UCD-5XX

User Manual

UCD Console SW Version 3.3

UNIGRAF

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Edition

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Unigraf warrants its hardware products to be free from defects in workmanship and materials, under normal use and service, for twelve (12) months from the date of purchase from Unigraf or its authorized dealer.

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CE Mark

UCD-5XX products meet the essential health and safety requirements, are 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-5XX products. UCD-5XX 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 UCD-5XX units.
- Provide instructions for the user on how to use UCD Console software.

Product and Software Version

This manual explains features found in UCD Console Software Bundle **3.3.** 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 software 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

UCD-5XX products are high speed, USB 3.0 connected video interface test units.

UCD Console is a common graphical user interface (GUI) for Unigraf's UCD-5XX, UCD-4XX and UCD-3XX units. The outlook and details of UCD Console will vary depending on the capabilities of the connected unit and will reflect the features enabled.

The software package for UCD-5XX features 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.

Product Features

- **UCD-500:** DP 2.1 capable Reference Sink and Reference Source for verifying DP and USB-C connected devices with link rates up to 20 Gbps (UHBR20) using USB-C interface and 10 Gbps (UHBR10) using DP interface.
- **UCD-500 Gen2**: DP 2.1 capable Reference Sink and Reference Source for verifying DP and USB-C connected devices with link rates up to 20 Gbps (UHBR20)
- High resolution video up to 8K @60Hz, 16K @60Hz with DSC and audio
- Generate HDR formats such as Dolby Vision™, HDR10 and HDR10+
- 16 GB video frame buffer
- High speed USB 3.0 host PC interface

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

Available Interface Roles

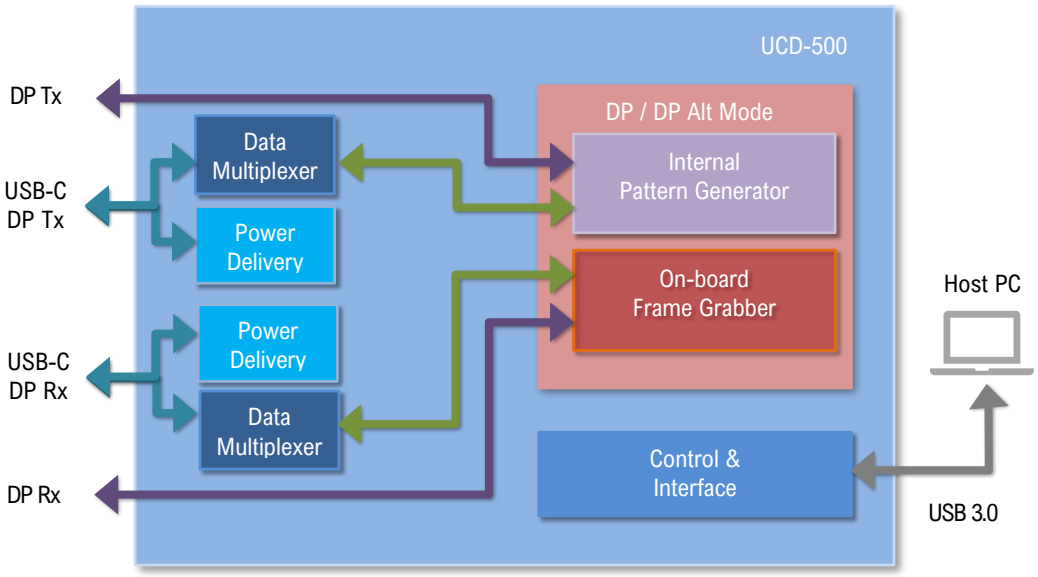
UCD-500 products can operate in various interface role combinations. The used role is selected when UCD Console is launched.

Selection	UCD-500	UCD-500 Gen2
DisplayPort Sink and Source	•	•
USB-C DP Alt-Mode Sink and Source	•	•
DisplayPort Source and USB-C DP Alt-Mode Sink	•	•
USB-C DP Alt-Mode Source and DisplayPort Sink	•	•

Functional Description

UCD-5XX units consist of a multimedia signal input stage, an internal pattern generator, a control stage with on-board frame buffer 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.

UCD-5XX Functional Diagram



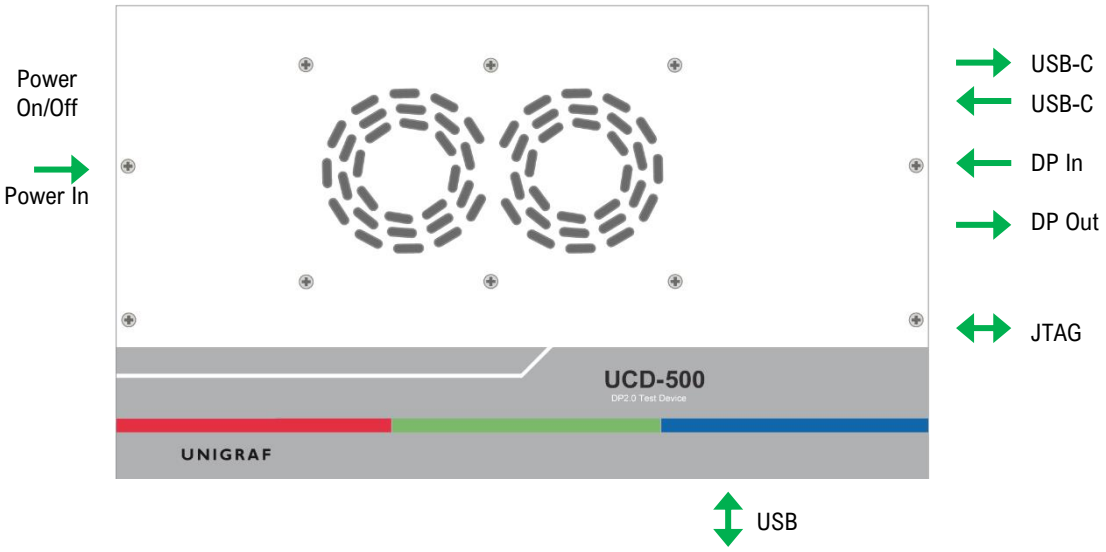
Delivery Content

Please find below an image of the items included in UCD-5XX unit delivery

1. UCD-5XX Unit
2. AC/DC Power Supply (100 to 240 Vac 50/60Hz input, +12 Vdc output)
3. DisplayPort cable 0.5 meters length
4. Micro USB cable for FW update
5. Passive TBT4 cables, 0.5 and 1.0 meters length
6. USB 3.0 compliant cable for host PC connection

Connections

The image below indicates the connections in **UCD-500** and **UCD-500 Gen2** unit and their description.



Name	Description
DP in	DisplayPort™ 2.1 capable input*
DP out	DisplayPort™ 2.1 capable output*
USB-C in	USB-C PD 3.0 DP Alt-Mode input (20 Gbps)
USB-C out	USB-C PD 3.0 DP Alt-mode output (20 Gbps)
Power in	+12 Vdc Power Supply Input
Power On/Off	Rocker power switch
USB	USB 3.0 connection to the host PC
JTAG	JTAG interface for maintenance purposes (micro USB)

(* In UCD-500 10 Gbps link rate maximum, in UCD-500 Gen2 20 Gbps link rate maximum

Note	Capturing and sourcing high resolution video modes and high frame rates set stringent requirements on the video cables and connectors. If in doubt, please contact Unigraf Support.

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.

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 and for TSI SDK. The bundle contains the following items:

- Windows/macOS drivers (installed during set up)
- UCD Console software (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, the firmware of the unit also 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** (X.X.XXXX denotes the installed software version)

The welcome page of the installer displays the software package release version.

The user is 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 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.

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-5XX device, please perform the following steps:

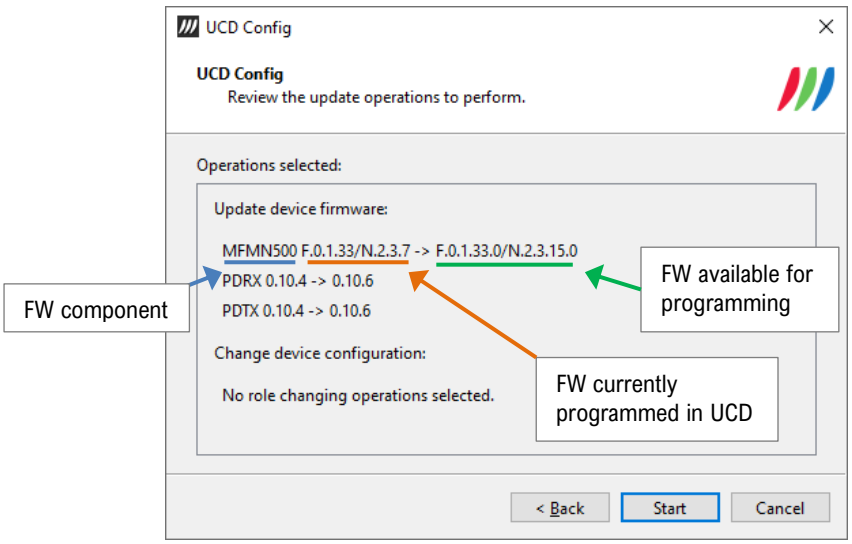
- Connect the UCD unit to a power supply and connect the USB cable.
- Open UCD Console. Select Tools > Firmware Update.

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 the 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

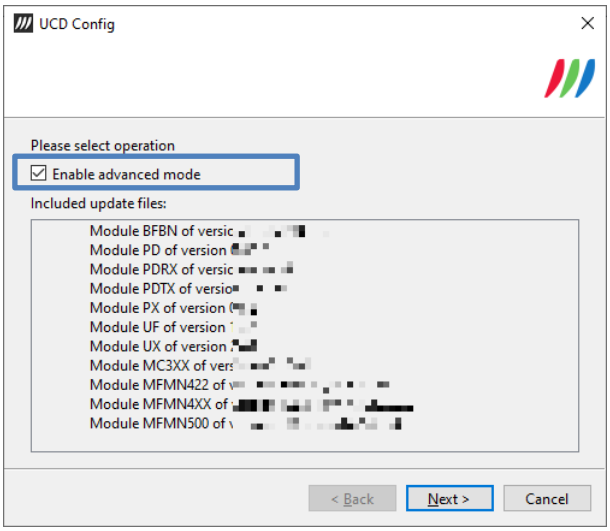
If FW Update procedure fails and cannot be re-initiated, please refer to Appendix I of this manual for instructions on *Firmware Recovery*.

Firmware Downgrading

The previously released Unigraf SW Bundle 2.4.XX package is not containing UCD Device Firmware (FW). In case UCD device has been installed with the FW delivered with Unigraf 3.X SW Bundle, and version downgrade is needed, also UCD Device Firmware has to be rolled back.

Please follow the procedure below.

1. Download the latest **Console 2 SW Bundle (2.4.XX)** from Unigraf download page at unigraf.fi/downloads.
2. Run the application **SoftwareBundle_2.4.XX.exe** in the package to install the package. Please do not launch UCD Console application yet.
3. Download **Console 2: FW Package 2.3.38** from the same download page
4. Run the application **FirmwarePackage_2.3.38.exe** to copy UCD device FW in a proper folder in your PC
5. Launch **UCD Console**
6. Select **Tools > Firmware Update** to start **UCD Config** utility
7. In UCD Config select **Enable advanced mode**



8. Click **Next** to proceed according to chapter *Updated Modules* above.
9. In **UCD Modules** select the module titled MFMN500 F.X.X.X/N.X.X.X
10. Click **Next** and **Start** to start programming FW to the connected UCD Device

License Manager

Licensing

The features of UCD Console GUI 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 **the UCD License Manager**. License manager can be found in the **Tools** menu of UCD Console.

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 on a sticker attached to the bottom of the device.

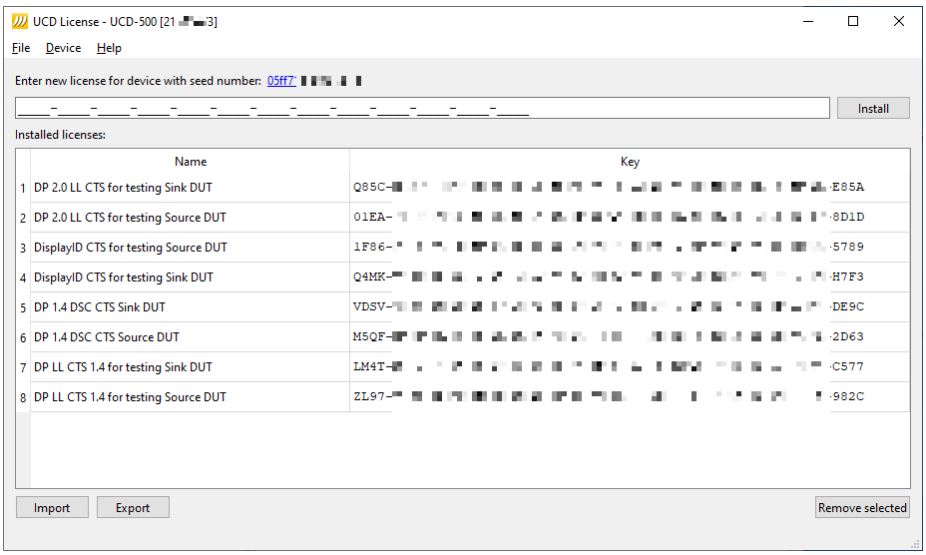
The **Rescan…** button will re-detect connected UCD devices.

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 cursor 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 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.

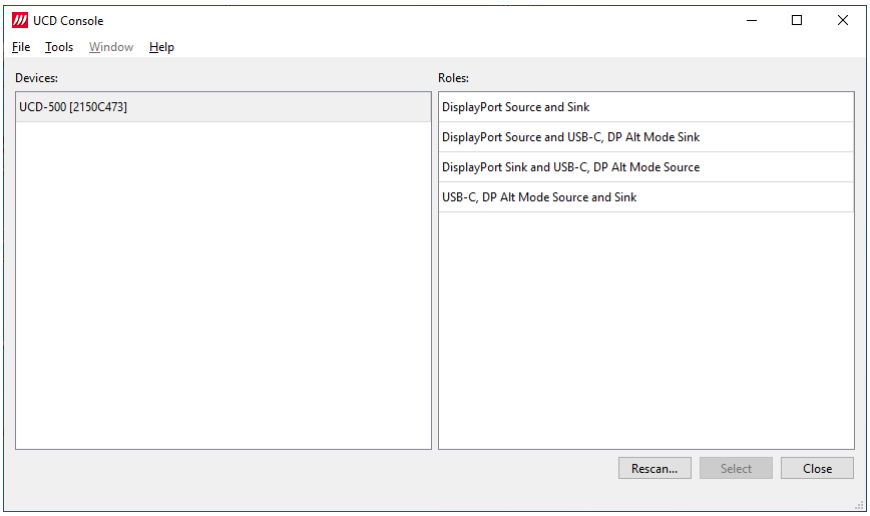
In UCD Console the various features of the UCD unit are divided into interface specific screens and tabs. Each tab contains data and controls for a specific feature.

Note: This version of the User Manual describes features in UCD Console software based on the functionality in Microsoft Windows operating system.
UCD Console is also available 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 GUI 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.

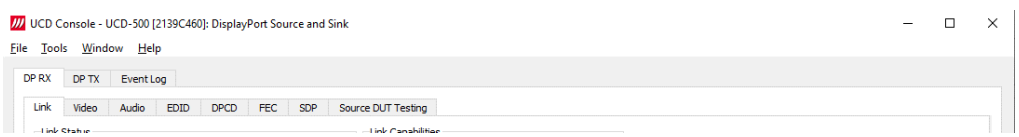


Role Selection

UCD-5XX features two alternative Sink interfaces (DP and USB-C), and in a similar way two alternative Source Interfaces. One Sink role and one Source role can be active at one time. Sink / Source role selection is done by selecting one of the four combinations during launch of UCD Console.

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**.

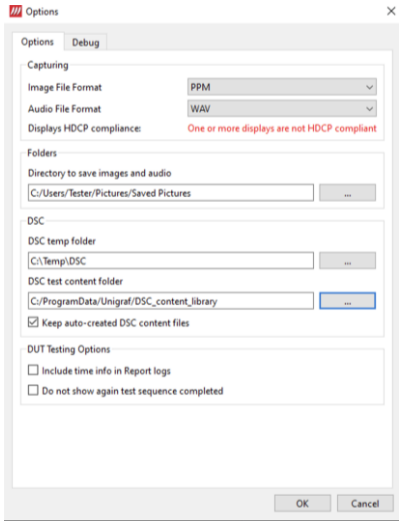


Image File Format

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.

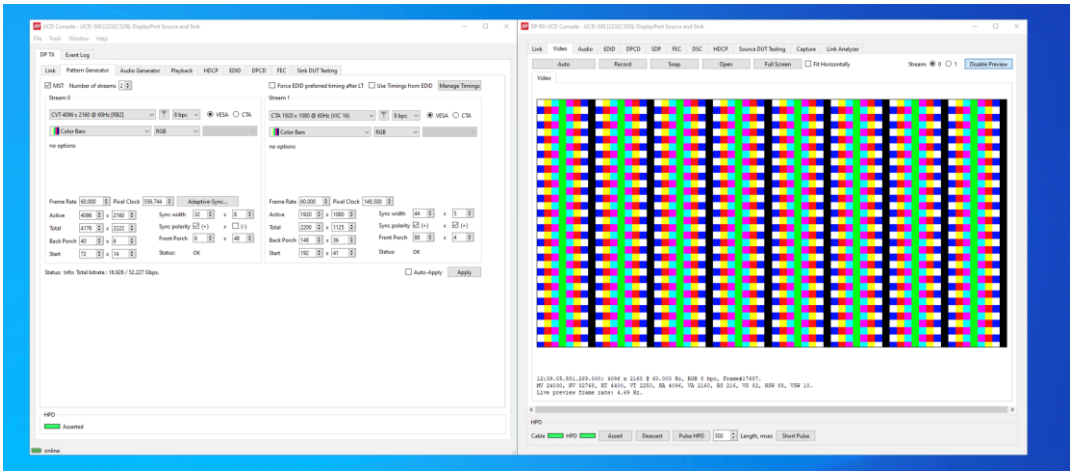
Include time info in Report logs:	Include system date and time in the beginning of each event line in created reports.

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-5XX device acts as DisplayPort or USB-C DisplayPort Alt Mode Sink or Receiver device.

Analyzer functionality related controls and dialogs can be used by selecting *DP RX* tab.

Please note that in UCD-5XX, *Generator* functionality is available simultaneously with Analyzer. Please find the description of Generator functionality later in this manual.

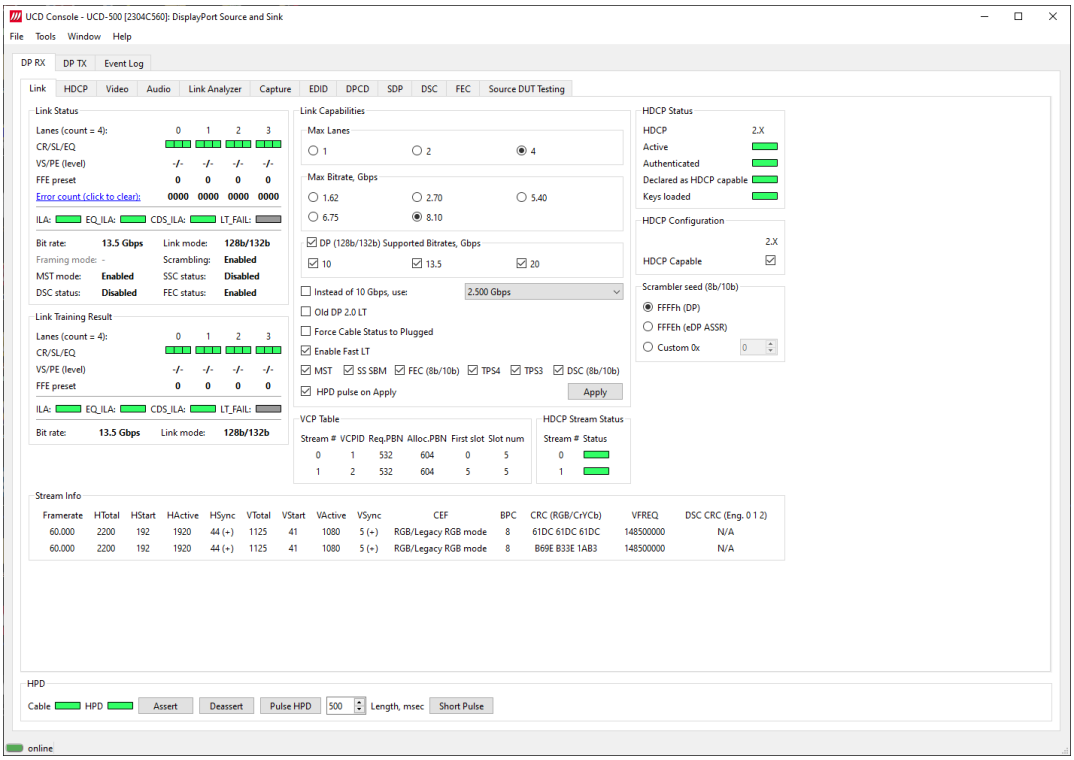
Functionality Tabs

UCD Console features are presented in tabs. Some of the tabs are enabled by default, some only when an applicable license is included.

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

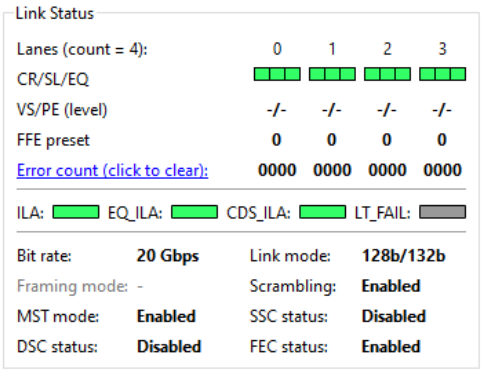
Link Tab

The Link tab contains the following panels: Link Status, Link Training Result, Link Capabilities, VCP Table, Stream Info and HPD.



Link Status

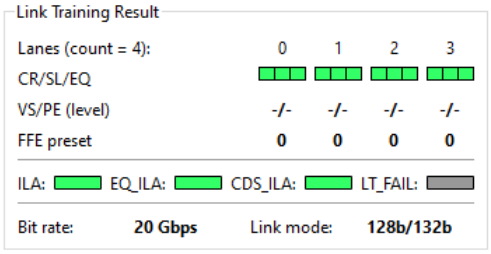
Link Status displays the status of the link training and the link parameters negotiated between UCD Sink and the Upstream Source. It also lists the status of other link modes. The data is retrieved from the DPCD status registers of the UCD Sink. The status is updated automatically.



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
FFE Preset:	TX Feed Forward Equalization (FFE) preset value (only with 128b/132b channel coding)
Error count:	Content of DPCD Error Count registers
ILA:	Status LED for Inter-Lane Alignment
EQ_ILA	Status LED for Inter-Lane Alignment on Equalization stage (only with 128b/132b channel coding)
CDS_ILA	Status LED for Inter-Lane Alignment on Clock and Data Switch stage (only with 128b/132b channel coding)
LT_FAIL	Status LED for Link Training failure (only with 128b/132b channel coding)
Bit rate:	Currently enabled link bit rate
Link mode:	Currently enabled channel coding (128b/132b or 8b/10b)
Framing mode:	Currently enabled Framing Mode (Normal or Enhanced) (only with 8b/10b channel coding)
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 (Enabled or Disabled)
FEC status:	Status of Forward Error Correction function (Enabled or Disabled)

Link Training Result

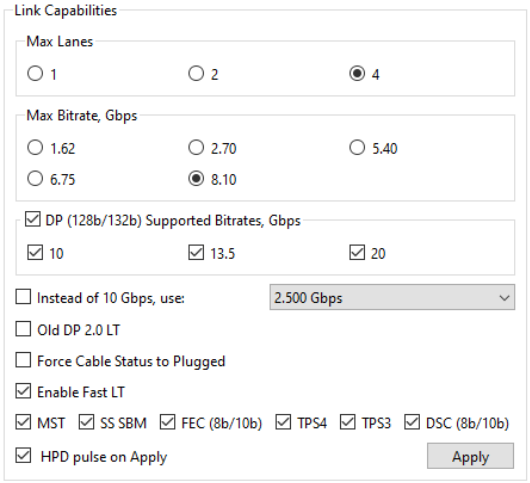
The result of the previous Link Training and values of some key parameters.



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
FFE preset:	TX Feed Forward Equalization (FFE) preset value (only with 128b/132b channel coding)
ILA:	Status LED for Inter-Lane Alignment
EQ_ILA	Status LED for Inter-Lane Alignment on Equalization stage (only with 128b/132b channel coding)
CDS_ILA	Status LED for Inter-Lane Alignment on Clock and Data Switch stage (only with 128b/132b channel coding)
LT_FAIL	Status LED for Link Training failure (only with 128b/132b channel coding)
Bit rate:	Currently enabled link bit rate
Link mode:	Currently enabled channel coding (128b/132b or 8b/10b)

Link Capabilities

The Link capabilities panel allows the user to change the way the Sink capabilities are announced in the DPCD capability registers of the UCD Sink. To enable the change, please click **Apply**.

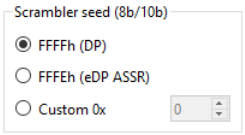


Max Lanes:	Maximum lane count used
Max Bitrate, Gbps	Maximum link rate used when 8b/10b link coding is selected in LT.
DP (128b/132b) Supported Bitrates, Gbps	When checkbox is selected, 128b/132b link coding is supported. Link rates used when 128b/132b link coding is selected in LT. **Please observe the Note about the long HPD pulse below**.
Instead of 10 Gbps, use:	For supporting low link rate Source devices, the user can make UCD-5XX sink PHY use a selectable lower link rate when performing “10 Gbps” link training in protocol level. Link rates are: 2.5 Gbps, 2.7 Gbps, 5.0 Gbps and 5.4 Gbps
Old DP 2.0 LT	When checked LT will follow initial DP 2.0 spec description. Otherwise, LT as per DP 2.1 specification
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:	Indicates support for link training without AUX transactions.
MST:	When 8b/10b link coding enabled, indicate support for MST mode and Sideband MSG handling. When 128b/132b link coding enabled, indicate support for multi-stream transport and Sideband MSG.
SS SBM:	When selected, indicate support Sideband MSG while not supporting multi-stream transport. Valid only with 128b/132b channel coding and when “MST” is unchecked.
FEC (8b/10b):	Indicated support for Forward Error Correction feature when 8b/10b link coding is enabled
TPS4, TPS3:	Indicate support for Link Training Pattern Sequence 4 and 3.
DSC (8b/10b)	Select to enable Display Stream Compression (DSC) feature when 8b/10b link coding is enabled
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.

Note:	Please note that deviating from to the rules set in DP 2.1 Specification, UCD-5XX allows selection of maximum link rate for 8b/10b coding also when support for 128b/132b link coding is enabled.

Note:	When changing link coding capability of the Sink device (8b/10b vs 128b/132b), please make sure to issue a Long HPD Pulse after applying new setting or make sure that "HPD pulse on Apply" is selected before applying the change

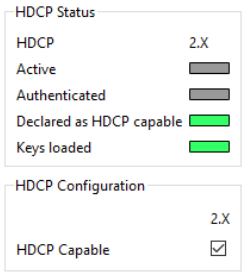
Scrambler Seed



Selection of the value to which the Linear Feedback Shift Register (LFSR) is reset during scrambler reset.

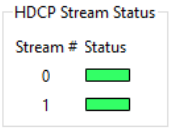
Used only when 8b/10b link coding is enabled.

HDCP Status & Configuration



Copy of HDCP status and controls on HDCP tab.

HDCP Stream Status



Shows HDPC status for each stream.

Stream Info

Stream Info is achieved from the Main-Stream Attributes (MSA) of the monitored stream. Frame rate is measured by UCD Local Sink

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

Stream Info

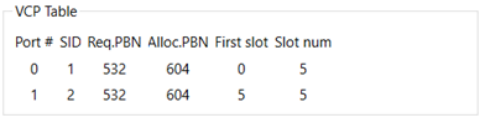
Framerate	HTotal	HStart	HActive	HSync	VTotal	VStart	VActive	VSync	CEF	BPC	CRC (RGB/CrYCb)	VFREQ	DSC CRC (Eng. 0 1 2)
30.000	9000	768	7680	176 (+)	4400	64	4320	20 (+)	RGB/Legacy RGB mode	6	8789 4AAD ED47	1188000000	N/A
59.996	4000	112	3840	32 (+)	2222	59	2160	5 (-)	RGB/Legacy RGB mode	8	0304 B31A 5E17	533250000	N/A

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.

VFREQ:	Video Frequency (128b/132b channel coding only)
MVID/NVID:	Mvid and Nvid video time stamp values (8b/10b channel coding only)
DSC CRC:	16-bit Cyclic redundancy check (CRC) calculated from compressed pixel stream. Value order: Engine 0, 1, 2.

VCP Table

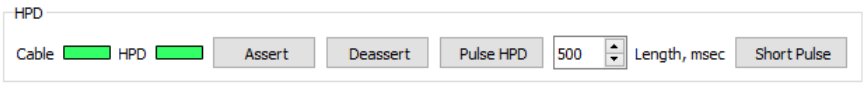
VCP Table shows allocation of Virtual Channel Payload for active virtual channels.



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 number) 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.

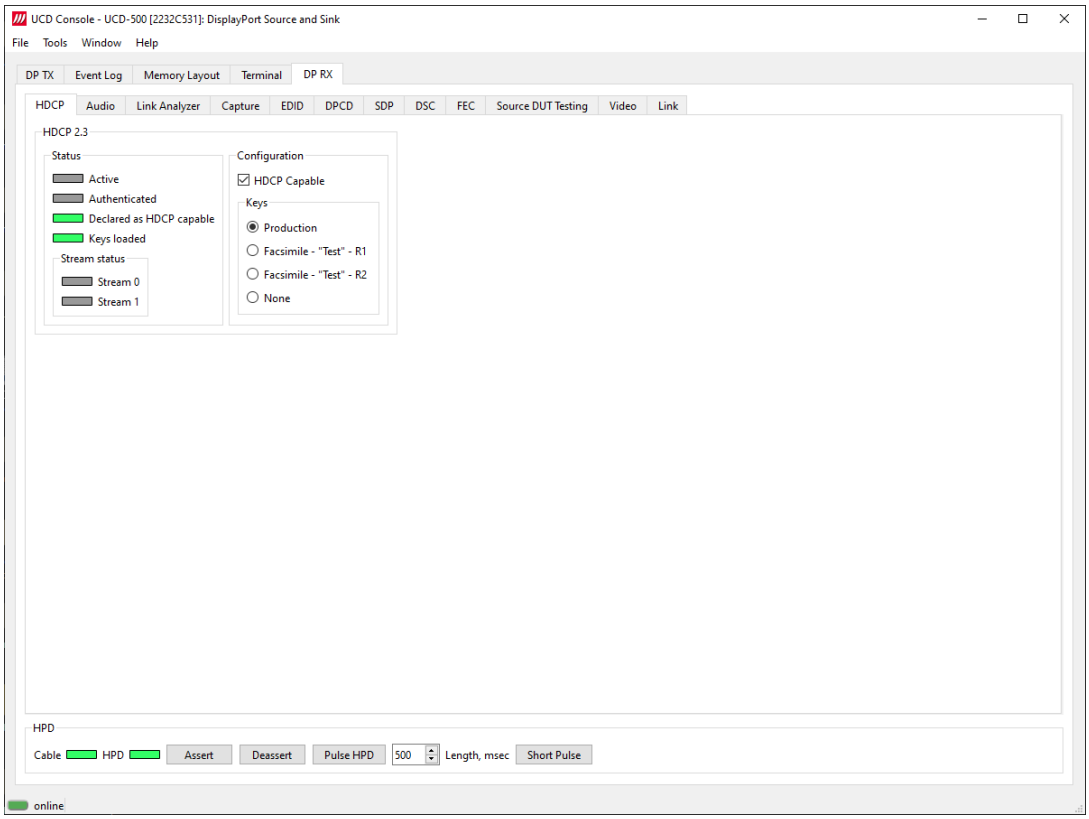
HPD



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

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.
Stream status	Shows HDPC status on each stream

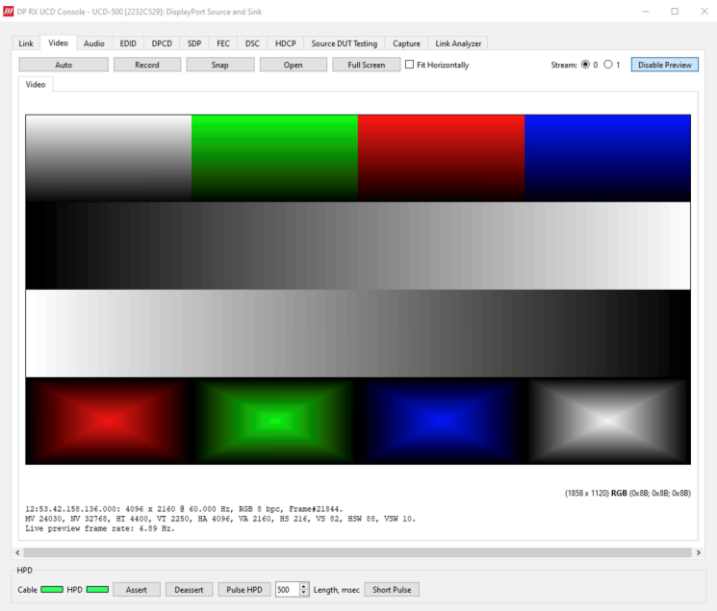
Configuration

HDCP Capable:	To disable HDCP, uncheck the box.

Keys

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

Video Tab



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

Disable / Enable Preview

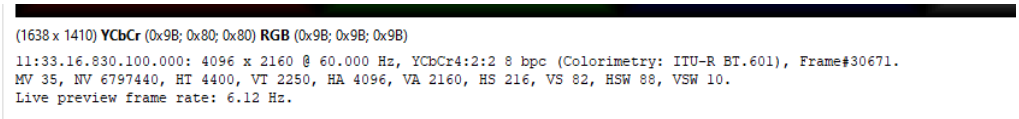
Click the button to start or stop capturing video frames.

Stream

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.

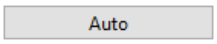


First row:	Cursor location, pixel value at cursor location in YCbCr and RGB
Second row:	Time stamp, Color mode, color depth, frame counter.
Third row:	Mvid, Nvid, Horiz Total, Vert Total, Horiz Active, Vert Active, Horiz Start, Vert Start, Hor Sync Width, Vert Sync Width.
Fourth row:	Live preview frame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

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

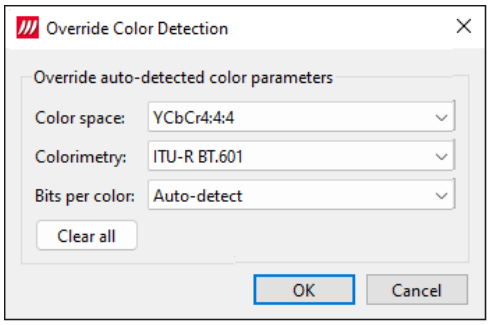
Please note that UCD test equipment are able to capture video at full frame rate.
Live preview frame rate indicates the rate of updating captured video on UCD Console preview screen. Live preview frame rate is limited e.g., by the USB communication between UCD test equipment and the PC.

Override Color Detection



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.

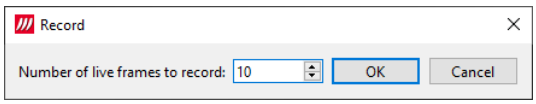


Color space:	Define as which format captured data will be interpreted. (Auto-detect, RGB, YCbCr4:4:4, YCbCr4:2:2, YCbCr4:2:0)
Colorimetry:	Define as which colorimetry captured data will be interpreted. (ITU-R BT.601, ITU-R BT.709, ITU-R BT.2020)
Bits per color	Define as which color depth captured data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

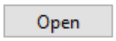
Frame recording

Clicking the button opens a dialog for definition of number of frames recorded.



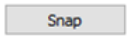
Recorded frames are stored by default in C:/Users/<Current user>/Pictures. Please refer to Tools > Options where the location of this folder can be customized.

Open

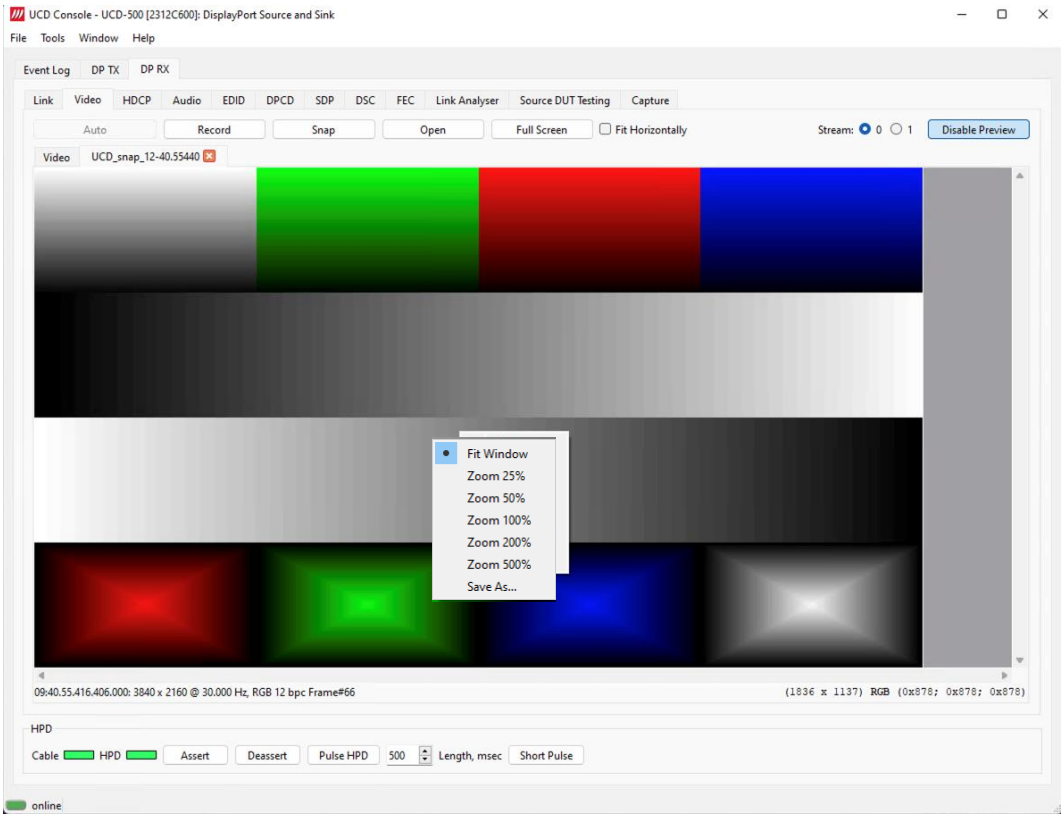


Open folder where captured frames are stored. Please refer to Tools > Options where the location of this folder can be customized.

