humidity 30% to 70% RH, non-condensing
Mechanical Size	280 × 200 × 80 mm
Weight	1.2 kg w/o power supply

UCD-422 and UCD-412

Input	HDMI 2.1 (10K@30Hz) (HDMI Rx) *(UCD-422 only)*
Output	HDMI 2.1 (10K@30Hz) (HDMI Tx)
HDMI 2.1 Features	FRL, TMDS, ALLM, VRR
Content Protection	HDCP 2.2, HDCP 2.3
Additional features	eARC, DSC*, FEC*
Computer interface	USB 3.0
Operating System	Windows 11, 10 and 8
Software	UCD Console TSI API with interface specific Test Sets
Power supply	AC/DC Power supply (100 to 240 Vac 50/60 Hz input, +12 Vdc output)
Environmental	Operating temperature: 15 to 35 deg C Storage temperature: 0 to 50 deg C Humidity 30% to 70% RH, non-condensing
Mechanical Size	272 × 170 × 60 mm
Weight	1.2 kg w/o power supply

*) Please contact Unigraf for detailed availability

UCD-424

Input	DisplayPort™ 1.4a compliant (DP Rx)
Output	DisplayPort™ 1.4a compliant (DP Tx)
Max video mode	7680 × 4320 p30 input and output 3840 × 2160 p120 input and output
Audio	LPCM, 2 – 8 channels, 44.1 to 192 kHz
Content Protection	HDCP 2.3, HDCP 1.3
DSC Capability	DSC sink with off-line decompression DSC source using pre-compressed content
Additional features	FEC, LTTPR*, DSC DP 1.4a LL CTS, DP DSC CTS HDCP 2.3 CTS
Computer interface	USB 3.0
Software	Windows 11, 10 and 8 compatible software drivers, UCD Console for Windows. Compatible with Unigraf TSI SDK.
Power supply	AC/DC Power supply (100 to 240 Vac 50/60 Hz input, +12 Vdc output)
Environmental	Operating temperature: 15 to 35 deg C Storage temperature: 0 to 50 deg C Humidity 30% to 70% RH, non-condensing
Mechanical Size	280 × 200 × 80 mm
Weight	1.2 kg w/o power supply

UCD-451

Output	DisplayPort™ 1.4a compliant (DP Tx)
Max video mode	7680 × 4320 p30 3840 × 2160 p120
Content Protection	HDCP 2.3, HDCP 1.3
Additional features	FEC, LTTPR, DSC DP 1.4a LL CTS, DP DSC CTS* HDCP 2.3 CTS*
DSC Capability	DSC source using pre-compressed content
User Interface	Windows 10 operated with monitor, keyboard, and mouse
Software	Installed Windows 10 UCD Console for Windows.
Video memory	Extended video memory up to 32 GBytes
PC Connections	6 x USB 3.0, 2 x Ethernet, 1 x HDMI
Power supply	AC/DC Power supply (100 to 240 Vac 50/60 Hz input, +12 Vdc output)
Environmental	Operating temperature: 15 to 35 deg C Storage temperature: 0 to 50 deg C Humidity 30% to 70% RH, non-condensing
Mechanical Size	329 × 188 × 215 mm
Weight	3.9 kg w/o power supply

*) Please contact Unigraf for availability

UCD-452

Output	HDMI 2.1 (HDMI Tx)
Max video mode	10240 x 4320 @ 30Hz 10240 x 4320 @ 60Hz with DSC
HDMI 2.1 Features	FRL, TMDS, ALLM, VRR DSC 1.2a, FEC, eARC*
Content Protection	HDCP 2.3, 1.4
User Interface	Windows 10 operated with monitor, keyboard, and mouse
Software	Installed Windows 10 UCD Console for Windows.
Video memory	Extended video memory up to 32 GBytes
PC Connections	6 x USB 3.0, 2 x Ethernet, 1 x HDMI
Power supply	AC/DC Power supply (100 to 240 Vac 50/60 Hz input, +12 Vdc output)
Environmental	Operating temperature: 15 to 35 deg C Storage temperature: 0 to 50 deg C Humidity 30% to 70% RH, non-condensing
Mechanical Size	329 × 188 × 215 mm
Weight	3.9 kg w/o power supply

*) Please contact Unigraf for availability

APPENDIX B: PRODUCT FEATURES

UCD-400, UCD-411, UCD-424 and UCD-451 Features

Input / Output Role	UCD-4XX Default	DSC Decoder	DP 1.4a LL CTS	DP 1.4a DSC CTS	DisplayID / EDID CTS	Adaptive-Sync CTS	HDCP 2.3 CTS Source DUT	HDCP 2.3 CTS Sink, Source & Repeater DUT	TSI Basic
DP Reference Sink (UCD-400 and UCD-424)									
Video status, preview and saving	●								▲
Buffered capture	●								
Audio monitoring, graphical preview and saving	●								▲
Link status	●								▲
Link control	●								▲
HPD status and control	●								▲
MST Feature (up to 4 streams)	●								▲
FEC Feature	●								▲
DSC Decoder, DSC Control		●		●					▲
Adaptive-Sync Feature**	●								▲
DPCD editor	●								
Monitor InfoFrame Status (SDP)	●								▲
EDID read and write	●								▲
EDID / DisplayID Editor	●								
HDCP 1.3 status and control*	●								▲
HDCP 2.3 status and control	●								▲
Event Log, AUX Analyzer	●								
Source DUT Testing (Link and CRC test)	●								▲
DP 1.4a LL, Audio, FEC CTS			●						
DP 1.4a DSC CTS for testing Source DUT				●					
DisplayID / EDID CTS for testing Source DUT					●				
Adaptive-Sync CTS for testing Source DUT						●			
HDCP 2.3 CTS for testing DP Source DUT							●	●	
HDCP 2.3 CTS for testing DP Repeater DUT								●	

*) HDCP 1.3 is currently not supported. It will be supported in later 3.X release package.

**) Adaptive-Sync is currently limited to SST mode.

UCD-400, UCD-411, UCD-424 and UCD-451 Features (cont.)

Input / Output Role	UCD-4XX Default	DSC Encoder	LTTPR	DP 1.4a LL CTS	DP 1.4a DSC CTS	DisplayID / EDID CTS	Adaptive-Sync CTS	HDCP 2.3 CTS Sink DUT	HDCP 2.3 CTS Sink, Source and Repeater DUT	TSI Basic
DP Reference Source										
Video pattern generator (fixed patterns and timings)	●									▲
Custom video patterns and timings	●									▲
Audio generator	●									▲
Playback	●									▲
Link status	●									▲
Link control	●									▲
HPD status	●									▲
EDID read and write	●									▲
EDID / DisplayID Editor	●									
MST Feature (up to 2 streams)	●									▲
MST Feature (up to 4 streams)	●									▲
FEC Feature	●									▲
DSC Encoder		●			●					
DPCD editor	●									
LTTPR Feature			●							
HDCP 1.3 status and control*	●									▲
HDCP 2.3 status and control	●									
Event Log, AUX Analyzer	●									
Sink DUT Testing	●									
DP 1.4a LL, Audio and FEC CTS for testing Sink DUT **				●						
DP 1.4a DSC CTS for testing Sink DUT**					●					
DisplayID / EDID CTS for testing Sink DUT**						●				
Adaptive-Sync CTS for testing Sink DUT**							●			
HDCP 2.3 CTS for testing DP Sink DUT**								●	●	
HDCP 2.3 CTS for testing DP Repeater DUT**									●	

*) HDCP 1.3 is currently not supported. It will be supported in later 3.X release package

**) Please check availability for UDC-451 from Unigraf

UCD-422, UCD-412 and UCD-452 Features

Input / Output Role	UCD-4XX Default	TSI Basic
HDMI Reference Sink (UCD-422 only)		
Video status, preview and saving	●	▲
Buffered capture	●	
Audio monitoring, graphical preview and saving	●	▲
Link status	●	▲
Link control	●	
HPD status and control	●	▲
EDID read and write	●	▲
EDID Editor	●	
HDCP 1.4 status and control*	●	▲
HDCP 2.3 status and control*	●	▲
FEC Feature	●	▲
DSC Decoder, DSC Control	●	
ALLM, VRR	●	▲
Event Log	●	
InfoFrame status	●	▲
eARC	●	▲
Source DUT Testing	●	▲

*) HDCP is currently not supported. It will be supported in later 3.X release package

HDMI Reference Source		
Video pattern generator (fixed patterns and timings)	●	▲
Custom video patterns and timings	●	▲
Playback	●	▲
Audio Generator	●	▲
Link status	●	▲
Link control	●	▲
EDID read and write	●	▲
EDID Editor	●	
DSC Encoder	●	
SCDC Editor	●	
Event Log	●	
Sink DUT Testing	●	
HDCP 1.4 status and control*	●	▲
HDCP 2.3 status and control*	●	▲

*) HDCP is currently not supported. It will be supported in later 3.X release package

UCD-424 USB-C Features

Input / Output Role	UCD-4XX Default	TSI Basic
USB-C Modes Common		
USB-C Data Role status & control	●	▲
USB-C Power Role status & control	●	▲
USB-C Vbus / CC / Vconn voltage / current monitoring	●	▲
Power Delivery protocol monitoring	●	▲
Cable Info (E-marker details)	●	▲
Event Logger	●	
Support for USB-C Power for 5V/3A	●	▲
Support for USB-C Power for 9V/3A	●	▲
DP Alt Mode Common		
USB-C DP ALT Mode status	●	▲
USB-C DP ALT Mode control	●	▲

Product Options

UCD-400, UCD-411 and UCD-424 Product Options

Product	P/N	Product	P/N
HDCP 2.3 CTS for testing Source DUT on DP	MT6634	DSC Decoder for testing Source DUT on DP	MT6670
HDCP 2.3 CTS for testing Sink DUT on DP	MT6636	DSC Encoder for testing Sink DUT on DP	MT6671
HDCP 2.3 CTS for testing Repeater DUT on DP	MT6638	DP 2.1 Adaptive-Sync CTS for testing Source DUT (8b/10b)	MT6648
DP 1.4a LL CTS for testing Sink DUT	MT6635	DP 2.1 Adaptive-Sync CTS for testing Sink DUT (8b/10b)	MT6649
DP 1.4a LL CTS for testing Source DUT	MT6637	HDR 10+ Display Device and SSTM Test for testing Sink DUT on DP	MT6676
DP 1.4a DSC CTS for testing Source DUT	MT6642	HDR 10+ Distribution Device for testing Source DUT on DP	MT6678
DP 1.4a DSC CTS for testing Sink DUT	MT6643		
DP 2.1 DisplayID / EDID CTS for testing Source DUT (8b/10b)	MT6646		
DP 2.1 DisplayID / EDID CTS for testing Sink DUT (8b/10b)	MT6647		

UCD-412, UCD-422 Product Options

Product	P/N	Product	P/N
DSC Decoder for testing Source DUT on HDMI	MT6672	HDR10+ DD and SSTM Tests for HDMI Sink DUT	MT6675
DSC Encoder for testing Sink DUT on HDMI	MT6673	HDR10+ DD and SSTM Tests for HDMI Source DUT	MT6677

APPENDIX C: PREDEFINED TIMINGS

Description*	HA	VA	HT	VT	HST	VST	HSYN	VSYN	FR	Pixel Clock (MHz)
CVT 640 × 480 @ 60 Hz	640	480	800	525	144	35	96	2	60	25,20
CTA 640 × 480 @ 60 Hz (VIC 1)	640	480	800	525	144	35	96	2	60	25,17
CTA 720 × 480 @ 60 Hz (VIC 2)	720	480	858	525	122	36	62	6	60	27,03
CTA 720 × 480 @ 60 Hz (VIC 3)	720	480	858	525	122	36	62	6	60	27,00
CTA 720 × 576 @ 50 Hz (VIC 17)	720	576	864	625	132	44	64	5	50	27,00
CTA 720 × 576 @ 50 Hz (VIC 18)	720	576	864	625	132	44	64	5	50	27,00
CTA 720 × 576 @ 100 Hz (VIC 42)	720	576	864	625	132	44	64	5	100	54,00
CTA 720 × 576 @ 100 Hz (VIC 43)	720	576	864	625	132	44	64	5	100	54,00
CTA 720 × 480 @ 120 Hz (VIC 49)	720	480	858	525	122	36	62	6	120	54,00
CTA 720 × 480 @ 120 Hz (VIC 48)	720	480	858	525	122	36	62	6	120	54,05
CTA 720 × 576 @ 200 Hz (VIC 52)	720	576	864	625	132	44	64	5	200	108,00
CTA 720 × 576 @ 200 Hz (VIC 53)	720	576	864	625	132	44	64	5	200	108,00
CTA 720 × 480 @ 240 Hz (VIC 56)	720	480	858	525	122	36	62	6	240	108,00
CTA 720 × 480 @ 240 Hz (VIC 57)	720	480	858	525	122	36	62	6	240	108,00
DMT 800 × 600 @ 60 Hz (ID Eh)	800	600	1056	628	216	27	128	4	60	39,79
DMT 848 × 480 @ 60 Hz (ID 14)	848	480	1088	517	224	31	112	8	60	33,75
DMT 1024 × 768 @ 60 Hz (ID 10h)	1024	768	1344	806	296	35	136	6	60	65,00
CTA 1280 × 720 @ 50 Hz (VIC 19)	1280	720	1980	750	260	25	40	5	50	74,25
CTA 1280 × 720 @ 100 Hz (VIC 41)	1280	720	1980	750	260	25	40	5	100	148,50
CTA 1280 × 720 @ 24 Hz (VIC 60)	1280	720	3300	750	260	25	40	5	24	59,40
CTA 1280 × 720 @ 25 Hz (VIC 61)	1280	720	3960	750	260	25	40	5	25	74,25
CTA 1280 × 720 @ 30 Hz (VIC 62)	1280	720	3300	750	260	25	40	5	30	74,25
CTA 1280 × 720 @ 24 Hz (VIC 65)	1280	720	3300	750	260	25	40	5	24	59,40
CTA 1280 × 720 @ 25 Hz (VIC 66)	1280	720	3960	750	260	25	40	5	25	74,25
CTA 1280 × 720 @ 30 Hz (VIC 67)	1280	720	3300	750	260	25	40	5	30	74,25
CTA 1280 × 720 @ 50 Hz (VIC 68)	1280	720	1980	750	260	25	40	5	50	74,25
CTA 1280 × 720 @ 60 Hz (VIC 69)	1280	720	1650	750	260	25	40	5	60	74,25
CTA 1280 × 720 @ 100 Hz (VIC 70)	1280	720	1980	750	260	25	40	5	100	148,50
CTA 1280 × 720 @ 120 Hz (VIC 71)	1280	720	1650	750	260	25	40	5	120	148,50
CTA 1280 × 720 @ 48 Hz (VIC 108)	1280	720	2500	750	260	25	40	5	48	90,00
CTA 1280 × 720 @ 48 Hz (VIC 109)	1280	720	2500	750	260	25	40	5	48	90,00
CTA 1280 × 720 @ 60 Hz (VIC 4)	1280	720	1650	750	260	25	40	5	60	74,25
CTA 1280 × 720 @ 120 Hz (VIC 47)	1280	720	1650	750	260	25	40	5	120	148,50
CVT 1280 × 768 @ 60 Hz [RB1]	1280	768	1440	790	112	19	32	7	60	68,26
DMT 1280 × 768 @ 60 Hz (ID 17h)	1280	768	1664	798	320	27	128	7	60	79,67
DMT 1280 × 800 @ 60 Hz (ID 1Bh) [RB1]	1280	800	1440	823	112	20	32	6	60	71,11
DMT 1280 × 800 @ 60 Hz (ID 1Ch)	1280	800	1680	831	328	28	128	6	60	83,76
DMT 1280 × 960 @ 60 Hz (ID 20h)	1280	960	1800	1000	424	39	112	3	60	108,00
DMT 1280 × 1024 @ 60 Hz (ID 23h)	1280	1024	1688	1066	360	41	112	3	60	107,96
DMT 1360 × 768 @ 60 Hz (ID 27h)	1360	768	1792	795	368	24	112	6	60	85,48
DMT 1400 × 1050 @ 60 Hz (ID 29h) [RB1]	1400	1050	1560	1080	112	27	32	4	60	101,09
DMT 1400 × 1050 @ 60 Hz (ID 2Ah)	1400	1050	1864	1089	376	36	144	4	60	121,79