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 RGB and YCbCr components of the pixel on the cursor location in hexadecimal 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.

Full Screen

Full Screen

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

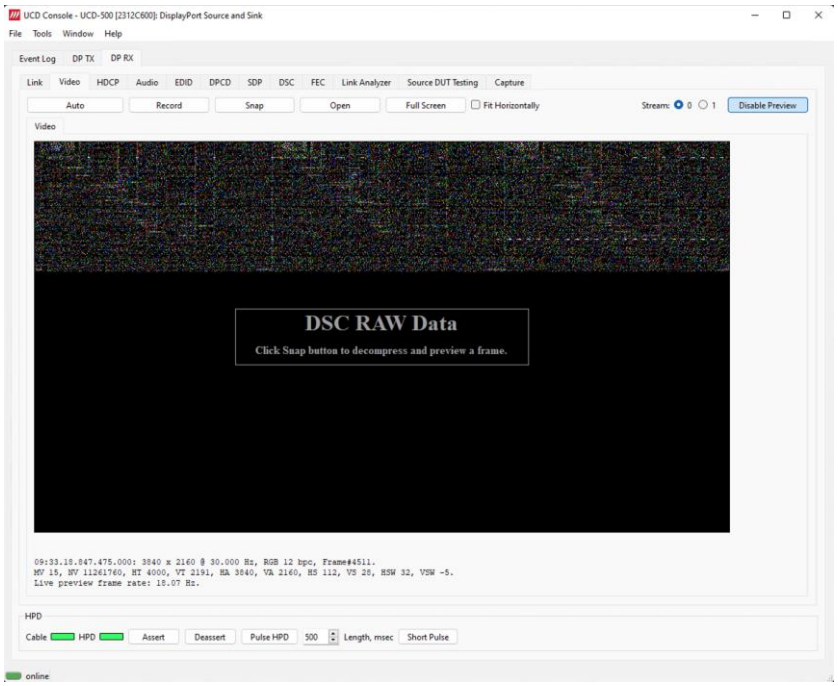
Double-click on the screen or press <Esc> to exit full screen mode.

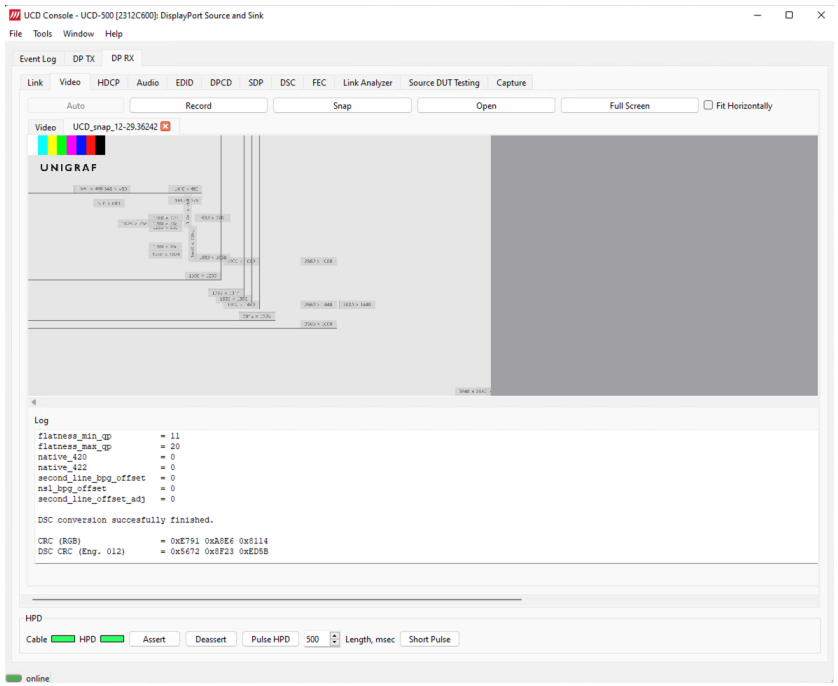
Preview DSC Decompressed Stream

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.

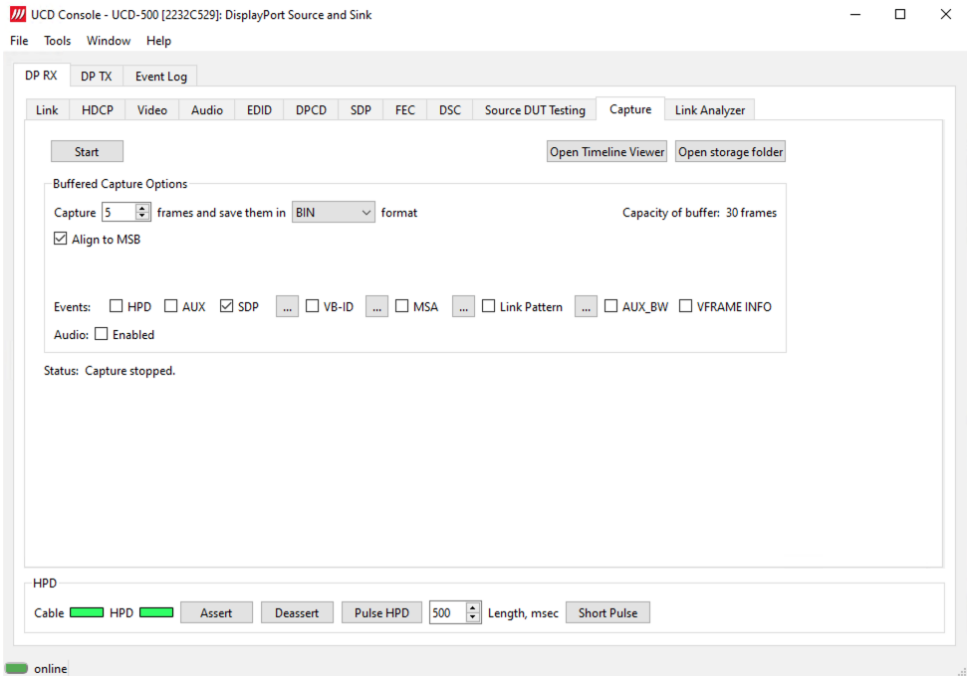
Click the Snap button to capture one frame and start the decompressor (offline in the PC). Once the decompression is ready, the frame is shown, and Log lists the details of the compressed image.





Capture Tab

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.

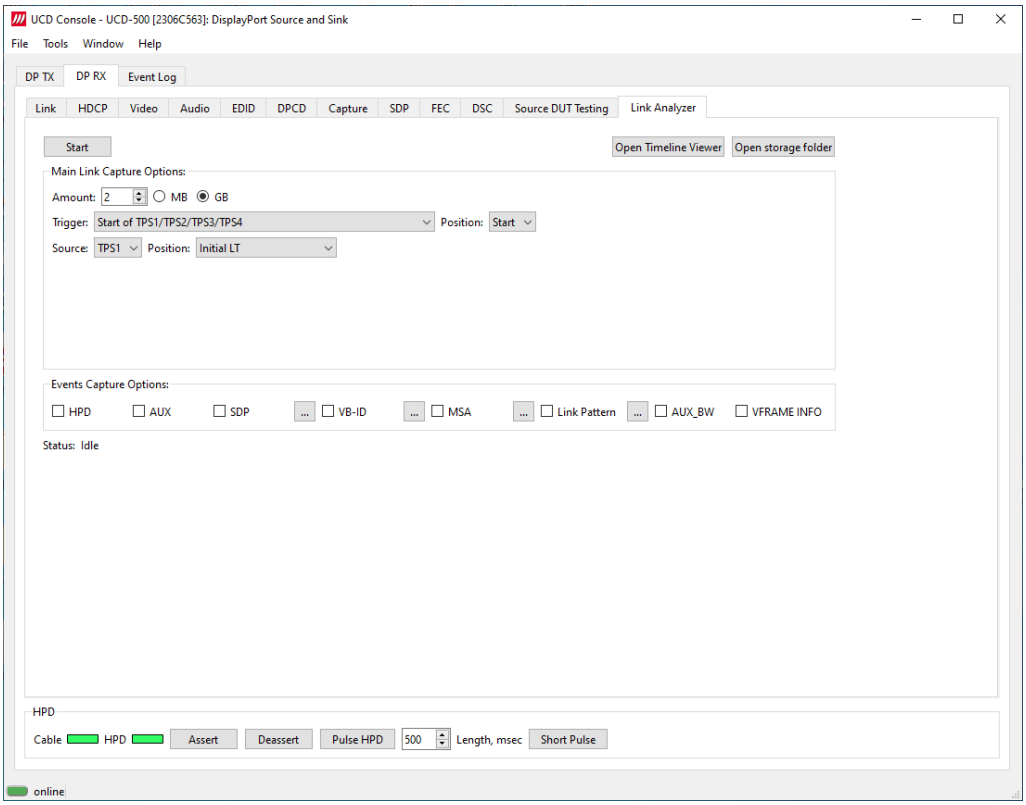


Start / Stop:	Start or Stop capturing
Capture N frames …:	The number of video frames captured.
Format:	Selection of the format of the saved video frame bitmaps. BIN, PPM, BMP, BIN + PPM, BIN + BMP.
Capacity of buffer:	The number of video frames that can be stored to UCD frame buffer using current video 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 Event Timeline Viewer to view the captured data. Refer to chapter seven of this manual for detailed instructions.
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.

Link Analyzer Tab

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



Start	Start capturing main link data defined by *Main Link Capture Options*
Open Timeline Viewer	Open Link Timeline Viewer. For detailed description of Link Timeline Viewer, please refer to chapter six of this manual.
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 4 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

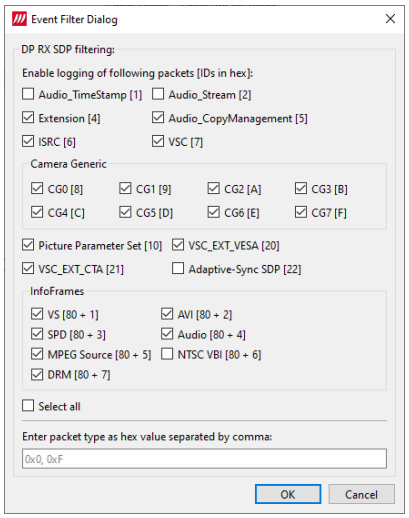
Status and status changes of Hot Plug Detect (HPD) signal

AUX

AUX Channel transactions.

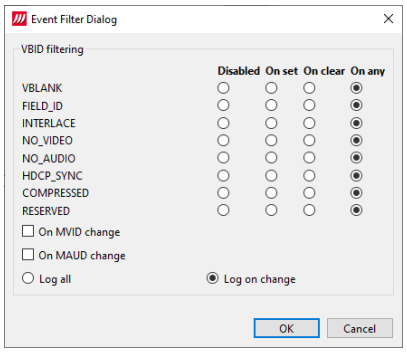
SDP

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 "[ ]".



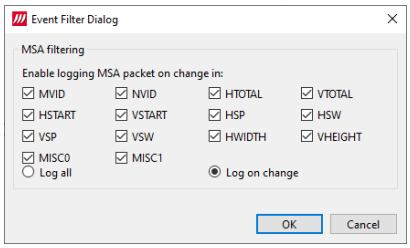
VB-ID

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



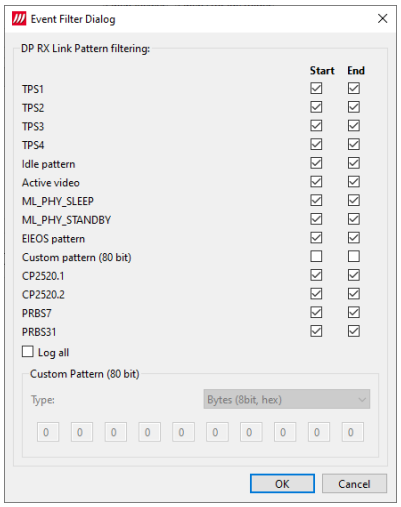
MSA

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:

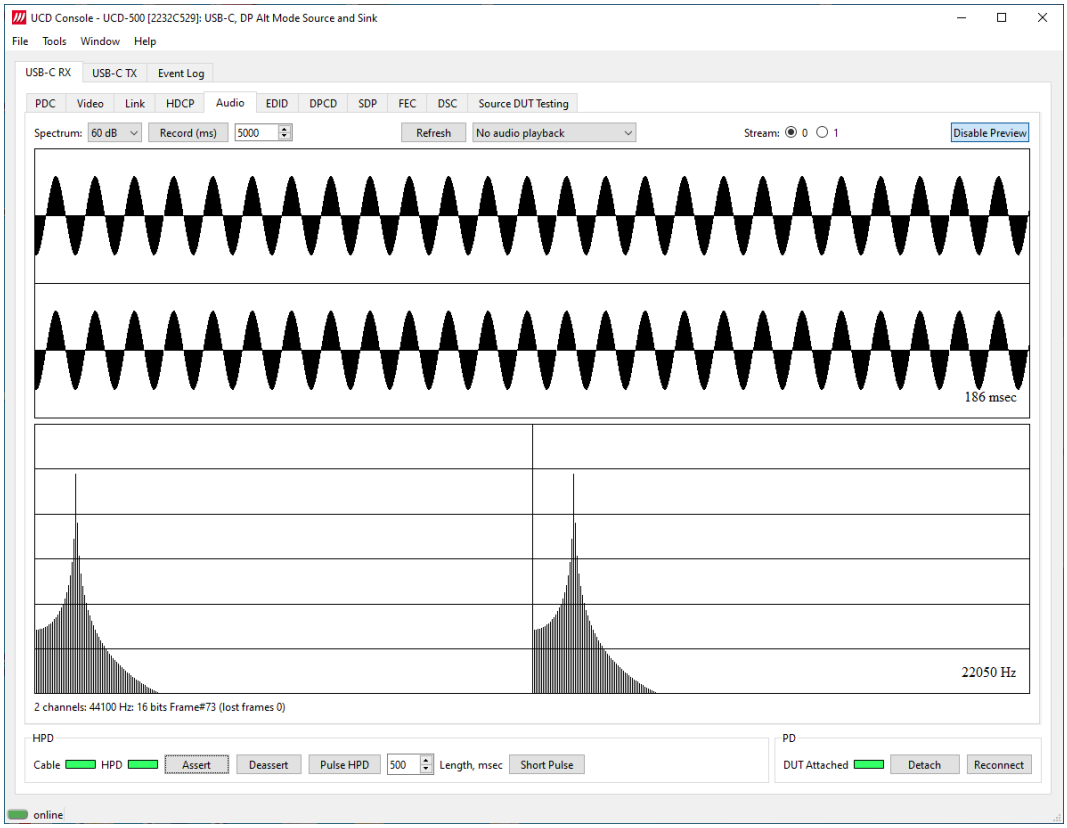
Capture AUX Channel signal details.

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

Enable Preview / Disable Preview

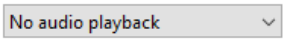
This button controls capturing the audio data.

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.

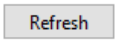
Playback Device Selection



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.

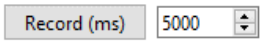
Note: Please note that the audio capabilities of the audio playback device of the PC are not automatically reflected in the audio capabilities description in UCD device EDID. Since UCD devices are not performing any audio format conversion, it might occur that the source provides an audio format that 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.

Start Audio Recording

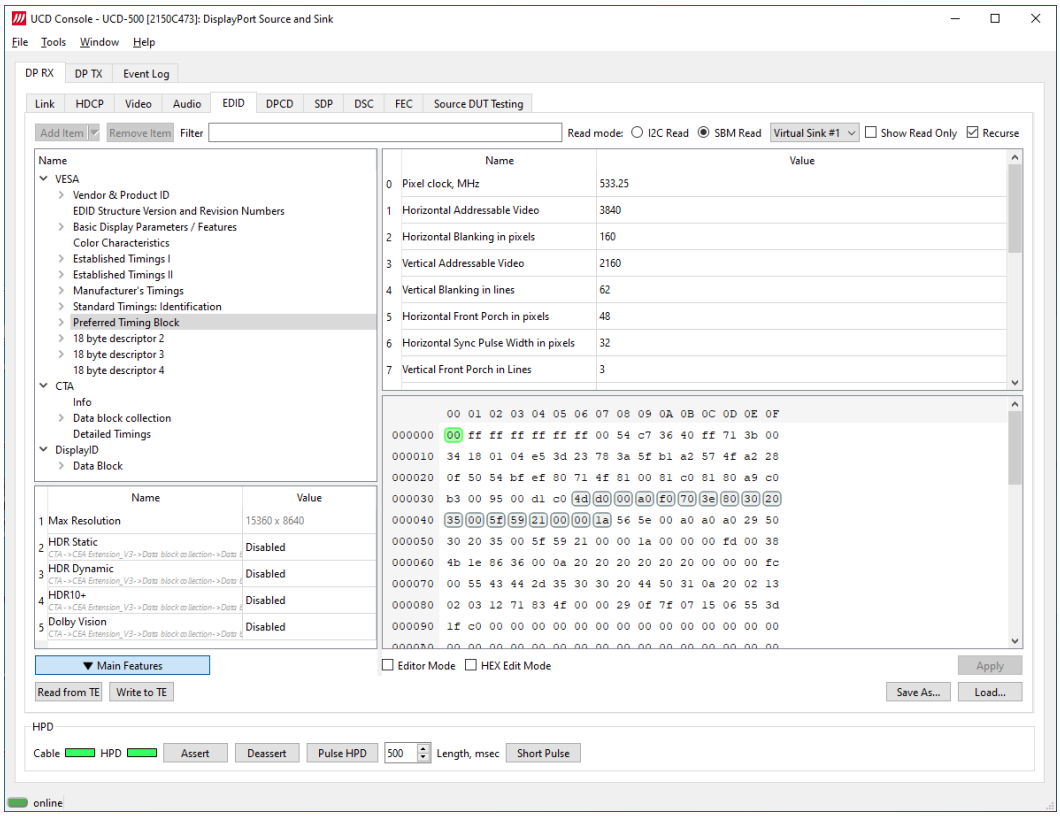


The captured audio can be recorded in the PC using Waveform Audio File Format, WAV (*.wav) format. Recording duration is defined in milliseconds (ms). The folder where the audio file will be saved can be selected in Tools > Options.

EDID Tab

EDID Tab provides tools for accessing the EDID including DisplayID extension of the UCD Sink presented to the Upstream 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 all virtual channels.



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.

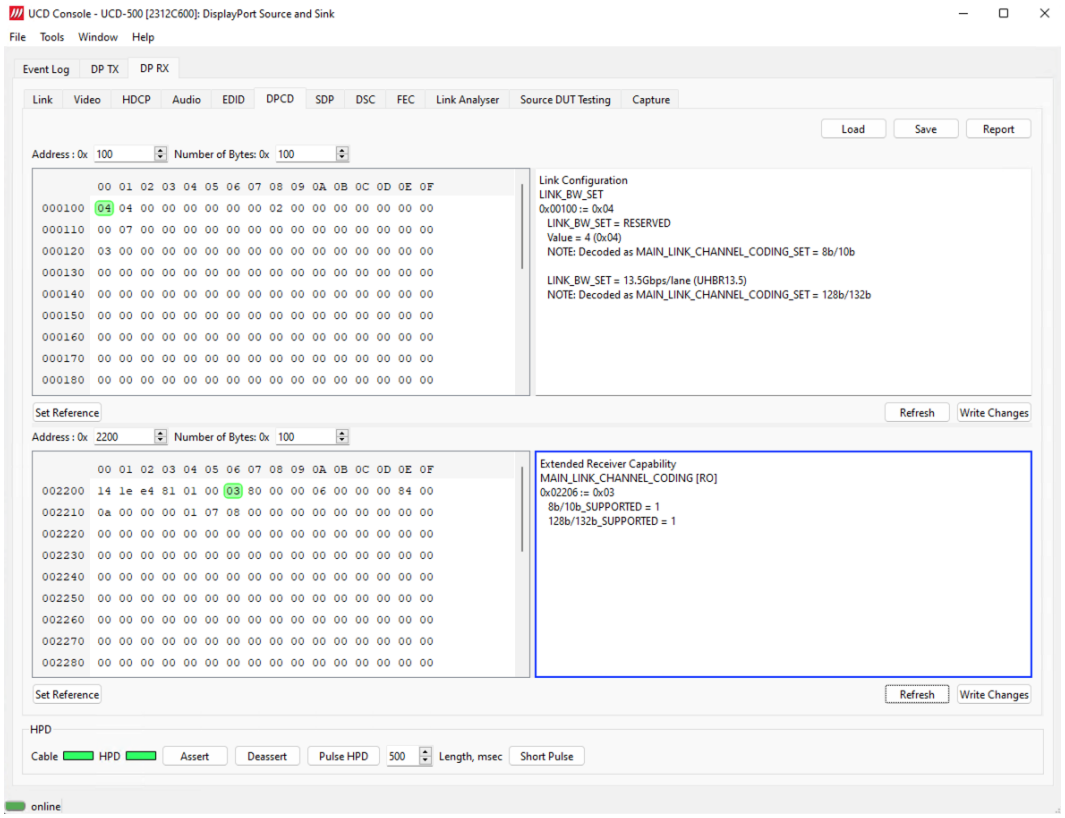
Note: Four blocks (512 bytes) of EDID code are read. If the device does not support all four blocks, the non-supported area is replaced with blanks.

EDID Editor

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

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.

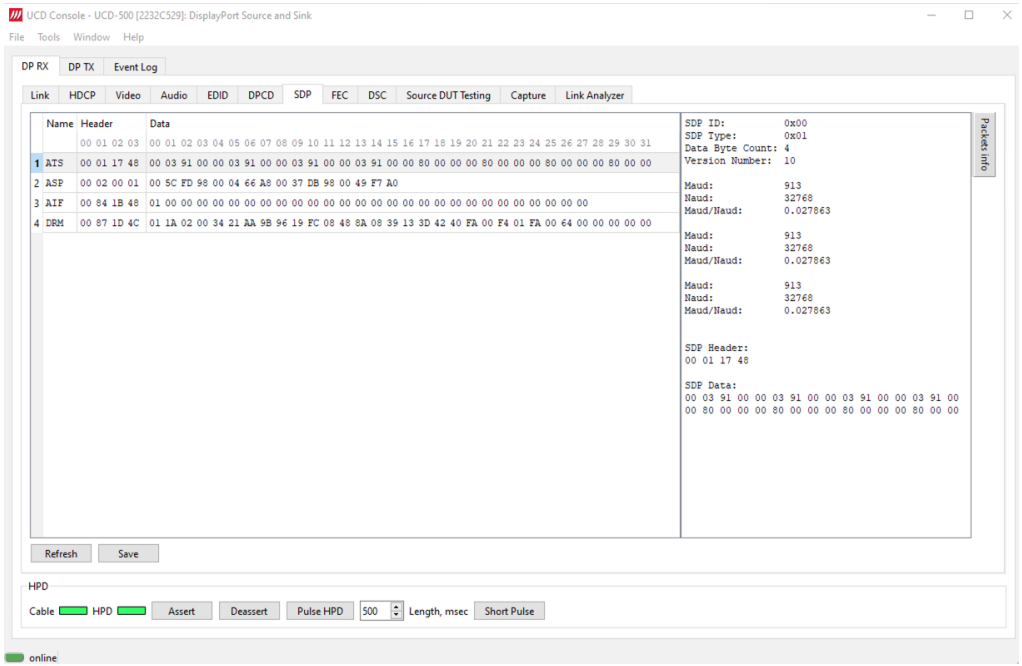
Save:	Select DPCD content to a binary *DPCD Data* file (*.DPD).
Load:	Select previously saved binary *DPCD Data* file (*.DPD).
Report:	Save parsed content of selected DPCD register ranges as HTML file
Refresh:	Re-read the data from the DPCD registers to the window in question
Write Changes	Write the portion of data shown in the window in question to the DPCD registers.
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.

Note:
- User control like Link Training or mode changes will modify the content of the DPCD registers
- During a reboot of the UCD device 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 selecting **Packet Info**.



The following packets are recognized:

- Audio_TimeStamp
- Audio_Stream
- Extension
- Audio_CopyManagement
- ISRC (International Standard Recording Code)
- Video Stream Configuration (VSC)
- Camera Generic 0
- Camera Generic 1
- Camera Generic 2
- Camera Generic 3
- Camera Generic 4
- Camera Generic 5
- Camera Generic 6
- Camera Generic 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)

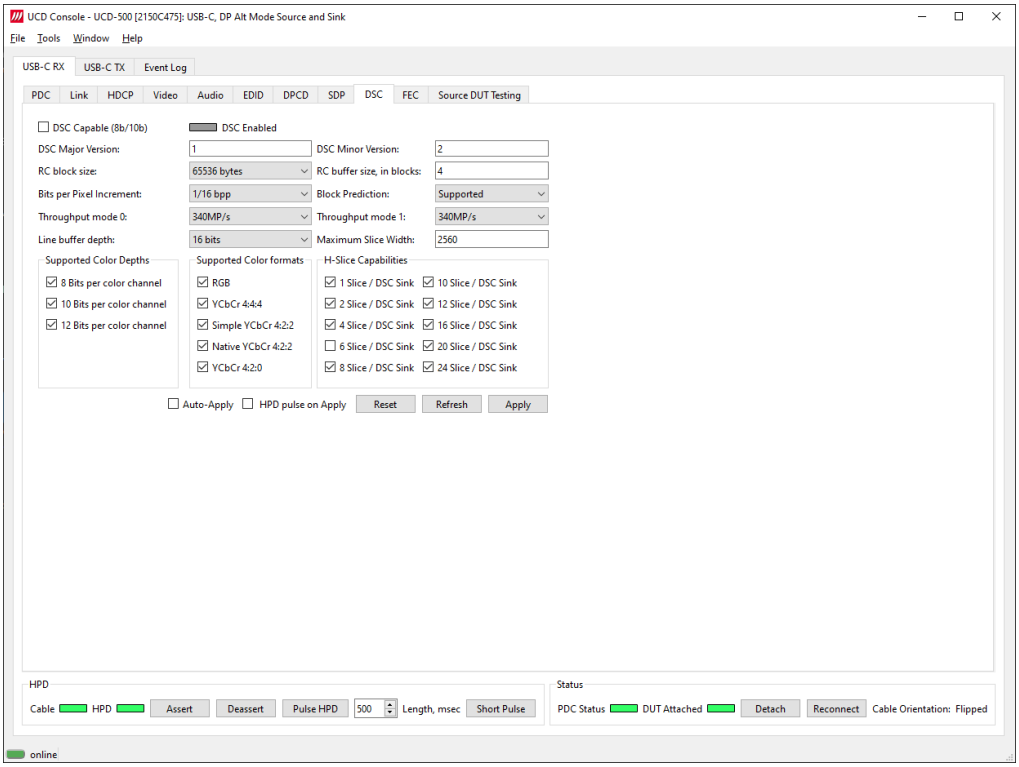
Saving SDP Packets

Packets can be saved in a file in binary format. Click **Save** and in the dialog select the packet types of choise. 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-5XX 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-5XX sink to find out if DSC capability is declared.

DSC Capable	UCD-5XX sink is declared as DSC capable. Control is only in use with 8b/10b link coding.
DSC Enabled	Connected source has enabled DSC

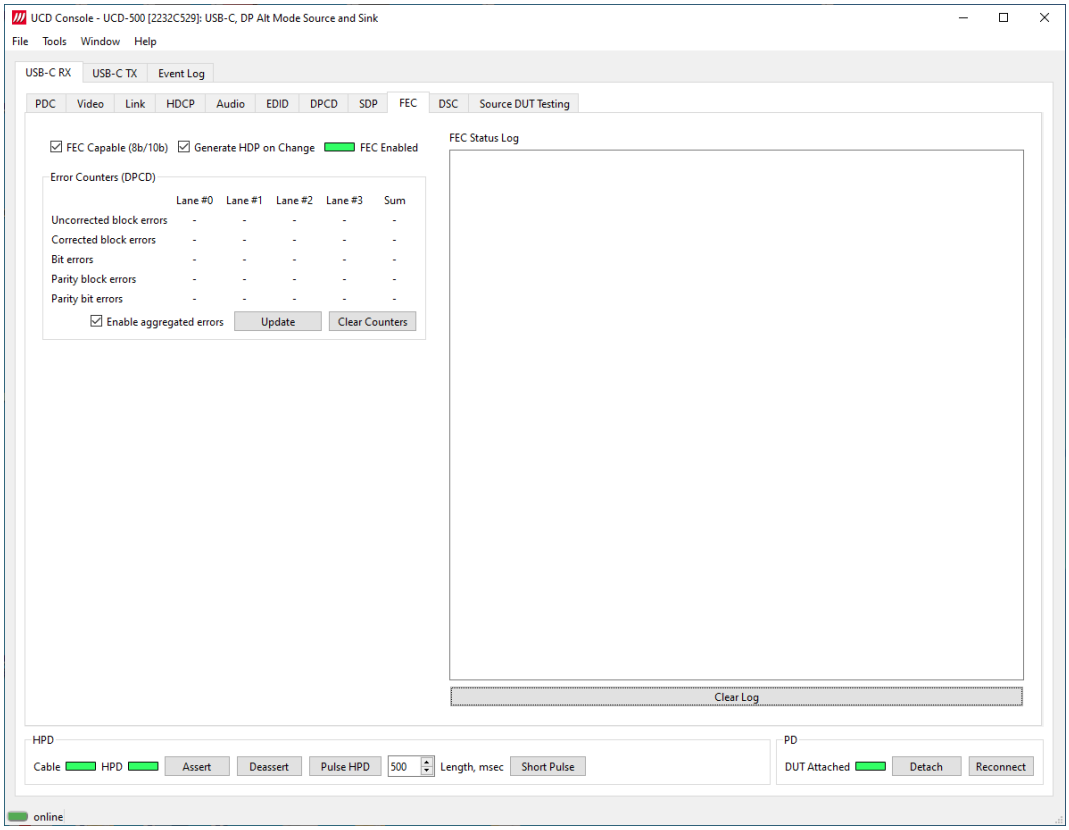
DSC Support Capabilities

The various controls in this tab change the content of UCD-5XX sink DPCD register address range (0x00061 through 0x0006F) related to DSC. Please click **Apply** to enable the change.

Apply:	Write changes to the DPCD registers of UCD Sink
Refresh:	Re-read the content of UCD Sink DPCD and update the control status.
Reset:	Reset the content of DSC related DPCD registers in UCD Sink (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.



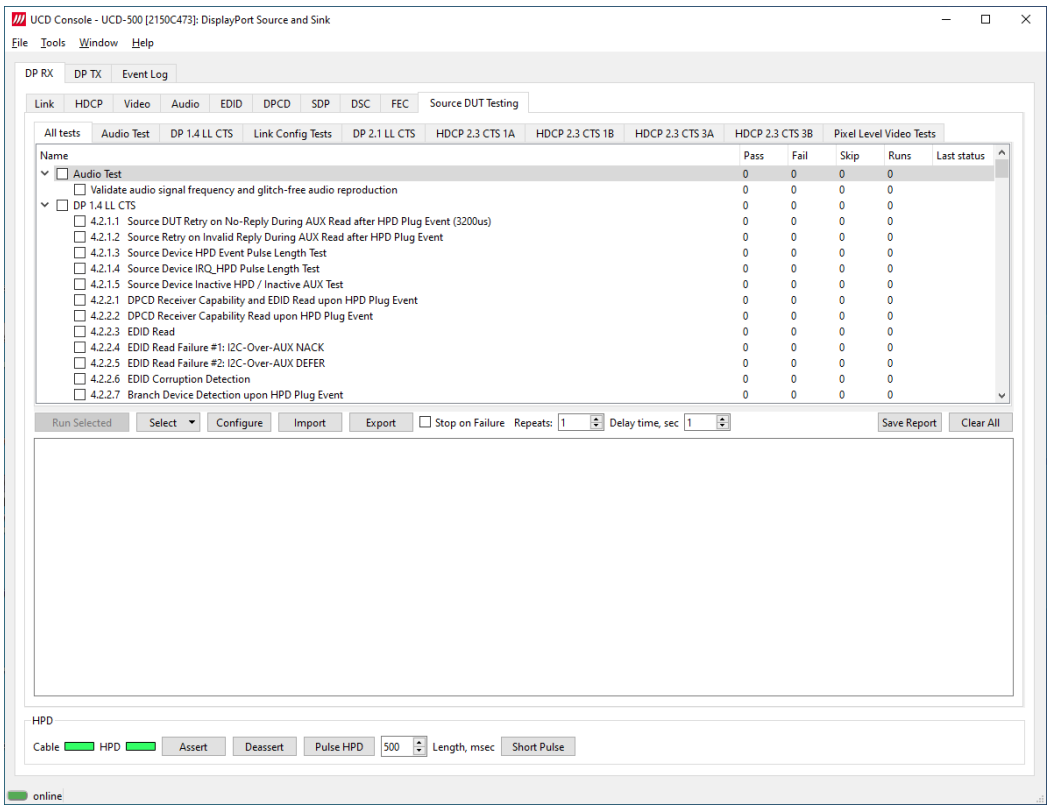
Enabling FEC

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. *FEC Status Log* lists FEC events

FEC Capable:	UCD-5XX Sink is declared as FEC capable. Control is only in use with 8b/10b link coding.
Generate HPD on change:	When selected, UCD-5XX Sink generates an HPD to establish a new connection after the change to make sure that connected Source re-reads the FEC capability status
FEC Enabled:	LED to indicate if the source has enabled FEC
Enable aggregated errors	Declare that UCD-5XX Sink is able to indicate aggregated errors in counters
Update:	Read FEC Error Counters from DPCD
Clear Counters:	Clear FEC Error Counters in DPCD.

Source DUT Testing Tab

Please refer to **Appendix E** later in this document for a 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.

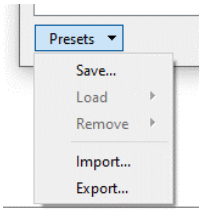
Saving Test Parameters

Test parameters can be saved in various ways.

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



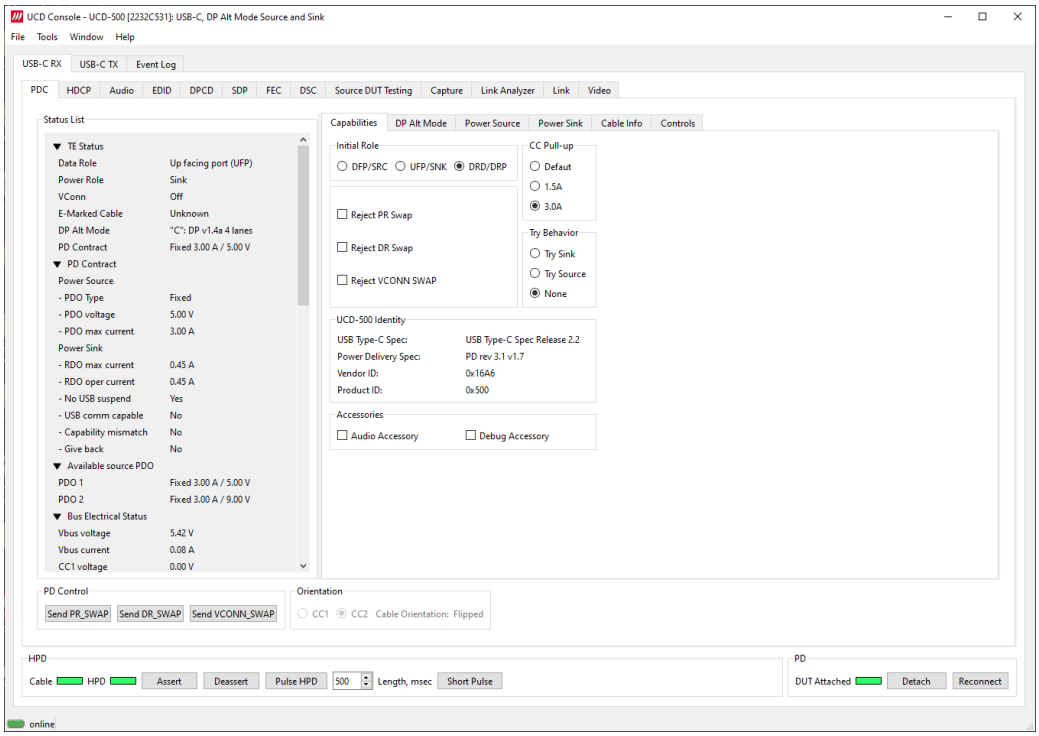
DUT Testing Options

Please refer to Tools > Options earlier in this manual for control on including system date and time in the beginning of each event line in created reports.

USB-C Monitoring

When UCD-5XX device is in USB-C DP Alt-Mode Sink or Source role, the following interface specific tabs are available.

- USB-C Power Delivery (PDC)



In *USB-C Power Delivery* tab ( ) 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 PD Contract roles for the UCD-5XX device and the optional USB-C PD Contract capabilities. Controls allow the user also to swap Power and Data roles.

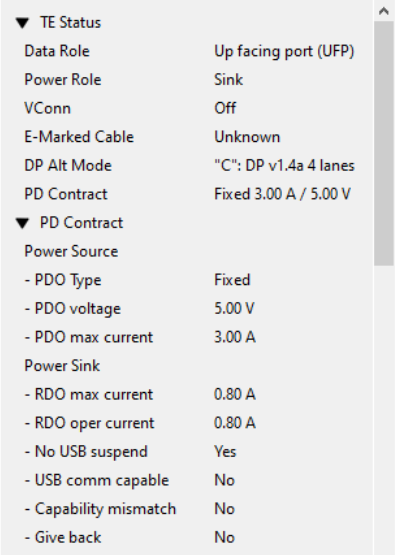
USB-C Monitoring dialog is divided into four panels. The upper left panel is a Status List indicating statuses of both port partners, UCD-5XX device, and the connected DUT.

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

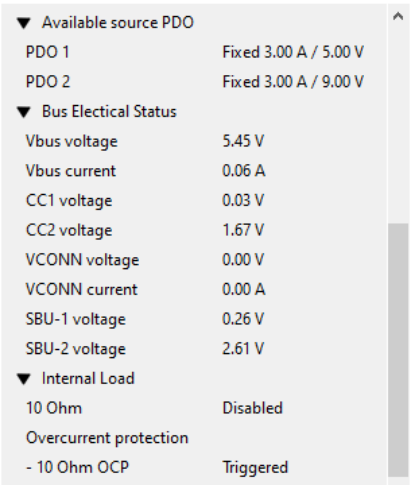
The two bottom panels indicate status of the cable connection and PD Control controls for role swaps.

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-5XX 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)

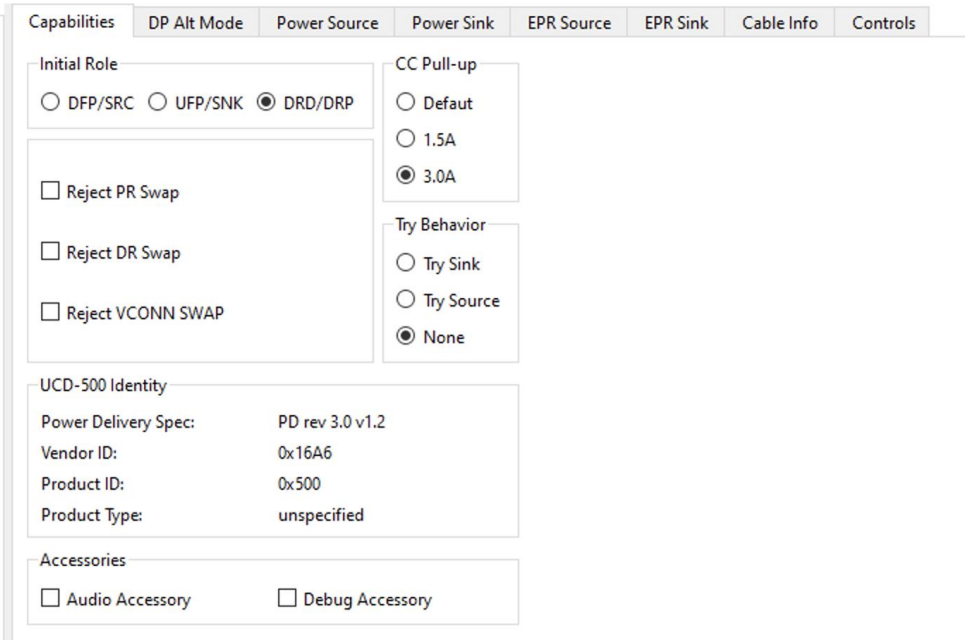


Available source PDO:	*Available source PDO offered by UCD-5XX* (PDO 1, PDO 2)
Bus Electrical Status:	(Vbus voltage, Vbus current, CC1 voltage, CC2 voltage, VCONN voltage, VCONN current, SBU-1 voltage, SBU-2 voltage)
Internal load:	*UCD-5XX internal load feature enabling status and over current protection status indicator* (10 Ohm, Overcurrent protection)

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 and UFP_D, DPAM Version)
TE DP Alt Mode Status:	UCD-5XX 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)

▼ DUT Discovery	
Data Capable as Host	N/A
Data Capable as Device	N/A
Product Type	N/A
USB Vendor ID	N/A
USB Product ID	N/A
BCD Device	N/A
SVID0	N/A
SVID1	N/A
▼ DP Alt Mode support	
Supports DP v1.3	yes
Supports USB gen2	no
Pin Assignment supported	
- DFP_D	no
- UFP_D	yes
- DPAM Version	Version 2.1 or higher
▼ TE DP Alt Mode Status	
Status	Active
Multi-function prefered	no
HPD state	asserted
Select DP v1.3	yes
Select USB gen2	no
Pin Assignment	"C": DP v1.4a 4 lanes
Cable UHBR 13.5 Support	Not Supported
Cable Active Component	Passive -or- cable type is unknown
DPAM Version	Version 2.0 or earlier
▼ DUT DP Alt Mode Status	
Status	DFP_D is connected.
Multi-function prefered	not relevant
HPD state	asserted
Power low	Normal operation.
No DPAM Suspend	UFP_U/ DP Sink device has no preference for entry into low power state

Capabilities



Initial Role:	Defines the role which UCD-5XX presents itself in the start of PD communication (both power and data role).
Reject Swaps:	Allow or reject role swap requests from the connected port partner.
CC Pull-up:	Control of Rp that Source uses to advertise the current source capability in initial USB Type-C operation and in PD Rev 2.0 operation.
Try Behavior:	Control the USB-C PD role that UCD-5XX initially takes in the connection handshake.
UCD-500 Identity:	Status information provided by UCD-5XX.

Accessories

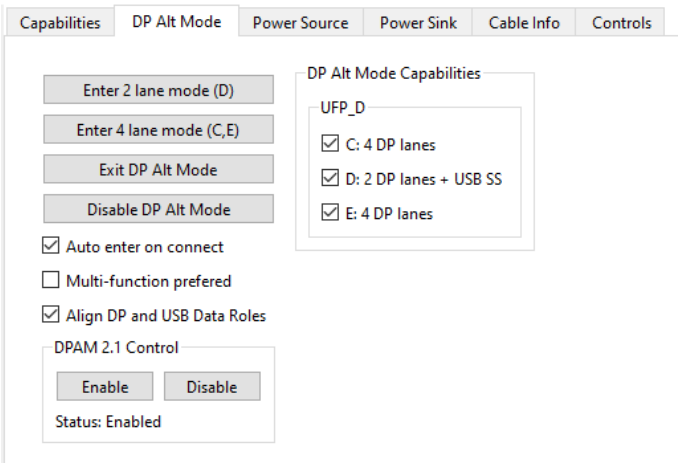
Audio Accessory:	Enable simulation of Audio Accessory support
Debug Accessory:	Enable simulation of Debug Accessory support

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-500 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.



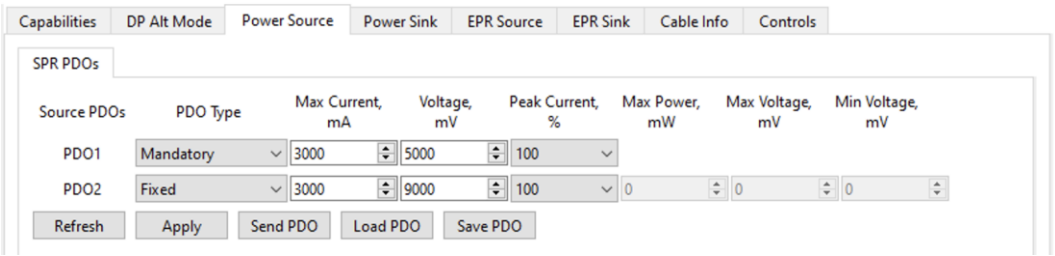
Enter 2 lane mode (D):	Restart mode discovery and advertise support for mode D (2 DP lanes + USB SS).
Enter 2 lane mode (C,E):	Restart mode discovery and advertise support for modes C and D (4 DP lanes).
Exit DP Alt Mode:	Exit DP Alternate mode.
Disable DP Alt Mode:	Exit DP Alternate mode and advertise no DP Alternate mode support.
Auto enter on connect:	Start mode discovery after connection and enter DP Alternate mode if suitable configuration is found.
Multi-function preferred:	When entering DP Alternate Mode, select mode D.
Align DP and USB Data Roles	When selected, before entering to DP Alternate Mode, DP role and USB Data role will be aligned to match the role selected for the UCD device, i.e. DFP in Generator role and UFP in Analyzer role.
DPAM 2.1 Control	Enable or Disable.

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-5XX when acting as *Power Source Port*.



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

Note:	Please note that UCD-5XX devices are not able to simulate as Source the electrical behavior of Variable and Battery source types.

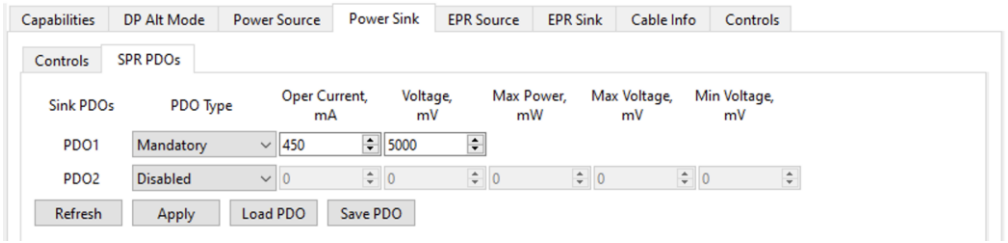
Refresh	Re-read status from UCD-5XX
Apply	Program new values to UCD-5XX
Send PDO	Send a Source Capabilities message
Load PDO	Load a stored Power Source PDO configuration from file.
Save PDO	Store current Power Source PDO configuration to a file

Power Sink

Controls and Definition of Power Data Objects (PDO) for UCD-5XX when acting as *Power Sink Port*.

Give back flag:	UCD-5XX sets *GiveBack* flag in its *Request Data Object*
No USB suspend:	UCD-5XX 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-5XX will ever require when operating as a Power Sink.

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

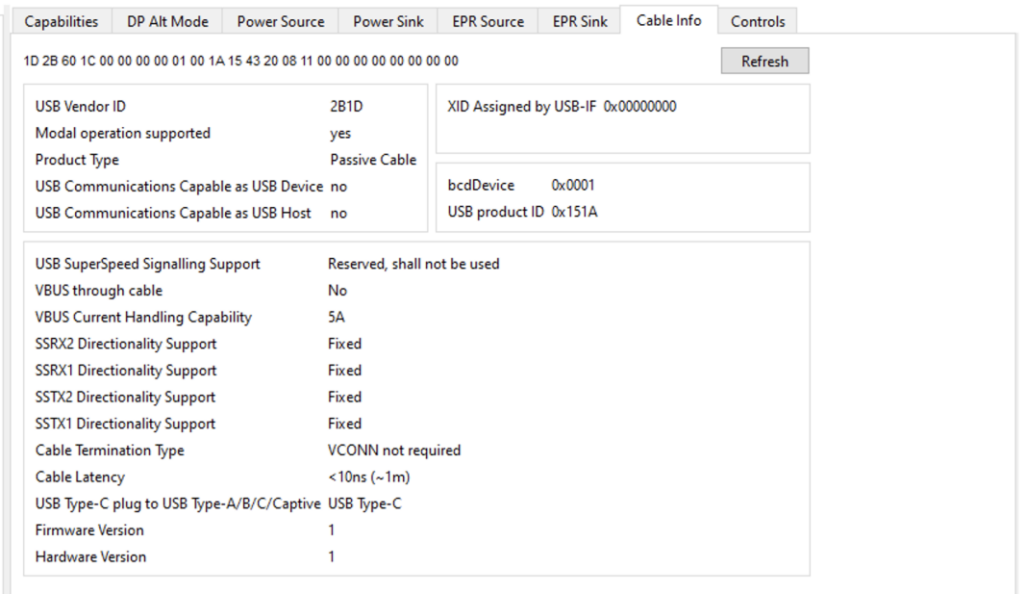


Note: The requirement is that Sources shall supply at least one fixed supply capable of supplying vSafe5V

Refresh	Re-read status from UCD-5XX
Apply	Program new values to UCD-5XX
Load PDO	Load a stored Power Source PDO configuration from file.
Save PDO	Store current Power Source PDO configuration to a file

Cable Info

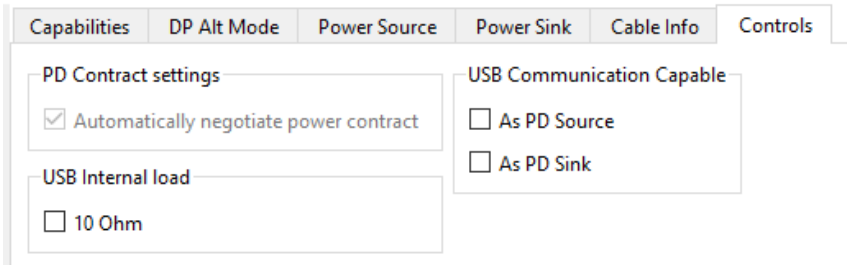
Cable Info tab displays the information received from the cable as a response to *Discover Identity* command sent to SOP'.



Note:	Please note that cable info can only be read when in Down Facing Port role. Please click *Refresh* after changing roles.

Controls

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



PD Contract Settings

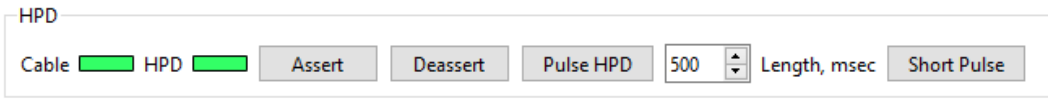
Automatically negotiate power contract: When selected UCD will start power contract negotiation if suitable configuration is found.

USB Internal Load

Current Load feature that only applicable when UCD-5XX is operating as Power Sink role. Only fixed current value in around 900mA is able to be sinked by UCD-5XX.

Bottom Panel

HDP



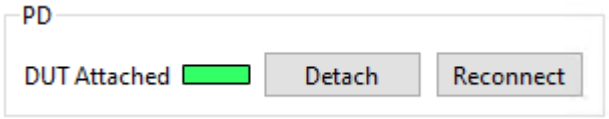
Cable	Cable status
HPD:	HPD status
Assert / Deassert:	Manually Assert or *Deassert*.
Pulse HPD:	Manually pulse HPD. Set the lenght in milliseconds.
Short pulse:	Manually perform a short pulse.

Note: Please note that UCD-5XX is not automatically Attached to the connected port partner even if the cable is connected physically. The user needs to click the Attach button manually to make the connection.

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.

PD



DUT Attached:	Indication that *Attach* event is detected by the Source port in one of its CC lines. Type of USB-C cable detected.
Detach:	Manually *Detach* USB-C port partners.
Reconnect:	Restart USB-C Source-to-Sink attach procedure.

5. GENERATOR OPERATION

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

Please note that in most UCD-5XX Series units *Analyzer* functionality is available simultaneously with Generator functionality. Please find description of Analyzer functionality earlier in this manual.

Functionality Tabs

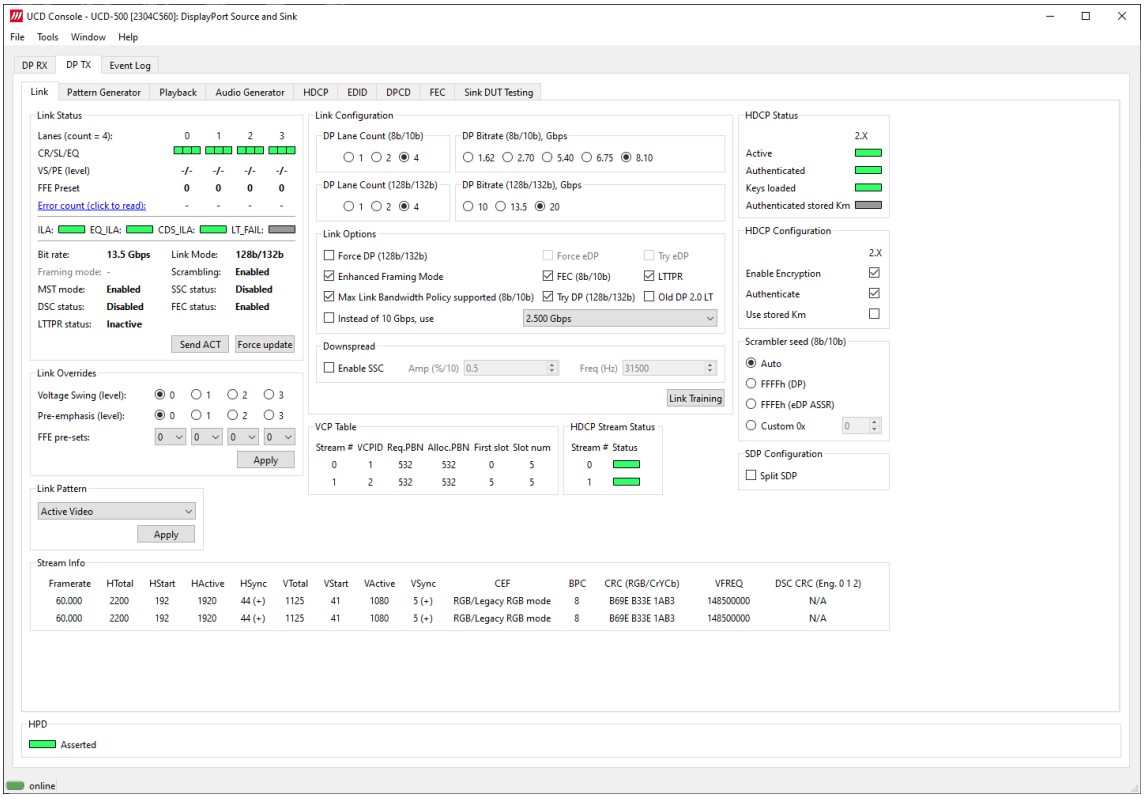
UCD Console features are presented in tabs. Standard tabs are similar in all functional roles, Interface Specific tabs present features and controls that are only available for a particular interface.

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

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

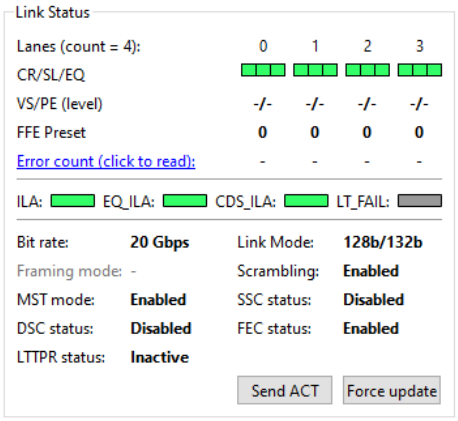
Link Tab

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



Link Status

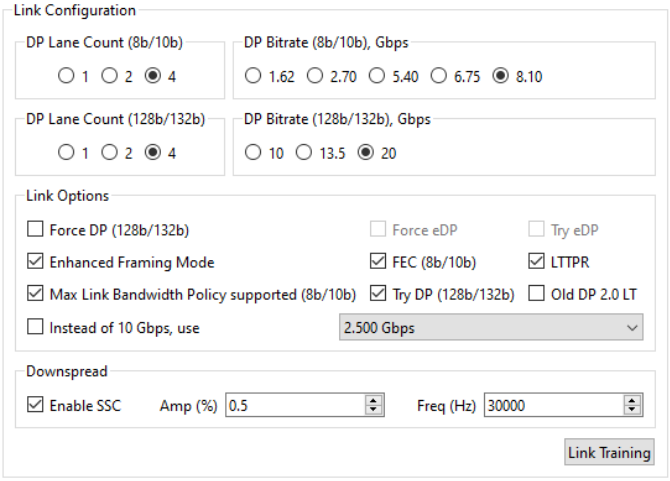
Link Status displays the status of the link training and the link parameters negotiated between the connected Sink and UCD Source. It also lists the status of other link modes. The data is retrieved from the DPCD status registers of the connected Sink. The status is updated automatically, but in case it seems that the update is delayed, please click on the *Force update* button.



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
FFE preset:	TX Feed Forward Equalization (FFE) preset value (only with 128b/132b channel coding)
Error count:	Content of DPCD Error Count registers
ILA:	Status LED for Inter-Lane Alignment
EQ_ILA	Status LED for Inter-Lane Alignment on Equalization stage (only with 128b/132b channel coding)
CDS_ILA	Status LED for Inter-Lane Alignment on Clock and Data Switch stage (only with 128b/132b channel coding)
LT_FAIL	Status LED for Link Training failure (only with 128b/132b channel coding)
Bit rate:	Currently enabled link bit rate
Link mode:	Currently enabled channel coding (128b/132b or 8b/10b)
Framing mode:	Status of Enhanced Framing symbol sequence (only with 8b/10b)
Scrambling:	Status of link Data Scrambling (Enabled or Disabled)
MST mode:	Status of the Multistreaming (MST) mode
SSC status:	Status of Spread-Spectrum Clock (SSC) function
DSC Status:	Status of Display Stream Compression (DSC) function
FEC status:	Status of Forward Error Correction (FEC) function.
LTTPR Status:	Status of Link Training-tunable PHY Repeater (LTTPR) function

Send ACT:	Force sending an Allocation Change Trigger (ACT) sequence over the Main-Link
Force update:	Re-read statuses to update the panel

Link Configuration



Set target capabilities for the link training. Click **Link Training** to with changed features.

DP Lane Count (8b/10b):	Lane count used when 8b/10b link coding is selected in LT
DP Bitrate (8b/10b), Gbps:	Link rate used when 8b/10b link coding is selected in LT
DP Lane Count (128b/132b):	Lane count used when 128b/132b link coding is selected in LT
DP Bitrate (128b/132b), Gbps:	Link rate used when 128b/132b link coding is selected in LT
Force DP (128b/132b):	UCD-5XX Source uses only 128b/132b link layer protocol, no fall back to 8b/10b link layer.
Enhanced Framing Mode:	Enable Enhanced Framing Mode
Max Link Bandwidth Policy supported (8b/10b):	When checked, UCD supports Link Training Flow with Maximum Link Data Bandwidth Policy (only in 8b/10b coding)
FEC (8b/10b):	Enable Forward Error Correction feature (only in 8b/10b coding)
LTTPR:	Select to enable Link Training Tunable PHY Repeater (LTTPR) protocol support
Try DP (128b/132b):	UCD-5XX Source checks capabilities of the connected Sink and, if it supports 128b/132b link layer protocol, it starts Link Training with 128b/132b link layer. If LT fails it falls back to 8b/10b link layer protocol
Old DP 2.0 LT:	When checked LT will follow initial DP 2.0 spec description. Otherwise, LT as per DP 2.1 specification
Instead of 10 Gbps, use:	For supporting low link rate Sink devices, the user can make UCD-5XX source PHY to use a selectable lower link rate when performing '10 Gbps' link training in protocol level. Link rates are: 2.5 Gbps, 2.7 Gbps, 5.0 Gbps and 5.4 Gbps
Enable SSC:	Enable down spreading of link frequency (SSC).
Amp (‰):	SSC Spreading Amplitude.
Freq (Hz):	SSC Modulation frequency.

Link Overrides

Voltage Swing (level):	*Override Voltage Swing level selected during link training*
Pre-emphasis (level):	*Override Pre-emphasis levels selected during link training*
FFE pre-sets:	*TX Feed Forward Equalization (FFE) preset value (only with 128b/132b channel coding)*

Click **Apply** to validate changes.

Link Pattern

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

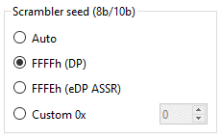
Active Video	Transmit Video Pattern, Audio and Metadata
Idle Pattern	Link is active but no stream data is being transmitted
Training Pattern 1	Send Link Training Pattern Sequence 1 (TPS1)
Training Pattern 2	Send Link Training Pattern Sequence 2 (TPS2)
Training Pattern 3	Send Link Training Pattern Sequence 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	Reference Source will continue Video pattern transmission on the previously established link configuration regardless of the link status.
Force Idle	Reference Source will continue Idle pattern transmission on the previously established link configuration regardless of the link status.
PRBS9	Send PRBS9 Link Quality Test Pattern
PRBS11	Send PRBS11 Link Quality Test Pattern
PRBS15	Send PRBS15 Link Quality Test Pattern
PRBS23	Send PRBS23 Link Quality Test Pattern
PRBS31	Send PRBS31 Link Quality Test Pattern
Link square pattern	Send Square Sequence Pattern. The number of continuous 1s followed by continuous 0s is given as a parameter. 0x00 represents one set of 1s and 0s, 0xFF represents 256 1s and 0s.

Click **Apply** to validate the selection.

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.

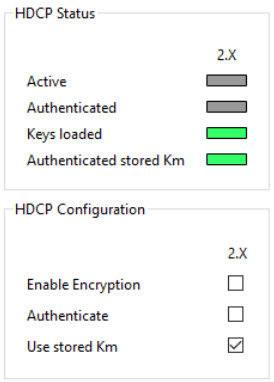
After using the special bit patterns, in order to return to the default operation mode, please select *Active Video* and click *Apply*.

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.

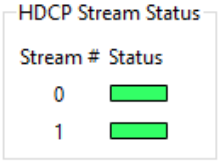
HDCP Status & Configuration



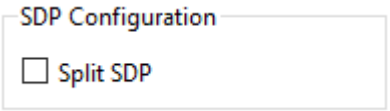
Copy of HDCP status and controls on HDCP tab.

HDCP Stream Status

Shows HDCP stream status for each stream.



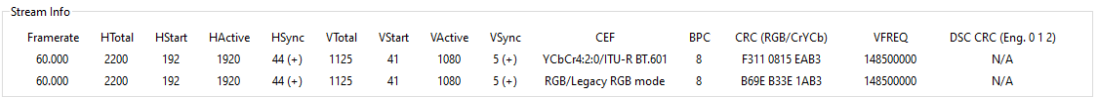
SDP Configuration



Enable SDP Splitting.

Note	Selecting this configuration option does not guarantee that SDP splitting will occur for a given configuration of the Video and Audio pattern generators. SDP splitting will take place when it makes sense and required for SDP splitting conditions are met.

Stream Info

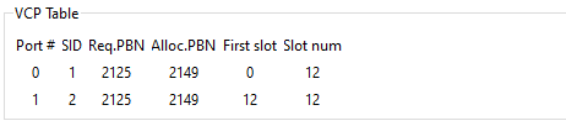


Stream Info is achieved from the Main-Stream Attributes (MSA) of the monitored stream. Frame rate is measured by UCD Local Sink

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.
VFREQ:	Video Frequency (128b/132b channel coding only)
MVID/NVID:	Mvid and Nvid video time stamp values (8b/10b channel coding only)
DSC CRC	16-bit Cyclic redundancy check (CRC) calculated from compressed pixel stream. Value order Engine 0, 1, 2.

VCP Table


VCP Table

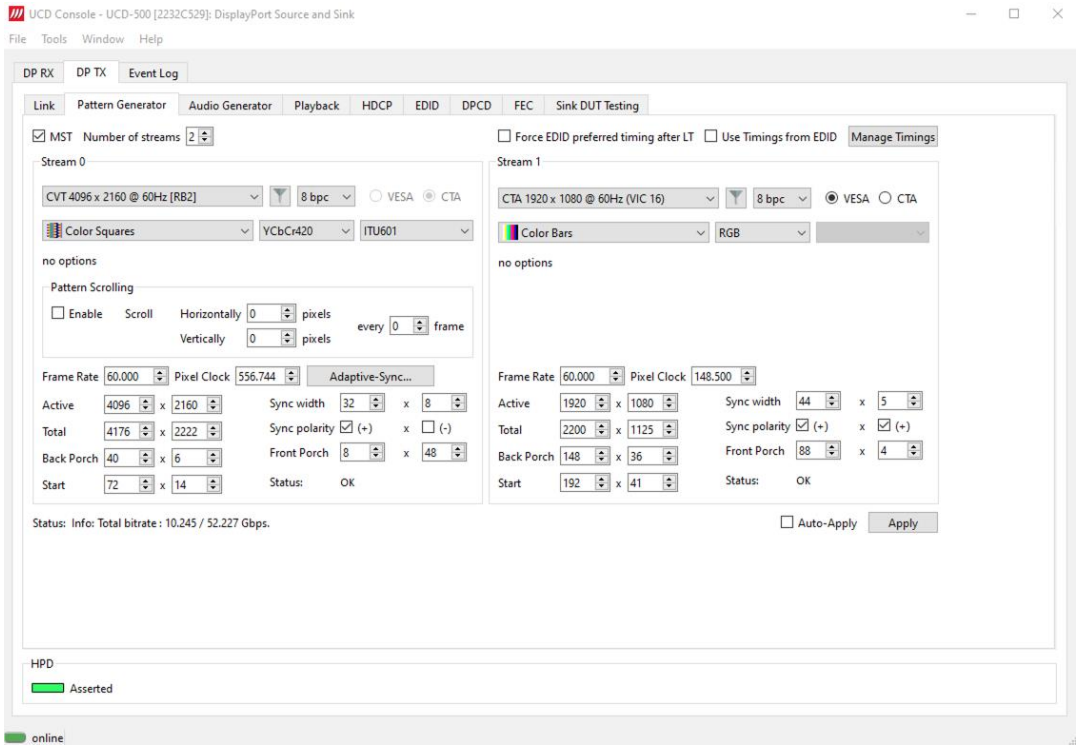
Port #	SID	Req.PBN	Alloc.PBN	First slot	Slot num
0	1	2125	2149	0	12
1	2	2125	2149	12	12

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

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 number) 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.

Pattern Generator Tab



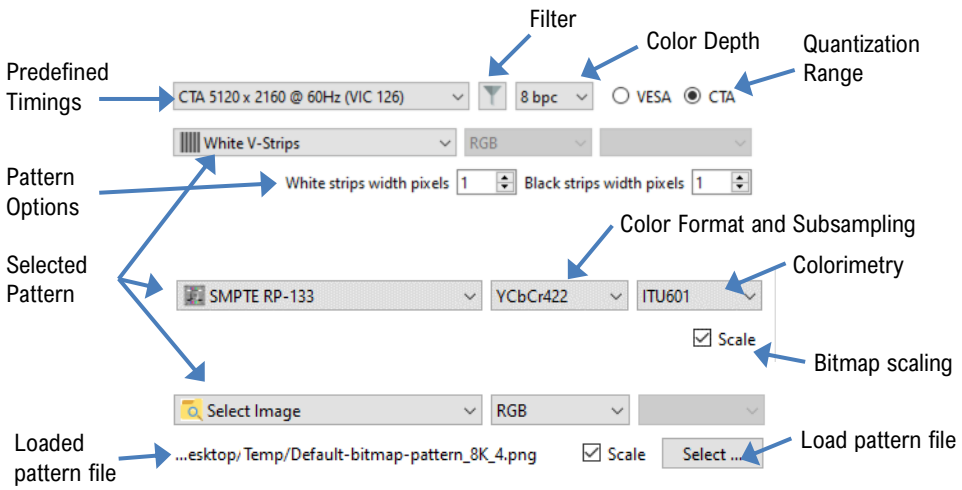
Note: Please note that the actual number of streams sent will be negotiated between the source and the sink during link training.

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.

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.
Use timings from EDID:	UCD reads the EDID of the connected Sink and lists only timings that are featured there.
Manage Timings:	Please see chapter *Manage Timings* later in this manual
Status Info:	Used link payload / Total link capability in Gbps
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

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 the *Manage Timings* function the user can add timings to the list and select which timings are shown in the selection.

Color Format, Subsampling and Color Depth

The table below lists the available color modes and related available color depths.

Selection	Color Format	Subsampling	Available Color Depths
RGB:	RGB	4:4:4	6, 8, 10, 12 and 16 bpc
YCbCr444:	YCbCr	4:4:4	8, 10, 12 and 16 bpc
YCbCr422:	YCbCr	4:2:2	8, 10, 12 and 16 bpc
YCbCr420:	YCbCr	4:2:0	8, 10, 12 and 16 bpc
Y-Only:	Y	4:0:0	6, 7, 8, 10, 12, 14 and 16 bpc
RAW:	RAW	N/A	6, 7, 8, 10, 12, 14 and 16 bpc

Quantization Range

VESA:	Patterns are sent with Full Range color values (0 to 255 with 8 bpc)
CTA:	Patterns are sent with Limited Range color values (16 to 235 with 8 bpc)

Quantization range selection is enabled based on the type of pattern selected.

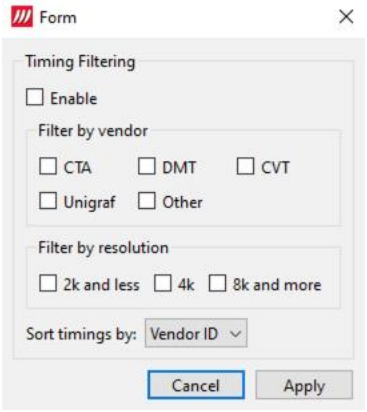
Video Pattern

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 virtual channel 0

Filter

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



Custom Image Patterns

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

Please refer to *Link Pattern* in description of Generator role *Link tab* earlier in this manual for sending special 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 top left 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.

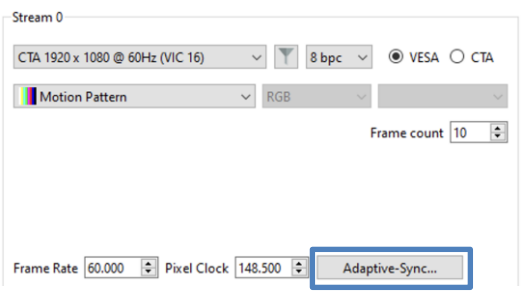
Enable:	Enable or disable pattern scrolling
Horizontally X pixels:	Horizontal step of the pattern movement in pixels (values in range -127…0…128, for YCbCr 4:2:2 even values). 0 = no movement, positive values = pattern moves to the right.
Vertically Y pixels:	Vertical step of the pattern movement in 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.

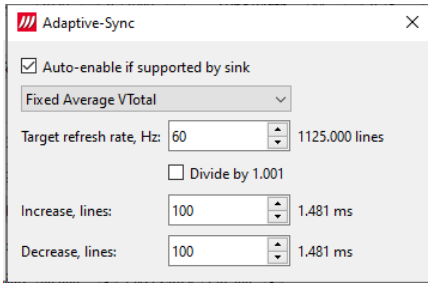
Note: Please click Apply to enable changes or check Auto-Apply.

Adaptive-Sync Control

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 Stream 0.



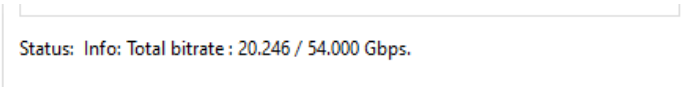


Auto enabled if supported by Sink:	The feature is enabled based on connected Sink status
Disabled:	Feature is disabled unless *Auto Enabled … box is checked. Please see the note below.*
Adaptive Total, constant refresh rate:	Added blank lines
Adaptive Total, Square pattern:	Added blank lines, min; Added 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.

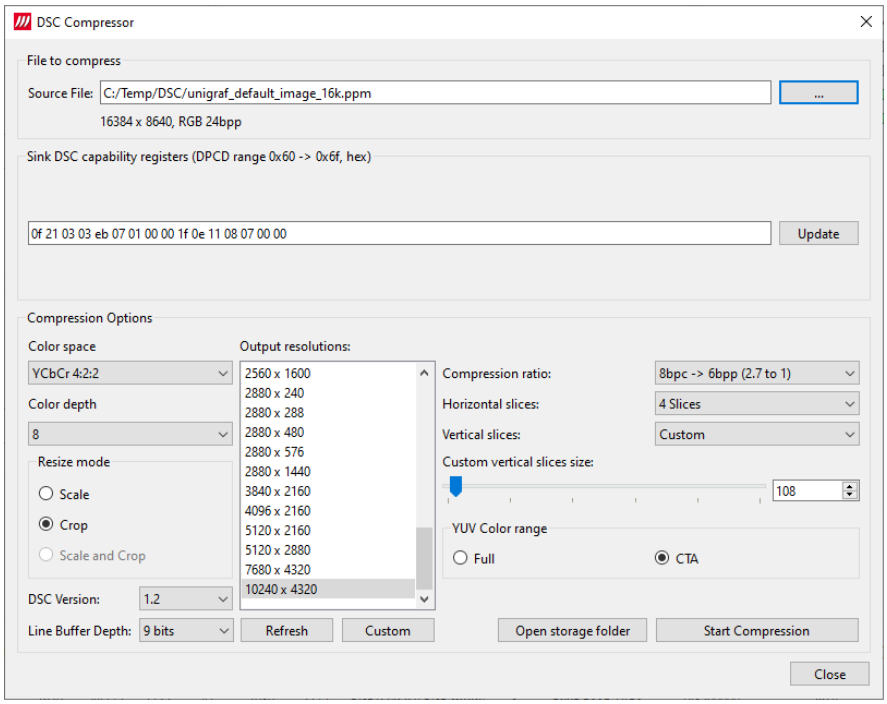
Info

The Info row indicates how much link capacity is being used by the streams and what is the total available link capacity.



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.



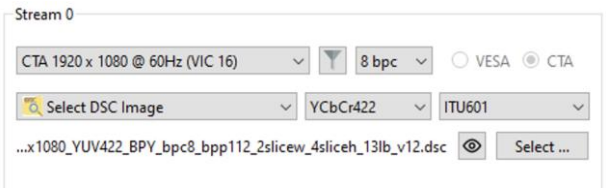
Select the source bitmap file in Source File field. Define the Output Resolution, the color depth, compression ratio and number of horizontal and vertical slices in the frame.