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Description*	HA	VA	HT	VT	HST	VST	HSYN	VSYN	FR	Pixel Clock (MHz)
CTA 1440 × 240 @ 60 Hz (VIC 8)	1440	240	1716	263	238	18	124	3	60	27,00
CTA 1440 × 240 @ 60 Hz (VIC 9)	1440	240	1716	263	238	18	124	3	60	27,00
CTA 1440 × 480 @ 60 Hz (VIC 14)	1440	480	1716	525	244	36	124	6	60	54,00
CTA 1440 × 480 @ 60 Hz (VIC 15)	1440	480	1716	525	244	36	124	6	60	54,00
CTA 1440 × 576 @ 50 Hz (VIC 22)	1440	576	1728	625	264	22	126	3	50	54,00
CTA 1440 × 288 @ 50 Hz (VIC 23)	1440	288	1728	314	264	22	126	3	50	27,00
CTA 1440 × 288 @ 50 Hz (VIC 24)	1440	288	1728	314	264	22	126	3	50	27,00
CTA 1440 × 576 @ 50 Hz (VIC 29)	1440	576	1728	625	264	44	128	5	50	54,00
CTA 1440 × 576 @ 50 Hz (VIC 30)	1440	576	1728	625	264	44	128	5	50	54,00
CVT 1600 × 1200 @ 60 Hz [RB1]	1600	1200	1760	1235	112	32	32	4	60	130,42
DMT 1600 × 1200 @ 60 Hz (ID 33h)	1600	1200	2160	1250	496	49	192	3	60	162,00
CTA 1680 × 720 @ 24 Hz (VIC 79)	1680	720	3300	750	260	25	40	5	24	59,40
CTA 1680 × 720 @ 25 Hz (VIC 80)	1680	720	3168	750	260	25	40	5	25	59,40
CTA 1680 × 720 @ 30 Hz (VIC 81)	1680	720	2640	750	260	25	40	5	30	59,40
CTA 1680 × 720 @ 50 Hz (VIC 82)	1680	720	2200	750	260	25	40	5	50	82,50
CTA 1680 × 720 @ 100 Hz (VIC 84)	1680	720	2000	825	260	100	40	5	100	165,00
CTA 1680 × 720 @ 48 Hz (VIC 110)	1680	720	2750	750	260	25	40	5	48	99,00
CTA 1680 × 720 @ 60 Hz (VIC 83)	1680	720	2200	750	260	25	40	5	60	99,00
CTA 1680 × 720 @ 120 Hz (VIC 85)	1680	720	2000	825	260	100	40	5	120	198,00
DMT 1680 × 1050 @ 60 Hz (ID 39h) [RB1]	1680	1050	1840	1080	112	27	32	6	60	119,23
DMT 1680 × 1050 @ 60 Hz (ID 3Ah)	1680	1050	2240	1089	456	36	176	6	60	146,36
DMT 1792 × 1344 @ 60 Hz (ID 3Eh)	1792	1344	2448	1394	528	49	200	3	60	204,75
DMT 1856 × 1392 @ 60 Hz (ID 41h)	1856	1392	2528	1439	576	46	224	3	60	218,27
CTA 1920 × 1080 @ 50 Hz (VIC 31)	1920	1080	2640	1125	192	41	44	5	50	148,50
CTA 1920 × 1080 @ 24 Hz (VIC 32)	1920	1080	2750	1125	192	41	44	5	24	74,25
CTA 1920 × 1080 @ 25 Hz (VIC 33)	1920	1080	2640	1125	192	41	44	5	25	74,25
CTA 1920 × 1080 @ 100 Hz (VIC 64)	1920	1080	2640	1125	192	41	44	5	100	297,00
CTA 1920 × 1080 @ 24 Hz (VIC 72)	1920	1080	2750	1125	192	41	44	5	24	74,25
CTA 1920 × 1080 @ 25 Hz (VIC 73)	1920	1080	2640	1125	192	41	44	5	25	74,25
CTA 1920 × 1080 @ 30 Hz (VIC 74)	1920	1080	2200	1125	192	41	44	5	30	74,25
CTA 1920 × 1080 @ 50 Hz (VIC 75)	1920	1080	2640	1125	192	41	44	5	50	148,50
CTA 1920 × 1080 @ 60 Hz (VIC 76)	1920	1080	2200	1125	192	41	44	5	60	148,50
CTA 1920 × 1080 @ 100 Hz (VIC 77)	1920	1080	2640	1125	192	41	44	5	100	297,00
CTA 1920 × 1080 @ 120 Hz (VIC 78)	1920	1080	2200	1125	192	41	44	5	120	297,00
CVT 1920 × 1080 @ 30 Hz [RB1]	1920	1080	2080	1096	112	13	32	5	30	68,39
CVT 1920 × 1080 @ 30 Hz [RB2]	1920	1080	2000	1096	72	14	32	8	30	65,76
CVT 1920 × 1080 @ 144 Hz [RB3]	1920	1080	2080	1157	152	14	32	8	144	346,66
CVT 1920 × 1080 @ 200 Hz [RB3]	1920	1080	2080	1190	152	14	32	8	200	495,21
CTA 1920 × 1080 @ 30 Hz (VIC 34)	1920	1080	2200	1125	192	41	44	5	30	74,25
CVT 1920 × 1080 @ 60 Hz [RB1]	1920	1080	2080	1111	112	28	32	5	60	138,65
CVT 1920 × 1080 @ 60 Hz	1920	1080	2000	1111	72	14	32	8	60	133,32
DMT 1920 × 1080 @ 60 Hz (ID 52h)	1920	1080	2200	1125	192	41	44	5	60	148,50
CTA 1920 × 1080 @ 60 Hz (VIC 16)	1920	1080	2200	1125	192	41	44	5	60	148,50
CVT 1920 × 1080 @ 120 Hz [RB1]	1920	1080	2080	1144	112	61	32	5	120	285,54
CVT 1920 × 1080 @ 120 Hz [RB2]	1920	1080	2000	1144	72	14	32	8	120	274,56
CTA 1920 × 1080 @ 120 Hz (VIC 63)	1920	1080	2200	1125	192	41	44	5	120	297,00

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Description*	HA	VA	HT	VT	HST	VST	HSYN	VSYN	FR	Pixel Clock (MHz)
CTA 1920 × 1080 @ 48 Hz (VIC 111)	1920	1080	2750	1125	192	41	44	5	48	148,50
CTA 1920 × 1080 @ 48 Hz (VIC 112)	1920	1080	2750	1125	192	41	44	5	48	148,50
DMT 1920 × 1200 @ 60 Hz (ID 45h)	1920	1200	2592	1245	536	42	200	6	60	193,62
DMT 1920 × 1440 @ 60 Hz (ID 49h)	1920	1440	2600	1500	552	59	208	3	60	234,00
CVT 2048 × 1536 @ 60 Hz [RB1]	2048	1536	2208	1580	112	41	32	4	60	209,32
CTA 2560 × 1080 @ 24 Hz (VIC 86)	2560	1080	3750	1100	192	16	44	5	24	99,00
CTA 2560 × 1080 @ 25 Hz (VIC 87)	2560	1080	3200	1125	192	41	44	5	25	90,00
CTA 2560 × 1080 @ 30 Hz (VIC 88)	2560	1080	3520	1125	192	41	44	5	30	118,80
CTA 2560 × 1080 @ 50 Hz (VIC 89)	2560	1080	3300	1125	192	41	44	5	50	185,63
CTA 2560 × 1080 @ 100 Hz (VIC 91)	2560	1080	2970	1250	192	166	44	5	100	371,25
CVT 2560 × 1440 @ 60 Hz [RB2]	2560	1440	2640	1481	72	14	32	8	60	234,59
CVT 2560 × 1440 @ 60 Hz [RB1]	2560	1440	2720	1481	112	38	32	5	60	241,70
CVT 2560 × 1440 @ 144 Hz [RB3]	2560	1440	2720	1543	152	14	32	8	144	604,57
CVT 2560 × 1440 @ 200 Hz [RB3]	2560	1440	2720	1586	152	14	32	8	200	863,09
CTA 2560 × 1080 @ 48 Hz (VIC 113)	2560	1080	3750	1100	192	16	44	5	48	198,00
CVT 2560 × 1080 @ 60 Hz	2560	1080	3424	1120	704	37	272	10	60	230,09
CVT 2560 × 1080 @ 60 Hz [RB1]	2560	1080	2720	1111	112	28	32	10	60	181,32
CVT 2560 × 1080 @ 144 Hz [RB3]	2560	1080	2720	1157	152	14	32	8	144	453,33
CVT 2560 × 1080 @ 200 Hz [RB3]	2560	1080	2720	1190	152	14	32	8	200	647,59
CTA 2560 × 1080 @ 60 Hz (VIC 90)	2560	1080	3000	1100	192	16	44	5	60	198,00
CTA 2560 × 1080 @ 120 Hz (VIC 92)	2560	1080	3300	1250	192	16	44	5	120	495,00
DMT 2560 × 1600 @ 60 Hz (ID 4Dh)	2560	1600	3504	1658	752	55	280	6	60	348,58
DMT 2560 × 1600 @ 60 Hz (ID 4Ch) [RB1]	2560	1600	2720	1646	112	43	32	6	60	268,63
CTA 2880 × 240 @ 60 Hz (VIC 12)	2880	240	3432	263	476	18	248	3	60	54,00
CTA 2880 × 240 @ 60 Hz (VIC 13)	2880	240	3432	263	476	18	248	3	60	54,00
CTA 2880 × 288 @ 50 Hz (VIC 27)	2880	288	3456	314	528	22	252	3	50	54,00
CTA 2880 × 288 @ 50 Hz (VIC 28)	2880	288	3456	314	528	22	252	3	50	54,00
CTA 2880 × 480 @ 60 Hz (VIC 35)	2880	480	3432	525	488	36	248	6	60	108,00
CTA 2880 × 480 @ 60 Hz (VIC 36)	2880	480	3432	525	488	36	248	6	60	108,00
CTA 2880 × 576 @ 50 Hz (VIC 37)	2880	576	3456	625	528	44	256	5	50	108,00
CTA 2880 × 576 @ 50 Hz (VIC 38)	2880	576	3456	625	528	44	256	5	50	108,00
2880 × 1440 @ 60 Hz	2880	1440	2976	1456	48	8	8	1	60	259,98
CVT 3840 × 2160 @ 30 Hz [RB1]	3840	2160	4000	2191	112	28	32	5	30	262,92
CVT 3840 × 2160 @ 30 Hz [RB2]	3840	2160	3920	2191	72	14	32	8	30	257,66
CVT 3840 × 2160 @ 60 Hz [RB1]	3840	2160	4000	2222	112	59	32	5	60	533,28
CVT 3840 × 2160 @ 60 Hz [RB2]	3840	2160	3920	2222	72	14	32	8	60	522,61
CVT 3840 × 2160 @ 60 Hz [RB3]	3840	2160	4000	2222	152	14	32	8	60	533,47
CTA 3840 × 2160 @ 60 Hz (VIC 97)	3840	2160	4400	2250	384	82	88	10	60	594,00
CTA 3840 × 2160 @ 24 Hz (VIC 93)	3840	2160	5500	2250	384	82	88	10	24	297,00
CTA 3840 × 2160 @ 25 Hz (VIC 94)	3840	2160	5280	2250	384	82	88	10	25	297,00
CTA 3840 × 2160 @ 30 Hz (VIC 95)	3840	2160	4400	2250	384	82	88	10	30	297,00
CTA 3840 × 2160 @ 50 Hz (VIC 96)	3840	2160	5280	2250	384	82	88	10	50	594,00
CTA 3840 × 2160 @ 24 Hz (VIC 103)	3840	2160	5500	2250	384	82	88	10	24	297,00
CTA 3840 × 2160 @ 25 Hz (VIC 104)	3840	2160	5280	2250	384	82	88	10	25	297,00
CTA 3840 × 2160 @ 30 Hz (VIC 105)	3840	2160	4400	2250	384	82	88	10	30	297,00

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Description*	HA	VA	HT	VT	HST	VST	HSYN	VSYN	FR	Pixel Clock (MHz)
CTA 3840 × 2160 @ 50 Hz (VIC 106)	3840	2160	5280	2250	384	82	88	10	50	594,00
CTA 3840 × 2160 @ 60 Hz (VIC 107)	3840	2160	4400	2250	384	82	88	10	60	594,00
CTA 3840 × 2160 @ 48 Hz (VIC 114)	3840	2160	5500	2250	384	82	88	10	48	594,00
CTA 3840 × 2160 @ 48 Hz (VIC 116)	3840	2160	5500	2250	384	82	88	10	48	594,00
CTA 3840 × 2160 @ 100 Hz (VIC 117)	3840	2160	5280	2250	384	82	88	10	100	1188,00
CTA 3840 × 2160 @ 100 Hz (VIC 119)	3840	2160	5280	2250	384	82	88	10	100	1188,00
CTA 3840 × 2160 @ 120 Hz (VIC 120)	3840	2160	4400	2250	384	82	88	10	120	1188,00
CVT 4096 × 2160 @ 60 Hz [RB2]	4096	2160	4176	2222	72	14	32	8	60	556,74
CVT 4096 × 2160 @ 60 Hz [RB1]	4096	2160	4256	2222	112	59	32	10	60	567,41
CVT 4096 × 2160 @ 60 Hz [RB3]	4096	2160	4256	2222	152	14	32	8	60	567,61
CTA 4096 × 2160 @ 60 Hz (VIC 102)	4096	2160	4400	2250	216	82	88	10	60	594,00
CTA 4096 × 2160 @ 120 Hz (VIC 219)	4096	2160	4400	2250	216	82	88	10	120	1188,00
CTA 4096 × 2160 @ 100 Hz (VIC 218)	4096	2160	5280	2250	384	82	88	10	100	1188,00
CTA 4096 × 2160 @ 50 Hz (VIC 101)	4096	2160	5280	2250	216	82	88	10	50	594,00
CTA 4096 × 2160 @ 48 Hz (VIC 115)	4096	2160	5500	2250	384	82	88	10	48	594,00
CTA 4096 × 2160 @ 24 Hz (VIC 98)	4096	2160	5500	2250	384	82	88	10	24	297,00
CTA 4096 × 2160 @ 25 Hz (VIC 99)	4096	2160	5280	2250	216	82	88	10	25	297,00
CTA 4096 × 2160 @ 30 Hz (VIC 100)	4096	2160	4400	2250	216	82	88	10	30	297,00
CVT 3840 × 2160 @ 120 Hz [RB1]	3840	2160	4000	2287	112	124	32	5	120	1097,76
CVT 3840 × 2160 @ 120 Hz [RB2]	3840	2160	3920	2287	72	14	32	8	120	1075,80
CTA 3840 × 2160 @ 120 Hz (VIC 118)	3840	2160	4400	2250	384	82	88	10	120	1188,00
CVT 5120 × 2160 @ 30 Hz [RB1]	5120	2160	5280	2191	112	28	32	10	30	347,05
CVT 5120 × 2160 @ 30 Hz [RB2]	5120	2160	5200	2191	72	14	32	8	30	341,80
CTA 5120 × 2160 @ 30 Hz (VIC 123)	5120	2160	6000	2200	216	32	88	10	30	396,00
CVT 5120 × 2160 @ 60 Hz [RB1]	5120	2160	5280	2222	112	59	32	10	60	703,93
CVT 5120 × 2160 @ 60 Hz [RB2]	5120	2160	5200	2222	72	14	32	6	60	693,26
CTA 5120 × 2160 @ 60 Hz (VIC 126)	5120	2160	5500	2250	216	82	88	10	60	742,50
5120 × 2880 @ 60 Hz	5120	2880	5280	2962	112	79	32	5	60	938,36
5120 × 2880 @ 60 Hz	5120	2880	5200	2962	72	14	32	8	60	924,14
5120 × 2880 @ 60 Hz	5120	2880	5280	2962	152	14	32	8	60	938,69
CTA 5120 × 2160 @ 48 Hz (VIC 124)	5120	2160	6250	2475	384	307	88	10	48	742,50
CTA 5120 × 2160 @ 50 Hz (VIC 125)	5120	2160	6600	2250	384	82	88	10	50	742,50
CTA 5120 × 2160 @ 100 Hz (VIC 127)	5120	2160	6600	2250	384	82	88	10	100	1485,00
CTA 5120 × 2160 @ 25 Hz (VIC 122)	5120	2160	7200	2200	384	32	88	10	25	396,00
CTA 5120 × 2160 @ 24 Hz (VIC 121)	5120	2160	7500	2200	384	32	88	10	24	396,00
CVT 7680 × 4320 @ 30 Hz [RB2]	7680	4320	7760	4381	72	14	32	8	30	1019,90
CVT 7680 × 4320 @ 30 Hz [RB1]	7680	4320	7840	4381	112	58	32	5	30	1030,41
CVT 7680 × 4320 @ 60 Hz [RB2]	7680	4320	7760	4443	72	14	32	8	60	2068,66
CVT 7680 × 4320 @ 100 Hz [RB2]	7680	4320	7760	4529	72	14	32	8	100	3514,50
CVT 7680 × 4320 @ 60 Hz [RB1]	7680	4320	7840	4443	112	120	32	5	60	2089,99
CVT 7680 × 4320 @ 100 Hz [RB1]	7680	4320	7840	4529	112	206	32	5	100	3550,74
CTA 7680 × 4320 @ 120 Hz (VIC 201)	7680	4320	8800	4500	768	164	176	20	120	4752,00
CTA 7680 × 4320 @ 120 Hz (VIC 209)	7680	4320	8800	4500	768	164	176	20	120	4752,00
CTA 7680 × 4320 @ 30 Hz (VIC 204)	7680	4320	9000	4400	768	64	176	20	30	1188,00
CTA 7680 × 4320 @ 30 Hz (VIC 196)	7680	4320	9000	4400	768	64	176	20	30	1188,00
CTA 7680 × 4320 @ 60 Hz (VIC 207)	7680	4320	9000	4400	768	64	176	20	60	2376,00
CTA 7680 × 4320 @ 60Hz (VIC 199)	7680	4320	9000	4400	768	64	176	20	60	2376,00