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

The 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

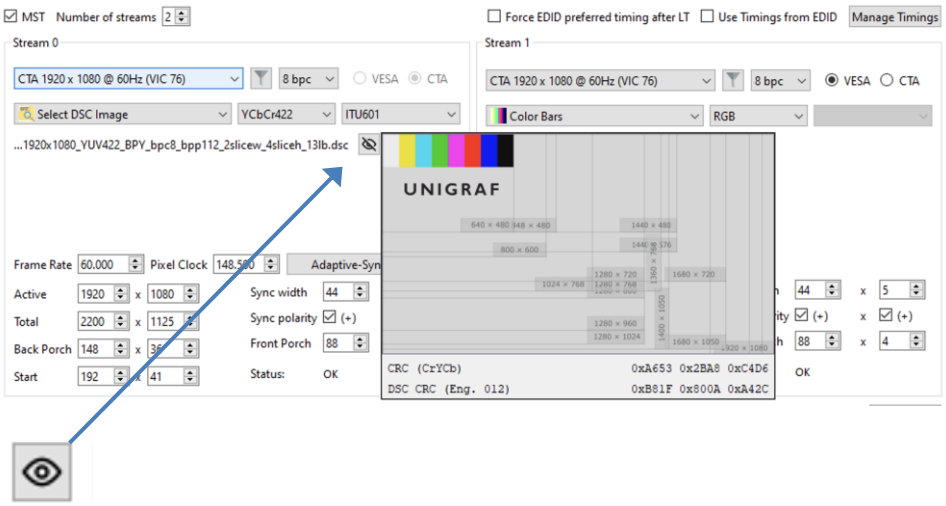
To use the created DSC file in Pattern Generator, select pattern:



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 the resolution and the color mode matching the DSC image. If the connected Sink device declares support for DSC in its DPCD, UCD Console enables DSC.

Preview DSC image

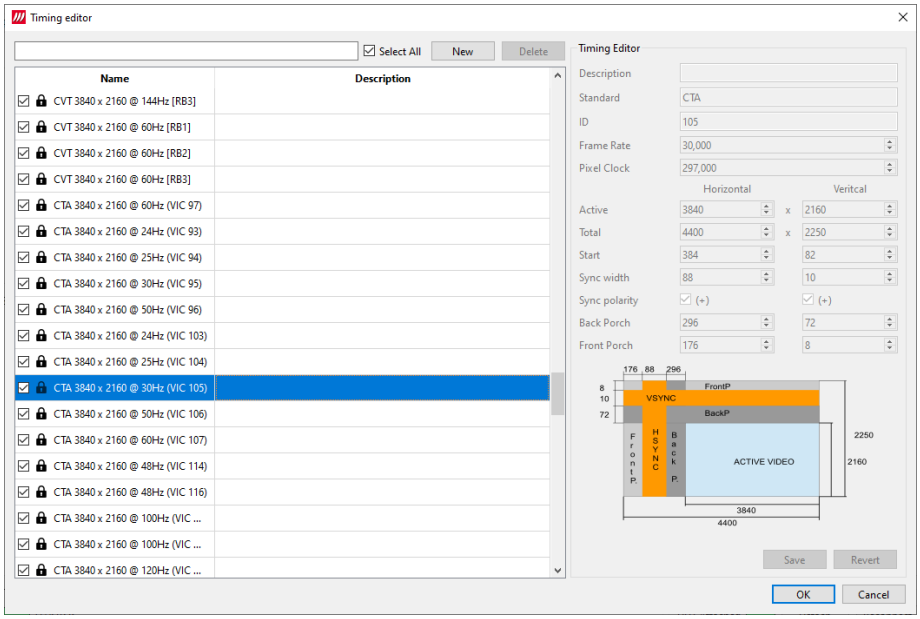


To preview an DSC image before it is applied to the pattern generator, select the eye icon. CRC and DSC CRC values will be indicated in the preview image.

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

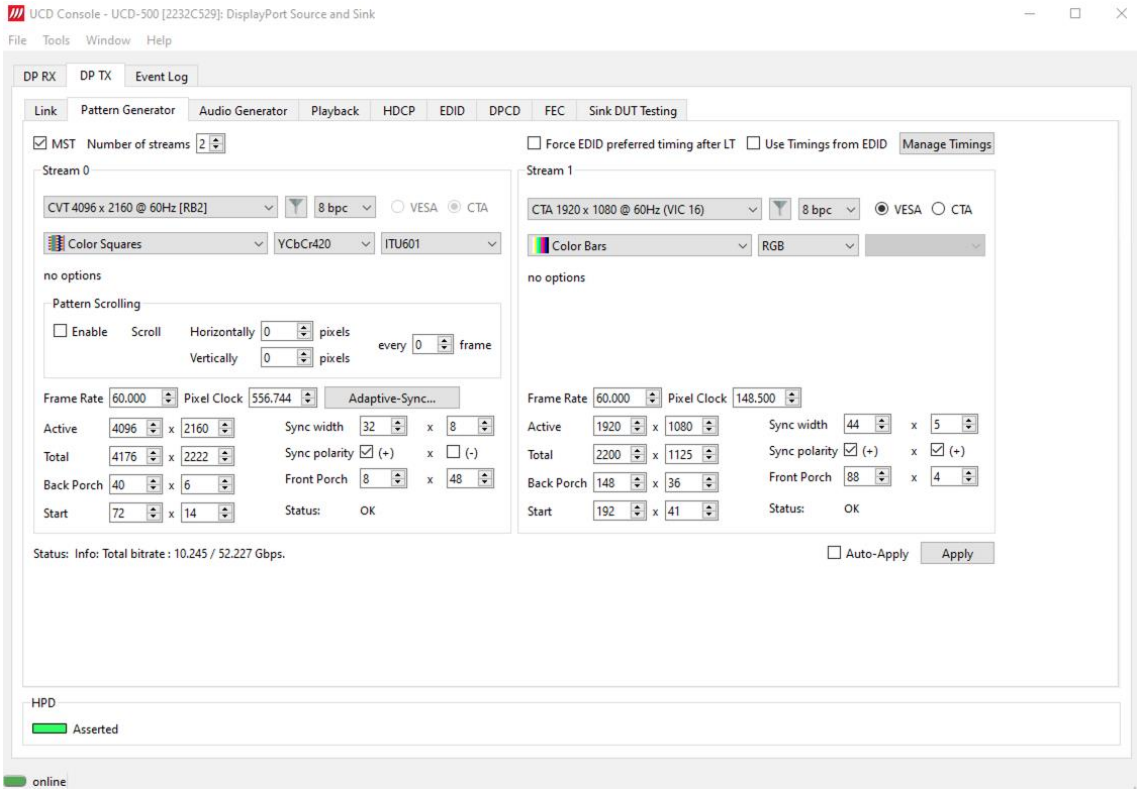
Video timing Name and Description are shown in the list. Lock icon indicates that a timing is a fixed timing which cannot be edited or deleted. Custom timings are indicated with a head icon .

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

The functionality of MST selection is different in 8b/10b and 128b/132b link modes. The difference is, however, transparent for the user.

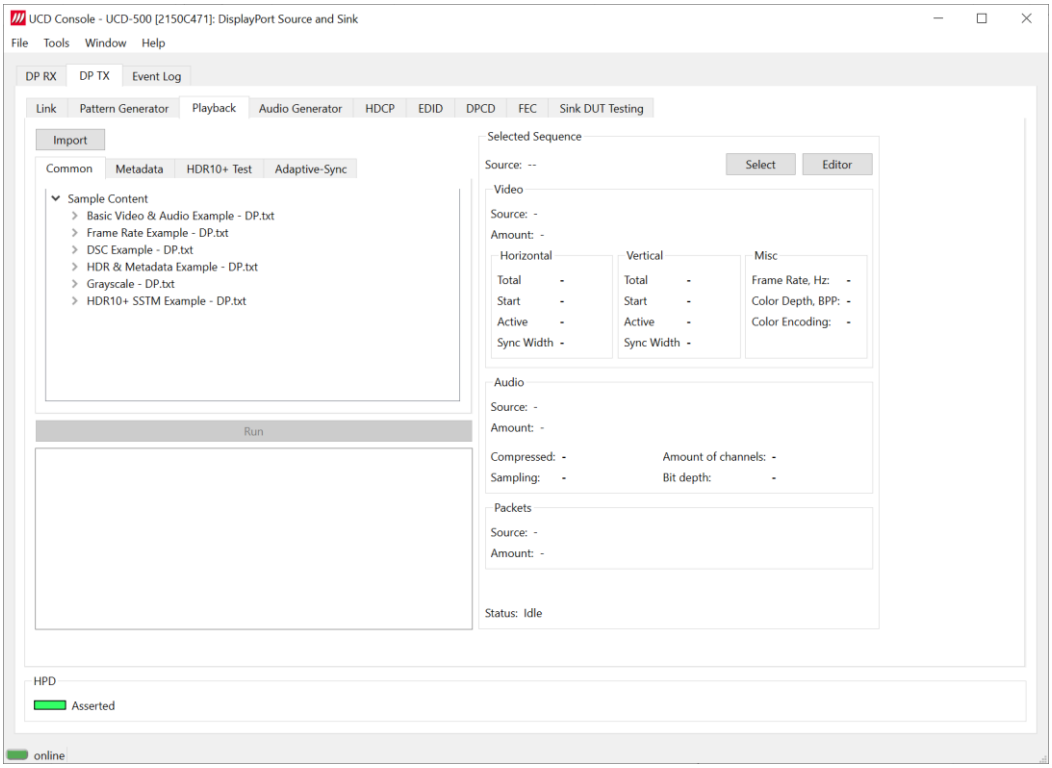


MST:	In 8b/10b link mode, select between SST and MST transport modes. In 128b/132b link coding mode, enable single stream output without stream allocation using Sideband messages if checkbox is cleared. Perform stream(s) allocation based on connected Sink Device capabilities if checkbox is set.
Number of streams:	When MST is enabled, select number of streams sourced

Note:	Maximum number of streams is currently limited to 2

Playback Tab

Playback allows for running predefined *Playlist* files. A Playlist contains a set of *Scenarios* with definitions of the timing, video pattern, audio content and related metadata packets and their duration. You can import playlists by clicking *Import.*

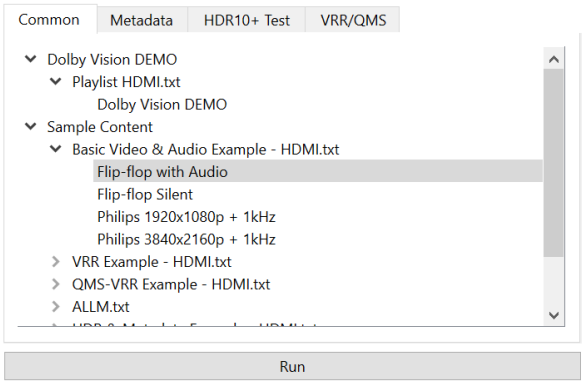


Term	Functionality
Playlist	Playlist defines the UCD device and the output where the content is played. It lists the played Scenarios and their duration.
Scenario	Scenario is an operating structure that allows user to determine a specific sequence of video frames, metadata packets and audio that are 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.

Common Tab

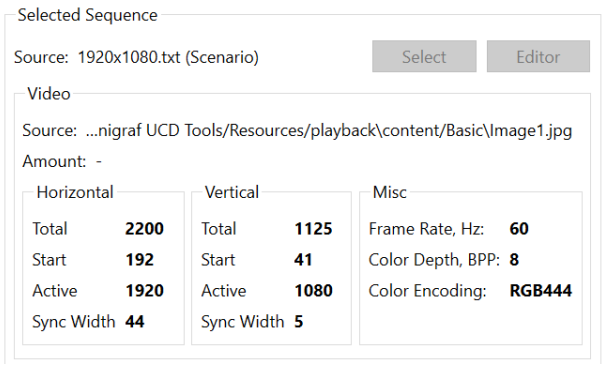
Sample playlists are included in UCD Console by default. Select a sequence (a scenario) from the playlists and press *Run* to play the sequence.



Click *Stop* to stop playing the scenario.

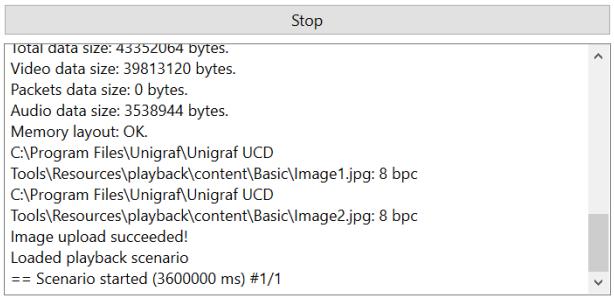
Selected Sequence

Currently run sequence and its details are indicated in *Selected Sequence*.



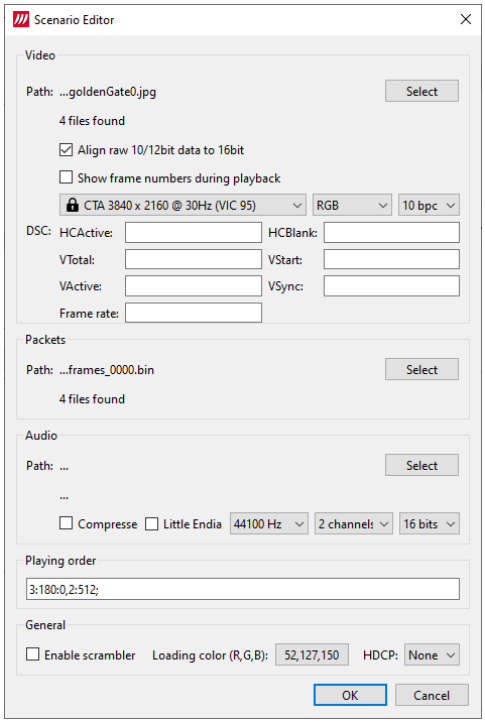
Status Log

The executed steps of the scenario are listed in the *Status Log*.

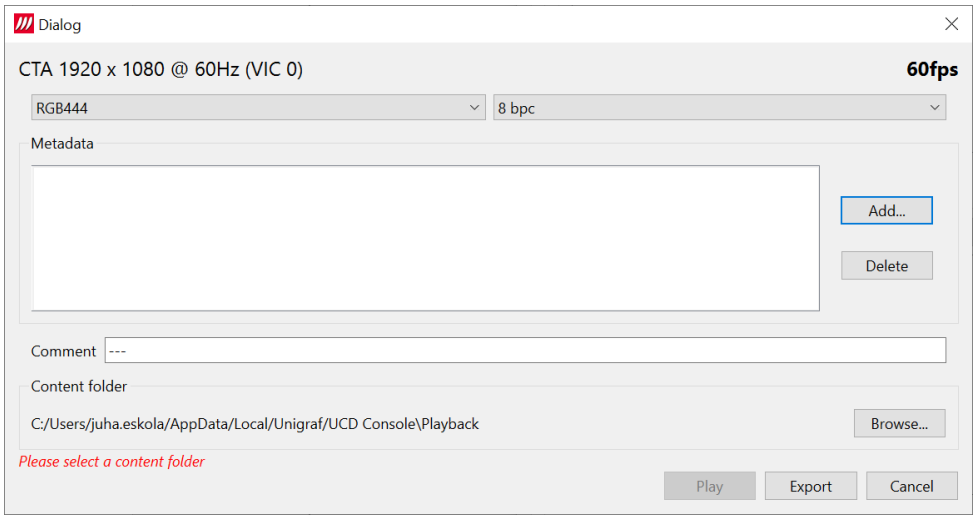


Scenario Editor

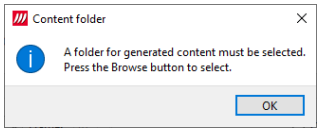
Details of a Scenario can be edited with *Scenario Editor*. Please refer to *Appendix H: Scenarios and Playlists* later in this manual for details



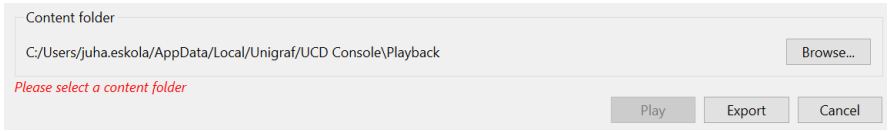
Metadata Tab



First you are asked to select the folder where the generated content will be stored.

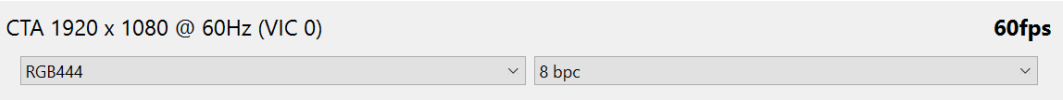


Click *Browse…* to select the folder.



Timing details

The uppermost part of the window shows the timing details. Please, note that the timing is set on the pattern generator tab. You can change the color mode (RGB444, YUV444, YUV422, YUV420) and color depth (8 bpc, 10 bpc, 12 bpc, 16 bpc).

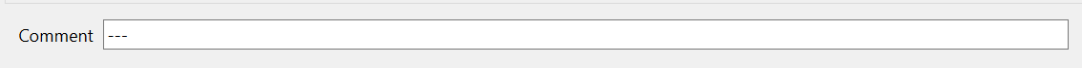


Metadata

In metadata section you can add and delete metadata packets.

Comment

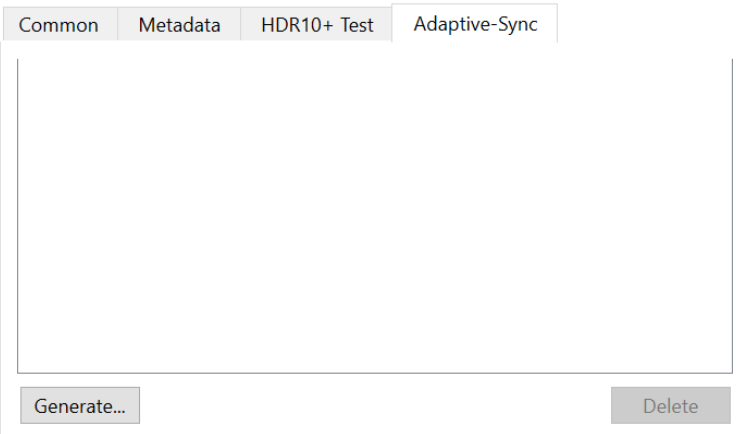
You can add comments after there dashes in the comment field.



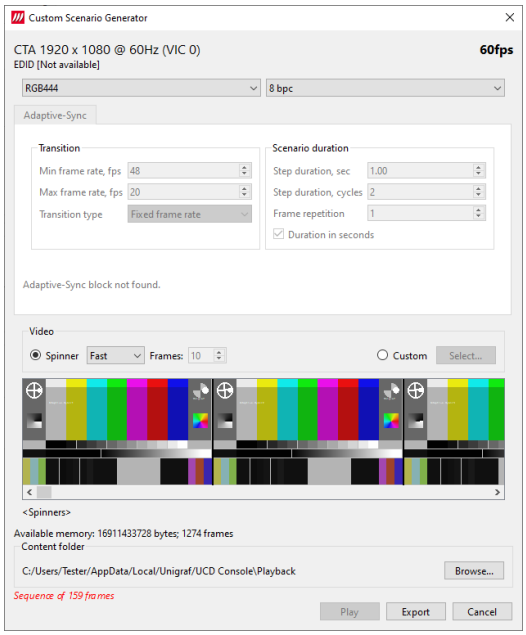
HDR10+ Test Tab

Please refer to HDR10+ CTS User Manual for detailed description of the tab.

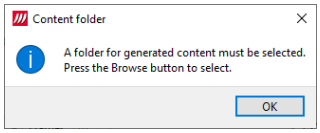
Adaptive-Sync tab



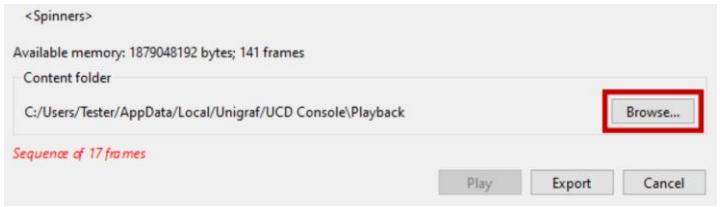
Click *Generate* to generate custom Adaptive-Sync scenarios. Custom Scenario Generator window will open.



First you are asked to select the floder where the generated content will be stored.

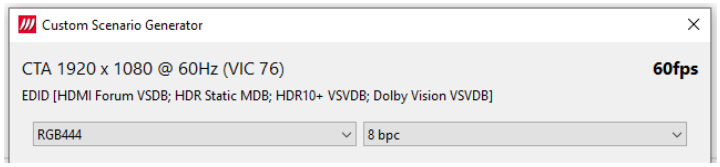


Click *Browse…* to select the folder.



Timing details

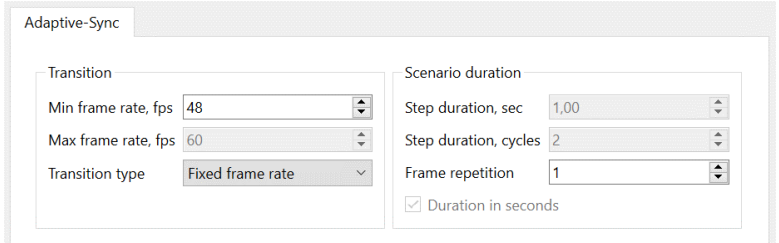
The uppermost part of the window shows the timing details. Please, note that the timing is set on the pattern generator tab. You can change the color mode (RGB444, YUV444, YUV422, YUV420) and color depth (8 bpc, 10 bpc, 12 bpc, 16 bpc).



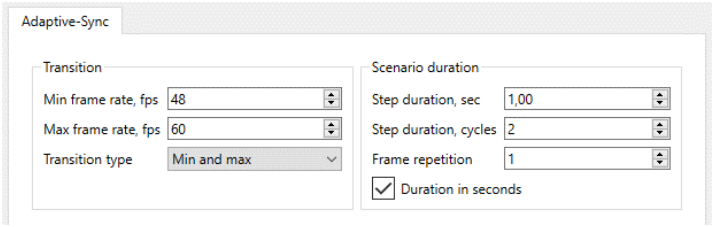
Adaptive-Sync settings

In the Adaptive-Sync section you can set the transition and scenario duration parameters. Different transition types are Fixed frame rate, Min and max and Gradual.

When *fixed frame rate* is selected, the scenario is played at the minimum frame rate set in the first field. In scenario duration, select how many times frame is repeated.

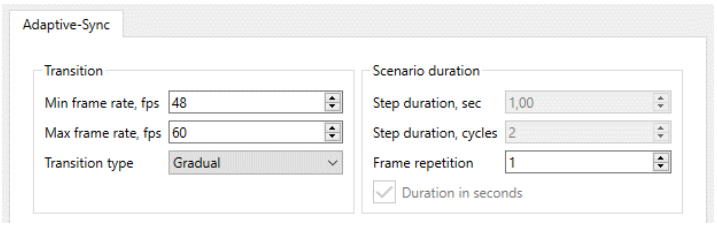


When *min and max* is selected, the output scenario will alter the framerate between the two values set in the drop down menus. You can also set the duration for step in seconds and select how many times frames are repeated.

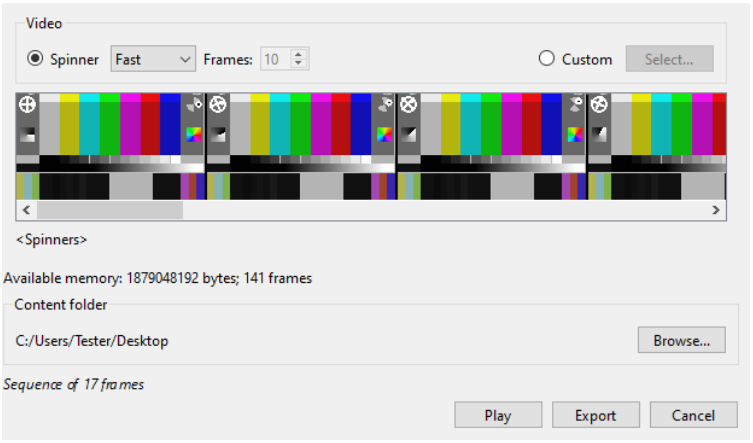


When *gradual* is selected, the frame rate is changed with each frame. For example, when min frame rate is set at 20 and max is set at 60 and the scenario has 40 frames, frame rate would be incremented by 1 with each frame.

Info at the bottom of the segment shows the minimum and maximum values for VRR framerate defined in EDID, and the base frame rate set in the pattern generator.



Video

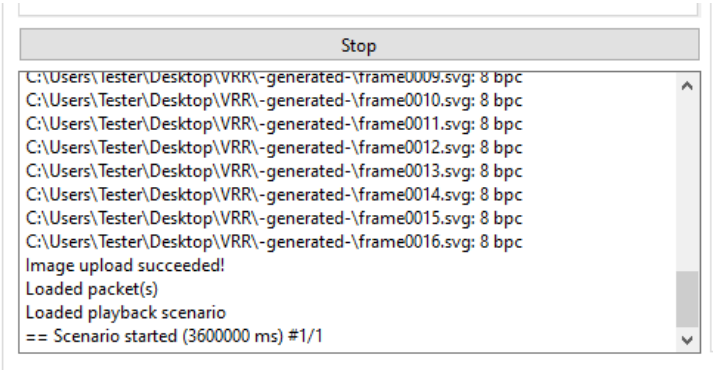


The section at the bottom shows details of the output video. The default pattern is a spinner. You can select the speed of the spinner video from the predefined options in the drop-down menu or you can set a number of frames it takes for the spinner to rotate a full circle. You can also select a custom video. The supported file types are .jpg, .png, .gif, .bmp, .tiff, .ppm and .tif

Available memory is shown in bytes and frames. Below, the folder selected for the sequence is shown. You can change the folder by clickin Browse… Lastly, the duration of the sequence is shown in frames.

You can export the scenario by clicking *Export.* When exporting, you are asked to select a location for the export. The content folder will be automatically created in the chosen location. The folder inlcudes the image files, packets and scenario parameters.

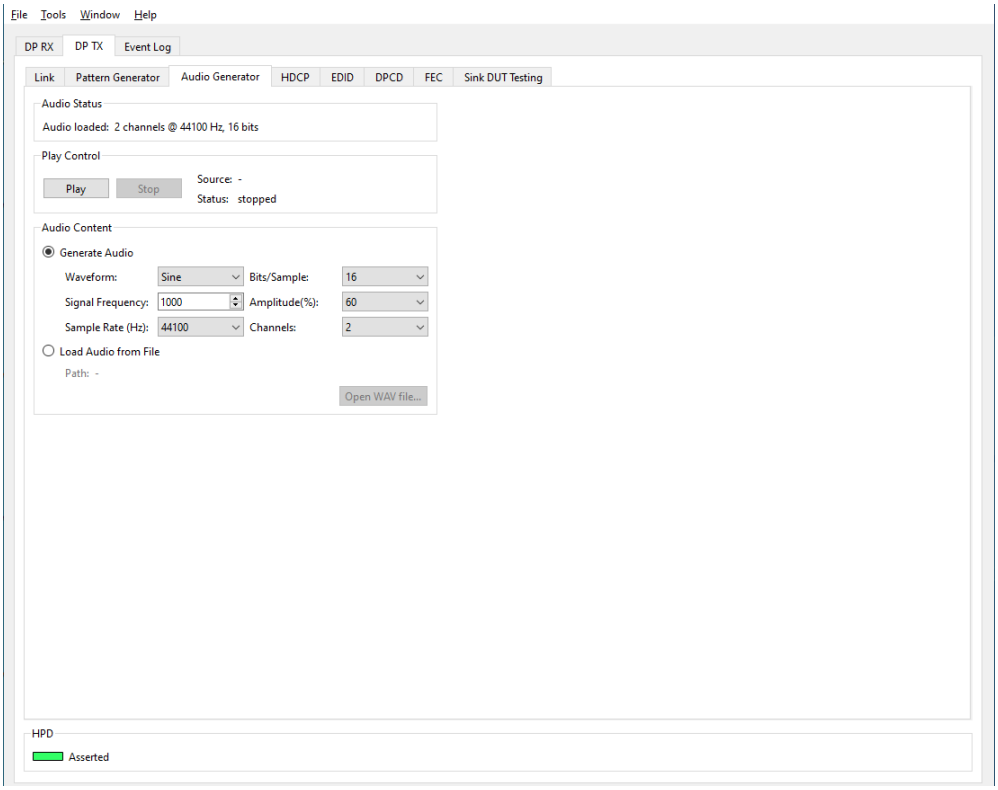
You can play the scenario by clickin *Play.* When the scenario starts playing, the scenario generator window will close. You can now inspect the progress in the log in the palyback tab as shown below.



Audio Generator Tab

Audio generator allows the user to play LPCM audio generated internally or from files in WAV format.

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.

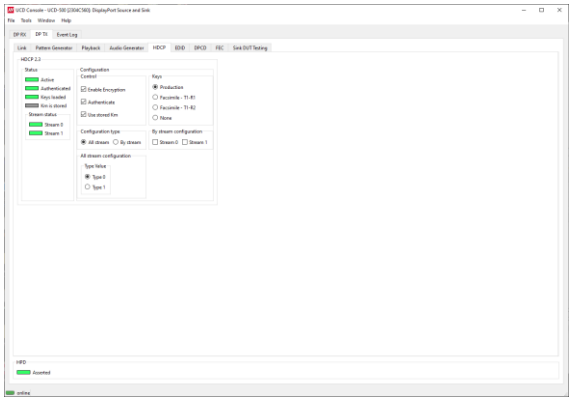
In case of a WAV audio file, the parameters stored in the file will be used. When generating audio internally, the user sets the details of the LPCM Audio signal.

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

Stream Status

Stream status shows HDCP status on each stream.

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)

Configuration type

User can select if they configure HDCP for all streams at once or stream by stream.

By stream configuration

Select the streams you want to configure.

All stream configuration

Select type value: Type 0 or Type 1.

Keys

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

Content level

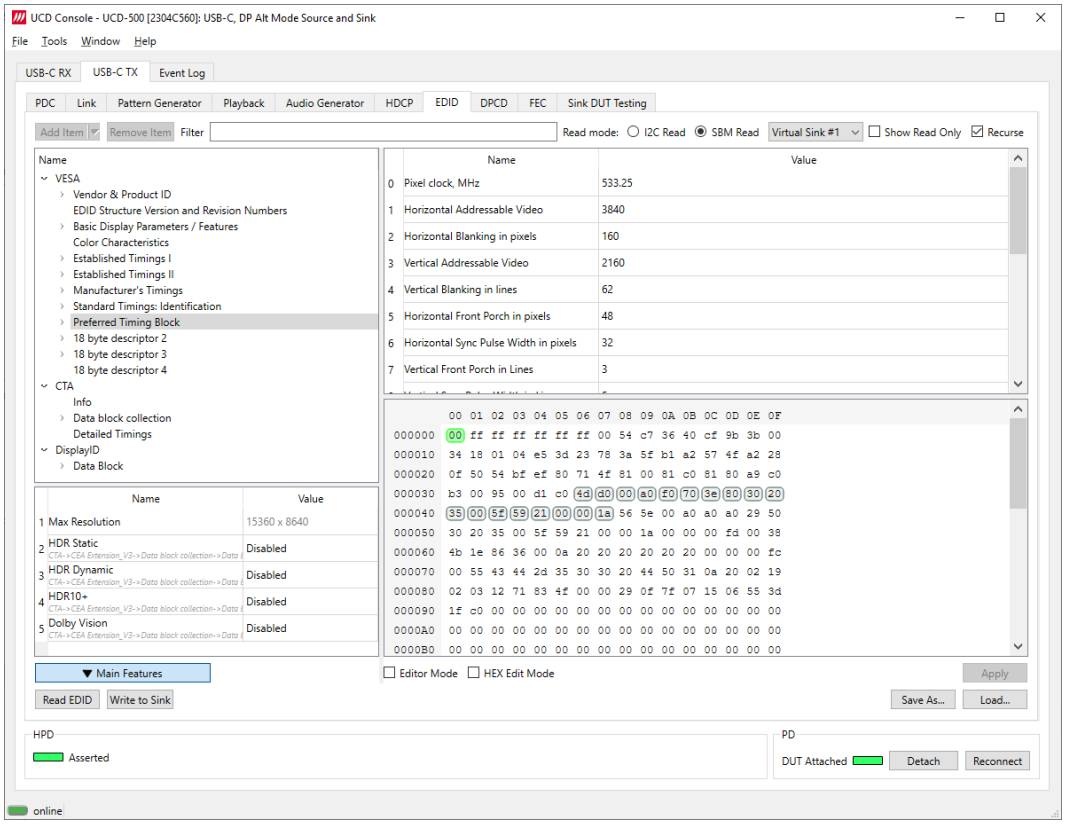
Selection of Type 1 content ensures that content encryption is done with HDCP version 2.2 or higher.

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 sink devices connected.

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.

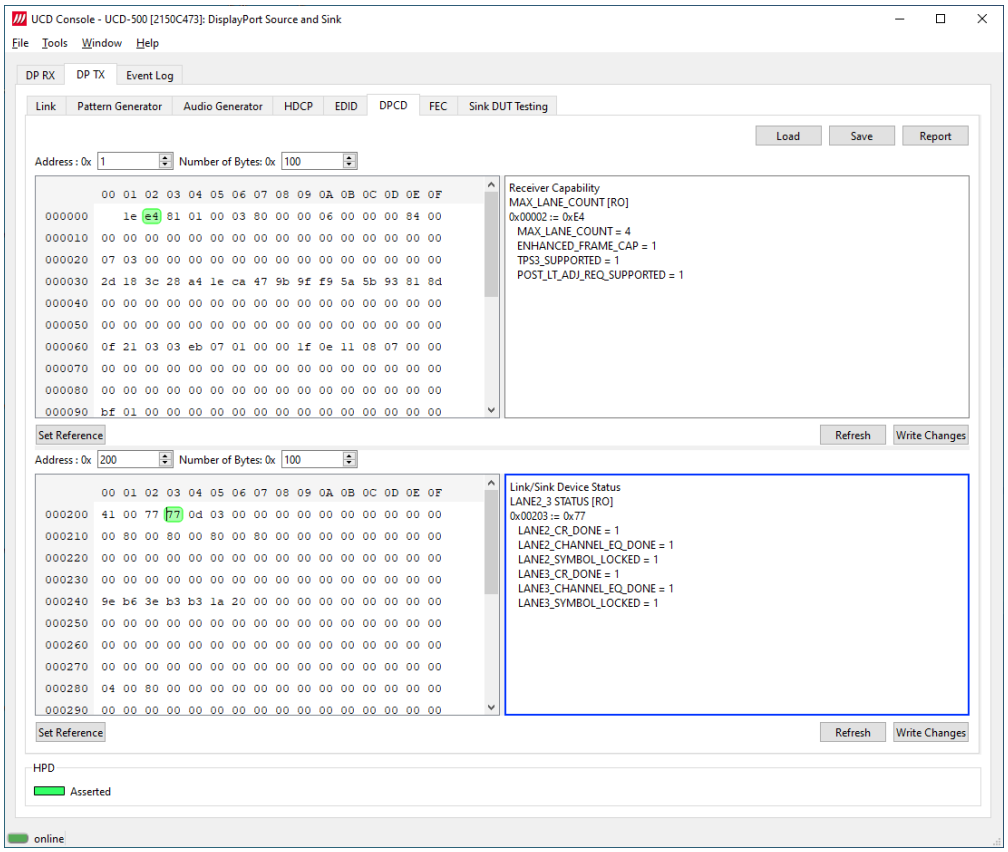
EDID Editor

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

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.

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.

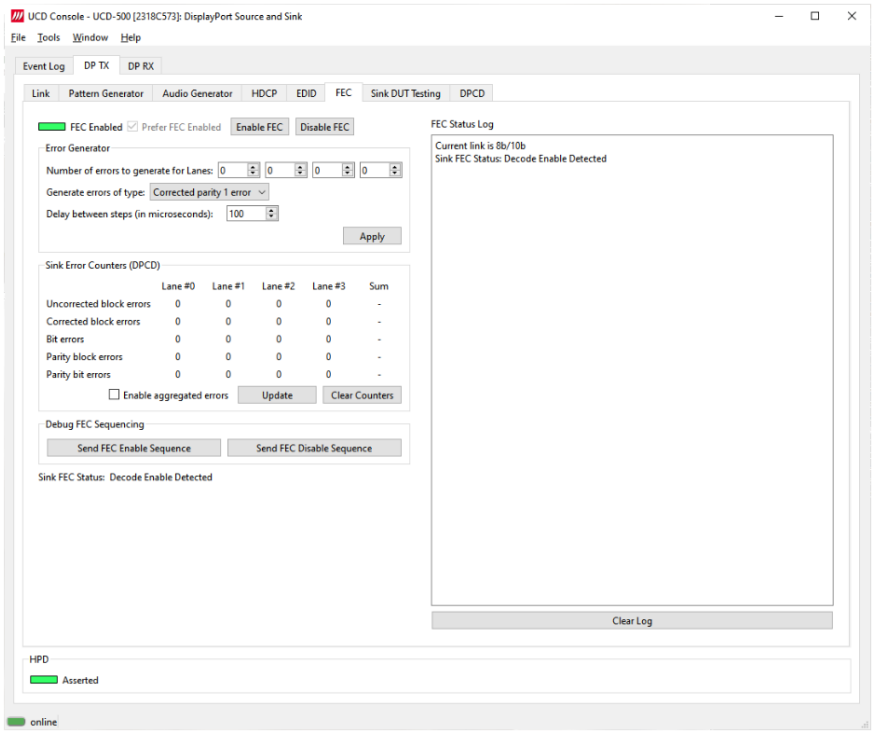
Save:	Select DPCD content to a binary *DPCD Data* file (*.DPD).
Load:	Select previously saved binary *DPCD Data* file (*.DPD).
Report:	Save parsed content of selected DPCD register ranges as HTML file
Refresh:	Re-read the data from the DPCD registers to the window in question
Write Changes	Write the portion of data shown in the window in question to the DPCD registers.
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.

FEC Tab

Forward Error Correction (FEC) can be enabled if connected sink supports it. For debugging 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. Only available with 8b/10b link coding.
Disable FEC	UCD will start the FEC disable handshake. Only available with 8b/10b link coding.
Prefer FEC Enabled	If selected, and the connected sink supports FEC, UCD will start the FEC Enable Sequence after a successful connection. Only available with 8b/10b link coding.



Error Generator 8b/10b Link Coding

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	2 symbol errors with 2 error bits together
Corrected parity	2 parity byte errors with 2 error bits together
Corrected block 1 error	1 symbol error with 1 error bit together
Corrected parity 1 error	1 parity byte error with 1 error bit together

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

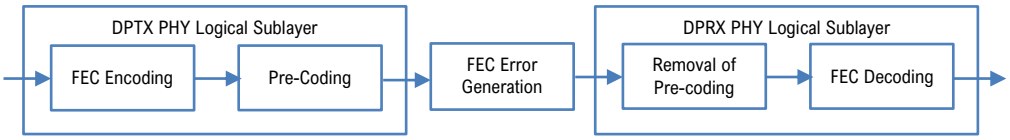
Error Generator 128b/132b Link Coding

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 4 errors	2 symbol errors with 4 error bits together
Corrected block 2 errors	1 symbol errors with 2 error bits together

Each lane can have its individual error amount. Errors can be injected to even and odd decoders by using L**ane #0** and **Lane #1** counters when link is configured to one lane.

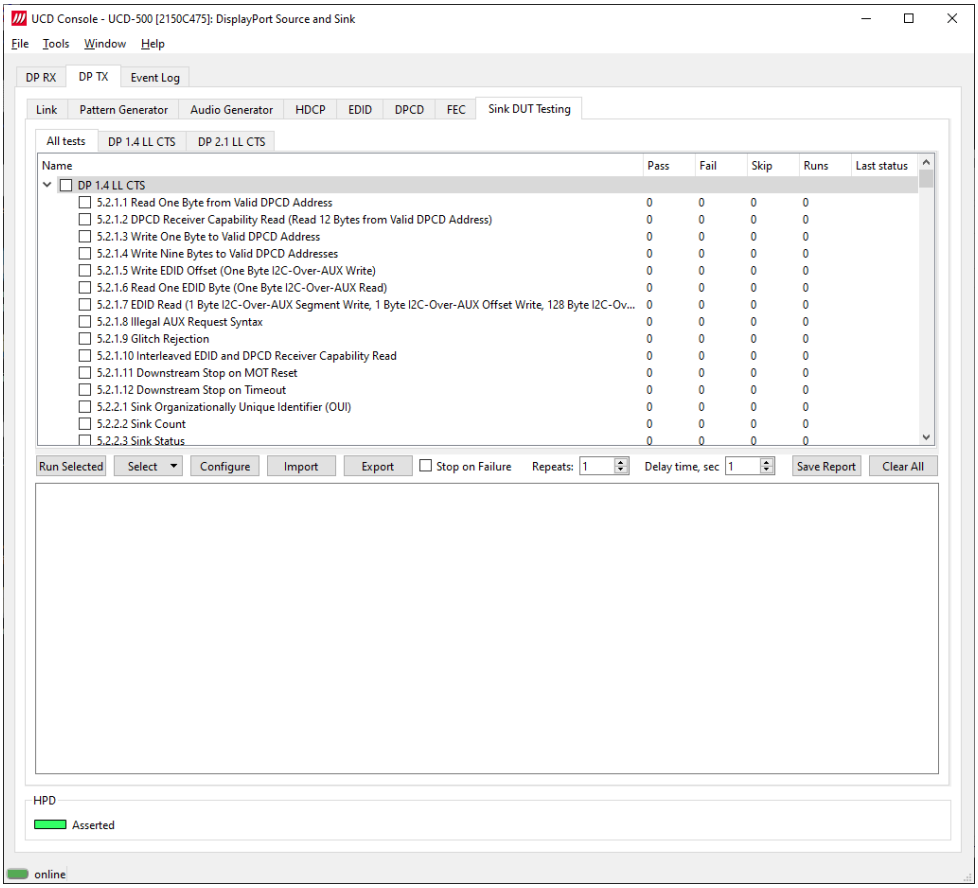
Apply	Start error injection
Enable aggregated errors	Enables FPGA logic that can calculate FEC errors sum across all active lanes.
Update	Read sink DPCD FEC error counter registers
Clear counters	Clear sink DPCD FEC error counter registers



Note: When using 128b/132b link coding the errors are inserted to Pre-coded RS block right after PHY Sync symbol (Pls see the illustration above). Because of this, on the RX side the number of bit errors will differ from the errors that are inserted on TX side, since pre-coding removal is XOR of the previous bit with the current bit.

Sink DUT Testing Tab

Please refer to **Appendix E** later in this document for a 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 Log:	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.

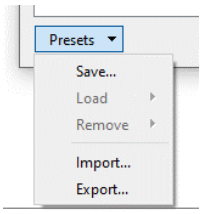
Saving Test Parameters

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 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.



DUT Testing Options

Please refer to Tools > Options earlier in this manual for control on including system date and time in the beginning of each event line in created reports.

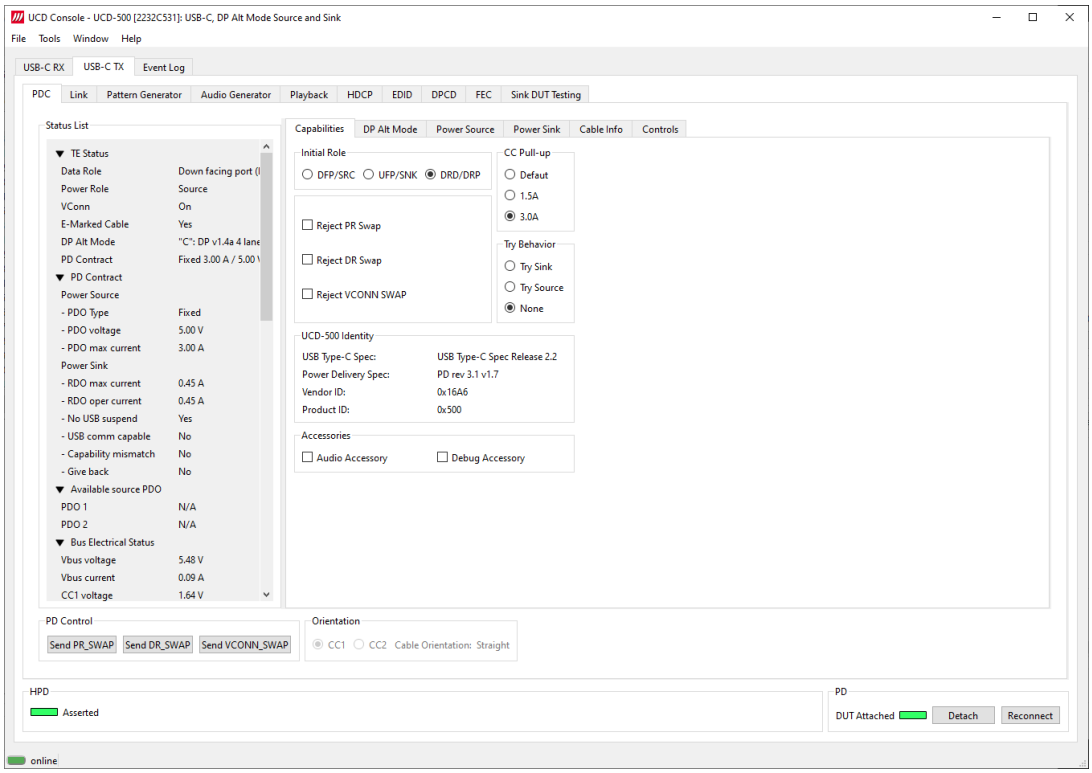
USB-C Monitoring

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

- USB-C Power Delivery (PDC)

When UCD-5XX is used in *DP Alt Mode Reference Source* role, *USB-C Power Delivery* (PDC) tab is available. The content of *USB-C Power Delivery* tab is similar to the tab available when in UCD-5XX 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.

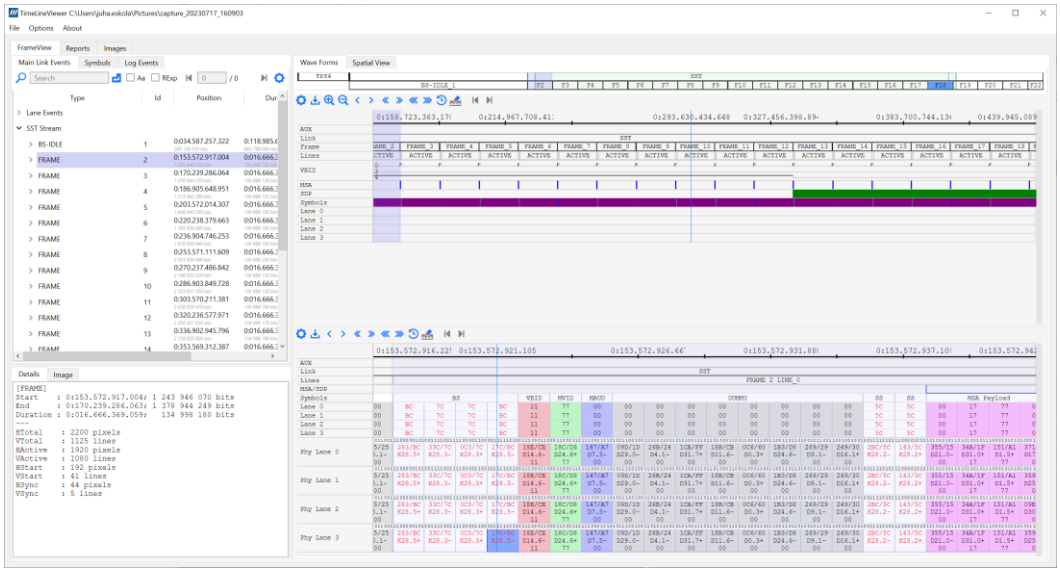


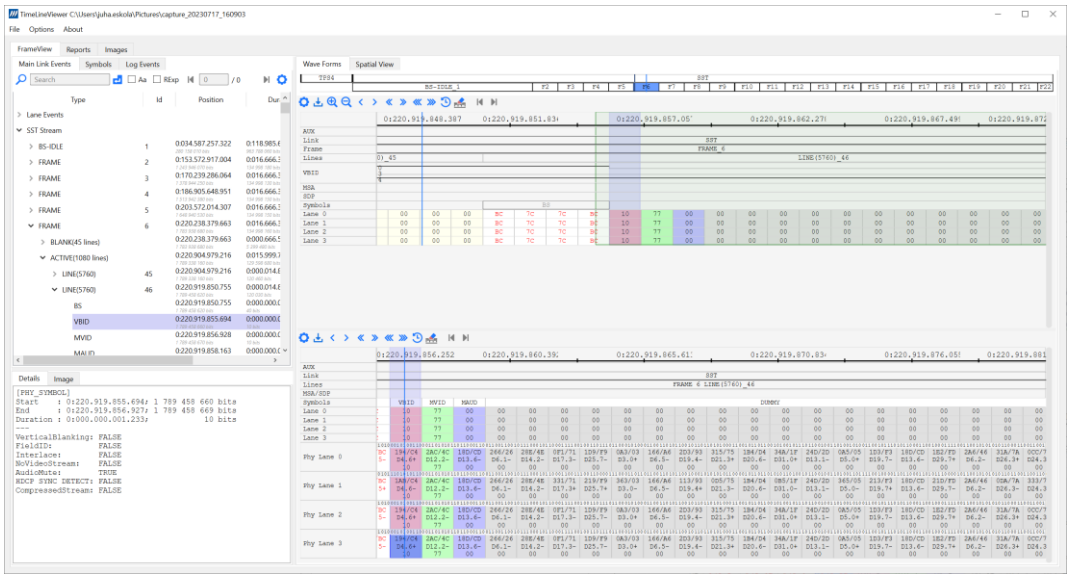
6. LINK TIMELINE VIEWER

Link Timeline Viewer is a tool for evaluating the content and timing of data captured with *Link Analyzer*.

Link Timline Viewer main panel contains two tabs:

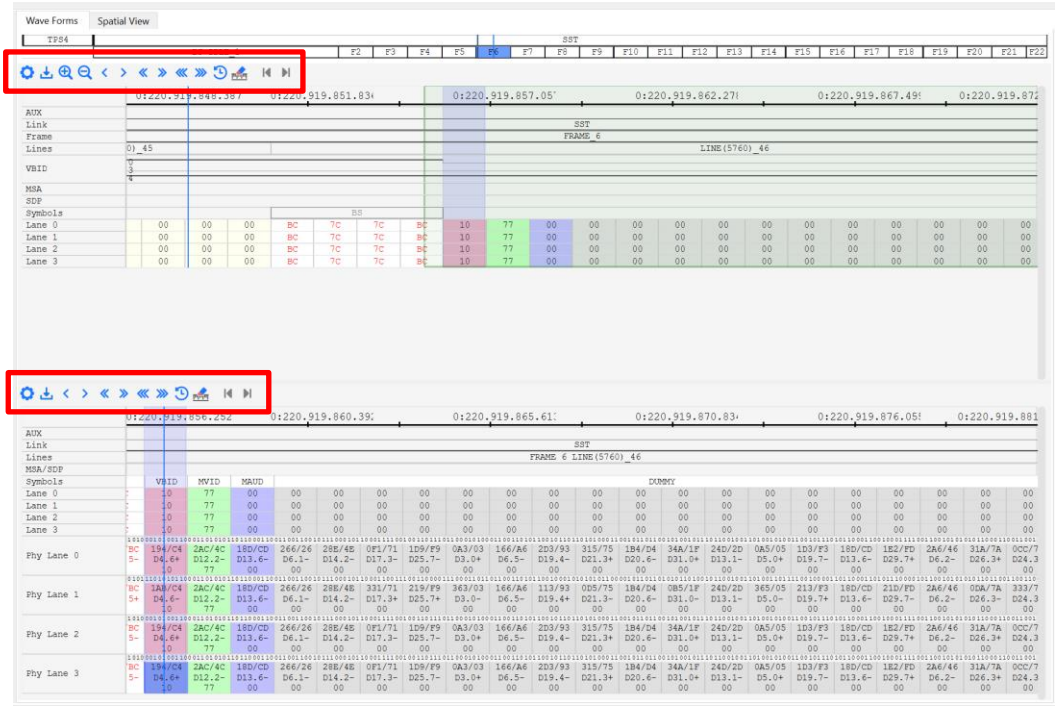
- *FrameView* provides the user ability to evaluate events within the captured data and their occurrence in time scale.
- *Images* lets the user view video frame images decoded from the captured data.





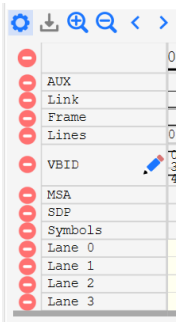
Note: When using Link Timeline Viewer with MST, it's possible that all information for all streams are not fitted in the default window size. Below you can see how different streams are presented in ***Wave Form View*** and ***Symbol View.*** To make room for either of the view areas, please scale the 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

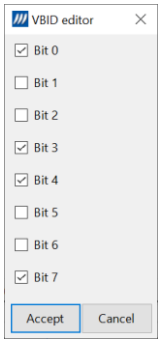


Gear Icon

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.

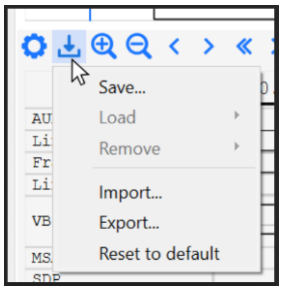


You can select which VBID bits are shown by clicking the pen tool.



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.

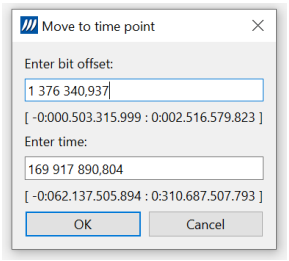
Scrolling

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

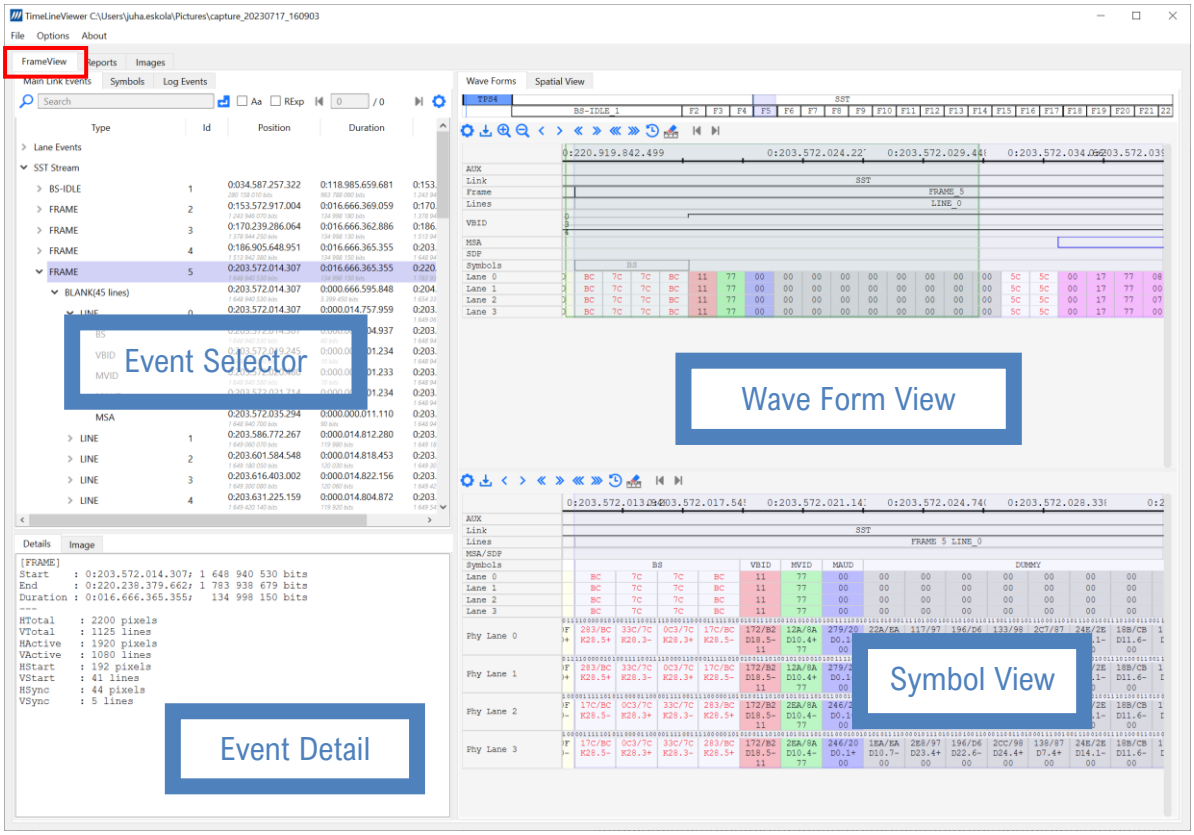
The eraser icon deletes all made measurements on the timeline.

FrameView Tab

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

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

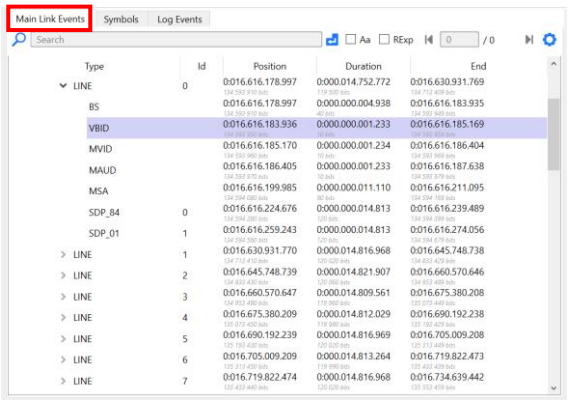
Each of these areas will be described in detail in the upcoming chapters. However, it is worth noting that all these areas are interconnected and actions in one area will affect the information shown in other areas.



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.

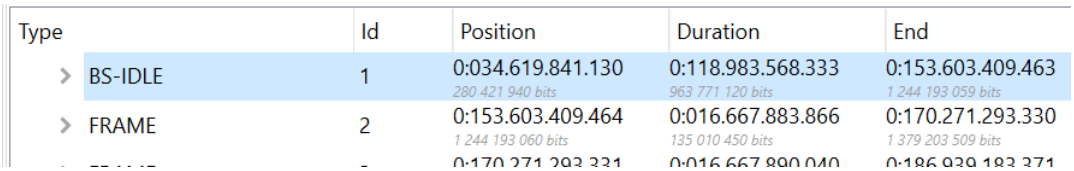


The timing format used in Timeline Viewer consists of two timings based on *time* and *bits*.

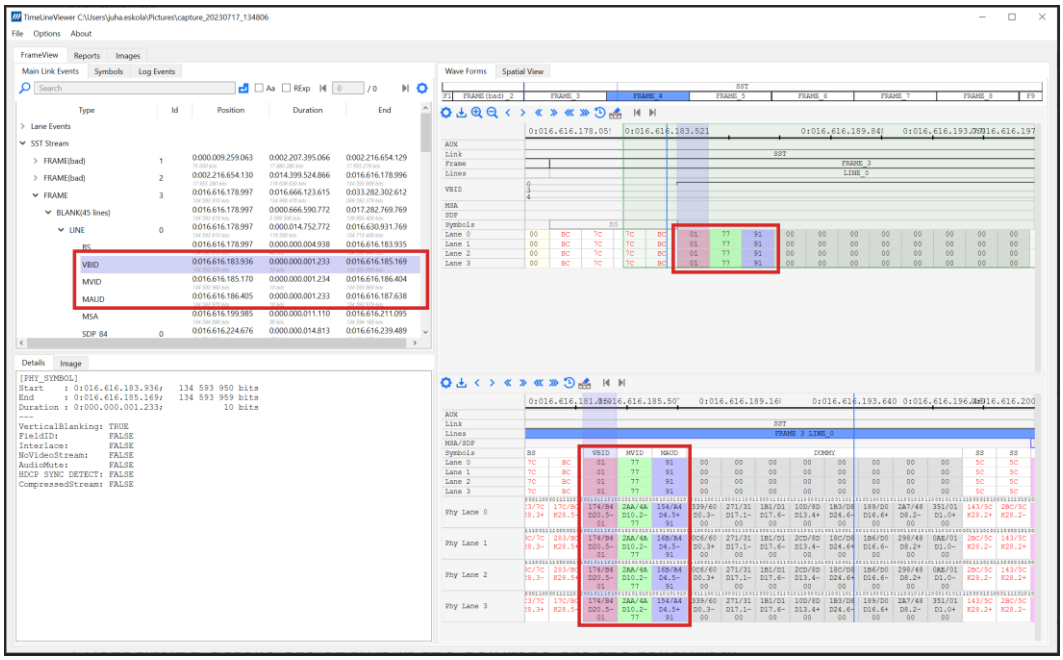
The time format is shown as follows:

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.



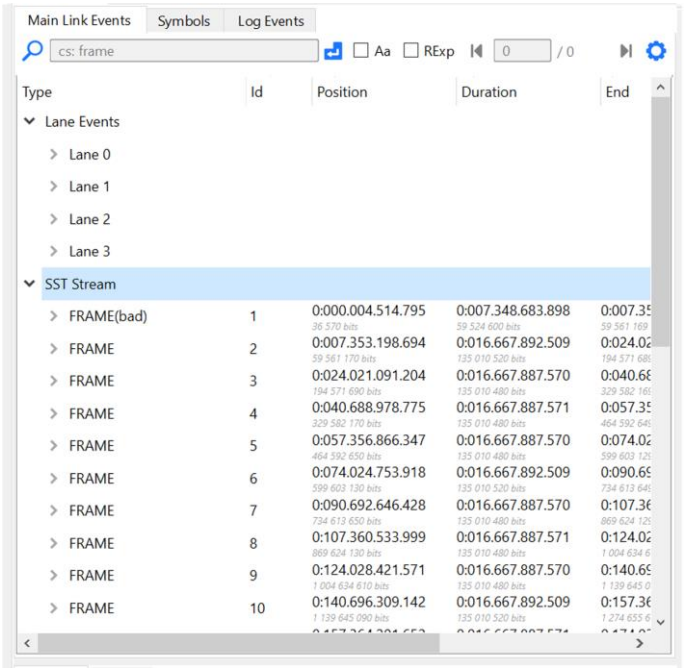
When clicking on a Frame, a Line, an Event, or a Symbol, both ***Wave Form View*** and ***Symbol View*** are focused on the item, and the time stamp of the item is indicated with light blue color highlighting as shown in the image below.



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**.

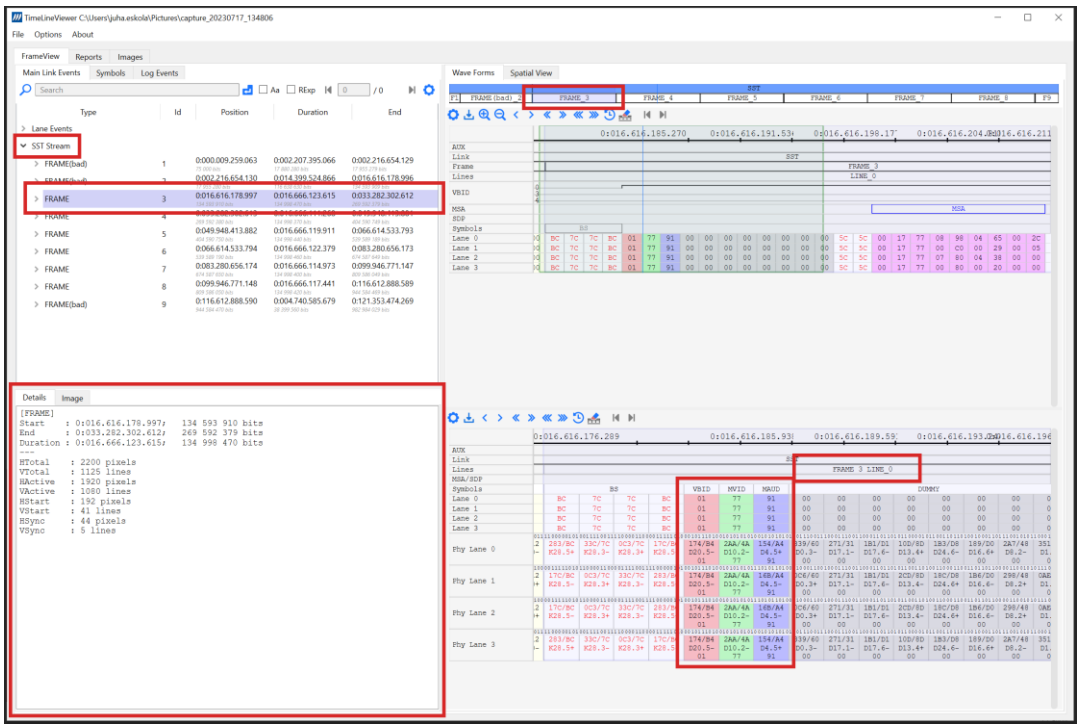


Lane Events

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

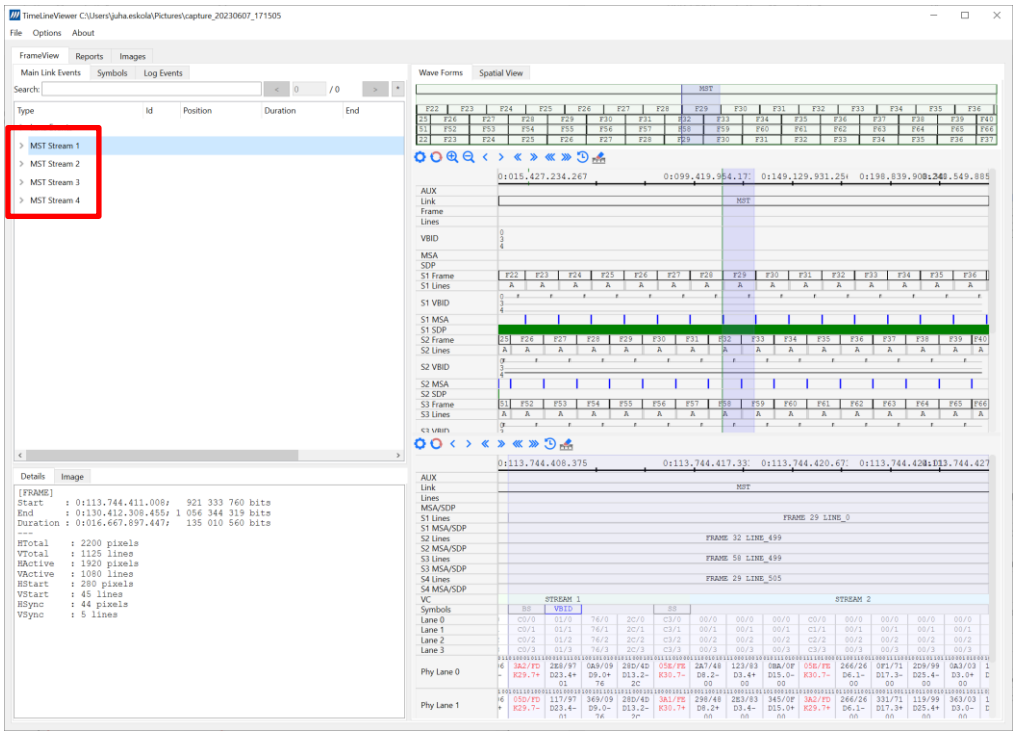
SST Stream

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.



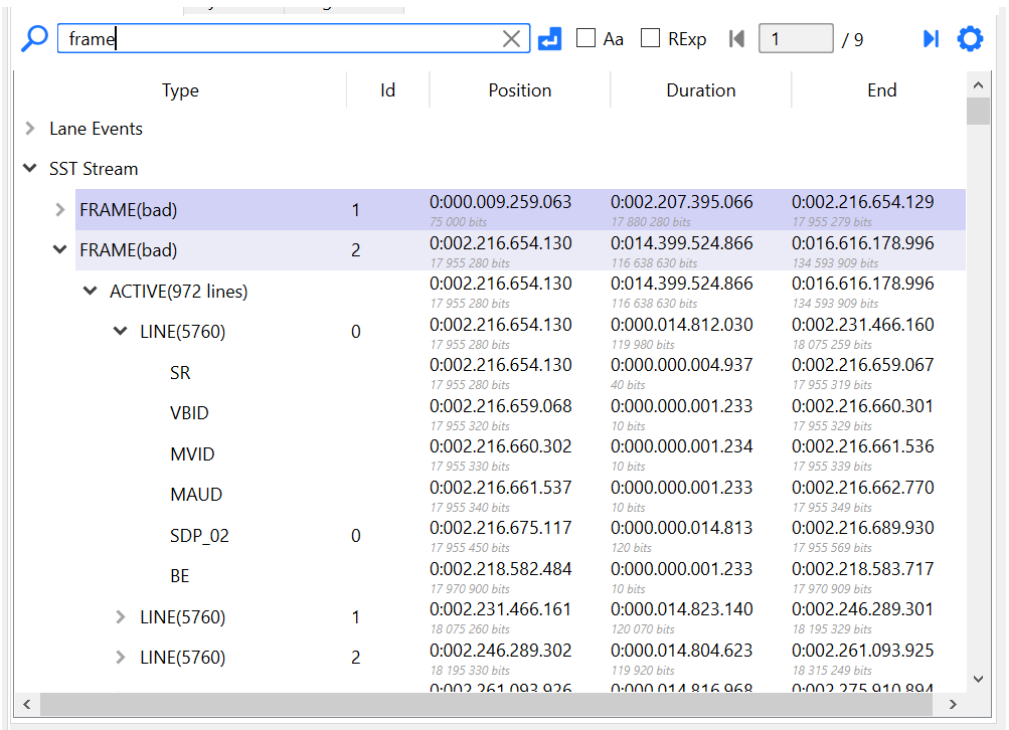
MST Stream

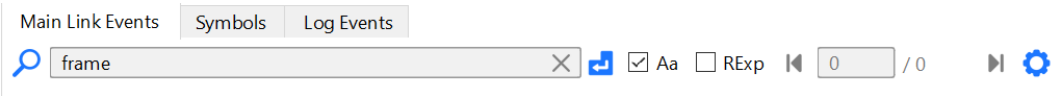
When using Link Timeline Viewer in MST mode, the streams are shown in the event selector as in the image below. Click on each stream to inspect its events. All aspects of the events found under different streams include the same aspects as in the SST mode described in the chapter above.



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.***

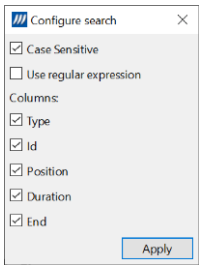




Aa:	Makes search function case sensitive.
RExp:	Use regular expressions.

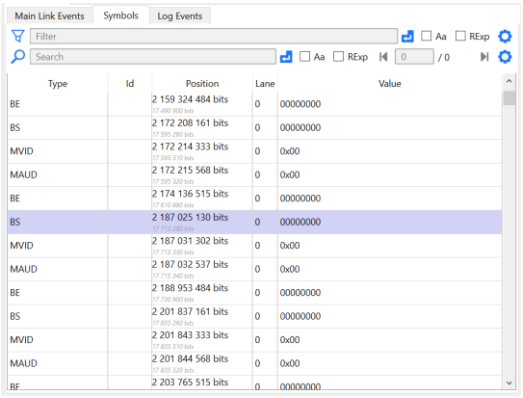
Click the enter icon to apply filters.

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

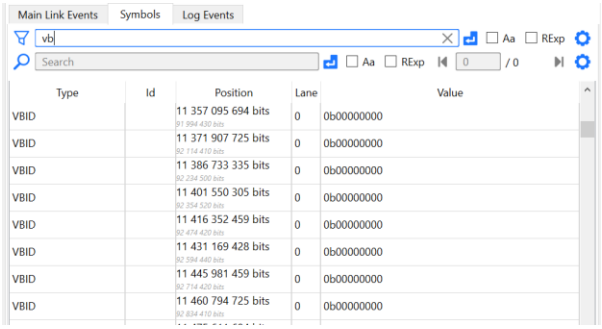
Symbols view lists all the PHY level events found in the capture made. Wheres *Main Link Events* is structured in a tree format, *Symbols* view is presented in a list format containing all symbols from the capture.



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:	

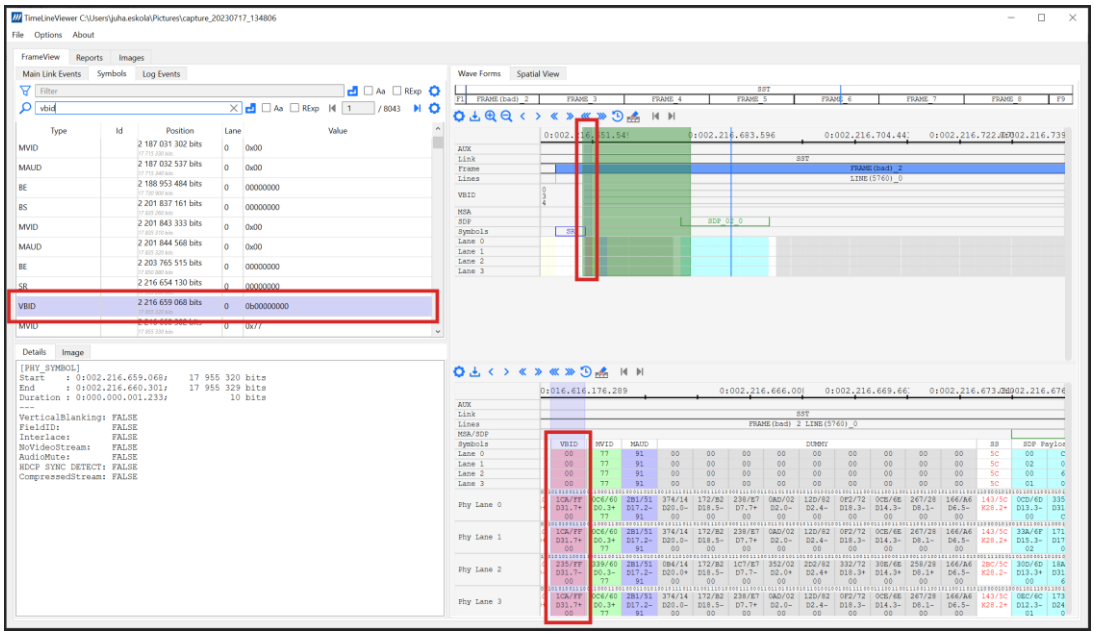
Filter

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:



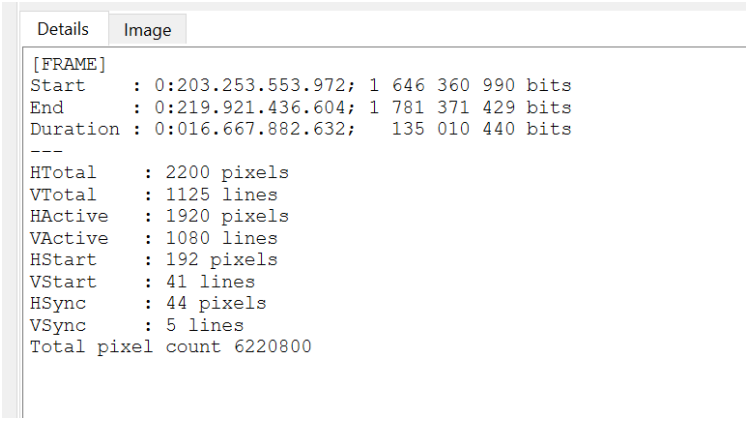
Event Details

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



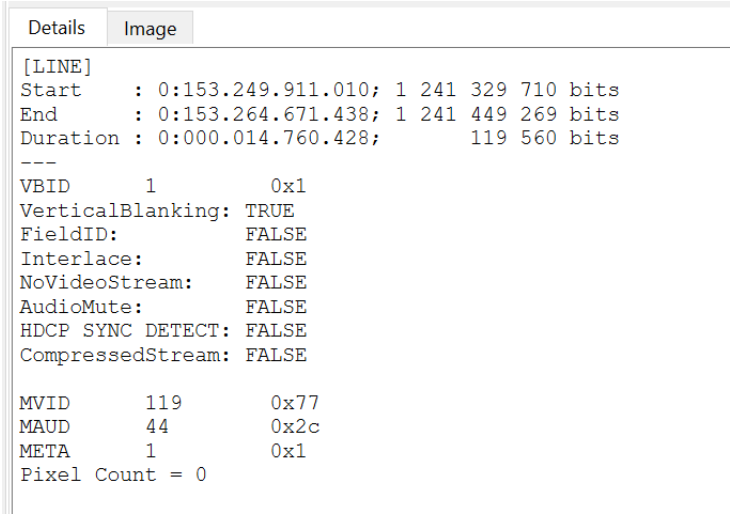
For frames the details include the following parameters:

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

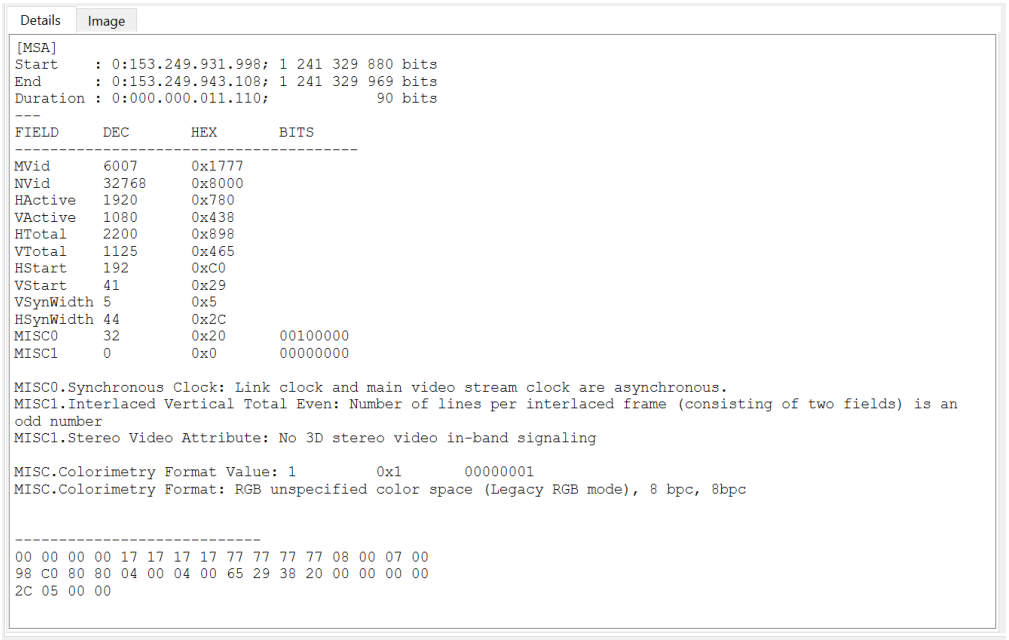
The above mentioned parameters can be set for the transferred pattern in the pattern generator tab. For detailed information, please refer to UCD-4XX/UCD-5XX user manual.