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Description*	HA	VA	HT	VT	HST	VST	HSYN	VSYN	FR	Pixel Clock (MHz)
CTA 7680 × 4320 @ 100 Hz (VIC 208)	7680	4320	10560	4500	768	164	176	20	100	4752,00
CTA 7680 × 4320 @ 100 Hz (VIC 200)	7680	4320	10560	4500	768	164	176	20	100	4752,00
CTA 7680 × 4320 @ 25 Hz (VIC 203)	7680	4320	10800	4400	768	64	176	20	25	1188,00
CTA 7680 × 4320 @ 25 Hz (VIC 195)	7680	4320	10800	4400	768	64	176	20	25	1188,00
CTA 7680 × 4320 @ 50 Hz (VIC 198)	7680	4320	10800	4400	768	64	176	20	50	2376,00
CTA 7680 × 4320 @ 50 Hz (VIC 206)	7680	4320	10800	4400	768	64	176	20	50	2376,00
CTA 7680 × 4320 @ 24 Hz (VIC 194)	7680	4320	11000	4500	768	164	176	20	24	1188,00
CTA 7680 × 4320 @ 48 Hz (VIC 197)	7680	4320	11000	4500	768	164	176	20	48	2376,00
CTA 7680 × 4320 @ 24 Hz (VIC 202)	7680	4320	11000	4500	768	164	176	20	24	1188,00
CTA 7680 × 4320 @ 48 Hz (VIC 205)	7680	4320	11000	4500	768	164	176	20	48	2376,00
Unigraf 10240 x 4320 @ 30 Hz [RB1]	10240	4320	11000	4500	112	58	32	5	30	1485,00
Unigraf 10240 x 4320 @ 30 Hz [RB2]	10240	4320	11000	4500	72	14	32	8	30	1485,00
CTA 10240 x 4320 @ 24 Hz (VIC 210)	10240	4320	12500	4950	768	614	176	20	24	1485,00
CTA 10240 x 4320 @ 25 Hz (VIC 211)	10240	4320	13500	4400	768	64	176	20	25	1485,00
CTA 10240 x 4320 @ 30 Hz (VIC 212)	10240	4320	11000	4500	472	164	176	20	30	1485,00
CTA 10240 x 4320 @ 48 Hz (VIC 213)	10240	4320	12500	4950	768	614	176	20	48	2970,00
CTA 10240 x 4320 @ 50 Hz (VIC 214)	10240	4320	13500	4400	768	64	176	20	50	2970,00
CTA 10240 x 4320 @ 60 Hz (VIC 215)	10240	4320	11000	4500	472	164	176	20	60	2970,00
CTA 10240 x 4320 @ 100 Hz (VIC 216)	10240	4320	13200	4500	768	164	176	20	100	5940,00
CTA 10240 x 4320 @ 120 Hz (VIC 217)	10240	4320	11000	4500	472	164	176	20	120	5940,00

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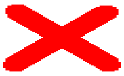
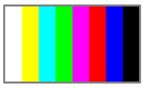
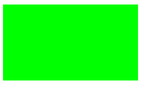
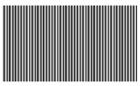
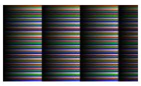
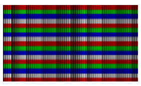
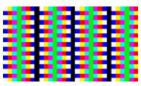
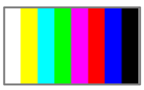
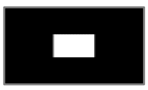
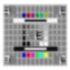
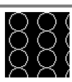
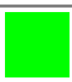
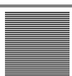
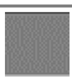
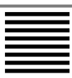
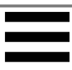
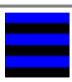
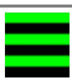
APPENDIX D: PREDEFINED PATTERNS

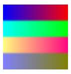
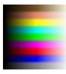
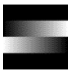
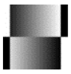
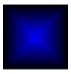
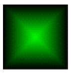
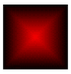
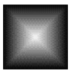
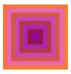
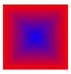
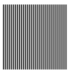
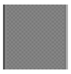
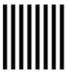
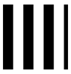
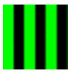
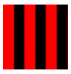
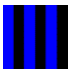
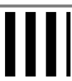
Fixed Patterns

Selection	Pattern	Description
Disabled		The links are activated but no video data transferred
Color Bar		100% intensity color bars of all primaries and mixed combinations.
Chessboard		8 by 8 chessboard with black (0%) and 100% intensity white
Solid Color		Solid color. User selected RGB values
Solid White		100% white
Solid Red		100% red
Solid Green		100% green
Solid Blue		100% blue
White V-Strips		Vertical stripes of black (0%) and white (100%). Parameters set the widths of the black and white stripes in pixels respectively. Default black / white = 20 / 20 pixels. Parameter range 1 to 1000.
RGB Wide Strips		16 pixels high horizontal red, green, blue and white stripes. Intensity is increased from 0 to 100% with steps defined by the given parameter (Color Step = cs) and selected color. (step = cs*color_depth/256). “n” range 0 to 5000 (default 100).
Color Ramp		Color Ramp test pattern defined by VESA DisplayPort Link Layer Compliance Test Specification.
Color Square		Color Square test pattern defined by VESA DisplayPort Link Layer Compliance Test Specification. Color mode can be selected between RGB, YCbCr 4:4:4, 4:2:2, 4:2:0 (ITU Rec 601 / 709)
Motion Pattern		Horizontally moving color bar pattern. The pattern is shifted to left one pixel in each frame in a sequence. The length of the sequence is defined with parameter. Range 0 to 34 (default is 20)
Square Window		100% intensity white square horizontally and vertically centered. Height and width defined by parameter as the percentage of height and width of the frame (default 30).

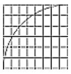
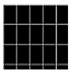
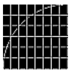
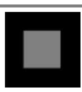
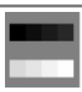
Extended Patterns

Selection	Icon	Description
Select Image		Custom image uploaded by the user. Click on Select … to browse.
Select DSC Image		Custom DSC compressed image file uploaded by the user. Click on Select … to browse.
Unigraf PM5544		Vpattern vector pattern based on PM5544
Color Web		Vpattern vector pattern.
Chinese Town Full HD		JPG Bitmap image (1920 x 1080 px)
UG-2111 HLG Narrow		Software generated pattern. HLG Narrow dynamic range.
UG-2111 PQ Narrow		Software generated pattern. PQ Narrow dynamic range.
UG-2111 PQ Full		Software generated pattern. PQ Full dynamic range.
Multi		Vpattern vector pattern. Multi-purpose pattern w square grid, cross-grids, 1x1 cross-hatches, circles, and color bars
SMPTE RP-133		Vpattern vector pattern based on SMTPE RP-133
SMPTE 303M		Vpattern vector pattern. SMPTE 303M; Full Range; RGB values before gamma correction based on D65 and PAL primaries
Blue		Vpattern vector pattern. 100% Blue
CirclesW		Vpattern vector pattern. Concentric circles
Complex		Vpattern vector pattern. Complex Pattern w 64 steps
Green		Vpattern vector pattern. 100% Green
Hor1W-Even		Vpattern vector pattern. Horizontal 1 px wide White bars in even rows
Hor1W-Odd		Vpattern vector pattern. Horizontal 1 px wide White bars in odd rows
Hor4W		Vpattern vector pattern. Horizontal 4 px high White bars
Hor10W		Vpattern vector pattern. Horizontal 10 px high White bars
Hor-10xB		Vpattern vector pattern. 10 pcs horizontal Blue bars
Hor-10G		Vpattern vector pattern. 10 pcs horizontal Green bars

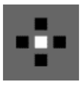
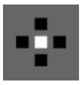
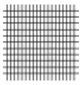
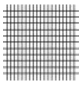
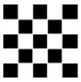
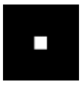
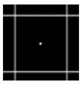
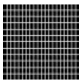
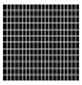
Extended Patterns (cont.)

Selection	Icon	Description
Hor-10xR		Vpattern vector pattern. 10 pcs horizontal Red bars
Hor-10xW		Vpattern vector pattern. 10 pcs horizontal White bars
HorRainbow-1024		Vpattern vector pattern. Horizontal Rainbow Ramps 1024 steps
HorRGBW-1024		Vpattern vector pattern. Horizontal RGBW Ramps 1024 steps
HorScale9		Vpattern vector pattern. Nine Horizontal Color Ramps
HorScaleW-64		Vpattern vector pattern. Horizontal White ramp 64 steps
HorScaleW-128		Vpattern vector pattern. Horizontal White ramp 128 steps
HorScaleW-X2		Vpattern vector pattern. Horizontal White ramp w edges 128 steps
InnerBox-BKtoB		Vpattern vector pattern. InnerBox pattern from Black to Blue
InnerBox-BKtoG		Vpattern vector pattern. InnerBox pattern from Black to Green
InnerBox-BKtoR		Vpattern vector pattern. InnerBox pattern from Black to Red
InnerBox-BKtoW		Vpattern vector pattern. InnerBox pattern from Black to White
InnerBoxMIX		Vpattern vector pattern. InnerBox pattern mixed hues.
InnerBox-RtoB		Vpattern vector pattern. InnerBox pattern from Red to Blue
Red		Vpattern vector pattern. 100% Red
Ver1W-Even		Vpattern vector pattern. Vertical 1 px wide White bars in even columns
Ver1W-Odd		Vpattern vector pattern. Vertical 1 px wide White bars in odd columns
Ver4W		Vpattern vector pattern. Vertical 4 px wide White bars
Ver10W		Vpattern vector pattern. Vertical 10 px wide White bars
Ver-10xG		Vpattern vector pattern. 10 pcs Vertical Blue bars
Ver-10xR		Vpattern vector pattern. 10 pcs Vertical Blue bars
Ver-10xB		Vpattern vector pattern. 10 pcs Vertical Blue bars
Ver-10xW		Vpattern vector pattern. 10 pcs Vertical Blue bars

Extended Patterns (cont.)

Selection	Icon	Description
VerBars75%		Vpattern vector pattern. Vertical 75% intensity Color bars
VerBars100%		Vpattern vector pattern. Vertical 100% intensity Color bars
VerRGBW-1024		Vpattern vector pattern. Vertical RGBW Ramps 1024 steps
X-HatchBK-C		Vpattern vector pattern. Black 16 x12 Grid w Circle on White background
X-HatchW		Vpattern vector pattern. White 16 x12 Grid on Black background
X-HatchW-C		Vpattern vector pattern. White 16 x12 Grid w Circle on Black background
X-HatchW-CC		Vpattern vector pattern. White 16 x12 Grid w Ellipses, Circle and 100% color bars
Gray Box 10		Vpattern vector pattern. China 5.6 White Window 10%
Gray Box 20		Vpattern vector pattern. China 5.6 White Window 20%
Gray Box 30		Vpattern vector pattern. China 5.6 White Window 30%
Gray Box 40		Vpattern vector pattern. China 5.6 White Window 40%
Gray Box 50		Vpattern vector pattern. China 5.6 White Window 50%
Gray Box 60		Vpattern vector pattern. China 5.6 White Window 60%
Gray Box 70		Vpattern vector pattern. China 5.6 White Window 70%
Gray Box 80		Vpattern vector pattern. China 5.6 White Window 80%
Gray Box 90		Vpattern vector pattern. China 5.6 White Window 90%
Gray Box 100		Vpattern vector pattern. China 5.6 White Window 100%
8 Level Gray		Vpattern vector pattern. China 5.5 Ultimate 8 Level Grayscale

Extended Patterns (cont.)

Selection	Icon	Description
Black'n'White Window HDTV		Vpattern vector pattern. China 5.8 Black and White Window(FOR HDTV)
Black'n'White Window SDTV		Vpattern vector pattern. China 5.8 Black and White Window(FOR SDTV)
Black Line HDTV		Vpattern vector pattern. China 5.10 Black Line HDTV
Black Line SDTV		Vpattern vector pattern. China 5.10 Black Line SDTV
Black Window		Vpattern vector pattern. China 5.7 Black Window
Check Board		Vpattern vector pattern. China 5.9 Check Board
Line'n'Window		Vpattern vector pattern. China 5.11 Line and Window
Narrow White Window		Vpattern vector pattern. China 5.19 Narrow White Window
Single Dot		Vpattern vector pattern. China Single Dot
White Line HDTV		Vpattern vector pattern. China 5.10 White Line for HDTV
White Line SDTV		Vpattern vector pattern. China 5.10 White Line for SDTV

More test patterns can be downloaded e.g. from www.icdm-sid.org/

APPENDIX E: SINK, SOURCE AND REPEATER TESTS

Source DUT Testing		Default	DP 1.4a LL CTS*	DP 1.4a DSC CTS	DP 2.1 DisplayID / EDID CTS (8b/10b)*	DP 2.1 Adaptive-Sync CTS (8b/10b)*	HDCP 2.3 CTS*	HDR10+ Distribution Device Tests
Audio Test	Validate audio signal frequency and glitch-free audio reproduction	●						
CEC Functional Test Set (HDMI) (UCD-422)	CEC functional test, CEC PHY Addr test, CEC Complete test, CEC Wake up test, CEC Standby test	●						
CRC Video Tests (UCD-400, UCD-422, UCD-424) *Will be available in future UCD-4XX versions*	CRC based single frame reference video test, CRC based single frame stability test, CRC based sequence of frames reference video test CRC based continuous sequence of frames reference video test	●						
Link Config Tests (DP) (UCD-400, UCD-424)	Link Training at All Supported Lane Counts and Link Rates	●						
Pixel Level Video Tests	Compare video frame sequence with a single reference							
VRR Source DUT Tests (HDMI) (UCD-412, UCD-422)	VRR static test, QMS Test, VRR Dynamic test	●						
DP 1.4a Link Layer CTS (UCD-400, UCD-424)	4.2.1.1 – 4.2.1.5, 4.2.2.1 – 4.2.2.10, 4.3.1.1 – 4.3.1.13, 4.3.2.1 – 4.3.2.5, 4.3.3.1, 4.4.1.1 – 4.4.1.3, 4.4.2, 4.4.3, 4.4.4.1 – 4.4.4.6, 4.5.1.1 – 4.5.1.2		●					
DP 1.4 DSC CTS (UCD-400, UCD-424)	4.6.1.1 – 4.6.1.9			●				
DP 1.4 DisplayID-EDID CTS (UCD-400, UCD-424)	4.7.1.1 – 4.7.1.4, 4.7.2.1 – 4.7.2.2, 4.7.3.1 – 4.7.3.3, 4.7.4.1, 4.7.5.1				●			
DP Adaptive-Sync CTS (UCD-400, UCD-424)	4.8.1.1 – 4.8.1.2, 4.8.2.1 – 4.8.2.2					●		
DP HDCP 2.3 CTS 1A Test Set (UCD-400, UCD-424)	HDCP2.3 CTS 1A-01 – HDCP2.3 CTS 1A-12						●	
DP HDCP 2.3 CTS 1B Test Set (UCD-400, UCD-424)	HDCP2.3 CTS 1B-01 – HDCP2.3 CTS 1B-10						●	
HDR10+ Distribution Device Tests (HDMI RX / DP RX) (UCD-400, UCD-422, UCD-424)	Tests from: *HDR10+ TEST SPECIFICATION, HDR10+ Distribution Device*							●
HDR10+ SSTM Tests for Source (HDMI RX / DP RX) (UCD-400, UCD-422, UCD-424)	Tests from: *HDR10+ TEST SPECIFICATION, Source Side Tone Mapping for Source Device*							●

*) Separate licenses for testing Sink, Source, Branch DUT (LL CTS, DSC, DisplayID, Adaptive-Sync)

Sink DUT Testing		Default	DP 1.4a LL CTS*	DP 1.4a DSC CTS Sink DUT*	DP 2.1 DisplayID / EDID CTS (8b/10b)*	DP 2.1 Adaptive-Sync CTS (8b/10b)*	DP HDCP 2.3 CTS*	HDR10+ DD & SSTM CTS
VRR Sink DUT Tests (HDMI) (UCD-412, UCD-422)	VRR static test, QMS Test, VRR Dynamic test	●						
DP 1.4a Link Layer CTS (UCD-400, UCD-411, UCD-424)**	5.2.1.1 – 5.2.1.12, 5.2.2.1 – 5.2.2.9, 5.3.1.1 – 5.3.1.9, 5.3.2.1 – 5.3.2.2, 5.4.1.1 – 5.4.1.4, 5.4.2, 5.4.3.1 – 5.4.3.2, 5.4.4.1 – 5.4.4.6, 5.5.1.1 – 5.5.1.7		●					
DP 1.4a DSC CTS (UCD-400, UCD-411, UCD-424)**	5.6.1.1 – 5.6.1.26, 5.6.2.1 – 5.6.2.14			●				
DP 1.4a DisplayID-EDID CTS (UCD-400, UCD-411, UCD-424)**	5.7.1.1 – 5.7.1.2, 5.7.1.3.1 – 5.7.1.3.4, 5.7.1.4.1 – 5.7.1.4.9, 5.7.1.5, 5.7.2.1 – 5.7.2.2, 5.7.2.3.1 – 5.7.2.3.5, 5.7.2.4.1 – 5.7.2.4.2, 5.7.2.5.1 – 5.7.2.5.2, 5.7.2.6.1 – 5.7.2.6.2, 5.7.2.7.1, 5.7.2.8, 5.7.3.1 – 5.7.3.5, 5.7.4.1 – 5.7.4.3, 5.7.4.5, 5.7.5.1, 5.7.6.1 – 5.7.6.5, 5.7.7.1 – 5.7.7.6, 5.7.8.1 – 5.7.8.6, 5.7.9.1 – 5.7.9.3, 5.7.10.1 – 5.7.10.3, 5.7.11.1 – 5.7.11.5, 5.7.12.1 – 5.7.12.3, 5.7.14.1 – 5.7.14.6, 5.7.15.1 – 5.7.15.9, 5.7.16.1 – 5.7.16.8, 5.7.17.1 – 5.7.17.5				●			
DP Adaptive-Sync CTS (UCD-400, UCD-411, UCD-424)**	5.8.1.1 – 5.8.1.3					●		
DP HDCP 2.3 CTS 2C Test Set (UCD-400, UCD-411, UCD-424)**	HDCP2.3 CTS 2C-01 – HDCP2.3 CTS 2C-06						●	
HDR10+ CTS Tests (HDMI & DP)	HDR10+ Display Device and SSTM Tests							●

*) Separate licenses for testing Sink, Source, Branch DUT (LL CTS, DSC, DisplayID, Adaptive-Sync)

**) Please check availability for UCD-451 from Unigraf

Repeater DUT Testing		Default	DP HDCP 2.3 CTS*
DP HDCP 2.3 CTS 3A Test Set (UCD-400, UCD-411, UCD-424)	HDCP2.3 CTS 3A-01 – HDCP2.3 CTS 3A-06		●
DP HDCP 2.3 CTS 3B Test Set (UCD-400, UCD-411, UCD-424)	HDCP2.3 CTS 3B-01 – HDCP2.3 CTS 3B-07		●
DP HDCP 2.3 CTS 3C Test Set (UCD-400, UCD-411, UCD-424)	HDCP2.3 CTS 3C-01 – HDCP2.3 CTS 3C-25		●

*) Separate licenses for testing Sink, Source and Repeater DUT (HDCP)

Compliance Tests

Role:	Product:
DP Reference Sink (DP RX)	UCD-400, UCD-424
DP Reference Source (DP TX)	UCD-400, UCD-411, UCD-424, UCD-451*

*) Please check availability for UCD-451 from Unigraf

Compliance test capability is a license enabled add-on to UCD Console.