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.

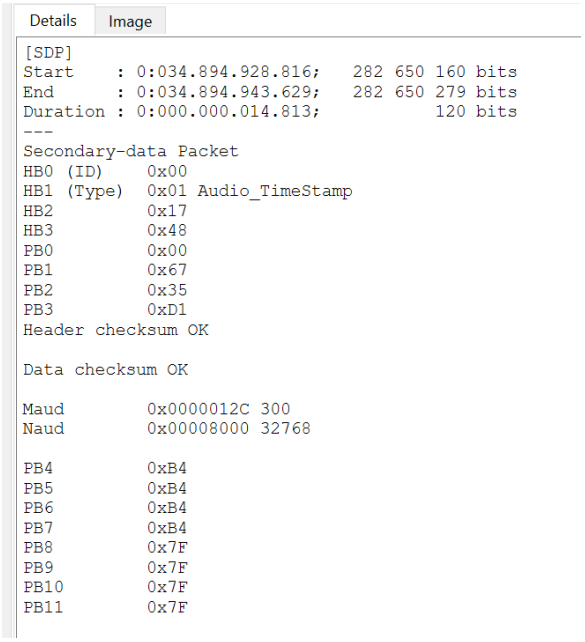


MSA



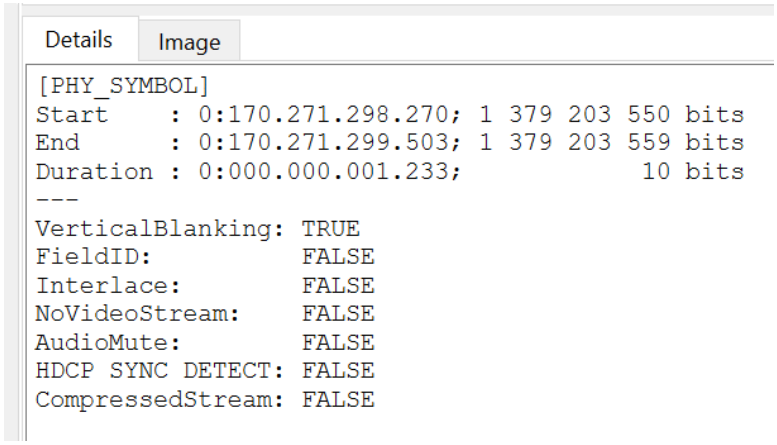
SDP

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



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.



PHY Area

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

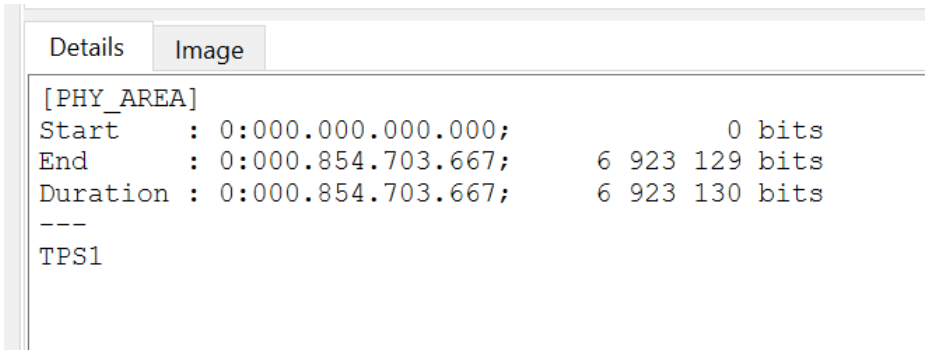
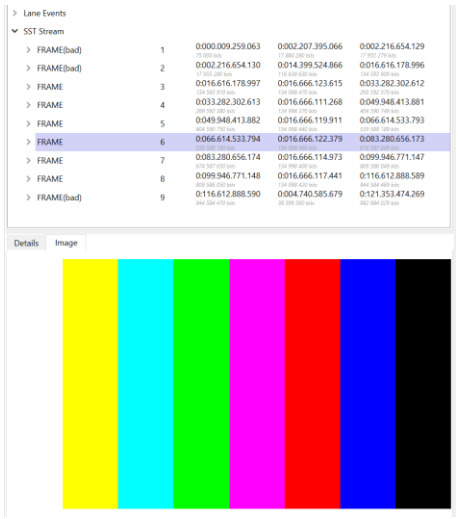


Image tab

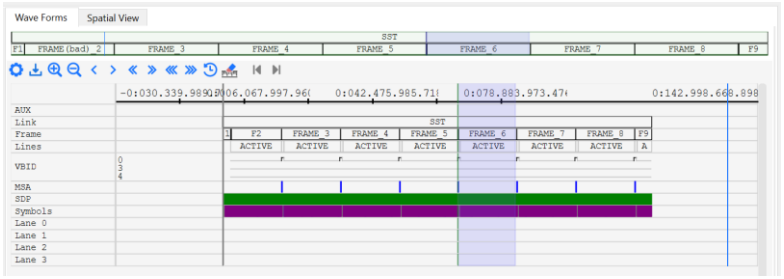
Image tab shows the frame captured with active area. Please note that Images are shown only shown when a frame is selected.



Wave Forms View

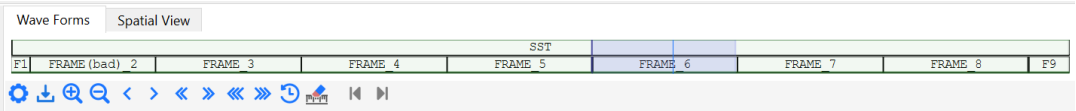
Wave Forms View consists of two tabs: *Wave Forms and Spatial View.*

Wave Forms

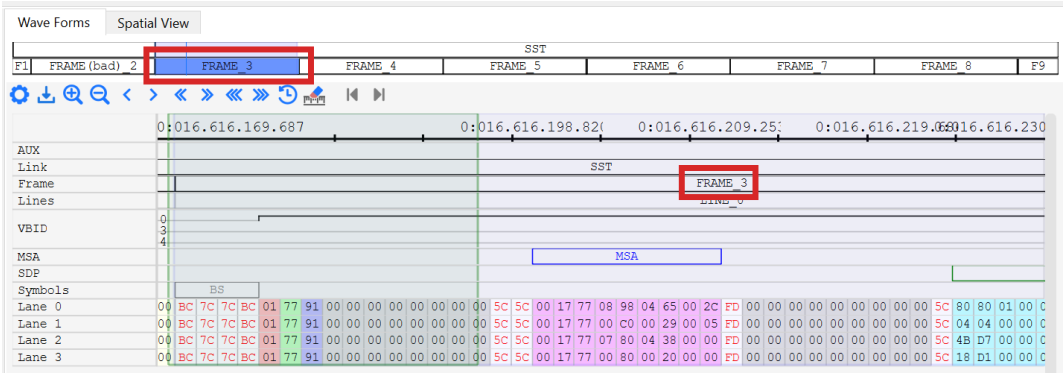


AUX:	Events of the AUX channel.
Link:	Link state (TPS1, TPS2, TPS3, TPS4, SST, MST etc.)
Lines:	Frame and line number
VBID:	Location of VBID events
MSA/SDP:	Location of MSA and SDP events
Symbols:	Control and special symbols
Lanes (0-3):	Decoded data and control symbols

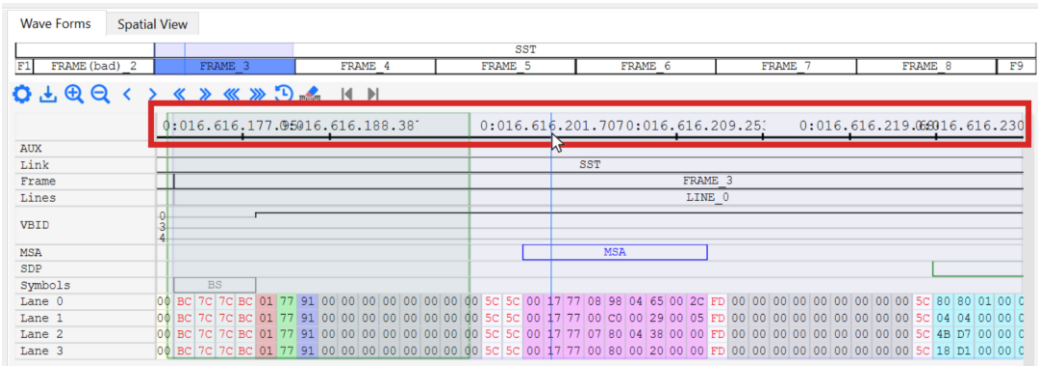
The scroll bar on the top of the panels shows all captured frames of the bulk. As no triggers were set on the example capture shown in the image below, the first frame is not captured fully. Please, note that this view cannot be zoomed in.



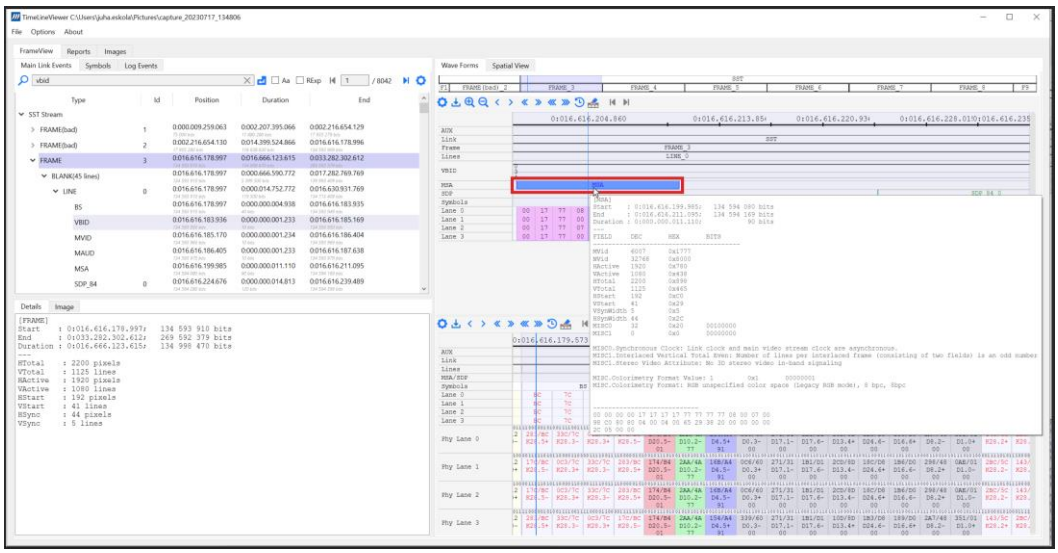
You can select a frame by double-clicking on it. After a frame is selected, it turns into light purple and ***Wave Form View*** will be focused to view this frame.



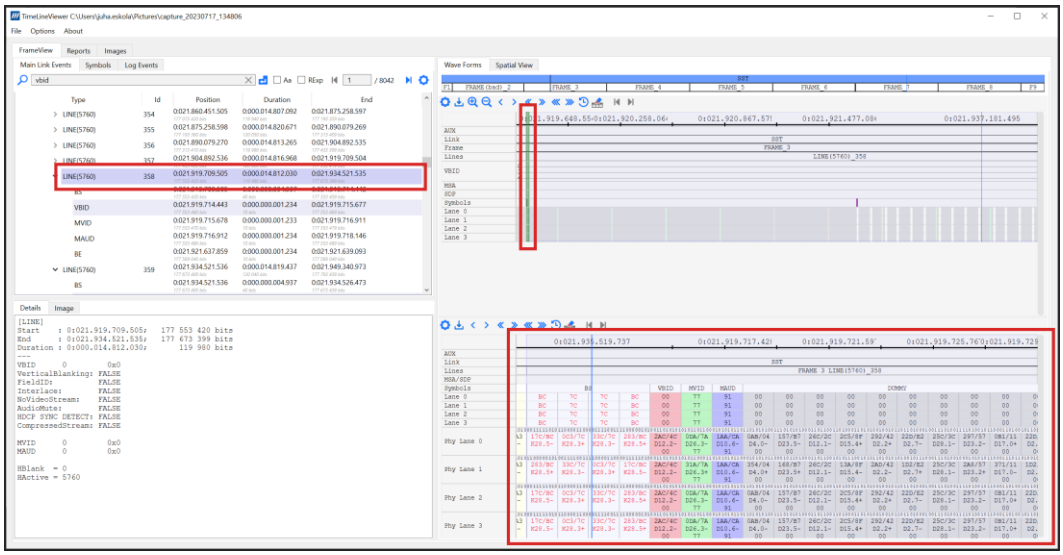
When you hover the cursor over the timeline, the timestamp of that position on the timeline is shown as illustrated in the image below.



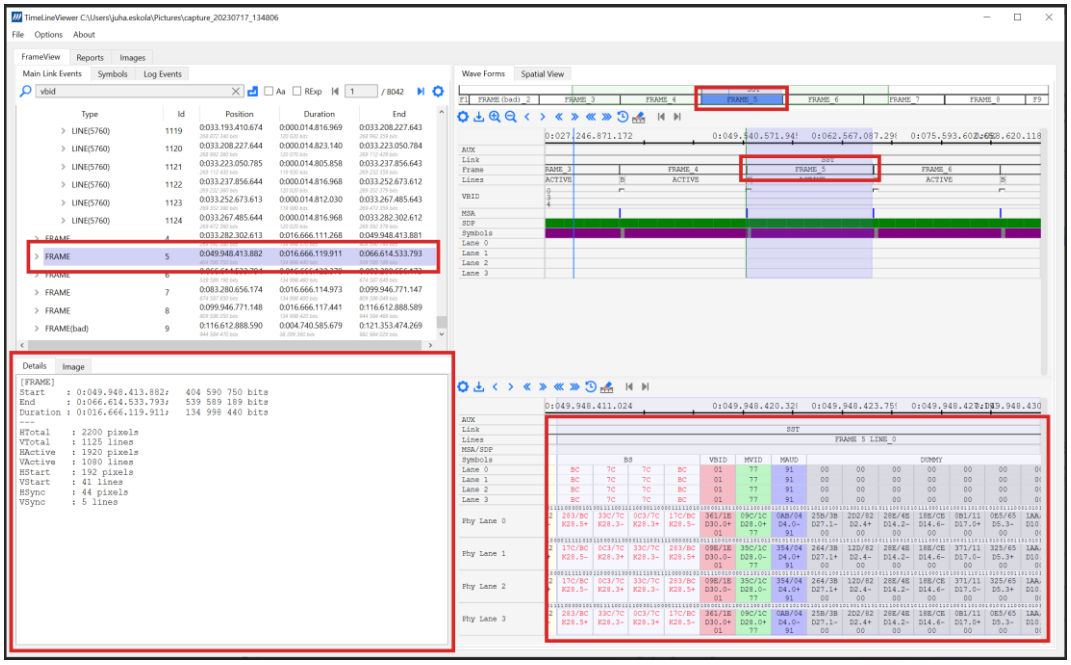
When you hover mouse cursor over an event in ***Wave Form View***, a popup windows shows details of the event.



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.

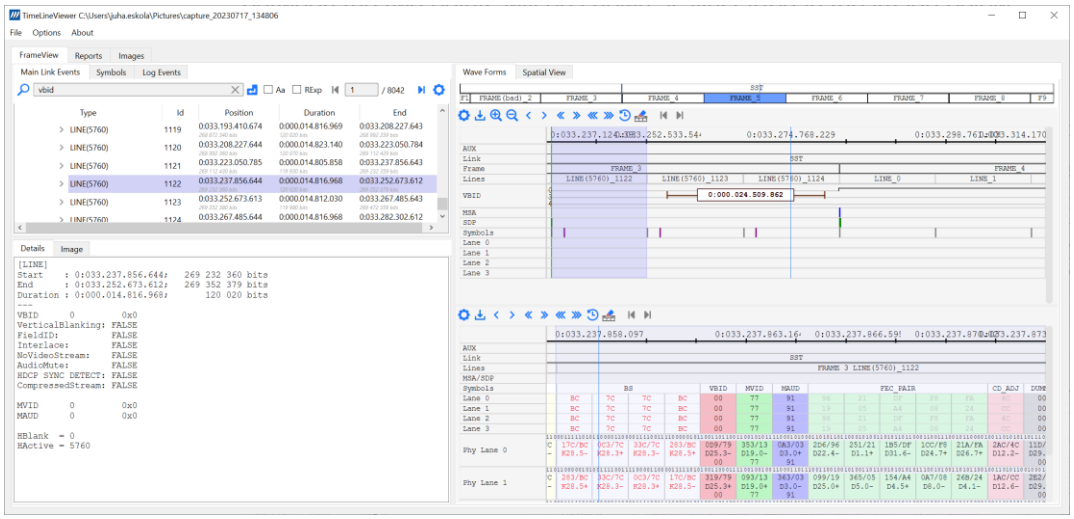


The image below further shows you how the different areas of the Timeline Viewer align when you double click on a frame in ***Wave Form View.***



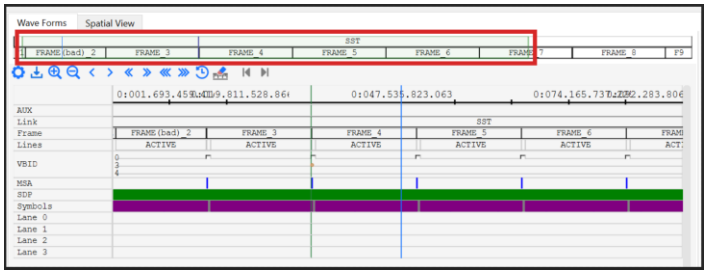
Measuring

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.

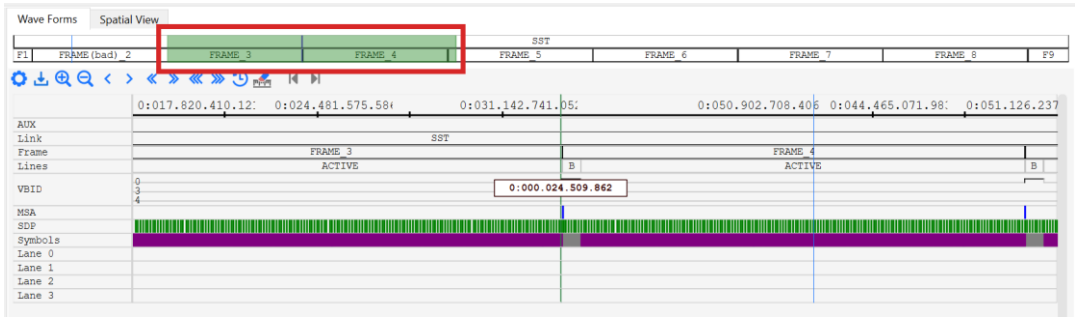


Zooming In

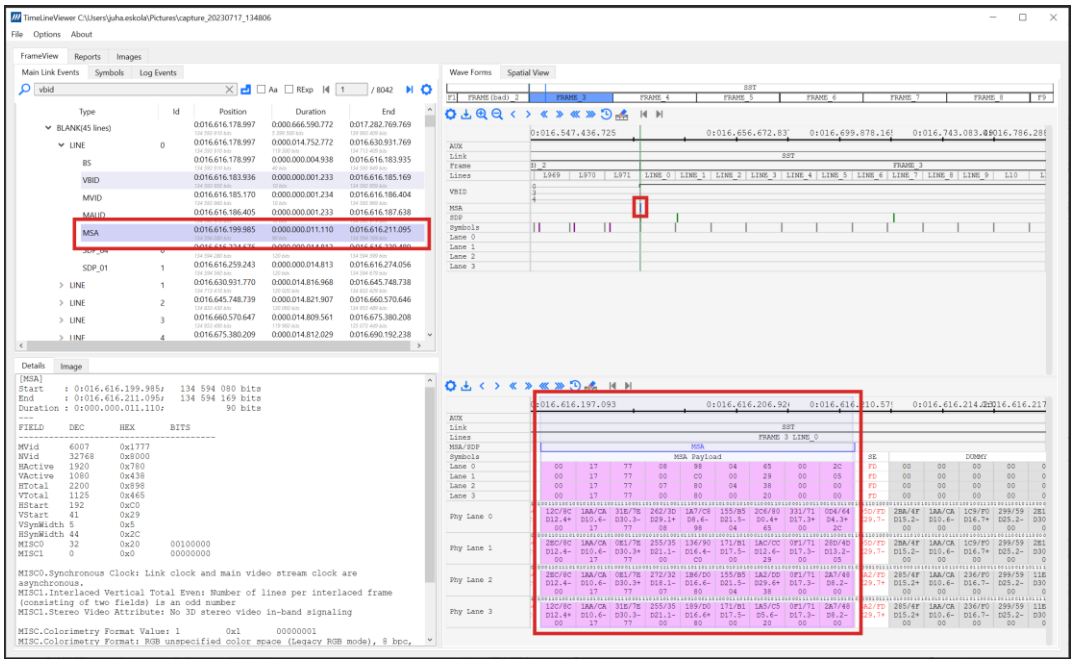
When you zoom in a little, the area shown in ***Wave Form View*** is highlighted with light green color as illustrated in the image below.



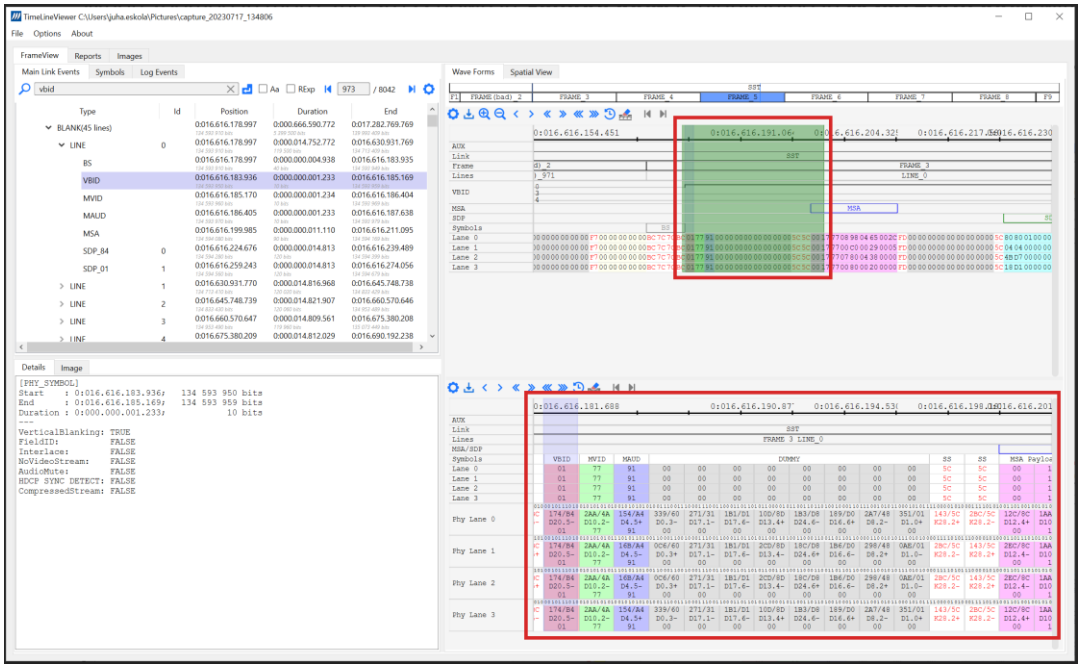
When you zoom in more, the frames shown in ***Wave Form View***, are highlighted in green in the scroll bar as shown in the image below.



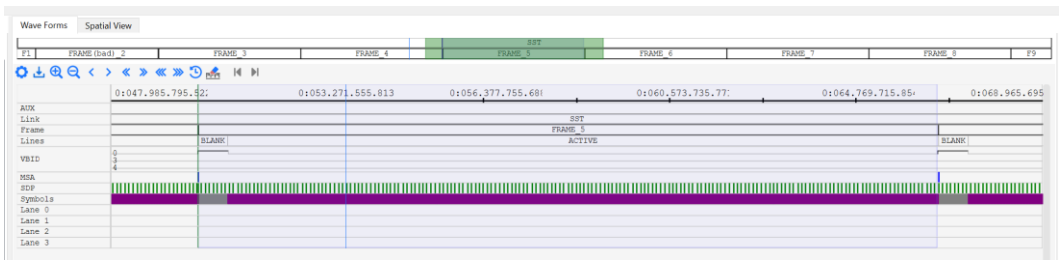
When zoomed in more, ***Wave Form View*** shows the events in small vertical lines as shown in the image below. When you want to zoom into a certain event, make sure to keep the cursor on top of the event you want to inspect more in detail.



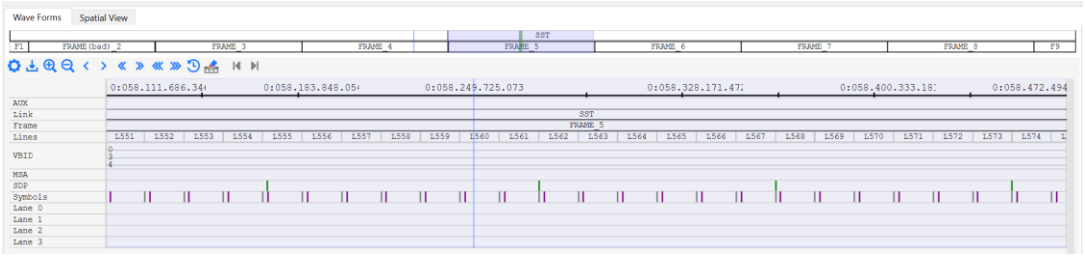
When zoomed in more, the area shown in ***Symbol View*** is highlighted in ***Wave Form View*** with green color as shown in the image below.



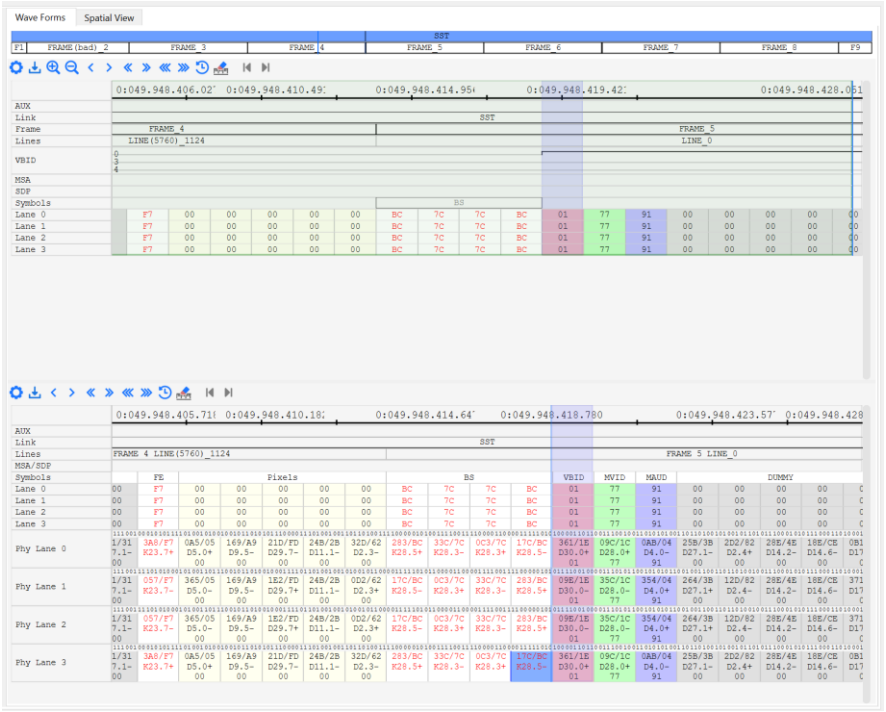
The image below shows a view of one frame in ***Wave Form View*** when zoomed in on a frame level. You can see the blank area and active in this view.



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

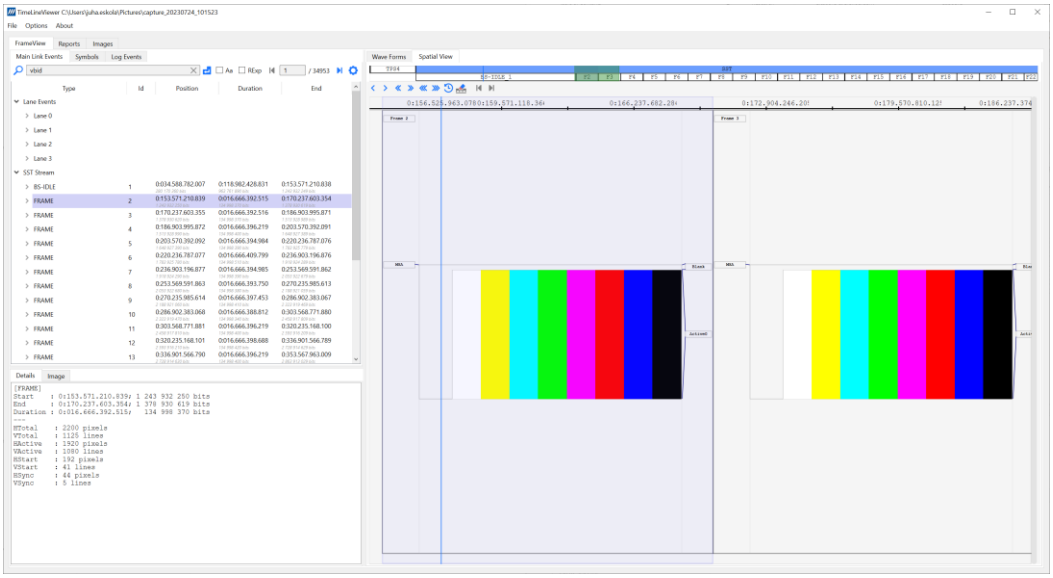


The lines shown in ***Wave Form View*** are symbols that match the ones shown in ***Symbol View***. When you zoom in close enough, you can see the symbols in both views as shown in the image below.

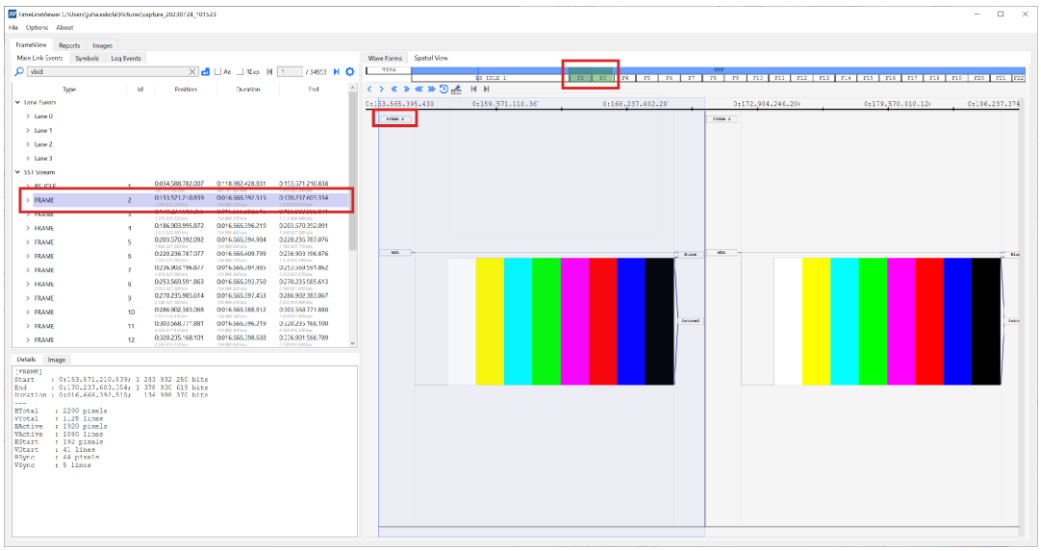


Spatial View

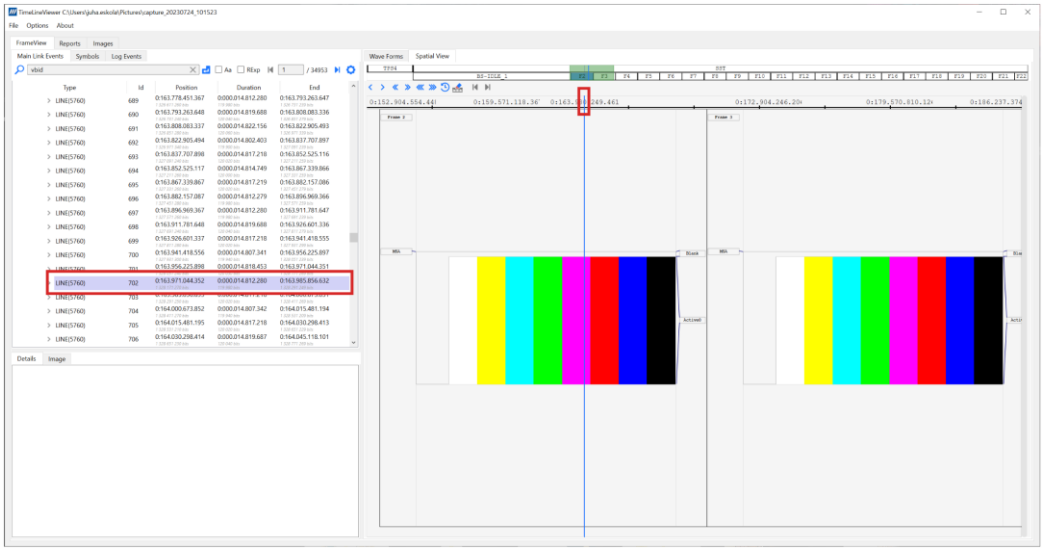
Spatial view shows the geometry of the frame.



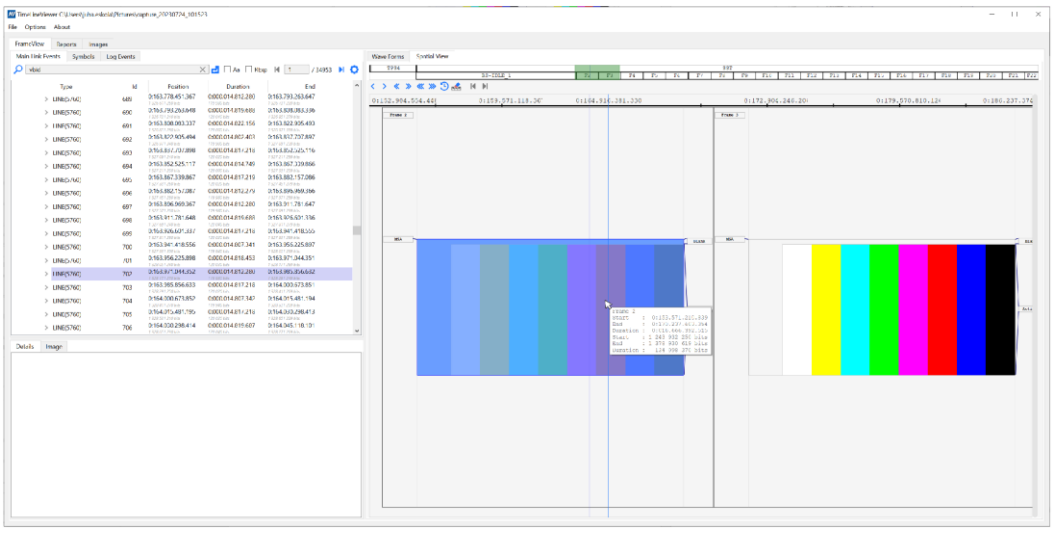
If you select a frame in ***Event Selector*** the frame will be shown in ***Spatial View*** as shown in the image below.



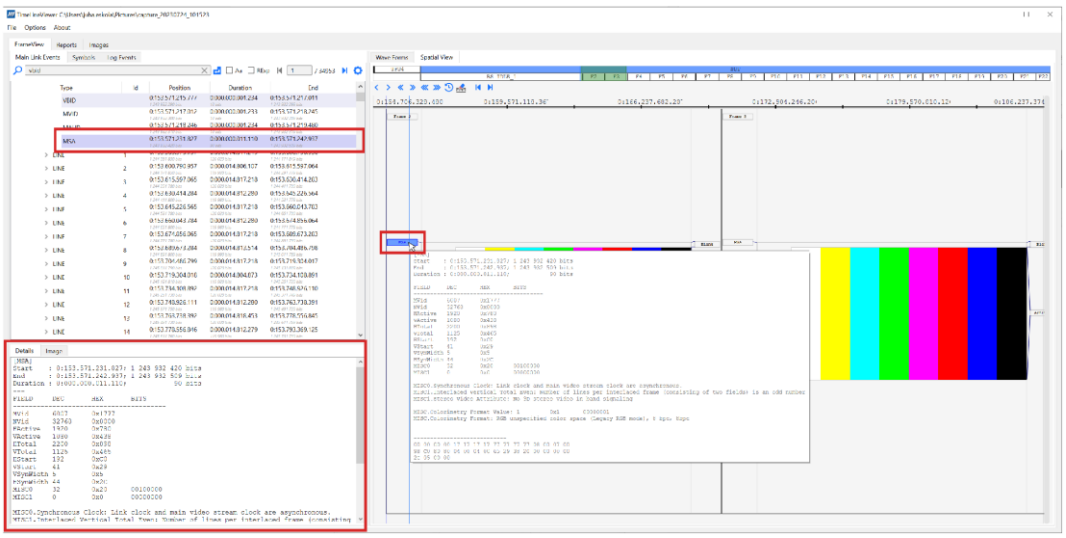
If you double-click on the timeline, the line on that time stamp will be selected in the ***Event Selector*** as illustrated in the image below.



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.

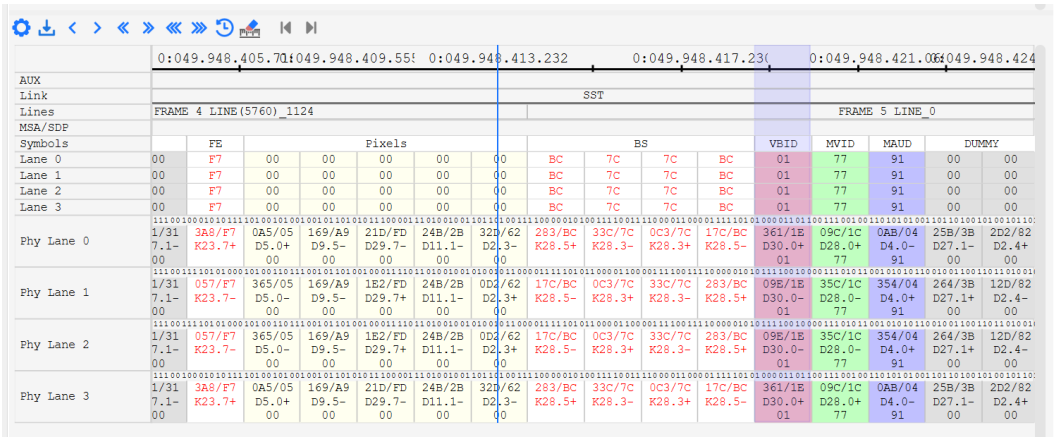


When you hover your mouse over an event shown next the frame, details of that event will be show in a popup window. If you double-click on the event, it will be selected in the ***Event Selector*** and its details will be shown in the ***Event Details.***



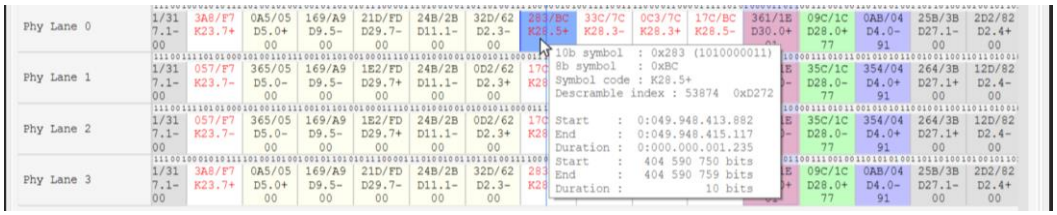
Symbol View

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

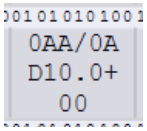
Link Symbols



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

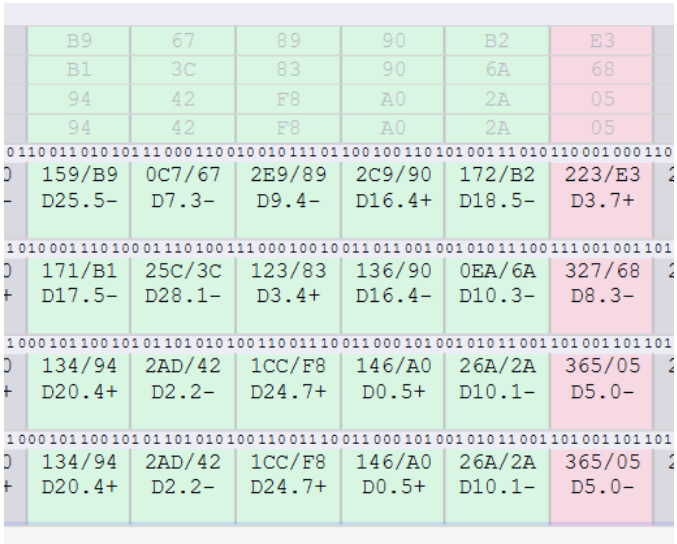
Scrambling

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.

Phy Lane 0	4B/EB 11.7+ 00	2CB/8B D11.4- 00	0E8/77 D23.3+ 00	15E/BE D30.5- 00	14D/AD D13.5- 00	14A/BF D31.5+ 00	2B5/5F D31.2- 00
Phy Lane 1	4B/EB 11.7+ 00	2CB/8B D11.4- 00	0E8/77 D23.3+ 00	15E/BE D30.5- 00	14D/AD D13.5- 00	14A/BF D31.5+ 00	2B5/5F D31.2- 00
Phy Lane 2	4B/EB 11.7+ 00	2CB/8B D11.4- 00	0E8/77 D23.3+ 00	15E/BE D30.5- 00	14D/AD D13.5- 00	14A/BF D31.5+ 00	2B5/5F D31.2- 00
Phy Lane 3	CB/EB 11.7- 00	10B/8B D11.4+ 00	317/77 D23.3- 00	161/BE D30.5+ 00	14D/AD D13.5- 00	175/BF D31.5- 00	28A/5F D31.2+ 00

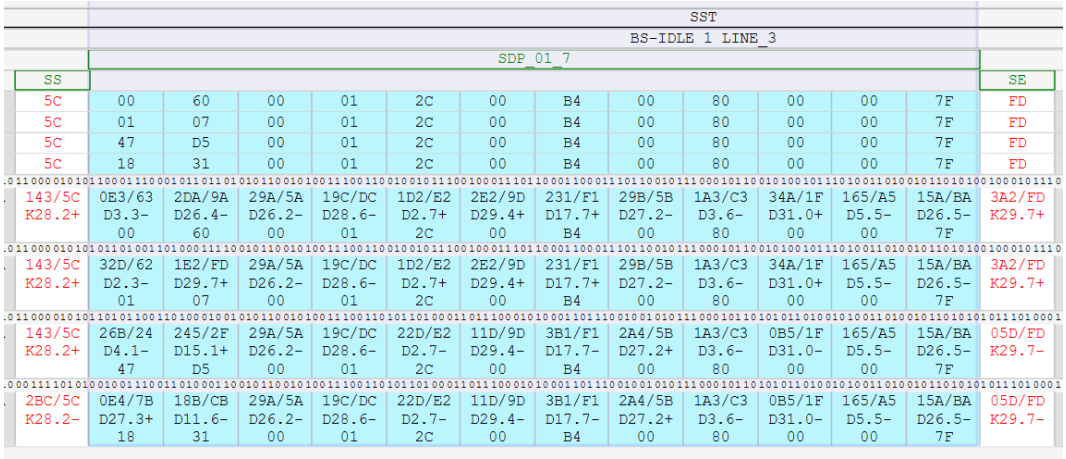
Forward Error Correction (FEC)

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



SDP

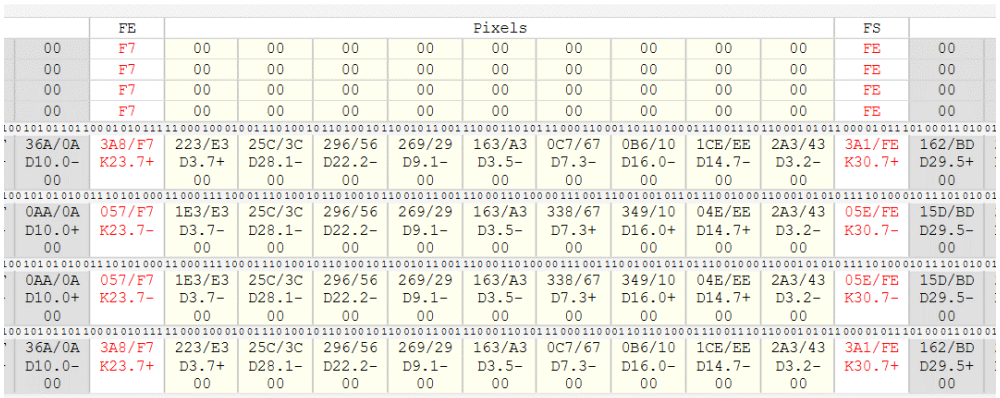
SDPs are highlighted with turquoise color. You can see the start of the SDP event marked as SS and the end of the SDP event marked as SE.



	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

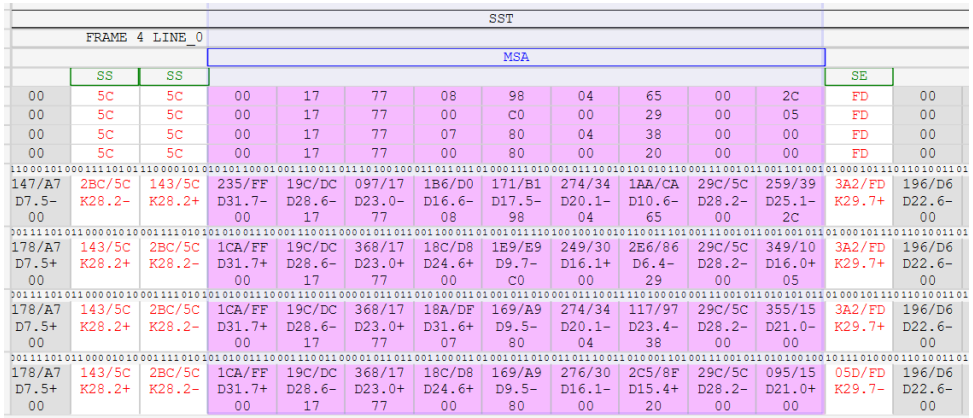
Grey area is fill symbols (scrambled 00). Light yellow area is actual pixels (surrounded by fill end symbol and fill start symbol). K30.7 is fill start and K23.7 is fill end.



	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

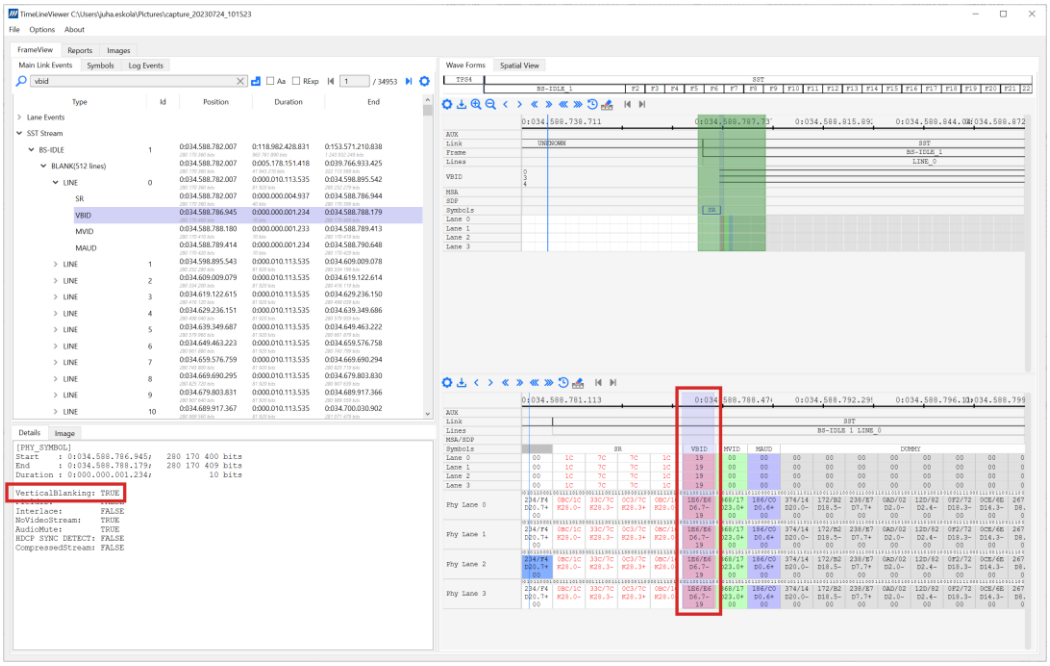
MSA symbols are highlighted in purple color.



		SST										
	FRAME 4 LINE_0		MSA									
	SS	SS									SE	
00	5C	5C	00	17	77	08	98	04	65	00	FD	00
00	5C	5C	00	17	77	00	C0	00	29	00	FD	00
00	5C	5C	00	17	77	07	80	04	38	00	FD	00
00	5C	5C	00	17	77	00	80	00	20	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

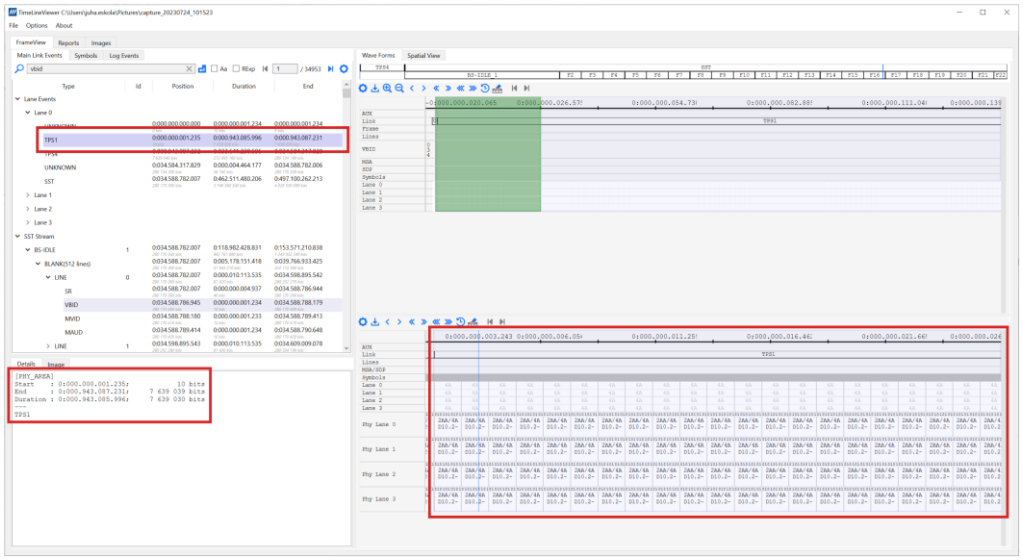
VBID

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.

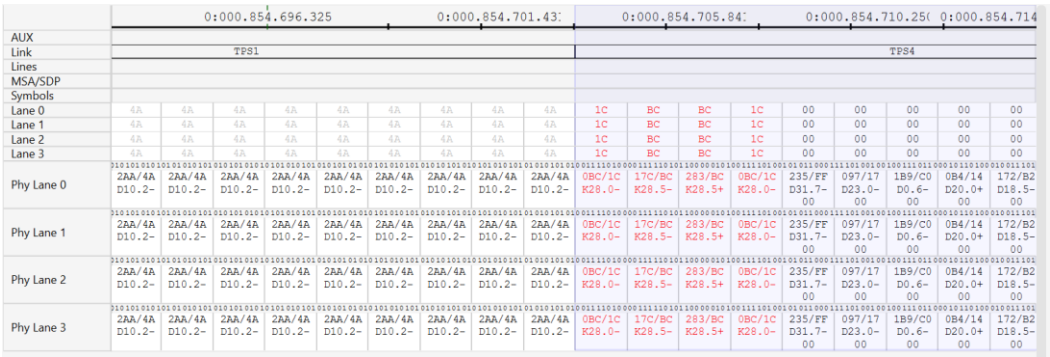


TPS Events

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.



	0:000.854.696.325									0:000.854.701.43:									0:000.854.705.84:									0:000.854.710.25(					0:000.854.714
AUX																																
Link	TPS1																		TPS4													
Lines																																
MSA/SDP																																
Symbols																																
Lane 0	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	1C	BC	BC	1C	00	00	00	00	00	00	00	00	00	00
Lane 1	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	1C	BC	BC	1C	00	00	00	00	00	00	00	00	00	00
Lane 2	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	1C	BC	BC	1C	00	00	00	00	00	00	00	00	00	00
Lane 3	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	4A	1C	BC	BC	1C	00	00	00	00	00	00	00	00	00	00
Phy Lane 0	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	0BC/1C K28.0-	17C/BC K28.5-	283/BC K28.5+	0BC/1C K28.0-	235/FF D31.7- 00	097/17 D23.0- 00	1B9/C0 D0.6- 00	0B4/14 D20.0+ 00	172/B2 D18.5- 00
Phy Lane 1	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	0BC/1C K28.0-	17C/BC K28.5-	283/BC K28.5+	0BC/1C K28.0-	235/FF D31.7- 00	097/17 D23.0- 00	1B9/C0 D0.6- 00	0B4/14 D20.0+ 00	172/B2 D18.5- 00
Phy Lane 2	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	0BC/1C K28.0-	17C/BC K28.5-	283/BC K28.5+	0BC/1C K28.0-	235/FF D31.7- 00	097/17 D23.0- 00	1B9/C0 D0.6- 00	0B4/14 D20.0+ 00	172/B2 D18.5- 00
Phy Lane 3	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	2AA/4A D10.2-	0BC/1C K28.0-	17C/BC K28.5-	283/BC K28.5+	0BC/1C K28.0-	235/FF D31.7- 00	097/17 D23.0- 00	1B9/C0 D0.6- 00	0B4/14 D20.0+ 00	172/B2 D18.5- 00

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.

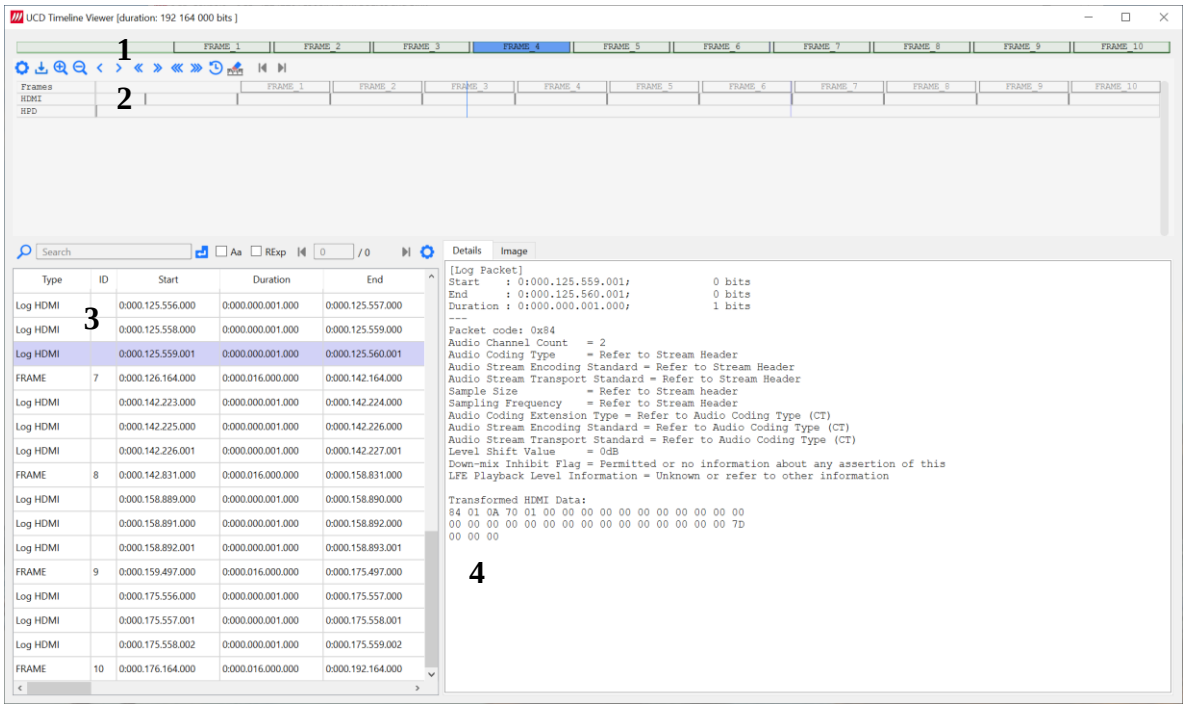
The second line is a structure frame, which shows total and active area.

7. EVENT TIMELINE VIEWER

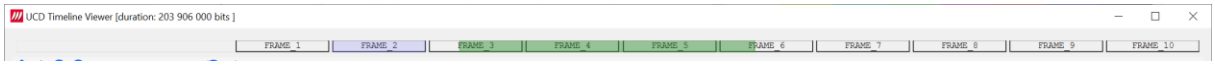
Event Timeline Viewer is an application for inspecting data captured in capture and event log tabs.

Event Timeline Viewer consists of four areas.

1. Frame View
2. Event View
3. Event Log
4. Details / Image

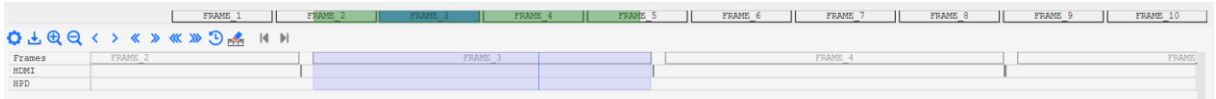


Frame View



The uppermost panel shwos the captured frames. The selected frame is highlighted in purple. You can select a frame by double-clickin it. The area highlighted in green indicates the area shown in the Events view. Please, note that you cannot zoom in or out in the frame view.

Event View

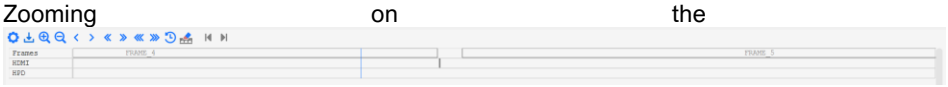


The view below shows all frames and events selected in the capture tab. The are highlighted in green in frame view indicates the are shown in events view.

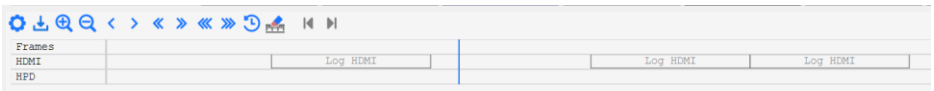
Tools

Tool	Function
Gear Icon	Hide / add events on the timeline
Save Icon	Save, load, remove, import, export and remove presets
Magnifying Glass Icons	Zoom in/out on the timeline
Arrow Icons	Move on the timeline. More arrows moves the timeline more. You can also move by clicking and dragging on the timeline.
Move to a time point	Move to a certain time point on the timeline by double clickin on the timeline. The selected event is highlighted in the event log. By right clicking on the timeline and right clicking again you can measure distance between two time points.
Erase all rulers	Erase all measurements made.

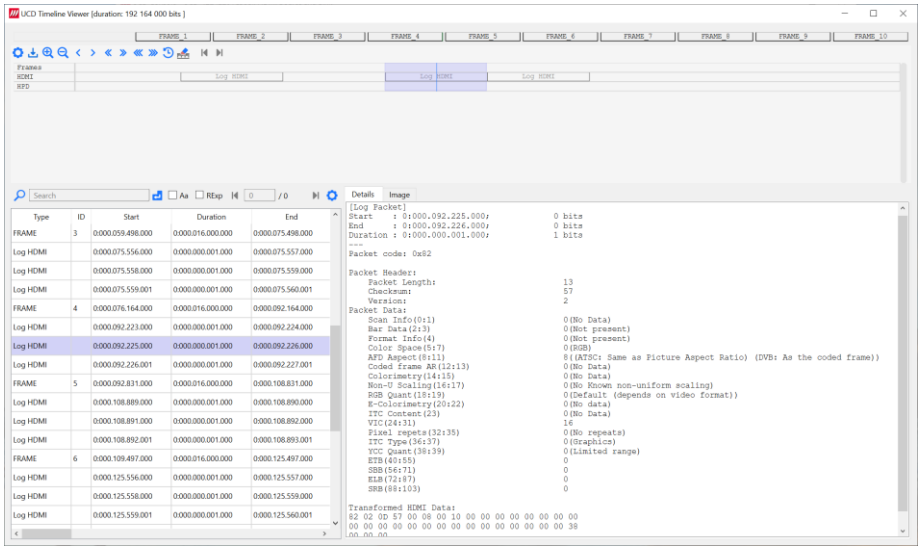
Zooming on the timeline



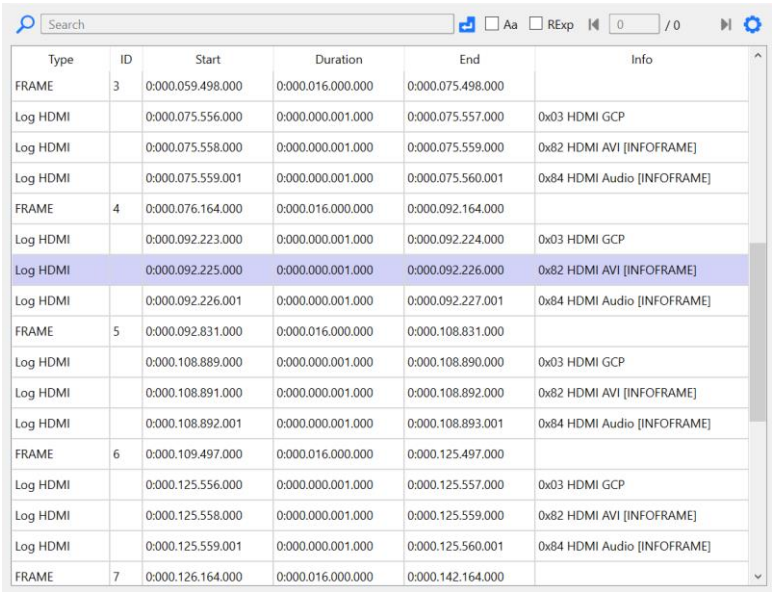
Went the timeline is zoomed out, you can see events as grey lines. When you zoom in you can see the event block. You can zoom in either with the magnifying glass icons or by scrolling with your mouse.



When you double click on event or frame, the corresponding event or frame is selected in the event log and highlighted in purple.



Event Log



Type	ID	Start	Duration	End	Info
FRAME	3	0:000.059.498.000	0:000.016.000.000	0:000.075.498.000	
Log HDMI		0:000.075.556.000	0:000.000.001.000	0:000.075.557.000	0x03 HDMI GCP
Log HDMI		0:000.075.558.000	0:000.000.001.000	0:000.075.559.000	0x82 HDMI AVI [INFOFRAME]
Log HDMI		0:000.075.559.001	0:000.000.001.000	0:000.075.560.001	0x84 HDMI Audio [INFOFRAME]
FRAME	4	0:000.076.164.000	0:000.016.000.000	0:000.092.164.000	
Log HDMI		0:000.092.223.000	0:000.000.001.000	0:000.092.224.000	0x03 HDMI GCP
Log HDMI		0:000.092.225.000	0:000.000.001.000	0:000.092.226.000	0x82 HDMI AVI [INFOFRAME]
Log HDMI		0:000.092.226.001	0:000.000.001.000	0:000.092.227.001	0x84 HDMI Audio [INFOFRAME]
FRAME	5	0:000.092.831.000	0:000.016.000.000	0:000.108.831.000	
Log HDMI		0:000.108.889.000	0:000.000.001.000	0:000.108.890.000	0x03 HDMI GCP
Log HDMI		0:000.108.891.000	0:000.000.001.000	0:000.108.892.000	0x82 HDMI AVI [INFOFRAME]
Log HDMI		0:000.108.892.001	0:000.000.001.000	0:000.108.893.001	0x84 HDMI Audio [INFOFRAME]
FRAME	6	0:000.109.497.000	0:000.016.000.000	0:000.125.497.000	
Log HDMI		0:000.125.556.000	0:000.000.001.000	0:000.125.557.000	0x03 HDMI GCP
Log HDMI		0:000.125.558.000	0:000.000.001.000	0:000.125.559.000	0x82 HDMI AVI [INFOFRAME]
Log HDMI		0:000.125.559.001	0:000.000.001.000	0:000.125.560.001	0x84 HDMI Audio [INFOFRAME]
FRAME	7	0:000.126.164.000	0:000.016.000.000	0:000.142.164.000	

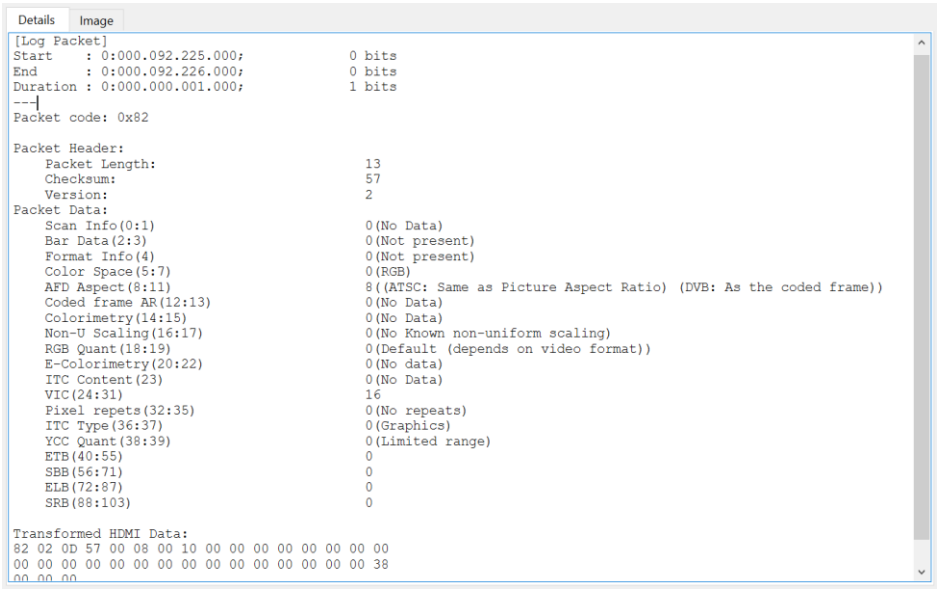
Event log shows all captured events and frames. The following info is presented in the table:

Type	Function
ID	Number of captured frame
Start	Start of the event
Duration	Duration of the event
End	End of the event
Info	Additional information about the event.

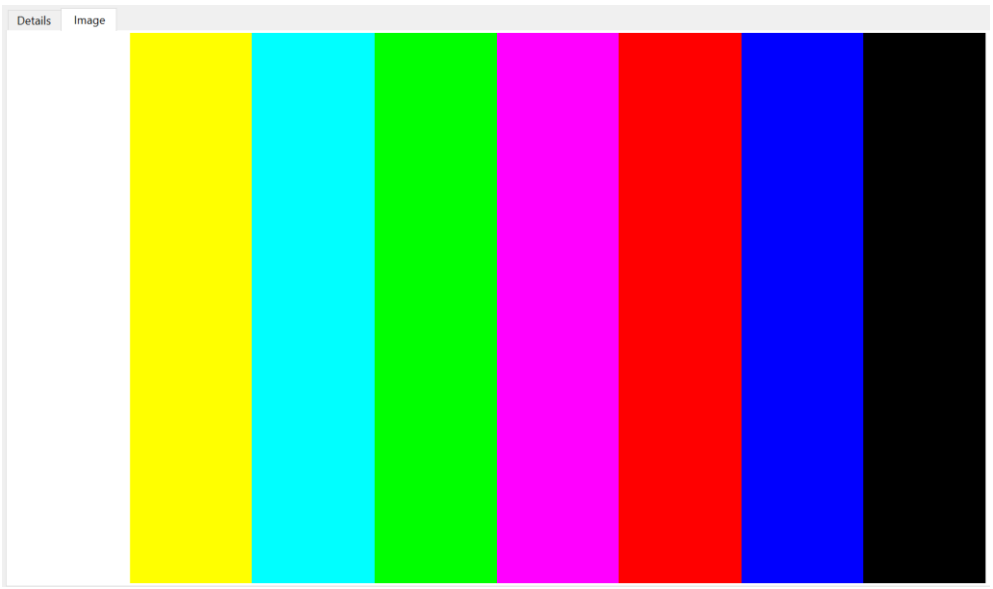
Event Log Tools

Search Search	Search events from the event log. Search results are highlighted in purple.
Apply search filters	Apply filters.
Aa RExp Search filters	Aa filter: Make search case sensitive RExp: Use regular expressions in search
7 / 12 Search results	Shows search results. Move from one search result to another by clicking the arrows.
Configure	Selec which columns are shown in event log.

Details / Image

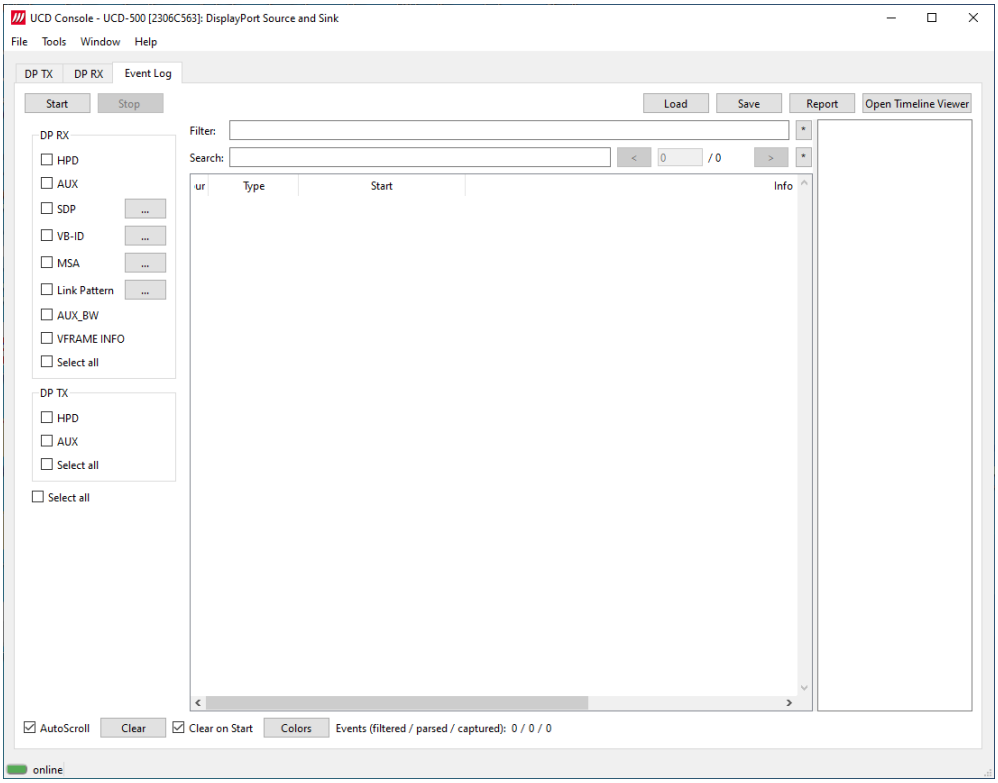


Details tab shows details of the selected event. When the selected event is a frame, the image tab shows the captured frame.



8. 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 DP Alt Mode Sink	HPD, AUX, SDP, VB-ID, MSA, Link Pattern, AUX_BW
DP Source DP Alt Mode Source	HPD, AUX
DP Alt Mode Sink DP Alt Mode Source	PD, LSE

Start:	Starts event logging and stop it by clicking *Stop*.
Save:	Save transactions as Event Log data as binary or as CSV
Load:	Load saved Event Log data
Report:	Store event logs as reports in HTML format to be shared and viewed with any web browser.
Open Timeline Viewer	Open Event Timeline Viewer to inspect the captured data. Refer to chapter seven of this manual for detailed instructions.
AutoScroll:	When selected, the transaction list is automatically 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

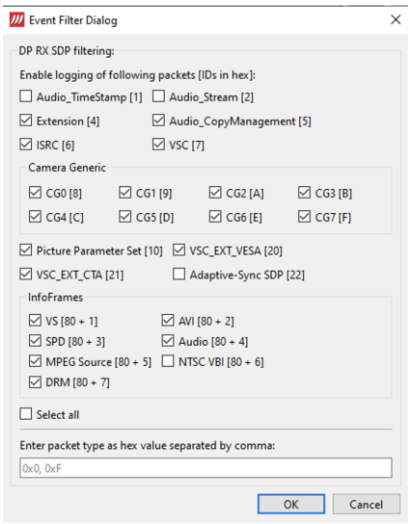
Status and status changes of Hot Plug Detect (HPD) signal, power detection status and cable connection status. HPD Trace, HPD De-assert to HPD Assert interval.

AUX

Log DP AUX Channel transactions and Sideband Messaging.

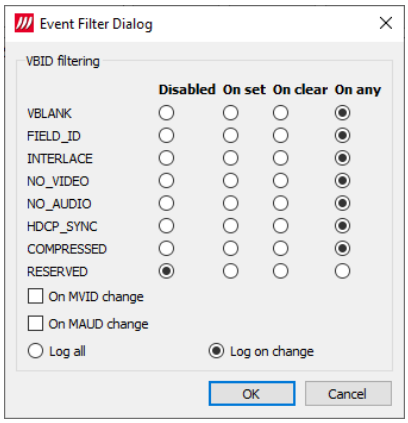
SDP

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



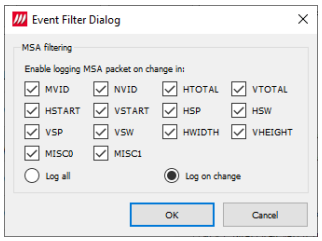
VB-ID

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 packets and the changes on the selected parameter.