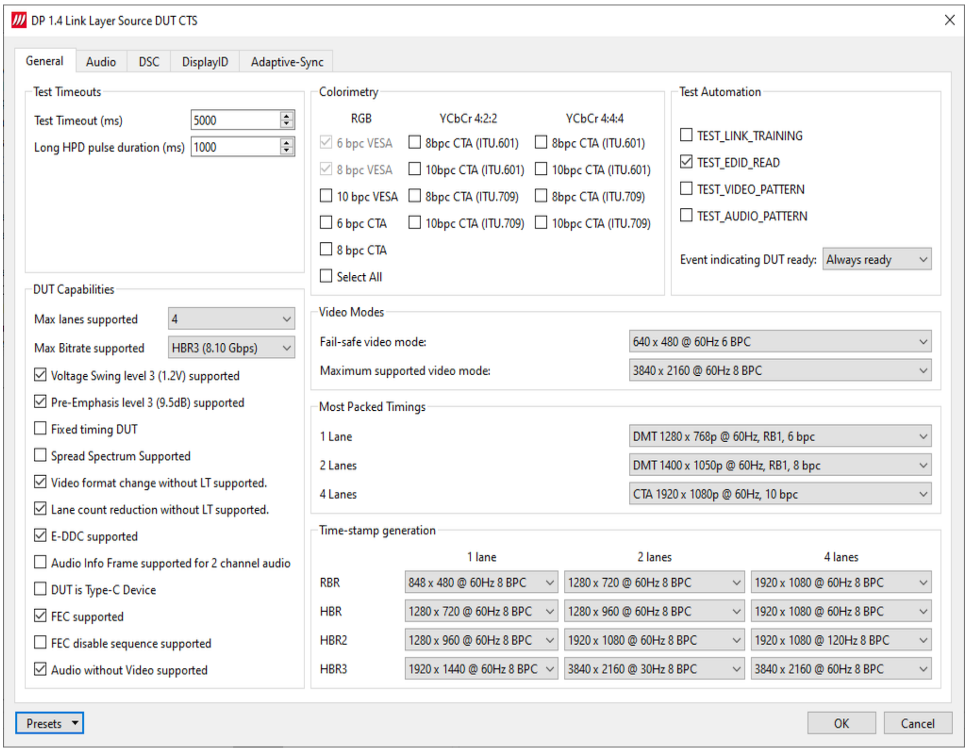
The tests are included in the GUI software, license codes enable the tests for use. Please refer to *Appendix B Licensing* for details. The list of compliance tests that UCD Console supports, please refer to document *DP CTS Tool Options for Unigraf UCD-400.pdf*. It can be downloaded in Unigraf Document Center at https://www.unigraf.fi/documents/. If you have any additional questions, please contact Unigraf or your local representative.

Compliance tests (CTS Tests) are part of tests included in **Source DUT Testing** tab of **DP RX** and **Sink DUT Testing** tab of **DP TX**.

The tests cases are divided to test categories as described in *Appendix E* of this document. Test categories are placed in sub-tabs. Test category tabs are enabled based on licenses present. Please refer to chapter 3 *License Manager* earlier in this document.

Test Parameters

Before running the tests, capabilities of the DUT have to be defined for the test engine. Each test category has its dedicated test parameter dialog. Click **Configure** in *Source DUT Testing* or *Sink DUT Testing* tab to open the parameter dialog.



For a detailed description of capabilities listed on the tab please refer to Chapter 3 Compliance Test Operation of document VESA DisplayPort v1.4a Link Layer Compliance Test Specification.

Note:	Please make sure that the capability tables are completed before running the tests. The result of the test might be misleading if the DUT capabilities and the table do not match.

DSC Test Content

When running DSC Compliance Tests, Console needs to have access to DSC content used as test patterns. This content will be automatically created during test execution. Creation of the test content takes time and considerably slows down the execution of the test. To avoid this after the first test run, users are able to save the created DSC content by selecting the option *Keep auto-created DSC content files* described below.

Warning — Please note, that the space needed for storing the full library **can be very large** (appr. 400 GBytes). Please make sure that the content will be stored in a medium that has the required space available.

Options

In Tools > Options menu you can define DSC Work folder and DSC test content directory.

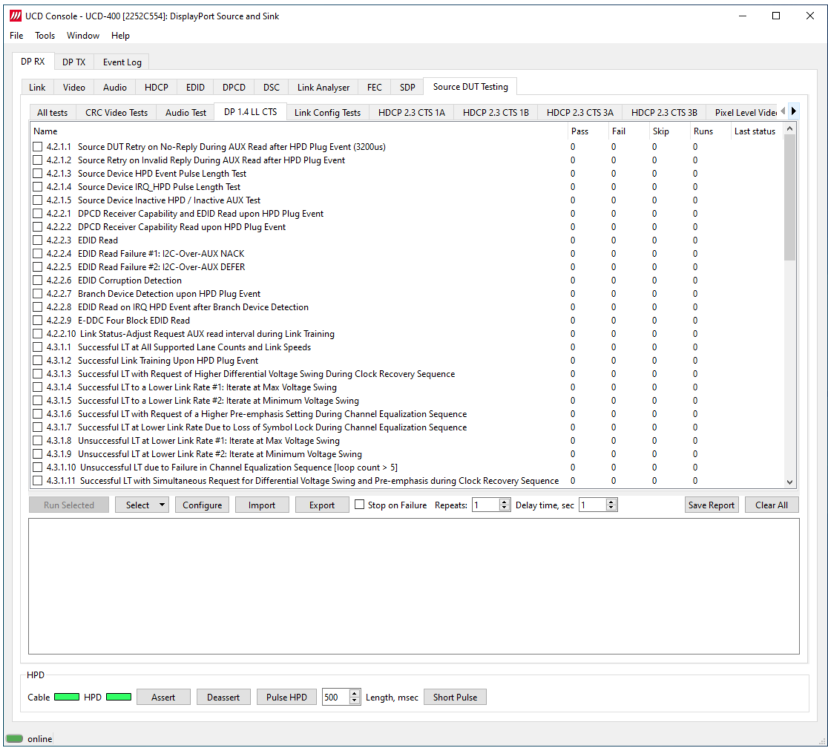
DSC temp folder:	Folder for DSC Work files.
DSC test content folder:	Folder where DSC source bitmap files, related configuration files and DSC conversion tools are stored.
Keep auto-created DSC content files:	By default, the DSC compressed content is deleted after use. If selected, the content is not deleted

Running CTS Tests

Source DUT Testing and *Sink DUT Testing* tabs include the tests enabled with the set of licenses present in UCD Console grouped in test set tabs. In tabs the tests are listed by the test name and reference number as in applicable compliance test specification. UCD-400 firmware implements the test according to the test specification.

For running a test, select it and click **Run selected**. For selecting multiple consecutive tests in the list hold down the **Shift** key of your keyboard while selecting the tests. For selecting multiple individual tests hold down the **Ctrl** key in your keyboard while selecting.

Test flow parameters like **Test timeout** and **Test cycle delay** can be defined in *Test Parameter* dialog launched by clicking **Configure**.



Run Selected	Click to start selected tests. By clicking *Abort* the sequence is stopped.
Select:	Includes the following options for creating templates for tests execution: Select All, Clear All, Invert All, Save, Import and Export
Configure	Clicking opens a dialog for defining the test parameters for that set. Please refer to *Test Parameters* below for description.
Import:	Load saved test parameter files (*.td or *.json).
Export:	Save test parameters for later use or for use in test automation. For saving parameters for later use in UCD Console, either format can be used. For saving parameters for TSI scripting, please use *.td files. For use with Python applications, please use *.json files.
Stop on Failure:	Stops execution of the selected tests if one of the tests fail
Repeats:	Repeat the selected test several times. When repeating a sequence of tests, all selected tests are performed in each repetition. E.g., when you repeat tests 1, 2 and 3 two times, the sequence is: 1, 2, 3, 1, 2, 3.
Delay time	Delay in seconds between individual tests.
Save Report:	Click to generate a report file in HTML format for sharing the results with other parties for viewing without UCD Console.
Clear Log	Clear the test log and the results matrix

Saving Test Parameters

Test parameters can be saved in various ways.

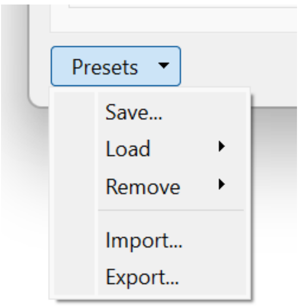
Export parameters in *Sink DUT Testing* tab to a *.td file for later use in UCD Console or with TSI scripting or sharing.

Export parameters in *Sink DUT Testing* tab to a *.json file for later use in UCD Console or with Python applications or sharing.

Save parameters in *Configure* dialog as Presets to be later used in UCD Console. Please find a description below.

Presets

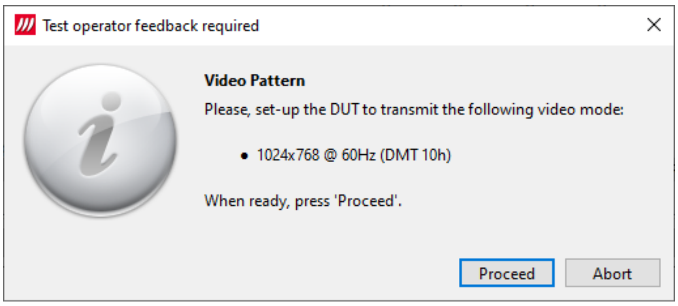
In all *Configure* dialogs the selected parameters can be saved as Presets. Please click **Presets…** to save or recall a configuration. Click Save first to assign the configuration a name, and after that you can e.g. Export it to a file.

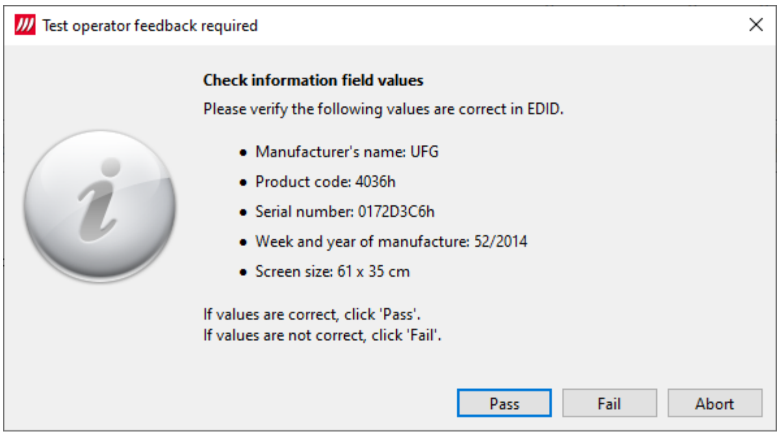


Operator Feedback

In some compliance tests operator action or feedback is required for items that the test itself cannot perform or confirm. In these cases test opens a pop-up dialog. In the dialog the operator is instructed about items to do or to be verified and buttons for providing the "Proceed" instruction or "Pass" and "Fail" feedback.

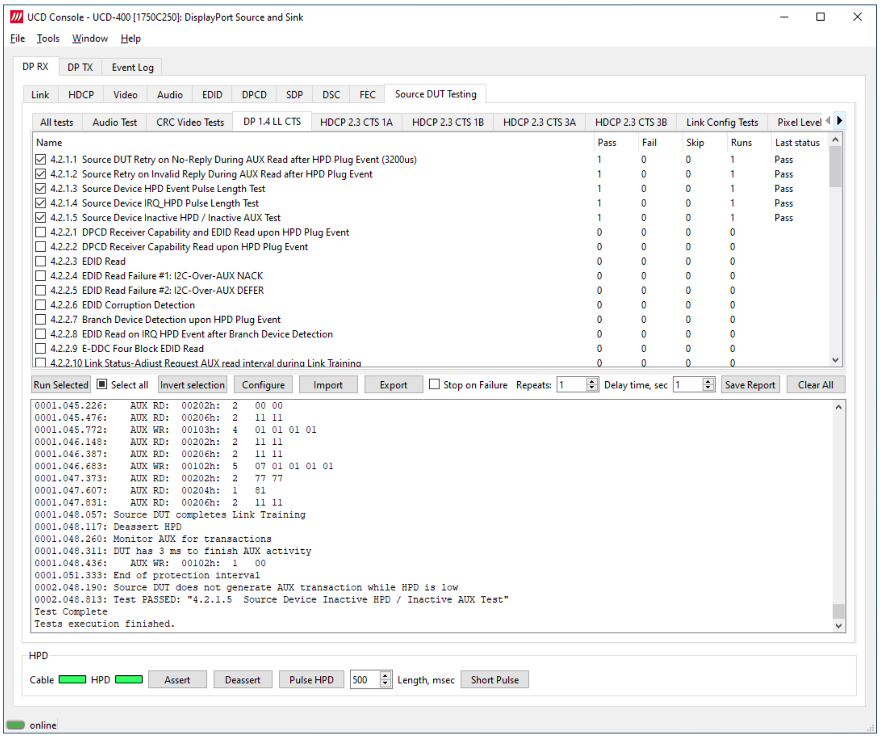
Clicking "Abort" stops execution of the test.





Evaluating CTS Test Results

The test procedure advancement can be monitored in the *Test Log* panel. It describes the steps of each individual test in the way defined in the corresponding VESA Compliance Test Specification. Please use the Status Log and Specification side by side when interpreting the results.



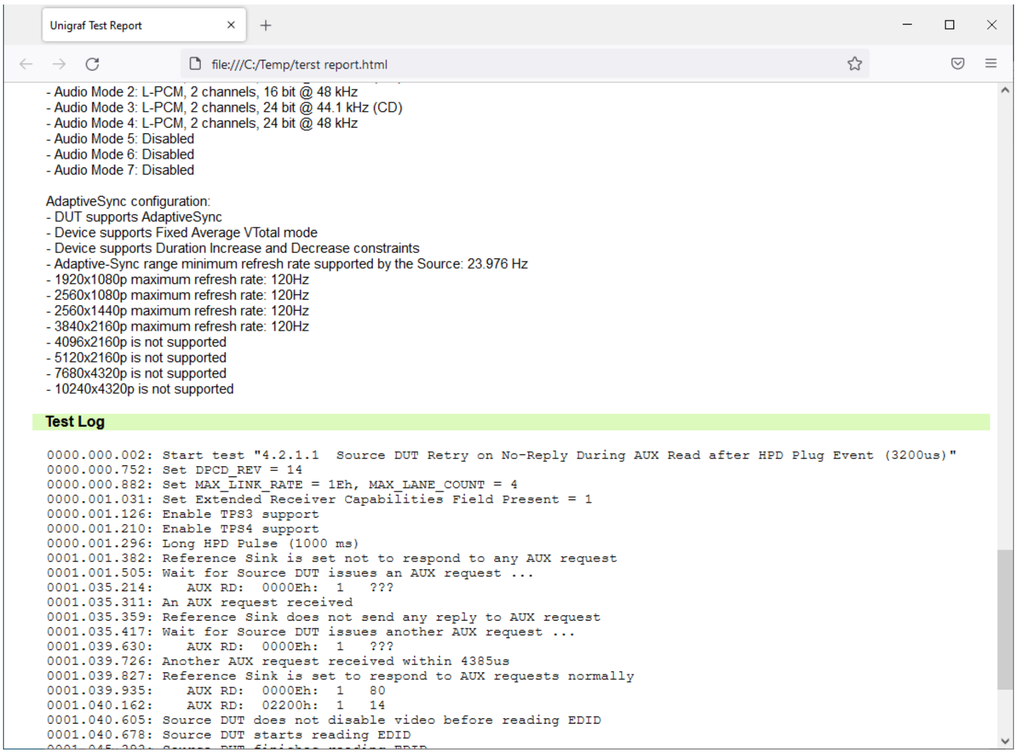
At the completion of each test the result of the test is indicated in the matrix on the right hand side of the test panel. For each test the matrix lists the number of occurrences of each result and the number of tries performed.

Test Report

Results of the test can be saved as a report in HTML format by clicking **Save Report**.

Viewing the CTS Test Report

The report file can be viewed with any HTML browser. The report has built-in views for Report Summary, Test Summary



Audio Test Set

Role:	Product:
DP Reference Sink (DP RX)	UCD-400
HDMI Reference Sink (HDMI RX)	UCD-422
DP Alt Mode Reference Sink (DP RX)	UCD-424

Validate audio signal frequency and glitch-free audio reproduction

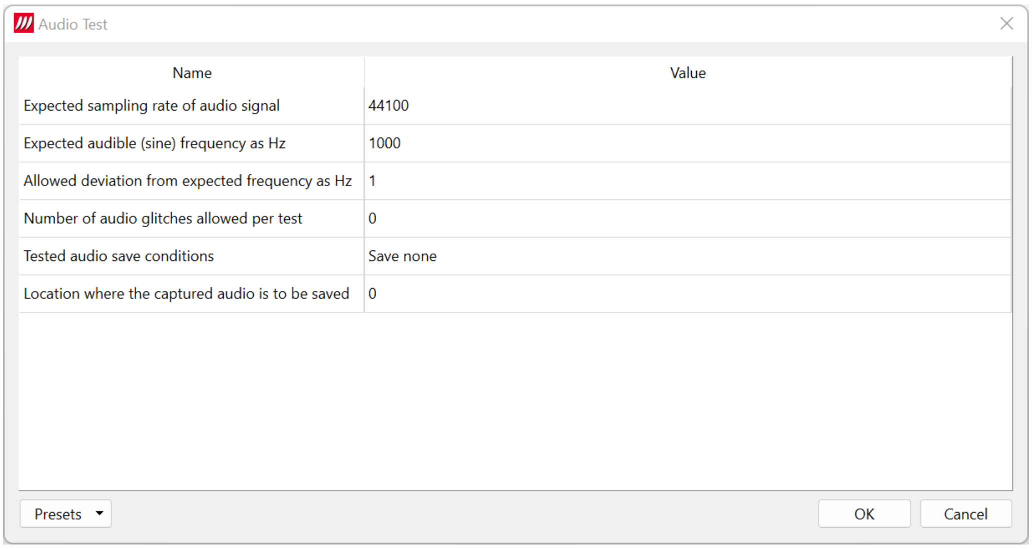
Perform frequency check on the digital audio content and verify the content to be glitch-free. This test assumes that a pure sine-wave audio signal content is being transmitted to the test equipment.

The test will first capture minimum of one second of audio content. The audio is then analyzed in two stages.

First, the power spectrum is calculated, and the highest peak must be within the defined window. Resolution of the peak frequency check is better than ±1 Hz.

In the second stage, received audio is checked for random glitches, such as dropped or duplicated samples. This is achieved by examining how the RDV ("Relative Distortion Value") changes over time within the sampled audio.

The test is considered passed if power of audio content spectrum has its maximum within the defined window, and the number of detected audio glitches does not exceed programmed limit.



Parameters in use

- Expected sampling rate of audio signal (default 44 100 s/sec)
- Expected audible (sine) frequency in Hz (default 1000 Hz)
- Allowed deviation from expected frequency in Hz (default 1 Hz)
- Number of audio glitches allowed per test (default 0)

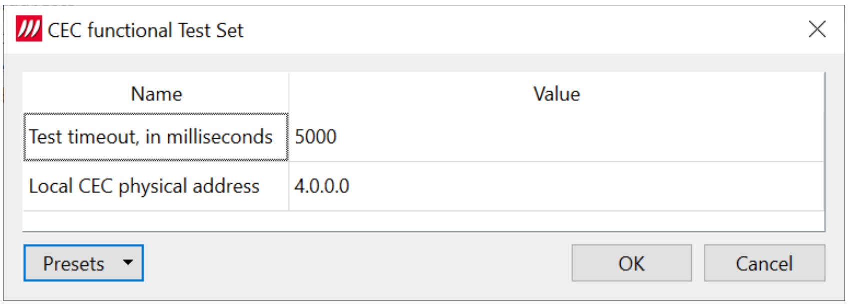
Click **Location where the captured audio is to be saved** to browse for the folder to store tests.

CEC Functional Tests Set

Role:	Product:
HDMI Reference Sink (HDMI RX)	UCD-422

Parameters in use

- Test timeout, in milliseconds
- Local CEC physical address



CEC Functional Test

Test is intended to check that DUT does CEC initialization correctly after HPD. TE initialize EDID with configured address. Apply HPD and expected that Logical Physical addresses that presented in EDID will be applied with Report Physical Address message to inform TE about the mapping Logical and Physical addresses. That is expectation of CEC behavior.

CEC Phy Address test.

Test is intended to check that CEC line is working properly, and DUT can receive CEC Report Physical Address or customized OP Code. TE checks that HPD is high and CEC line available and send Report Physical Address (or customized OP Code) message in broadcast mode (or with specific destination).

CEC Wake Up test

Test is intended to check that CEC line is working properly, and DUT can send CEC Wake Up command. TE checks that HPD is high and CEC line available and wait for Wake Up message.

CEC Stand By test

Test is intended to check that CEC line is working properly, and DUT can send CEC Stand By command. TE checks that HPD is high and CEC line available and wait for Stand By message.

CEC Complete test

Test is intended to check that CEC line is working properly, and DUT can send sequence of commands from Stand By mode. TE checks that HPD is high and CEC line available. TE waiting for sequence of commands from DUT Wake UP and then again Stand By.

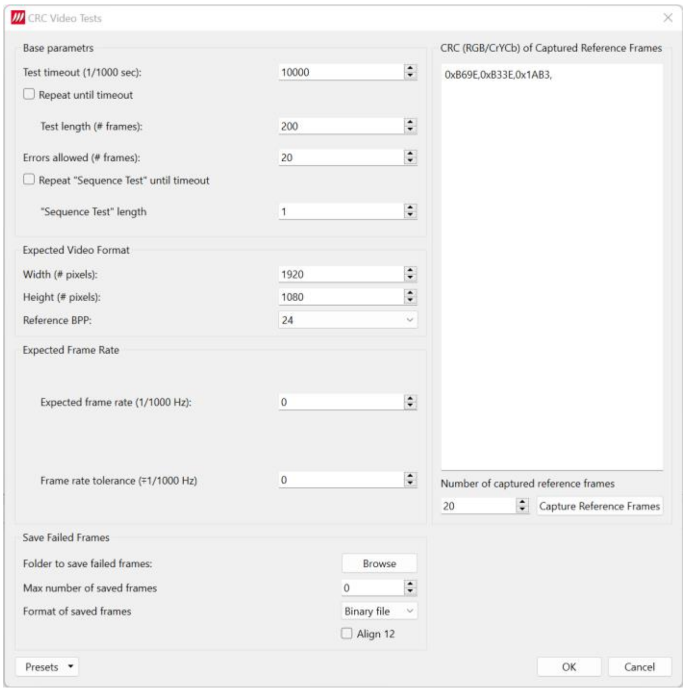
Note:	The default physical address in UCD EDID is 1:0:0:0. In order to simulate a change in the address, please use another address range

Note:	As a side effect, the CEC will also verify functionality of HPD and EDID reading if the test passes.

CRC Based Video Test Set

Role:	Product:
DP Reference Sink (DP RX)	UCD-400
HDMI Reference Sink (HDMI RX)	UCD-422
DP Alt Mode Reference Sink (DP RX)	UCD-424

Configuration



Test timeout:	If enabled test will abort when the time has elapsed
Repeat until timeout:	Omit "Test length" parameter
Test length (# frames):	Number of captured frames to test
Errors allowed (# frames):	Number of failing frames allowed before test Fails
Repeat "Sequence Test" until timeout:	Repeat test sequence until the timeout set (length parameter below omitted)
"Sequence Test" length	Repeat count of the "Sequence Test"
Expected Video Format	Format of the signal expected
Expected Frame Rate:	Verify stability of the video signal. Verification disabled if Expected Frame Rate is set to "0"
Number of captured reference frames:	Number of frames stored as reference
Capture Reference Frames:	Capture reference frames for the test
Folder to save failed frames:	PC folder where failed frames are stored.
Max number of saved frames:	Maximum number of failed frames stored to PC
Format of saved frames:	Select saved image format (Binary file, PPM image, BMP image)
Align 12	12bpc values are be shifted to MSB of a 16bits container. If not checked, 12 LSB are used to store colour component values.
Presets:	Store and recall settings

CRC Based Single Reference Frame Video Test

The test compares captured frames to a captured reference. In Configure dialog, please select 1 to *CRC Capture length* and click *Capture Now.*

TE compares the video mode (Frame Width, Height, BPP and optionally Frame rate) to provided parameters and after that captures frames and compares the CRC (check sum) of their three color components to the provided reference until the number of bad frame limit provided is detected or the provided total number of frames is reached.

The test is judged FAIL if video mode does not match, or the number of bad frames is exceeded.

The test optionally captures the failed frames as bitmap images and stores them into the hard disc.

Parameters in use

- Test Timeout (default 10 000 ms)
- Total number of frames (default 2 00 ms)
- Number of bad frames allowed (default 20)
- Reference width (default 1920)
- Reference height (default 1080)
- Reference BPP (default 24)
- Expected frame rate (mHz, 1/1000 Hz)
- Frame rate tolerance (mHz, 1/1000 Hz)
- Reference CRCs (R, G, B)

CRC Based Single Frame Video Stability Test

The test verifies that the captured video is stable.

TE captures a frame and sets the CRC of its color components as reference. After that TE captures frames and compares their CRC (check sum) to the reference until the number of bad frame limit provided is detected or the provided total number of frames is reached.

The test is judged FAIL if the number of bad frames is exceeded.

The test optionally captures the failed frames as bitmap images and stores them into the hard disc.

Parameters in use

- Test Timeout (default 100 00 ms)
- Total number of frames (default 200 ms)
- Number of bad frames allowed (default 20)

CRC Based Sequence of Reference Frames Test

The verifies that a sequence of frames is captured in the right order.

TE compares the video mode (frame Width, Height, BPP and optionally Frame rate) to provided parameters. After that captures frames to find a frame with matching CRC (check sum) of their three color components to the first provided reference. After the first matching CRC is found it compares the CRC of the following frames until the Number of frames tested parameter is reached.

The test is judged FAIL if video mode does not match, the first frame in the list is not found or the CRC of the following frames do not match the provided list.

The test optionally captures the failed frames as bitmap images and stores them into the hard disc.

Parameters in use

- Test Timeout (default 10 000 ms)
- Number of frames to be tested (default 20)
- Reference width (default 1920)
- Reference height (default 1080)
- Reference BPP (default 24)
- Expected frame rate (mHz, 1/1000 Hz)
- Frame rate tolerance (mHz, 1/1000 Hz)
- Reference CRCs (R, G, B)

Note: Please note that in order for the TE to maintain the sequence, all CRCs in the reference frame list should be different.

CRC Based Continuous Sequence of Reference Frames Test

The test verifies that a sequence of frames is captured in the right order many times repeatedly.

TE compares the video mode (frame Width, Height, BPP and optionally Frame rate and Color format) to provided parameters. After that captures frames to find a frame with matching CRC (check sum) of their three color components to the first provided reference. After the first matching CRC is found it compares the CRC of the following frames until the Number of frames tested parameter is reached. After that it resets the list and starts from the first CRC. The list is repeated until timeout or until the provided number of repetitions is reached.

The test is judged FAIL if video mode does not match, the first frame in the list is not found or the CRC of the following frames do not match the provided list.

The test optionally captures the failed frames as bitmap images and stores them into the hard disc.

Parameters in use

- Test Timeout (default 10 000 ms)
- Number of frames to be tested (default 20)
- Number of iterations
- Reference width (default 1920)
- Reference height (default 1080)
- Reference BPP (default 24)
- Expected frame rate (mHz, 1/1000 Hz)
- Frame rate tolerance (mHz, 1/1000 Hz)
- Expected color format
- Reference CRCs (R, G, B)

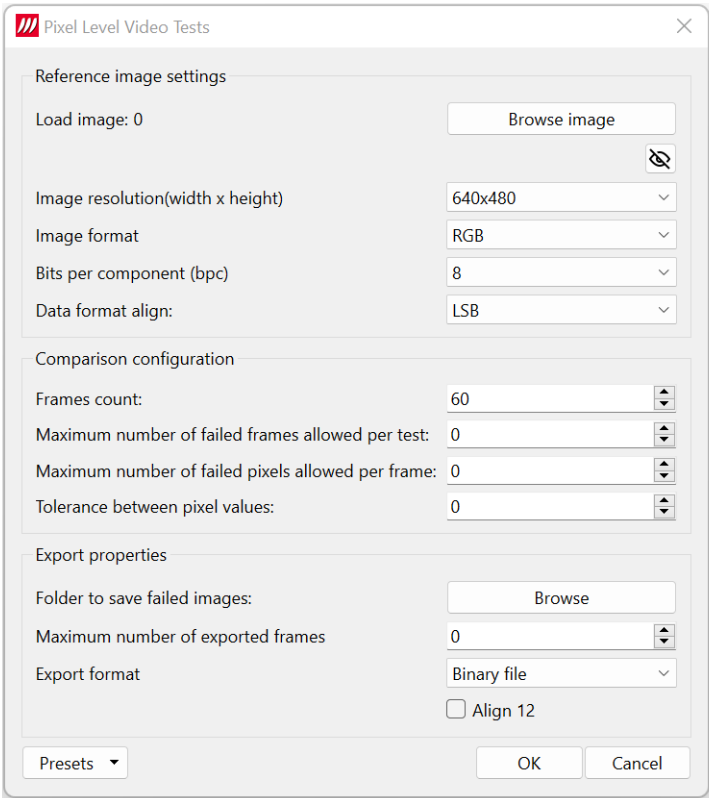
Note: Please note that in order for the TE to maintain the sequence, all CRCs in the reference frame list should be different.

Pixel Level Video Tests

Role:	Product:
DP Reference Sink (DP RX)	UCD-400
HDMI Reference Sink (HDMI RX)	UCD-422
DP Alt Mode Reference Sink (DP RX)	UCD-424

Compare video frame sequence with a single reference

The test compares captured frames to the provided reference image on pixel level by buffering the indicated number of captured frames first in the local UCD device frame buffer and after that downloads them to the PC for evaluation.



The test compares the captured frames to a provided reference image on pixel level.

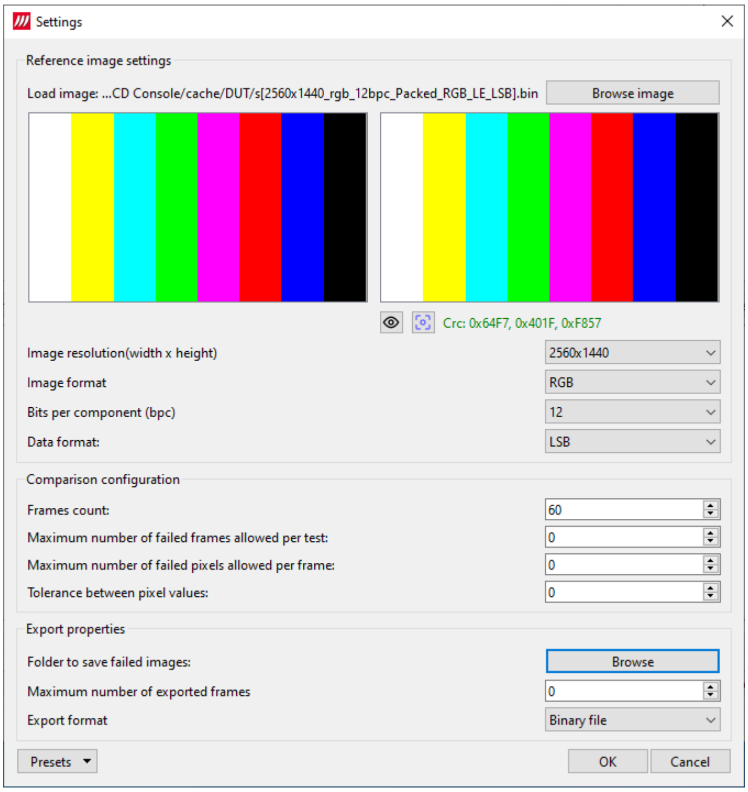
- The color component values of each pixel in the captured frame is compared to the corresponding pixels in the reference image.
- If the difference is larger than the provided tolerance, the pixel is considered failed.
- If the number of failed pixels in a frame is larger than the provided tolerance, the frame is considered failed.
- If the number of failed frames in the test is larger than the provided tolerance, the test is considered failed.
- Failed frames can be stored for evaluation.

Load image:	Load the reference image
Image resolution:	Video resolution expected
Image format:	Image format expected
Bits per component:	Bits per component expected
Data format align:	Video data format expected
Frames count:	Number of frames buffered for testing
Maximum number of failed frames allowed per test:	Number of failed frames allowed totally
Maximum number of failed frames allowed per test:	Number of failed pixels allowed per buffered frame
Tolerance between pixel values:	The allowed difference between a color component of pixel in the captured frame to the reference bitmap.
Folder to save failed images:	PC folder where failed frames are stored.
Maximum number of exported frames:	Maximum number of failed frames stored to PC
Export format:	Format of exported image: Binary file, PPM image, BMP image
Align 12	12bpc values are be shifted to MSB of a 16bits container. If not checked, 12 LSB are used to store colour component values.
Presets:	Store and recall settings

Capturing Reference Image

User can use the received video as reference.

In *Settings* dialog click the enable preview icon .



When the preview has been enabled click the *Capture reference* icon to store a frame and use it as reference. Before accepting the frame, stability of the video is verified with a CRC stability check. Captured CRC can also be verified by the user.

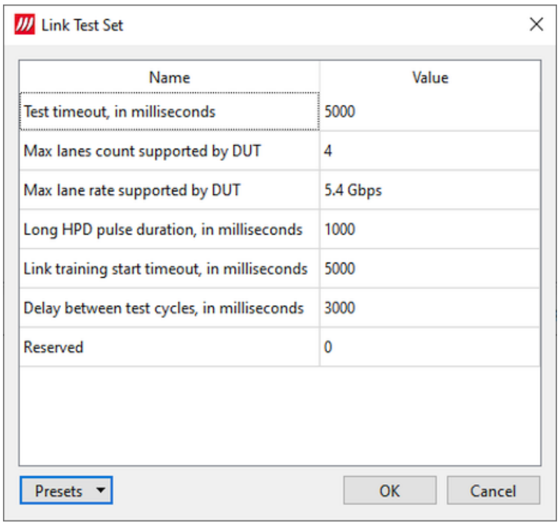
Link Config Tests

Role:	Product:
DP Reference Sink (DP RX)	UCD-400
DP Alt Mode Reference Sink (DP RX)	UCD-424

Link Training at All Supported Lane Counts and Link Rates

Test requests link training on all supported lane counts and link rates. Each link training must be successfully completed in order to pass the test.

In Configure, please define the parameters for the test.



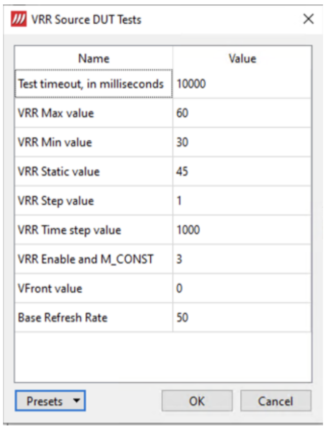
Parameters in use

- Test Timeout (default 5 000 ms)
- Max lane count supported by DUT (default 4)
- Max lane rate supported by DUT
- Long HPD pulse duration (default 1 000 ms)
- Link training start timeout (default 5 000 ms)
- Delay between test cycles (default 3 000 ms)

VRR Source DUT Tests – HDMI Rx

Role:	Product:
HDMI Reference Sink (HDMI RX)	UCD-422

Configure



VRR Max value:	Maximum VRR frame rate
VRR Min value:	Minimum VRR frame rate
VRR Static value:	Static VRR frame rate
VRR Step value:	Change of current VRR value during a test
VRR Time step value:	Change of current VRR value during a test
VRR Enable and M_Const:	Click to open dialog for enabling *VRR Enable* and *M_CONST*
VFront value:	Click to open dialog for enabling *Base VFront* and *RB*
Base Refresh Rate:	Set Base Refresh Rate

VRR Static Test

Test verifies that DUT Source applies expected static VRR value.

After configuring the parameters operator starts the test. Test waits until DUT Source starts VRR mode. When VRR mode is detected, test verifies that received timing matches the VRR Value parameter and the data in received EMP packets match the timing.

Quick Media Switching (QMS) Test

Verify that VRR is set correctly when frame rate is changing with a set time interval. For example, change VRR from 30 to 60 Hz with step for each 1 second.

After configuring the parameters operator starts the test. Test waits until DUT Source starts VRR mode. When VRR mode is detected, test verifies that VRR is changed after each time interval set by VRR Time parameter, and the applied VRR change is as set in the parameter. Test also verifies that data in received EMP packets match with applied VRR.

VRR Dynamic Test

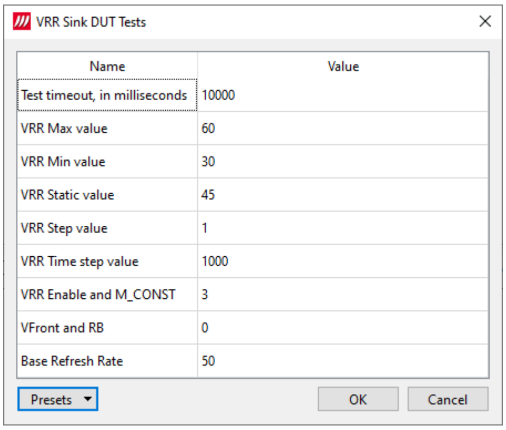
Verify that VRR is set correctly when frame rate is changing with each frame. For example, change VRR from 60 to 120 Hz with step 1 each frame.

After configuring the parameters operator starts the test. Test waits until DUT Source starts VRR mode. When VRR mode is detected, test verifies that VRR is changed between each frame. Test also verifies that data in received EMP packets match with applied VRR.

VRR Sink DUT Tests – HDMI Tx

Role:	Product:
HDMI Reference Source (HDMI TX)	UCD-422, UCD-412, UCD-452

Configure



VRR Max value:	Maximum VRR frame rate
VRR Min value:	Minimum VRR frame rate
VRR Static value:	Static VRR frame rate
VRR Step value:	Change of current VRR value during a test
VRR Time step value:	Change of current VRR value during a test
VRR Enable and M_Const:	Click to open dialog for enabling *VRR Enable* and *M_CONST*
VFront value:	Click to open dialog for enabling *Base VFront* and *RB*
Base Refresh Rate:	Set Base Refresh Rate

Static VRR Test

Test verifies that DUT Sink correctly applies a static VRR value.

After configuring the parameters operator starts the test. Operator verifies that DUT Sink has applied VRR correctly and provides the information in the dialog of the test.

Quick Media Switching (QMS) Test

Verify that VRR is set correctly when frame rate is changing with a set time interval. For example, change VRR from 30 to 60 Hz with step 1 each 1 second.

After configuring the parameters operator starts the test. Operator verifies that DUT Sink has applied VRR correctly and frame rate is changing as expected. Operator provides the information in the dialog of the test.

Dynamic Test

Verify that VRR is set correctly when frame rate is changing with each frame. For example, change VRR from 60 to 120 Hz with step 1 each frame.

After configuring the parameters operator starts the test. Operator verifies that DUT Sink has applied VRR correctly and frame rate is changing as expected. Operator provides the information in the dialog of the test.

APPENDIX F: VTP PATTERN LANGUAGE

General

The Vpattern definition language (in the following simply “VTP”) is a straightforward yet flexible way of describing test patterns for UCD Generators. This description is providing an introduction and examples of the most usable instructions and parameters.

The VTP language uses text command syntax. Each row represents one drawing instruction. The coordinate system can be either absolute or scaled. In the absolute mode the actual pixel position is referred while in the scaled mode the coordinates refer to the “Drawing resolution” used while drawing. For both absolute and scaling coordinates the origin is the upper left hand corner of the screen.

Terminology

The following terms are used in this document:

Coordinate system: two numerical ranges of integer, positive numbers. E.g. {0,799},{0,599} or {0,10000},{0,10000}.

Coordinates: a tuple of integer, positive numbers used to address a position on an image, e.g. (100,250). The first number is the horizontal position, the second one the vertical position. The actual position is always related to the coordinate system currently in use.

Drawing resolution: the width and height of the space that can be used for drawing, expressed in pixels. E.g., 2560 by 1600.

Drawing area: a 2-dimensional area spanning all of the drawing resolution, expressed in the current coordinate system notation. E.g., if the drawing resolution is 800 x 600 pixels, the drawing area includes all points (x,y) where x = 0 to 799 and y = 0 to 599 in ABSOLUTE mode or x = 0 to 10000 and y = 0 to 10000 in SCALED mode.

Notation

The following notation is used in this document:

- A token is enclosed by characters ‘<’ and ‘>’. For instance, <variable> represents a generic variable.
- Different legal choices for a command parameter are separated by character ‘|’. For instance, <variable> | <number> means that either variable or number can be used as parameters.
- Items that can be repeated 0, 1 or more times are preceded by ‘{‘ and followed by ‘}*’. For instance {<number>}* means zero, one or more occurrences of a number.

Syntax rules

The following general syntax rules apply to VTP language files:

- The VTP is a text-based, interpreted language.
- Commands, variables, and constant names are not case-sensitive.
- All text to the right of a semicolon (‘;’) is treated as a comment.
- All strings are delimited by quotation marks (“a string”).
- Quotation mark and backslash characters must be prefixed by a backslash character (a quotation mark character = \”) (a backslash character = \\).
- Filenames cannot contain pathnames.

Commands

Scaling commands

All drawing commands using coordinates can refer either to absolute or scaled coordinates. The absolute coordinate system starts at 0 and its measurement unit is the pixel (vertically the line). It extends up to the maximum drawing resolution in use minus one, expressed in pixels too.

Conversely, the scaled coordinate system ranges from 0 to 10000, independently from the drawing resolution. Its measurement unit is thus a flexible, virtual pixel.

Absolute coordinates provide the fastest drawing speed, but they are resolution specific. Scaled coordinates are resolution independent while introducing a slight speed penalization.

For both systems, the origin (0,0) refers to the upper left hand corner of the screen.

ABSOLUTE

```
Syntax: ABSOLUTE
```

This command is normally used in the beginning of the VTP file. All drawing commands issued after ABSOLUTE will have absolute coordinate values, i.e., their coordinates will be interpreted as pixels and lines.

The allowed coordinate values are from 0 to the maximum drawing resolution minus one. For instance, for a drawing resolution of 2560 x 1600 pixels, the allowed coordinate range (x,y) for x is 0 to 2559 and for y 0 to 1599.

Constants MAXX and MAXY can be used in place of the numeric values to achieve basic scaling capabilities.

SCALED

```
Syntax: SCALED
```

All drawing commands issued after the SCALED command will have their coordinates interpreted as within a range from 0 to 10000 (10001 possible coordinate values), regardless of the current drawing resolution. Positioning can be calculated as percentages. If you wanted to address a point at 50% of the drawing resolution, then you would use the number 5000. If you wanted 75% you would simply use the 7500.

Graphics Drawing Commands

All of the following graphics drawing commands use the currently selected foreground color for shape perimeter and filling.

LINE

```
Syntax: LINE x1 y1 x2 y2
```

Draws a line from point (x1,y1) to point (x2,y2).

Example:

You can draw a white diagonal cross using either ABSOLUTE and SCALED coordinate mode and get the same result.

ABSOLUTE ; Set scaling mode to absolute

COLORDEPTH 8 ; 8 bits per color

COLORRGB 255 255 255 ; white

LINE 0 0 MAXX MAXY ; Draw a line from upper left to lower right corner

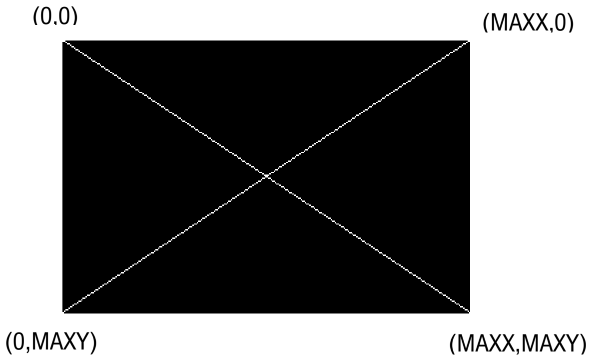
LINE 0 MAXY MAXX 0 ; Draw a line from lower left to upper right corner

Or if you want a fixed size for 640 x 480 resolution

LINE 0 0 639 479

LINE 0 479 639 0

The pattern will look like this:



Using SCALED instead of ABSOLUTE.

SCALED

COLORDEPTH 8

COLORRGB 255 255 255

LINE 0 0 10000 10000

LINE 0 10000 10000 0

BOX

```
Syntax: BOX x1 y1 x2 y2
```

Draws a filled rectangle with upper left corner (x1,y1) and lower right corner (x2,y2).

Example:

This code will create a full white screen with all resolutions.

SCALED

COLORDEPTH 8

COLORRGB 255 255 255

BOX 0 0 10000 10000

DOT

```
Syntax: DOT x y
```

Draws a single dot at location (x,y).

FILL

```
Syntax FILL x y
```

Initiates a flood fill (or seed fill) with foreground color starting from position (x,y).

CIRCLE

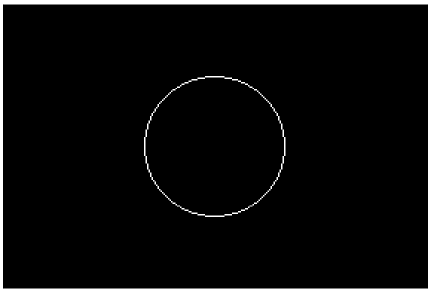
```
Syntax: CIRCLE x y r
```

Draws a circle with center point at (x,y) and radius r. Please, note that when using SCALED coordinates radius r is expressed using reference to vertical maximum.

Example:

SCALED
COLORDEPTH 8
COLORRGB 255 255 255
CIRCLE 5000 5000 2500

The pattern will look like this:

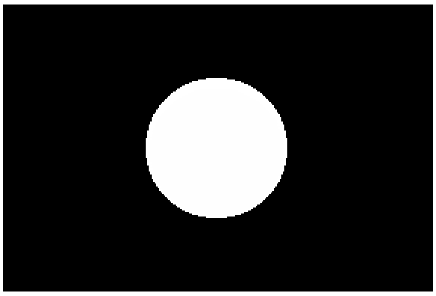


FCIRCLE

Syntax: FCIRCLE x y r

Draws a circle with center point at (x,y) and radius r. Filled with foreground color. Please, note that when using SCALED coordinates radius r is expressed using reference to vertical maximum.

The pattern will look like this:



ELLIPSE

```
Syntax: ELLIPSE x y hr vr
```

Draws an ellipse with center point at (x,y), horizontal radius hr and vertical radius vr.

You can use ELLIPSE instead of CIRCLE for example for compensating the stretching in applications where the displayed pixel is not square.

Example:

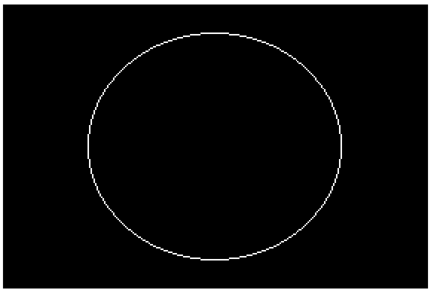
SCALED

COLORDEPTH 8

COLORRGB 255 255 255

ELLIPSE 5000 5000 3000 4000

The pattern will look like this:



Text Drawing Commands

All of the following commands use the currently selected foreground color for the “foreground” pixels of the font and the currently selected background color for “background” pixels.

TEXTPOS

```
Syntax: TEXTPOS x y
```

Sets the text drawing position to point (x,y).

TEXT

```
Syntax: TEXT <string> | <var> | <const> { <string> | <var> | <const> }*
```

The command executes a CR and LF (carriage return and line feed) and then draws a text string <string>, a variable <var>, a constant <const> or a combination of them starting from the current text position.

<string> parameter is a quoted sequence of characters. If the string contains a quote character (“) or a backslash character (\) then it must be preceded with a back slash character (\).

<var> is a parameter variable (A – Z, MAXX, MAXY) defined by SET command.

<const> one of the Timing Variables. Timing variables are defined by currently loaded timing parameters. Please refer to Chapter 3.

Example:

ABSOLUTE

COLORDEPTH 8

COLORRGB 255 255 255

TEXTPOS 100 100 *; Text starting point 100 pixels from left edge and*
; 100 display lines down from top

TEXT “HRES=” HR “ PIXELS” *; This will draw the text HRES then the value of variable HR*
; and PIXELS

TEXT “Quote character \” and backslash \\”

Program Flow Commands

REPEAT

```
Syntax: REPEAT <variable> a b s
```

All commands after between REPEAT and END command are repeated the number of times defined by <variable>. <variable> is set to value a before starting the first iteration loop. At the end of each iteration, variable is incremented by s (variable = variable + s). The REPEAT is terminated when variable reaches or exceeds value b, and the execution continues from the command following the END command. For example:

SCALED

COLORDEPTH 8

COLORRGB 255 255 255

REPEAT W 0 10000 200

LINE W 0 W 10000

END

A maximum of 2 REPEAT loops can be nested (placed inside each other).

END

Syntax: END

This command follows a REPEAT command and defines a group of instructions to be repeated.

Color Commands

The user can assign the used colors in two basic ways: either by giving the actual Red, Green and Blue (or R, G and B) color component values or using pre-defined color palettes. The first method is referred as True Color Mode and the latter as Palette Mode.

In True Color Mode the numerical values given for R, G and B will be the actual output signal intensity values for the pixel in question. The numerical color value in Palette Mode will act as an address (or index) to a pre-defined color in a 256 color table. The output signal intensity will be the R, G and B value entry in the cell where the address points to.

Palette mode can only be used with True Color Mode is .

COLORDEPTH

```
Syntax: COLORDEPTH n
```

The command is used in True Color Mode (COLORMODE 2), to define the number of bits used for each color component (R, G and B) of the data to be displayed. Possible values for the parameter n are 6, 8, 10 and 12. If COLORDEPTH command is not used, 10 bits per color is used.

Example: To display a bitmap that uses 8 bits for r, g and b (24-bit colors) you have to use COLORDEPTH 8.

Command	Nr of color bits	Range of values for R, G and B
COLORDEPTH 6	18	0 to 63
COLORDEPTH 8	24	0 to 255
COLORDEPTH 10	30	0 to 1023
COLORDEPTH 12	36	0 to 4095

COLORDEPTH can be used only once in a VTP file, and it has to be placed before all drawing instructions it is supposed to affect.

COLORRGB

```
Syntax: COLORRGB r g b
```

The command defines the foreground color used for the following drawing commands. The command is used in True Color Mode only.

The range of values for r, g and b depends on the bits per color used. If not changed with COLORDEPTH command, 10 bits per color is used. Please refer to COLORDEPTH command for range of values.

Various Commands

SET

```
Syntax: SET <variable> n
```

Assigns value n to programming variable called variable. n must be a positive number or zero.

Variables

Timing Variables

Timing Variable	Value name
HF	Drawing resolution horizontal size minus one
HP	Drawing resolution vertical size minus one
HR	Current timing horizontal frequency (MHz?)
HA	Current timing horizontal period (pixels)
HS	Current timing horizontal resolution (pixels)
HBP	Current timing horizontal active time (pixels)
HFP	Current timing horizontal sync length (pixels)
VF	Current timing horizontal back porch length (pixels)
VP	Current timing horizontal front porch length (pixels)
VR	Current timing vertical frequency (MHz?)
VA	Current timing vertical period (lines)
VS	Current timing vertical resolution (lines)
VBP	Current timing vertical active time (lines)
VFP	Current timing vertical sync length (lines)
PF	Current timing vertical back porch length (lines)
HLB	Current timing vertical front porch length (lines)
HRB	Pixel frequency (Mpps?)
VTB	Drawing resolution horizontal size minus one
VBB	Drawing resolution vertical size minus one

Expressions

Any command numeric parameter can be replaced by an expression, according to the syntax below:

<term> ::= <variable> | <constant> | <number>

<expression> ::= <term> { '+' | '-' | '*' | '/' | '%' } <term>

```
<parameter> ::= <term> | <expression>
```

Some example of legal parameter values:

B
MAXX
342
B + MAXX
B / 2
*B * C*

Expressions have always positive integers or zero value. When an expression evaluates to a negative value, it is set automatically to zero. Number values are also always positive integers or zero.

Assignments

A variable can be assigned a numerical value by using the SET command.

The second parameter of the SET command can be replaced by an expression thus allowing commands like those here below:

SET C B+MAXX

SET K K+1

SET K A+B

Default state at VTP execution startup

Coordinate system:	ABSOLUTE
Foreground color:	1023 1023 1023
Background color:	0 0 0
Image:	Output image is cleared (all black)
Variables:	All variables are initialized to zero
Color depth:	COLORDEPTH 10

APPENDIX G: FIRMWARE UPDATE WITH QUARTUS

FW Update Tool

The chapter below describes a procedure for updating UCD-4XX Series Firmware in a case when e.g., the normal FW Update procedure failed because a critical error.

Note	The firmware recovery procedure is only available for Windows operating system.

Download the latest 3.2 SW Bundle version from Unigraf website https://www.unigraf.fi/downloads/ and install it. Please do not launch UCD Console yet.

UCD-4xx-recovery.zip file will be by default installed in C:\Program Files\Unigraf\Unigraf UCD Tools\Recovery. Perform the *Recovery* procedure according to the instruction in the following pages.

Without removing power from the UCD-4XX device perform FW update procedure as described in section 4 FIRMWARE UPDATE PROCEDURE earlier in this manual.

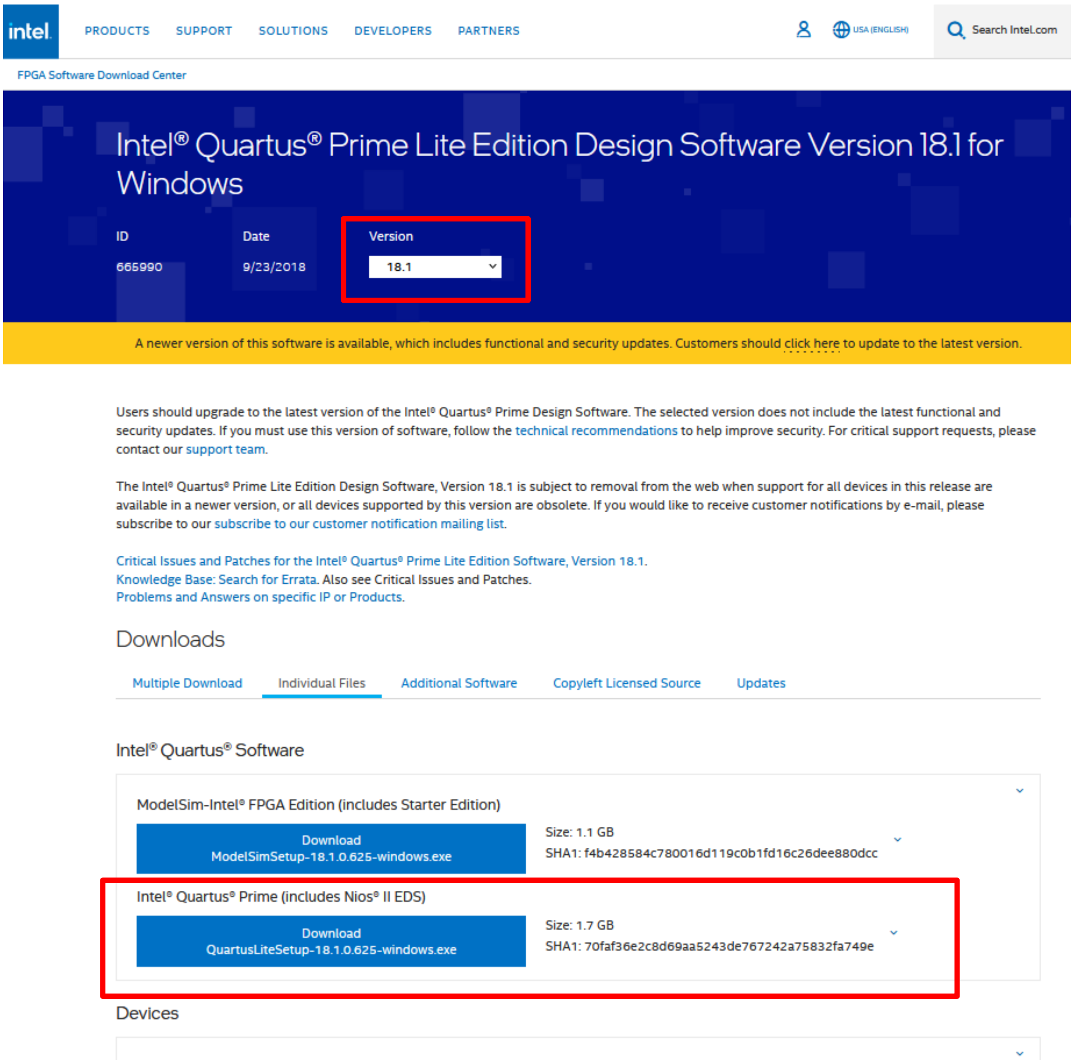
Note	The FW patch loaded in the UCD device during Recovery procedure is stored in a temporary memory. When power is removed from UCD device, the content of the temporary memory will be erased. Therefore, please do not power down the UCD device after performing the *Recovery* before instructed in the end of the FW Update procedure. If power will accidentally be removed before the FW Update procedure, Recovery procedure needs to be re-initiated.

The Recovery patch is programmed to UCD Device with a separate tool called **Quartus Prime (includes Nios II EDS)**. The tool can be downloaded from **Intel® FPGA** website: https://www.intel.com/content/www/us/en/software-kit/665990/intel-quartus-prime-lite-edition-design-software-version-18-1-for-windows.html

On the download page, please **Select release 18.1.** Please download **Quartus Prime (includes Nios II EDS)**.

Note:	Registering is needed for the download.

Please download and install the tool in the PC.



Note:	After the installation is completed, make sure to select the "Launch USB Blaster II driver installation" option to installe the required drivers.

Connect to the UCD-4XX Unit

- Power on the UCD-4XX.
- Connect UCD-4XX with a USB cable to the PC through Programmer connector. (Please refer to page 10 of this document)

Programming the FW

- Locate the UCD-4xx-recovery.*zip* folder. It is by default installed in C:\Program Files\Unigraf\Unigraf UCD Tools\recovery. Extract the content of the zip file in a folder in your PC, e.g., c:\Temp
- Run **Nios II 18.1 Command Shell** application as Administrator

Note:	Nios II 18.1 Command Shell application needs to be run as Administrator (Right click with mouse and select **Run as Administrator)**

Hint:	Right click on the top edge of *Command Shell* and select **Edit > Paste** to paste the commands below

- Select the folder location where the downloaded FW was stored. For example (C:\Temp)

cd /cygdrive/c/Temp

- Run the loader.

source recovery.sh

This instruction will load a temporary patch to the FW of the UCD Device to enable normal FW Update procedure

- Once the upload has completed, please close the command shell.
- Launch UCD Console and initiate FW Update by selecting Tools > Firmware update. Please follow the instructions given in section 4 FIRMWARE UPDATE PROCEDURE earlier in this manual.

Note:	The FW patch loaded in the UCD device during Recovery procedure is stored in a temporary memory. When power is removed from UCD device, the content of the temporary memory will be erased. Therefore, please do not power down the UCD device after performing the Recovery before instructed in the end of the FW Update procedure. If power will accidentally be removed before the FW Update procedure, Recovery procedure needs to be re-initiated.

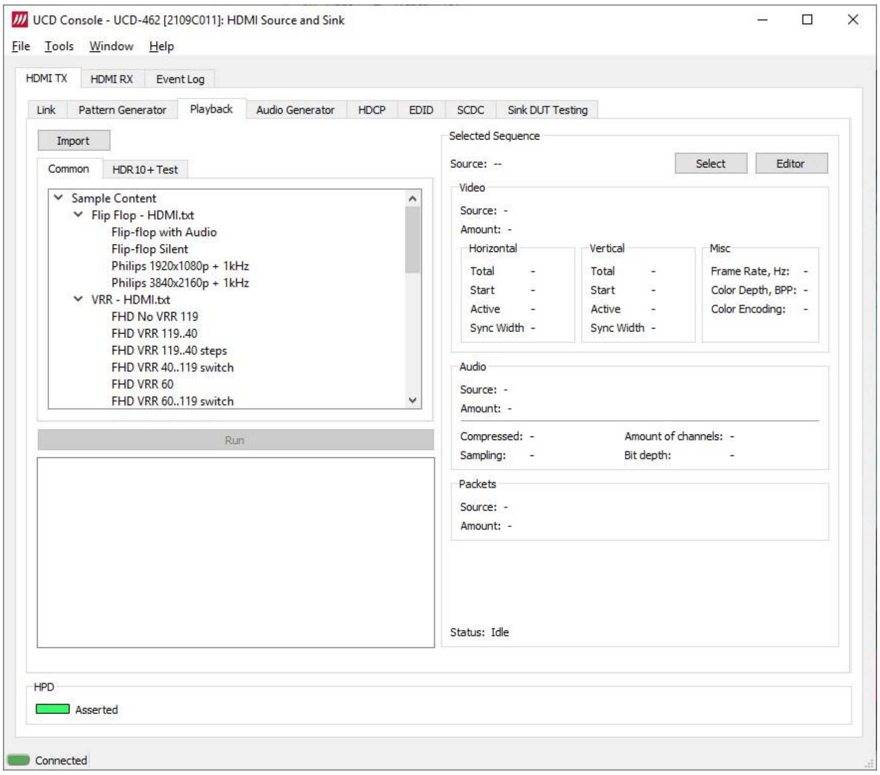
- Once FW update procedure has completed, cycle power on the UCD Device (switch off power > wait for 10 seconds > turn on power).

Note:	Please cycle the power on the UCD-4XX unit to enable the FW update (switch off power > wait for 10 seconds > turn on power).

After Recovery procedure has been completed, you can delete the files stored in e.g., C:/Temp.

APPENDIX H: PLAYLISTS AND SCENARIOS

UCD Console's Playback tab enables the user to execute playback macros called Playlists. Playlists define the video and audio content and the related metadata streamed in predefined sequences.



Playlist

Playlist defines the UCD device and the output where the content is played. It lists the played Scenarios and their duration.

Scenario

Scenario is an operating structure that allows user to determine a specific sequence of video frames, metadata packets and audio that are going to be played in the defined order.

Playlists and Scenarios are stored as human readable text files. The files can be edited using any text-editor software.

Frame Memory

When played, all content is first loaded to the frame memory buffer of the UCD device. This enables smooth transition between content items during execution of the Scenario.

The size of frame buffer memory sets a limit for content that can be played. In their default configuration UCD devices feature a 2 GBytes frame buffer memory. This frame buffer enables loading up to 40 pcs 4K video frames or 10 pcs 8K video frames simultaneously. For information about models with larger frame buffer memory, please contact Unigraf.

Sample Content

UCD Console's Playback tab features a set of sample content. These examples can be used as a basis for creating custom test sequences. The sample content is stored as files by default in *C:\Program Files\Unigraf\Unigraf UCD Tools\data\playback\content*. It is advisable to create copy of the installed original files and edit the copies.

Please find a description of the sample content later in this Appendix.

Playlists

Playlist defines the UCD device and the output where the content is played. It lists the played video and audio sequences called Scenarios and their duration.

Playlists are stored as human readable text files. The files can be edited using any text-editor software. It is advisable to create copy of the installed original files and edit the copies.

Note: Please note that Playlists and Scenarios are interface technology dependent. Metadata (or packets) are different between HDMI and DisplayPort

Device section

Section describes what device and what output connector to use.

Key	Description	Possible values
[Device]	Required. Start of the Device section.	
serialnumber	Required. Specifies serial number of the UCD device. The '*' wildcard can be used if only one UCD source device is connected to the PC.	'*' '1722C333'
connectortype	Required. Specifies output connector to be used. Playlist cannot contain scenarios for different connector types.	'HDMI Out' 'DisplayPort Out' 'USBC Out'
reset	N/A	'0' or '1' Default '0'

Scenario section

Section describes selected scenario and its playback parameters. Playlist runs scenarios in the order they are listed in the Playlist file.

Key	Description	Possible values
[Scenario]	Required. Start of a Scenario section. Playlist can have multiple Scenario sections.	
caption	Optional. Title of the Scenario. Any character string accepted.	'Scenario 1' 'Playlist completed'
path	Required. Specifies path to scenario file.	Any path
period	Required. Duration of Scenario in msec. The duration is ignored if close-after-upload is set to '1'.	'60000' '5000'
close-after-upload	Optional. When set to '1', command line version of the Playback tool will exit after loading scenario content and starting playback.	'0' or '1' Default '0'
execute-after-upload	Optional. Executes provided command in cmd.exe or bash and waits for its completion. Calculation of 'period' starts after the command is executed.	'script.bat && dir' 'rmdir /home/user/test/'

Scenarios

Scenario is an operating structure that allows user determine a specific sequence of video frames, events and audio that are going to be played in a certain order. In addition, scenario determines environment for sequence to play.

Scenarios are stored as human readable text files. The files can be edited using any text-editor software. It is advisable to create copy of the installed original files and edit the copies.

Note: Please note that Playlists and Scenarios are interface technology dependent.

Parameters

Scenario parameters are defined as a list of items. Please find below a description of Scenario items.

Scenario item	Description
video= :	Path and file name format of video frame files
audio= :	Path and file name of the audio file
packets= :	Path and file name format of metadata packet files
porder= :	Content Playing Order. Please see *Content Playing Order* below.
align12=1	Alignment of 12-bit binary pixel data. '1' aligned to LSB; '0' aligned to MSB.
audioswap= :	'1' for Little Endian audio samples
audiocompressed= :	'1' compressed audio; '0' uncompressed audio
audiosampling= :	Audio sampling rate. E.g., 44100
audiochannels= :	Nr. of audio channels
audiobits= :	Audio bits per sample (usually 16 or 24)
scrambler= :	'1' scrambling enabled; '0' scrambling disabled
colorspace= :	Video color space: RGB; YUV444; YUV422; YUV420
bitspercolor= :	Video color depth (bpc)
timing.hactive= :	Timing: Horizontal active
timing.vactive= :	Timing: Vertical active
timing.htotal= :	Timing: Horizontal total
timing.vtotal= :	Timing: Vertical total
timing.hstart= :	Timing: Horizontal start
timing.vstart= :	Timing: Vertical start
timing.hsync= :	Timing: Horizontal sync width
timing.vsync= :	Timing: Vertical sync width
timing.frate= :	
hdcp= :	HDCP version used
loadingRGB= :	The R, G and B color components of solid color pattern shown when content is being uploaded to the device before playback (e.g., 0,0,0)
linkRate:	Default link rate. HDMI: 0 = TMDS; 1 – 5 = FRL with 3, 6, 8, 10 and 12 Bbps link rate. DP: Link rate = Value × 0.27 Gbps. (E.g., 20 = 5.4 Gbps/lane (HBR2)).
linkRateMin= :	Minimum link rate used. If available link rate is lower, scenario will fail.
DSC timing parameters:	Parameters are different between DP and HDMI. Please see below.

DSC Timing parameters for HDMI

dscFrameRate=	DSC Timing: Frame rate [fps] × 1000
dscHcactive=	DSC Timing: Horizontal active
dscHcblank=	DSC Timing: Horizontal blank
dscVtotal=	DSC Timing: Vertical total
dscVsync=	DSC Timing: Vertical sync
dscVstart=	DSC Timing: Vertical start
dscVactive=	DSC Timing: Vertical active

DSC Timing parameters for DP

dscFrameRate=	DSC Timing: Frame rate [fps] × 1000
dscVtotal=	DSC Timing: Vertical total
dscVsync=	DSC Timing: Vertical sync
dscVstart=	DSC Timing: Vertical start
dscVactive=	DSC Timing: Vertical active
dscHtotal=	DSC Timing: Horizontal total
dscHsync=	DSC Timing: Horizontal sync
dscHstart=	DSC Timing: Horizontal start
dscHactive=	DSC Timing: Horizontal active

Content Playing Order

Playing order is described in a textual format as a sequence of steps. Steps are separated with ';' symbol.

Each step describes:

- Index of played video frame or a range of video frames,
- How many times the frame(s) are played,
- Index of the packet or the set of packets that will be sent during the video frame(s),
- Color format used for the step.
- Optional frame rate when VRR is enabled.

Format structure

Each scenario step is described in following textual format:

```
pV:R:E:FvXX;
```

Parameters

Please see table below for description of used parameters.

Char	Description	Possible values	Examples
:	Required. Separator between general step parameters.	':'	See any below
;	Required. Indication of step description end.	';'	See any below
p	Optional. Indicates assertion of a HPD pulse on HDMI RX connector of UCD device during current step. Preceding video frame index. Only for HDMI playback.	'p'	'p1:60:1:256;' 'p0-59:60:1:256;'
V	Required. Index of a video frame. Index is zero based. Images are loaded from the indicated file path. Parameter can state either a single image or a range of images. The order in which images are called in scenario steps is optional. All specified parameters are applied to all frames in the scenario step.	'1' '0-59'	'1:60:16:256;' '0-59:60:16:256;'
R	Required. Repetitions of current step. E.g., stating '1' with 60 FPS frame rate means that current step will be played only for 1/60 of a second.	'30' '1'	'1:30:16:256;' '1:1:16:256;'
E	Optional. Index of metadata packet. Index is zero based. Packets are loaded from the indicated file path. Parameter can indicate either a single packet or a comma separated list of packets. Order of packets is optional.	'0' '4,1,29' none	'1:30:0:256;' '1:30:4,1,29:256;' '1:30::256;'
F	Required. Color format and color depth. Pls see chapter Color Format below.	'256' '513'	'1:30:0:256;' '1:30:0:513;'
vXX	Optional. Control of frame rate when VRR is enabled. In order to enable VRR, corresponding HDMI VSIF event must be included into this step. Parameter is always in format of 'vXX', where 'XX' states frame rate. Parameter is provided with color format value, separated with 'v'.	'v60' 'v30'	'1:30:0:256v60;' '1:30:0:256v30;'

Color Format

Color format is a two-byte value presented in decimal. The lower byte provides an index to used color space and the higher byte an index to the color depth. Please find the indexes in the table below.

Index	Color Depth (bits/color)	Color Space
0	6	RGB
1	8	YCbCr 4:4:4
2	10	YCbCr 4:2:2
3	12	YCbCr 4:2:0
4	16	–

The encoded parameter value is calculated using the following formula:

[Color Depth] × 256 + [Color Space],

where *[Color Depth]* and *[Color Space]* are indexes obtained from the table above.

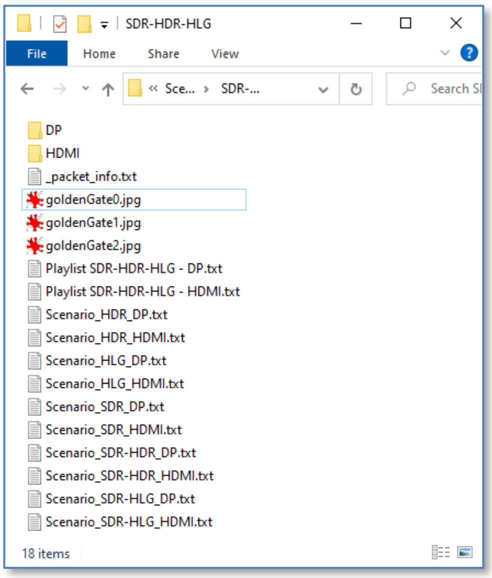
For example, parameter for YCbCr 4:4:4, 10 bits is (2 × 256 + 1) = 513.

Pre-calculated values for available color formats:

	6 BPC	8 BPC	10 BPC	12 BPC	16 BPC
RGB	0	256	512	768	1024
YCbCr 4:4:4	N/A	257	513	769	1025
YCbCr 4:2:2	N/A	258	514	770	1026
YCbCr 4:2:0	N/A	259	515	771	1027

Example

Please find below description of Playlist SDR-HDR-HLG – HDMI.



Playlist file (Playlist SDR-HDR-HLG - HDMI.txt)

Playlist item and example content	Description
[Device]	Start of device section
serialnumber=*	Only one UCD device present.
connectortype=HDMI Out	HDMI output
[Scenario]	Start of Scenario 1
caption = SDR	Scenario title “SDR”
period = 10000	Duration 10 sec
path = Scenario_SDR_HDMI.txt	Scenario file: Scenario_SDR_HDMI.txt in current folder
[Scenario]	Start of Scenario 2
caption = HDR	Scenario title “HDR”
period = 10000	Duration 10 sec
path = Scenario_HDR_HDMI.txt	Scenario file: Scenario_HDR_HDMI.txt in current folder
[Scenario]	Start of Scenario 3
caption = HLG	Scenario title “HLG”
period = 10000	Duration 10 sec
path = Scenario_HLG_HDMI.txt	Scenario file: Scenario_HLG_HDMI.txt in current folder
[Scenario]	Start of Scenario 4
caption = SDR – HDR	Scenario title “SDR – HDR”
period = 10000	Duration 10 sec
path = Scenario_SDR-HDR_HDMI.txt	Scenario file: Scenario_SDR-HDR_HDMI.txt in current folder
[Scenario]	Start of Scenario 5
caption = SDR – HLG	Scenario title “SDR – HLG”
period = 10000	Duration 10 sec
path = Scenario_HDR_HDMI.txt	Scenario file: Scenario_SDR-HLG_HDMI.txt in current folder

Scenario File (Scenario_SDR-HDR-HDMI.txt)

Scenario item and example content	Description
video=goldenGate0.jpg	Video files in current folder, file name format goldenGate0.jpg (0…)
audio=<Audio not selected>	Audio not selected
packets=HDMI\Infoframes_0000.bin	Packet files in folder HDMI\, file name format Infoframes_0000.bin (0…)
porder=0:180:2:256;1:180:2,0:256;	180 frames of image index 0, Packet index 2, RGB 8 bpc 180 frames of image index 1, Packets index 2 and 0, RGB 8 bpc
align12=1	Pixel data is aligned to LSB
audioswap=0	-
audiocompressed=0	-
audiosampling=0	-
audiochannels=0	-
audiobits=0	-
scrambler=0	scrambling disabled
colorspace=RGB444	Video color space: RGB 4:4:4
bitspercolor=8	Video color depth: 8 (bpc)
timing.hactive=1920	Timing: Horizontal active
timing.vactive=1080	Timing: Vertical active
timing.htotal=2200	Timing: Horizontal total
timing.vtotal=1125	Timing: Vertical total
timing.hstart=192	Timing: Horizontal start
timing.vstart=41	Timing: Vertical start
timing.hsync=44	Timing: Horizontal sync width
timing.vsync=5	Timing: Vertical sync width
timing.frate=60000	Timing: Frame rate 60 fps
hdcp=none	HDCP not enabled
loadingRGB=52,127,150	Solid color pattern shown when content is being uploaded to the device before playback is R=52, G=127, B=150. (Sample:)

Sample Content in Playback Tab

UCD Console's Playback tab features a set of examples for the user to create custom test content. This content is stored by default in *C:\Program Files\Unigraf\Unigraf UCD Tools \data\playback\content*. It is advisable to create copy of the installed files and edit the copies.

Note: Please note that Playlists and Scenarios are interface technology dependent.
The provided examples are also somewhat different for HDMI and DisplayPort.

In the table below, please find a list of examples provided.

HDMI

Playlist Name	Description
Basic Video & Audio Example	Example playlist for demonstrating the use of video and audio files.
VRR Example	Playlist for demonstrating Variable Refresh Rate (VRR) capability of a DUT monitor.
QMS-VRR Example	Playlist for demonstrating Quick Media Switching VRR (QMS-VRR) capability of a DUT monitor.
ALLM	Playlist for demonstrating Auto Low-latency Mode (ALLM) capability of a DUT monitor
HDR & Metadata Example	Example playlist that demonstrates the use of video files and metadata packets in testing a DUT monitor

DP

Playlist Name	Description
Basic Video & Audio Example	Example playlist for demonstrating the use of video and audio files.
HDR & Metadata Example	Example playlist that demonstrates the use of video files and metadata packets in testing a DUT monitor
Frame Rate Example	Playlist for demonstrating use of multiple frame rates with FHD and UHD resolution.

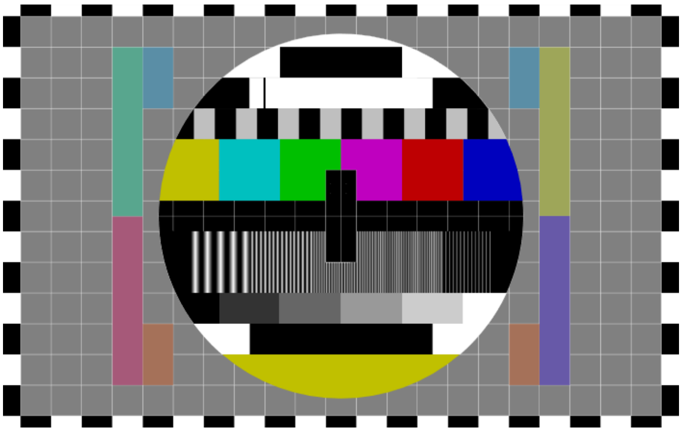
Playlist: Basic Video & Audio Example

The playlist sequences video files and audio according to the description below.

Video

Frames used for Scenario 1 and Scenario 2 (Image1.jpg, Image 2.jpg)

Frame used for Scenario 3 and Scenario 4 (Philips.svg)



Description of Scenarios

	Name	Duration	Repeated sequence
1	Flip-flop with Audio	60 s	CTA 1920×1080 60 Hz (VIC 16), RGB 8 BPC, 60 frames Image1.jpg, 60 frames Image2.jpg, Audio: Rhythm.wav
2	Flip-flop Silent	60 s	CTA 1920×1080 60 Hz (VIC 16), RGB 8 BPC, 60 frames Image1.jpg, 60 frames Image2.jpg, No Audio.
3	Philips 1920x1080p + 1kHz	60 s	CTA 1920×1080 60 Hz (VIC 16), RGB 8 BPC, 60 Frames Philips.svg, Audio: 1 kHz sine wave (1kHz.wav)
4	Philips 3840x2160p + 1kHz	60 s	CTA 3840 x 2160 @ 60Hz (VIC 97), RGB 8 BPC 60 Frames Philips.svg, Audio: 1 kHz sine wave (1kHz.wav)

Playlist: HDR & Metadata Example

Example demonstrates the use of metadata packets.

Video:

The Scenarios use four versions of the same image: GoldenGate0.jpg, GoldenGate1.jpg, GoldenGate2.jpg and GoldenGate3.jpg.

All four images use the same dynamic range in pixel data but contain a text label indicating pixel dynamic range applied in the metadata. If DUT behaves correctly, applying different metadata changes the appearance of the image on DUT screen.

Scenarios for HDMI Output

Video mode in all steps: CTA 1920×1080 60 Hz (VIC 16), RGB 8 BPC, No audio.

Name	Duration	Repeated sequence
SDR	10 sec	180 frames GoldenGate0.jpg, Packet: Infoframes_0002;
HDR	10 sec	180 frames GoldenGate1.jpg, Packets: Infoframes_0002, Infoframes_0000
HLG	10 sec	180 frames GoldenGate2.jpg, Packets: Infoframes_0001, Infoframes_0002
HDR10+	10 sec	180 frames GoldenGate3.jpg, Packets: Infoframes_0002, Infoframes_0003, Infoframes_0000
SDR – HDR	10 sec	180 frames GoldenGate0.jpg, Packets: Infoframes_0002; 180 frames GoldenGate1.jpg, Packets: Infoframes_0002, Infoframes_0000
SDR – HLG	10 sec	180 frames GoldenGate0.jpg, Packet: – ; 180 frames GoldenGate2.jpg, Packets: Packets: Infoframes_0001, Infoframes_0002
SDR – HDR10+	10 sec	180 frames GoldenGate0.jpg, Packet: Infoframes_0002; 180 frames GoldenGate3.jpg, Packets: Infoframes_0002, Infoframes_0003, Infoframes_0000

Playlist: VRR Example (HDMI)

Playlist demonstrates controlling VRR (Variable Refresh Rate) in Scenarios when using HDMI output.

Video

The image used for the test contains a combination of color bars, gray scales, and rotating items. The test uses a sequence of images creating a full rotation in 60 frames.

Scenarios with Video Mode 1920.1080 120 Hz

The first 6 Scenarios are using 1920×1080 119.88/120 Hz video timing (VIC 63). No audio.

	Name	Duration	Repeated sequence
1	FHD No VRR 119	60 s	VRR disabled. RGB 8 BPC. Packet: infoframe_03
2	FHD VRR 119..40	60 s	VRR enabled. Packets: infoframe_00, infoframe_03 60 frames each with changing frame rate (Hz): 119, 112, 105, 97, 86, 73, 59, 45, 42, 41, 40, 43, 51, 67, 82, 95, 109, 113, 114, 115, 116, 117, 118.
3	FHD VRR 119..40 steps	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_03 60 frames with changing frame rate: 119 – 80 (1 Hz step), 78 – 40 (2 Hz step), 60 frames with 40 Hz frame rate, 60 frames with changing frame rate, 40 – 79 (2 Hz step), 79 – 119 (1 Hz step). 60 frames with 119 Hz.
4	FHD VRR 40..119 switch	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_03 300 frames with 40 Hz frame rate, 300 frames with 119 Hz frame rate
5	FHD VRR 60	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_03 60 frames with 60 Hz frame rate.
6	FHD VRR 60..119 switch	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_03 300 frames with 60 Hz frame rate, 300 frames with 119 Hz frame rate.

Scenarios with Video Mode 1920×1080 60 Hz

Scenarios 7 to 11 are using 1920×1080 59.94/60 Hz video timing (VIC 16). No audio.

	Name	Duration	Repeated sequence
7	FHD No VRR 59	60 s	VRR disabled. RGB 8 BPC. Packet: infoframe_01
8	FHD VRR 40	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_01 60 frames with 40 Hz frame rate.
9	FHD VRR 40..59 switch	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_01 300 frames with 40 Hz frame rate, 300 frames with 59 Hz frame rate.
10	FHD VRR 59..40	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_01 60 frames each with changing frame rate: 59, 52, 50, 48, 46, 45, 44, 43, 42, 41, 40, 41, 43, 45, 47, 49, 51, 53, 54, 55, 56, 57, 58 (Hz).
11	FHD VRR 59..40 steps	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_01 29 frames with changing frame rate: 59 – 41 10 frames with 40 Hz frame rate, 29 frames with changing frame rate 41 – 59 40 frames with 60 Hz frame rate.

Scenarios with Video Mode 3840×2160 120 Hz

Scenarios 12 to 18 are using 3840×2160 119.88/120 Hz video timing (VIC 120). No audio.

	Name	Duration	Repeated sequence
12	UHD No VRR 119	60 s	VRR disabled. RGB 8 BPC. Packet: infoframe_04
13	UHD VRR 119..40	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_04 60 frames each with changing frame rate: 119, 112, 105, 97, 86, 73, 59, 45, 42, 41, 40, 43, 51, 67, 82, 95, 109, 113, 114, 115, 116, 117, 118 (Hz).
14	UHD VRR 119..40 steps	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_04 60 frames with changing frame rate: 119 – 80 (1 Hz step), 78 – 40 (2 Hz step), 60 frames with 40 Hz frame rate, 60 frames with changing frame rate 40 – 79 (2 Hz step), 79 – 119 (1 Hz step). 60 frames with 119 Hz frame rate.
15	UHD VRR 40		VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_04 60 frames with 40 Hz frame rate.
16	UHD VRR 119..40 switch	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_04 300 frames with 40 Hz frame rate, 300 frames with 119 Hz frame rate
17	UHD VRR 60	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_04 60 frames with 60 Hz frame rate.
18	UHD VRR 60..119 switch	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_04 300 frames with 60 Hz frame rate, 300 frames with 119 Hz frame rate.

Scenarios with Video Mode 3840×2160 60 Hz

Scenarios 19 to 23 are using 3840×2160 59.94/60 video timing (VIC 97). No audio.

	Name	Duration	Repeated sequence
19	UHD No VRR 59	60 s	VRR disabled. RGB 8 BPC. Packet: infoframe_02
20	UHD VRR 40	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_02 60 frames with 40 Hz frame rate.
21	UHD VRR 40..59 switch	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_02 300 frames with 40 Hz frame rate, 300 frames with 59 Hz frame rate.
22	UHD VRR 59..40	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_02 60 frames each with changing frame rate: 59, 52, 50, 48, 46, 45, 44, 43, 42, 41, 40, 41, 43, 45, 47, 49, 51, 53, 54, 55, 56, 57, 58 (Hz).
23	UHD VRR 59..40 steps	60 s	VRR enabled. RGB 8 BPC. Packets: infoframe_00, infoframe_02 29 frames with changing frame rate: 59 – 41, 10 frames with 40 Hz frame rate, 29 frames with changing frame rate 41 – 59, 40 frames with 60 Hz frame rate.

Playlist: Frame Rate Example (DP)

Playlist for demonstrating use of multiple frame rates with FHD and UHD resolution when using DisplayPort output.

Video

The image used for the test contains a combination of color bars, gray scales, and rotating items. The test uses a sequence of images creating a full rotation in 60 frames

Executed Scenarios

The test is using four scenarios (RGB 8 BPC, No audio)

	Name	Duration	Repeated sequence
1	Spinners FHD 59fps	60 s	1920×1080 59.94/60 Hz video timing (VIC 16), 60 frames ‘colorBarsSpinning-X.svg’ X= 0 to 59
2	Spinners FHD 119fps	60 s	1920×1080 119.88/120 Hz video timing (VIC 63), 60 frames ‘colorBarsSpinning-X.svg’ X= 0 to 59
3	Spinners UHD 59fps	60 s	3840×2160 59.94/60 Hz video timing (VIC 97) 60 frames ‘colorBarsSpinning-X.svg’ X= 0 to 59
4	Spinners UHD 119fps	60 s	3840×2160 119.88/120 Hz Hz video timing (VIC 120) 60 frames ‘colorBarsSpinning-X.svg’ X= 0 to 59

Playlist: ALLM (HDMI)

Playlist for demonstrating Auto Low-latency Mode (ALLM) capability of a DUT monitor.

Video:

The Scenarios use a series of images: allm_on_off_000.jpg to allm_on_off_0011.jpg. Text panel on the images indicate if ALLM is enabled or not. The first scenario is presented with ALLM enabled and the second by switching ALLM on and off sequentially.

Scenarios for HDMI Output

Video mode in all steps: CTA 1920×1080 60 Hz (VIC 16), RGB 8 BPC, No audio.

Name	Duration	Repeated sequence
ALLM Static	60 sec	10 frames allm_on_off_000.jpg, Packet: allm_0.bin; 10 frames allm_on_off_001.jpg, Packet: allm_0.bin; 10 frames allm_on_off_002.jpg, Packet: allm_0.bin; 10 frames allm_on_off_003.jpg, Packet: allm_0.bin; 10 frames allm_on_off_004.jpg, Packet: allm_0.bin; 10 frames allm_on_off_005.jpg, Packet: allm_0.bin
ALLM Toggle	60 sec	10 frames allm_on_off_000.jpg, Packet: allm_0.bin; 10 frames allm_on_off_001.jpg, Packet: allm_0.bin; 10 frames allm_on_off_002.jpg, Packet: allm_0.bin; 10 frames allm_on_off_003.jpg, Packet: allm_0.bin; 10 frames allm_on_off_004.jpg, Packet: allm_0.bin; 10 frames allm_on_off_005.jpg, Packet: allm_0.bin; 10 frames allm_on_off_006.jpg, Packet: allm_1.bin; 10 frames allm_on_off_007.jpg, Packet: allm_1.bin; 10 frames allm_on_off_008.jpg, Packet: allm_1.bin; 10 frames allm_on_off_009.jpg, Packet: allm_1.bin; 10 frames allm_on_off_0010.jpg, Packet: allm_1.bin; 10 frames allm_on_off_0011.jpg, Packet: allm_1.bin