VFRAME INFO

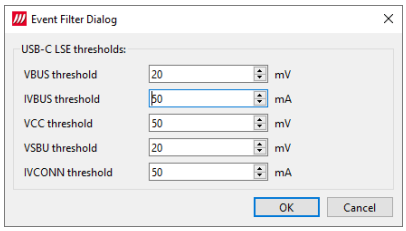
Dimensions of the catured frame measured by the Sink

PD

Log USB-C PD 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.

AUX_BW

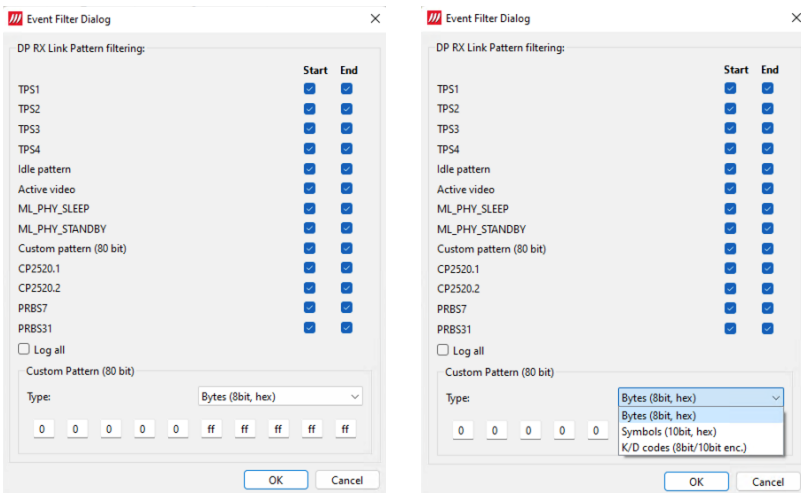
Log AUX_Bitwise transactions as a series of Manchester II codes.

Link Pattern

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

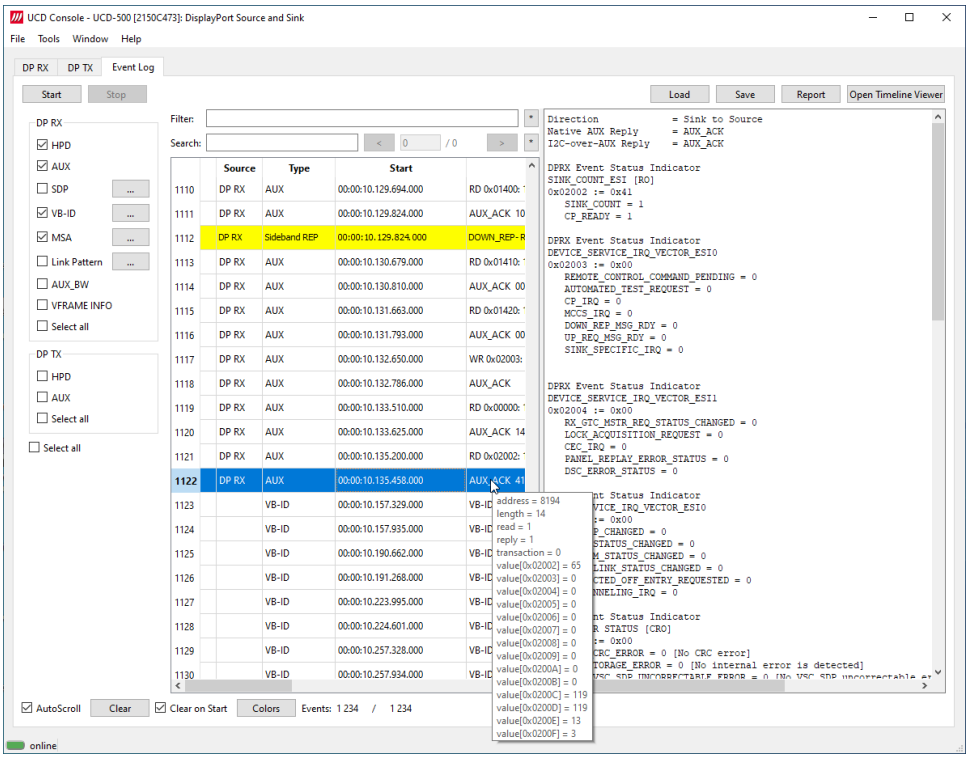
Log link patterns. Event filter dialog sets the type of link patterns that will be captured.

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



Event Transaction List

Transaction data in Transaction List is ordered in columns. Each column provides additional.



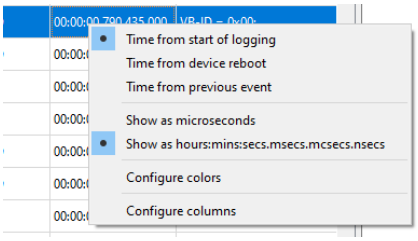
Source:	The communication port: DP RX to DP TX
Type	The logged item: HPD, AUX, SDP, VB-ID, MSA, Link Pattern, AUX_BW, VFRAME INFO
Start:	Each line is identified by its timestamp, marking the instant when an event or error was detected, or when a data transaction got started. The timestamp can be displayed 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. Users 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:

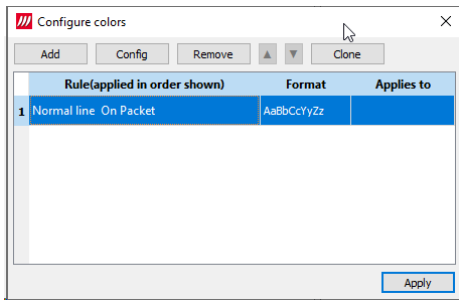
- Time from start of logging.
- Time from previous reboot.
- Time from previous event.

The time can be expressed either:

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

Configure Colors

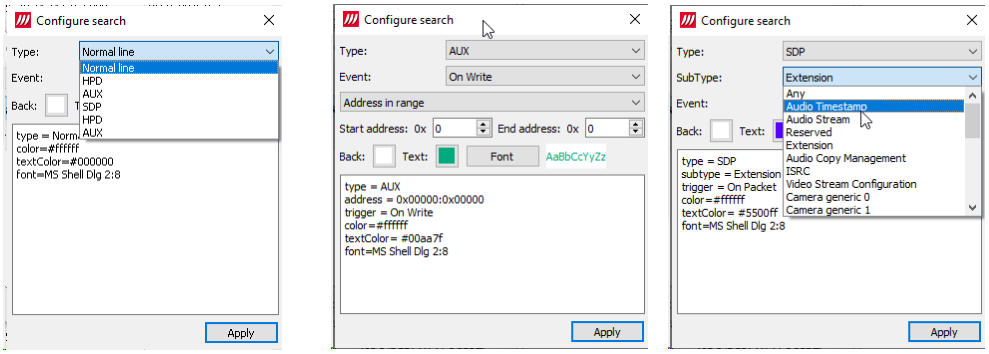
Configure colors dialog allows the user to highlight various types of transactions in the list by changing character color and background color of the transaction line.



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

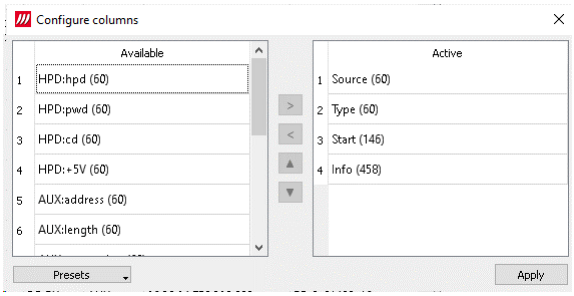
Adding Rules

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

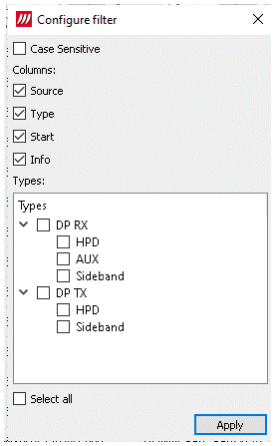
In the dialog there are two columns: *Available* and *Active*. An item from the Available list can be included in the Active column by selecting it and clicking on the right arrow [>] in the middle of the two columns.



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

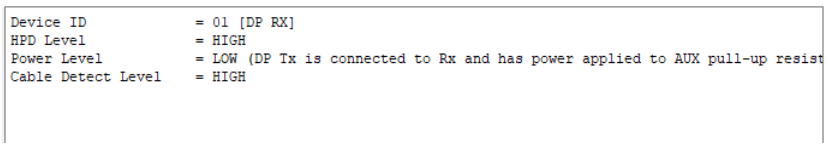
By entering a DPCD address in the Quick Filter field on top of the transaction line, the user can limit the list to show only the reads or writes to this DPCD address.

Event Details

HPD

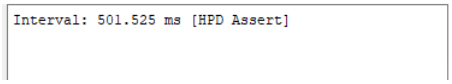
HPD transactions include the following statuses:

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



HPD Trace

HPD De-assert to HPD Assert interval.



AUX

Transaction list includes the following DP AUX Channel transactions. The 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

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 00 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 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 (PB: 00 00 00 00)
```

VB-ID

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

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
```

VFRAME INFO

Measured dimensions of the captured video frame

```
Stream ID           = 0

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

PD

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

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]
```

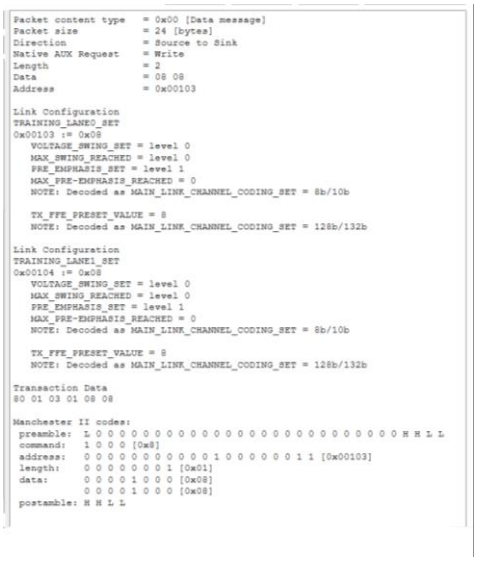
Link Pattern

Status of link pattern detected in which lane.

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

AUX_BW

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



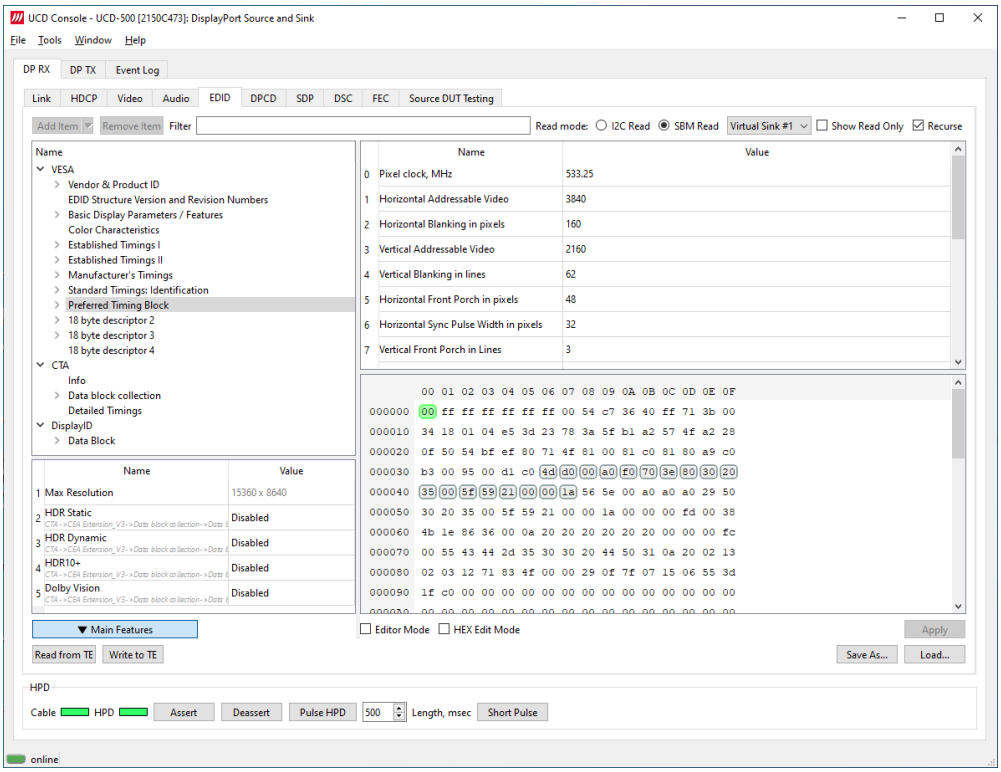
```
Packet content type   = 0x00 [Data message]
Packet size           = 24 [bytes]
Direction             = Source to Sink
Native AUX Request    = Write
Length                = 2
Data                  = 08 08
Address               = 0x00103

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 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 0 0 0 0 1 0 0 0 0 0 0 0 1 1 [0x00103]
 length:    0 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
```

9. EDID EDITOR

The *EDID Editor* main window is divided into four data panels and command buttons below them.

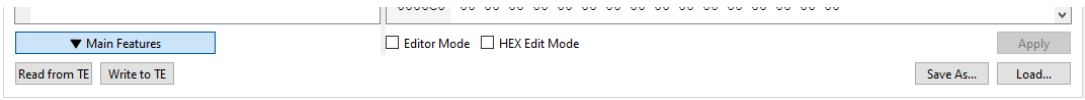
The top left panel shows the currently edited E-EDID blocks in a tree form, the top right panel shows parsed content of the currently selected item, and lower right panel a HEX view of the data block.

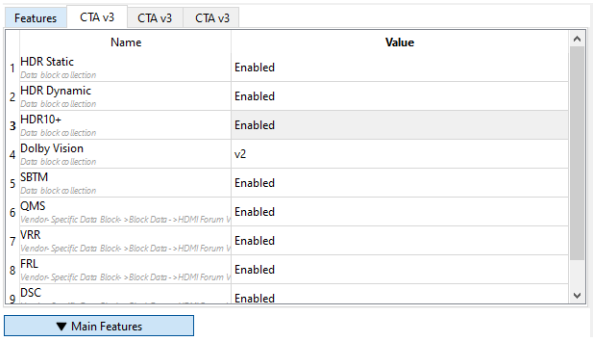
The lower left panel shows a snapshot of key features of the EDID.



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:	The Main features panel gives an overview of items of common interest. For example, whether the sink is capable of HDR, or Dolby Vision, etc. The small grey italic text shows corresponding location in EDID. If you click on the Value cell, the corresponding address in the HEX mode table is shown. 
Read from TE (Analyzer):	Read UCD-5XX local EDID.
Write to TE (Analyzer):	Program UCD-5XX 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. When disabled, all the controls are in read-only mode. For example, for testing purposes it's possible to load invalid EDID and write it to TE without modifications. Once editor mode is enabled, EDID validator corrects errors such as invalid checksums. Modifications are possible in the upper panel with Name – Value pairs.
HEX Edit Mode:	Enable editing EDID content in HEX mode table. When enabled, modifications are possible in the lower panel with HEX values. Click the Apply button to validate the changes and copy them to the upper panel.
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

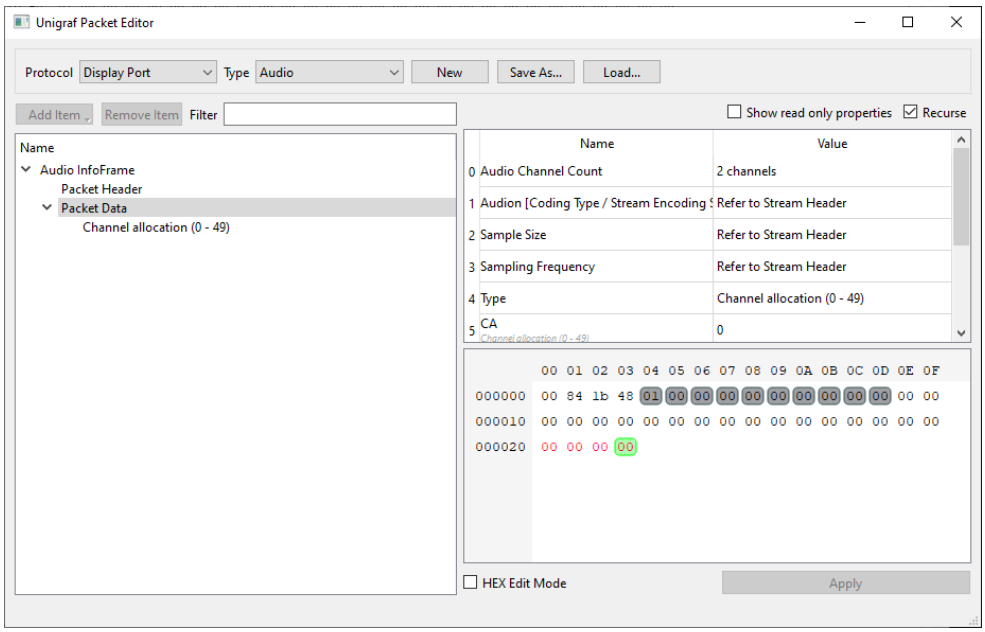
Editing an EDID block is very straightforward, but there are some special cases where the user must know how to accomplish certain types of tasks.

- 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.

10. 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.

11. PATTERN EDITOR

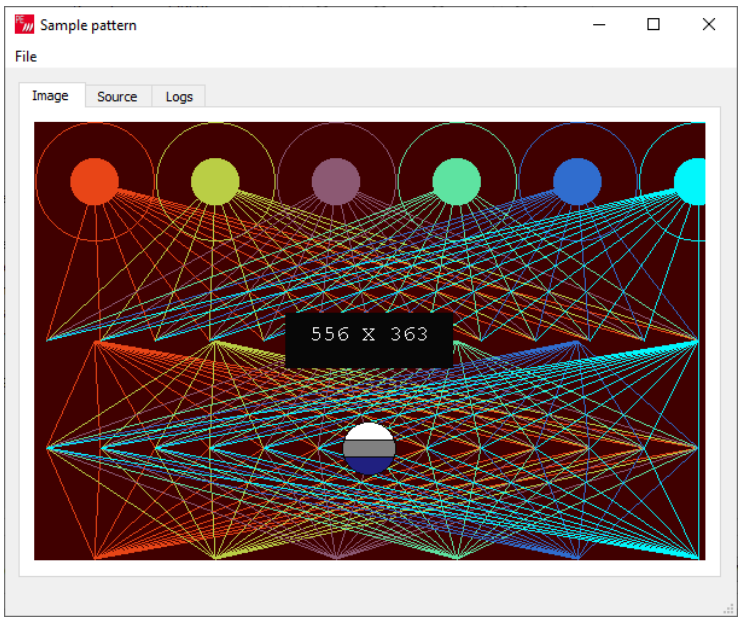
Pattern Editor is a tool for editing and debugging Unigraf Custom VTP Pattern scripts.

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:

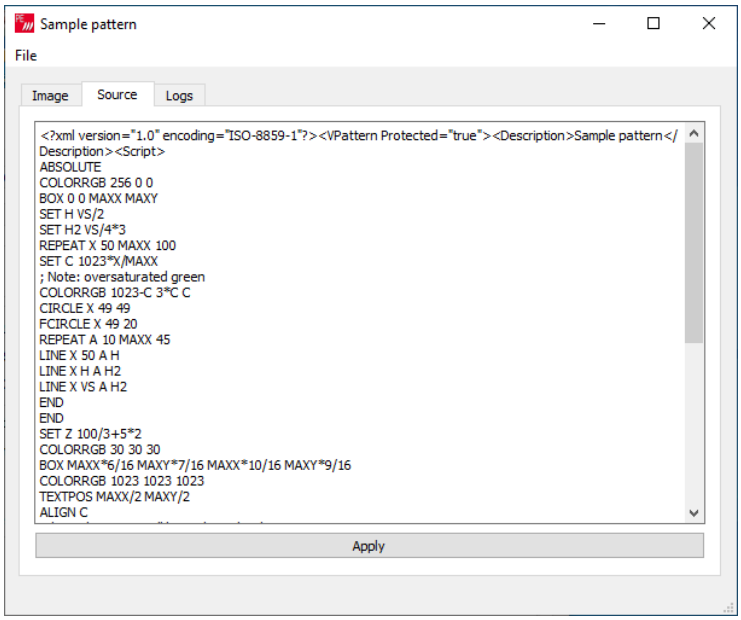
Image Tab

Monitoring the rendering of the VTP pattern script.



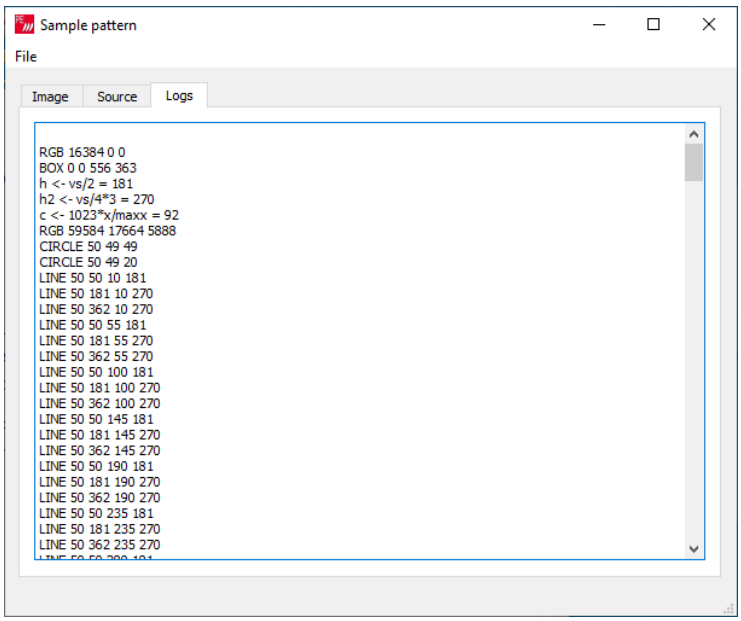
Source Tab

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.



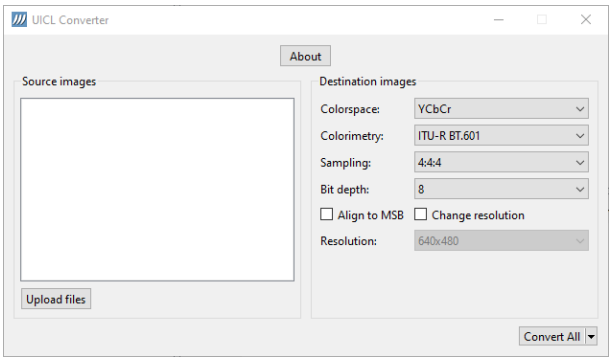
Saving and Recalling the Script

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

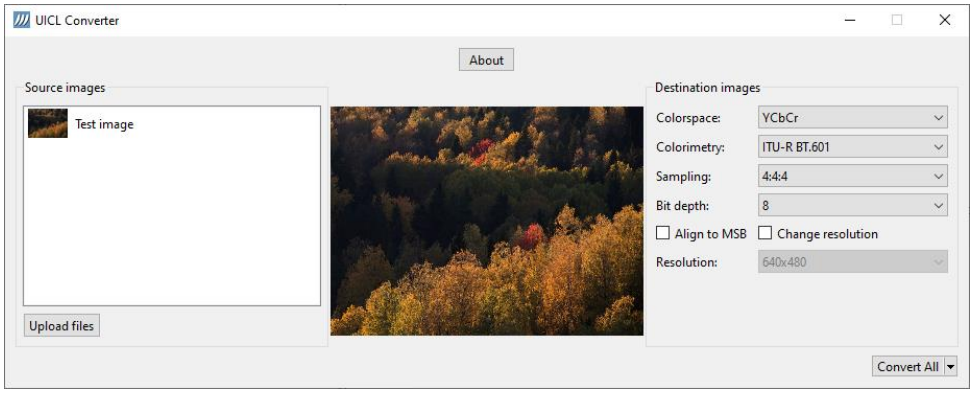
Open:	Open a VTP language script from PC
Save Script:	Save the script currently in Source tab to PC
Save Image:	Save a rendered pattern in PNG, BMP, JPG or PPM format
Select Save Resolution:	Select from six common resolutions the size in which the pattern script will be rendered when saved.

12. 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. Open the image converter from UCD Console's menu **Tools > Image Converter.**



Click **Upload files** to load the Source image.



Colorspace	YCbCr, RGB
Colorimetry	ITU-R BT.601, ITU-R BT.709, ITU-R BT2020
Sampling	4:4:4, 4:2:2, 4:2:0
Bit depth	8, 10, 12, 16
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).
Change resolution	Select a resolution for the destination image from the pre-defined list
Covert All	Convert all uploaded images to destination format and save them in the same folder as the source images.
Covert All and save to the custom folder	Convert all uploaded images to destination format and save to the selected folder.

File name for the destination image is of form:

Test image[1920x1080_yuv444_8bpc_BT601_Packed_YCbCr_LSB]

APPENDIX A: PRODUCT SPECIFICATION

UCD-500

Input	DisplayPort: DP 2.0/2.1 capable (DP In) (10 Gbps link rate maximum) USB-C: PD 3.0 compliant (USB-C In) (20 Gbps link rate maximum)
Output	DisplayPort: DP 2.1 compliant (DP Out) (10 Gbps link rate maximum) USB-C: PD 3.0 compliant (USB-C Out) (20 Gbps link rate maximum)
Max video mode	7680 × 4320 p60 input and output. 15360 × 8640 p60 input and output with DSC.
Audio	Source and receive LPCM, 2 – 8 channels, 44.1 to 192 kHz. Source compressed formats using TSI
Content Protection	HDCP 2.3 supported
DSC Capability	DSC sink, with off-line decompression DSC source using pre-compressed content
Additional features	Playback function
Computer interface	USB 3.0
Software	Windows, MacOS, Linux UCD Console application, TSI SDK.
Power supply	AC/DC Power supply (100 to 240 Vac 50/60 Hz input, +24 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	331 mm x 197 mm x 66 mm
Weight	1.9kg

UCD-500 Gen2

Input	DisplayPort: DP 2.1 compliant (DP In) (20 Gbps link rate) USB-C: PD 3.0 compliant (USB-C In) (20 Gbps link rate)
Output	DisplayPort: DP 2.1 compliant (DP Out) (20 Gbps link rate) USB-C: PD 3.0 compliant (USB-C Out) (20 Gbps link rate)
Max video mode	7680 × 4320 p60 input and output. 15360 × 8640 p60 input and output with DSC
Audio	Source and receive LPCM, 2 – 8 channels, 44.1 to 192 kHz. Source compressed formats using TSI
Content Protection	HDCP 2.3 supported
DSC Capability	DSC sink, with off-line decompression DSC source using pre-compressed content
Additional features	Playback function
Computer interface	USB 3.0
Software	Windows, MacOS, Linux UCD Console application, TSI SDK.
Power supply	AC/DC Power supply (100 to 240 Vac 50/60 Hz input, +24 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	331 mm x 197 mm x 66 mm
Weight	1.9kg

APPENDIX B: PRODUCT FEATURES

Input / Output Role	UCD-5XX Default	DP 1.4a LL CTS	DP 2.1 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	DP 2.1 LTTPR CTS for Source DUT	TSI Basic
DP Reference Sink										
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 2 streams)	●									▲
FEC Feature	●									▲
DSC Decoder, DSC Control	●									▲
Adaptive-Sync Feature**	●									▲
DPCD editor	●									
Monitor InfoFrame Status (SDP)	●									▲
EDID read and write	●									▲
EDID / DisplayID Editor	●									
HDCP 2.3 status and control	●									▲
Event Log, AUX Analyzer	●									▲
Source DUT Testing (Link and CRC test)	●									▲
DP 1.4 LL, Audio, FEC CTS for testing Source DUT		●								
DP 2.1 LL CTS for testing Source DUT			●							
DP 1.4 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								●		
DP 2.1 LTTPR CTS for testing Source DUT									●	

**) Adaptive-Sync feature is currently limited to Stream 0. Adaptive-Sync CTS is currently limited to 8b/10b link coding and SST.

Input /Output Role	UCD-5XX Default	DP 1.4a LL CTS	DP 2.1 LL CTS	DP 1.4a DSC CTS	DisplayID / EDID CTS	Adaptive-Sync CTS	HDCP 2.3 CTS Sink DUT	HDCP 2.3 CTS for Sink, Source & Repeater DUT	DP 2.1 LTTPR CTS for Sink DUT	TSI Basic
DP Reference Source										
Video pattern generator	●									▲
Audio generator	●									▲
Link status	●									▲
Link control	●									▲
HPD status	●									▲
EDID read and write	●									▲
EDID / DisplayID Editor	●									
MST Feature (up to 2 streams)	●									▲
FEC Feature	●									▲
DSC Encoder	●									▲
Adaptive-Sync Feature**	●									▲
DPCD editor	●									
LTTPR Feature	●									▲
HDCP 2.3 status and control	●									▲
Event Log, AUX Analyzer	●									
Sink DUT Testing	●									
DP 1.4 LL, Audio and FEC CTS for testing Sink DUT		●								
DP 2.1 LL CTS for testing Sink DUT			●							
DP 1.4 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								●		
DP 2.1 LTTPR CTS for testing Sink DUT									●	

**) Adaptive-Sync feature is currently limited to Stream 0. Adaptive-Sync CTS is currently limited to 8b/10b link coding and SST.

UCD-5XX Product Options

Hardware Test Tool	P/N
UCD-500 Gen2	066710
HDCP 2.3 CTS Testing	
HDCP 2.3 CTS for testing Source DUT on DP	MT6634
HDCP 2.3 CTS for testing Sink DUT on DP	MT6636
HDCP 2.3 CTS for testing Repeater DUT on DP	MT6638
DP 2.1 CTS Testing	
DP 2.1 LL CTS for testing Source DUT	MT6662
DP 2.1 LL CTS for testing Sink DUT	MT6660
DP 2.1 DSC CTS for testing Source DUT	MT6656
DP 2.1 DSC CTS for testing Sink DUT	MT6657
DP 1.4a CTS Testing	
DP 1.4a LL CTS for testing Source DUT	MT6637
DP 1.4a LL CTS for testing Sink DUT	MT6635
DP 1.4a DSC CTS for testing Source DUT	MT6642
DP 1.4a DSC CTS for testing Sink DUT	MT6643
DisplayID / EDID CTS testing	
DP 2.1 DisplayID / EDID CTS for testing Source DUT	MT6646
DP 2.1 DisplayID / EDID CTS for testing Sink DUT	MT6647
Adaptive Sync CTS Testing	
DP 2.1 Adaptive-Sync CTS for testing Source DUT	MT6648
DP 2.1 Adaptive-Sync CTS for testing Sink DUT	MT6649
LTTPR CTS Testing	
DP 2.1 LTTPR CTS for testing Source DUT	MT6680
DP 2.1 LTTPR CTS for testing Sink DUT	MT6679
DP 2.1 LTTPR CTS for testing LTTPR Device	MT6682

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 9)	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 16)	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 23)	1280	768	1664	798	320	27	128	7	60	79,67
DMT 1280 × 800 @ 60 Hz (ID 27)	1280	800	1440	823	112	20	32	6	60	71,11
DMT 1280 × 800 @ 60 Hz (ID 28)	1280	800	1680	831	328	28	128	6	60	83,76
DMT 1280 × 960 @ 60 Hz (ID 32)	1280	960	1800	1000	424	39	112	3	60	108,00
DMT 1280 × 1024 @ 60 Hz (ID 35)	1280	1024	1688	1066	360	41	112	3	60	107,96
DMT 1360 × 768 @ 60 Hz (ID 39)	1360	768	1792	795	368	24	112	6	60	85,48
DMT 1400 × 1050 @ 60 Hz (ID 41)	1400	1050	1560	1080	112	27	32	4	60	101,09
DMT 1400 × 1050 @ 60 Hz (ID 42)	1400	1050	1864	1089	376	36	144	4	60	121,79

*) CVT: Coordinated Video Timings (CVT v2.0)
DMT: VESA and Industry Standards and Guidelines for Computer Display Monitor Timings
CTA: A DTV Profile for Uncompressed High Speed Digital Interfaces (CTA-861-H)

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 51)	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 57)	1680	1050	1840	1080	112	27	32	6	60	119,23
DMT 1680 × 1050 @ 60 Hz (ID 58)	1680	1050	2240	1089	456	36	176	6	60	146,36
DMT 1792 × 1344 @ 60 Hz (ID 62)	1792	1344	2448	1394	528	49	200	3	60	204,75
DMT 1856 × 1392 @ 60 Hz (ID 65)	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 82)	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

*) CVT: Coordinated Video Timings (CVT v2.0)
DMT: VESA and Industry Standards and Guidelines for Computer Display Monitor Timings
CTA: A DTV Profile for Uncompressed High Speed Digital Interfaces (CTA-861-H)

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 69)	1920	1200	2592	1245	536	42	200	6	60	193,62
DMT 1920 × 1440 @ 60 Hz (ID 73)	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 77)	2560	1600	3504	1658	752	55	280	6	60	348,58
DMT 2560 × 1600 @ 60 Hz (ID 76)	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 @ 144 Hz [RB3]	3840	2160	4000	2314	152	14	32	8	144	1333,33
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

*) CVT: Coordinated Video Timings (CVT v2.0)
DMT: VESA and Industry Standards and Guidelines for Computer Display Monitor Timings
CTA: A DTV Profile for Uncompressed High Speed Digital Interfaces (CTA-861-H)

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
CVT 4096 × 2160 @ 144 Hz [RB3]	4096	2160	4256	2314	152	14	32	8	144	1418,66
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
CVT 5120 × 2160 @ 120 Hz [RB1]	5120	2160	5280	2287	112	124	32	10	120	1449,04
CVT 5120 × 2160 @ 120 Hz [RB3]	5120	2160	5280	2287	152	14	32	8	120	1449,55
CVT 5120 × 2160 @ 120 Hz [RB2]	5120	2160	5200	2287	72	14	32	8	120	1427,09
CTA 5120 × 2160 @ 120 Hz (VIC 193)	5120	2160	5500	2250	216	82	88	10	120	1485,00
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 [RB1]	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 [RB1]	7680	4320	7760	4443	72	14	32	8	60	2068,66
CVT 7680 × 4320 @ 100 Hz [RB1]	7680	4320	7760	4529	72	14	32	8	100	3514,50
CVT 7680 × 4320 @ 60 Hz	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

*) CVT: Coordinated Video Timings (CVT v2.0)
DMT: VESA and Industry Standards and Guidelines for Computer Display Monitor Timings
CTA: A DTV Profile for Uncompressed High Speed Digital Interfaces (CTA-861-H)

Description*	HA	VA	HT	VT	HST	VST	HSYN	VSYN	FR	Pixel Clock (MHz)
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 @ 60 Hz (VIC 199)	7680	4320	9000	4400	768	64	176	20	60	2376,00
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
CTA 10240 × 4320 @ 24 Hz (VIC 210)	10240	4320	12500	4950	768	614	176	20	24	1485,00
CTA 10240 × 4320 @ 25 Hz (VIC 211)	10240	4320	13500	4400	768	64	176	20	25	1485,00
CTA 10240 × 4320 @ 30 Hz (VIC 212)	10240	4320	11000	4500	472	164	176	20	30	1485,00
CTA 10240 × 4320 @ 48 Hz (VIC 213)	10240	4320	12500	4950	768	614	176	20	48	2970,00
CTA 10240 × 4320 @ 50 Hz (VIC 214)	10240	4320	13500	4400	768	64	176	20	50	2970,00
CTA 10240 × 4320 @ 60 Hz (VIC 215)	10240	4320	11000	4500	472	164	176	20	60	2970,00
CTA 10240 × 4320 @ 100 Hz (VIC 216)	10240	4320	13200	4500	768	164	176	20	100	5940,00
CTA 10240 × 4320 @ 120 Hz (VIC 217)	10240	4320	11000	4500	472	164	176	20	120	5940,00
CTA 15360 x 8640 @ 30Hz [RB1]	15360	8640	15520	8761	112	118	32	5	30	4079,00
CTA 15360 x 8640 @ 30Hz [RB2]	15360	8640	15440	8761	72	14	32	8	30	4058,10
CTA 15360 x 8640 @ 30Hz [RB3]	15360	8640	15520	8761	152	14	32	8	30	4080,55

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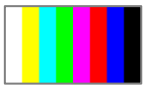
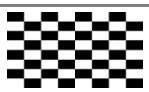
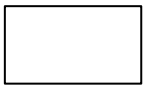
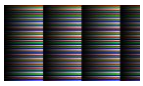
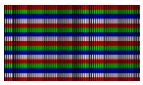
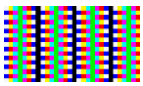
APPENDIX D: PREDEFINED PATTERNS

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 crosshatches, 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 LL CTS*	DP 2.1 DSC CTS	DP 2.1 DisplayID & EDID CTS*	DP 2.1 Adaptive-Sync CTS DUT*	DP 2.1 LTTPR CTS	HDCP 2.3 CTS*
Audio Test	Validate audio signal frequency and glitch-free audio reproduction	●								
CRC Video Tests	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	●								
DP 1.4a Link Layer CTS	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, 4.4.4.2 – 4.4.4.6, 4.5.1.1 – 4.5.1.2		●							
DP 1.4a DSC CTS	4.6.1.1 – 4.6.1.9			●						
DP 2.1 Link Layer CTS	4.2.1.1 – 4.2.1.5, 4.2.2.1 – 4.2.2.2, 4.2.2.4 – 4.2.2.5, 4.2.2.7 – 4.2.2.8, 4.2.2.10, 4.2.2.11 – 4.2.2.12, 4.3.1.1 – 4.3.1.24, 4.3.2.1 – 4.3.2.5, 4.3.3.1 – 4.3.3.2, 4.4.1.1-4.4.1.6, 4.4.2.1 – 4.4.2.2				●					
DP 2.1 DSC CTS	4.6.1.1 – 4.6.1.9					●				
DisplayID-EDID CTS***	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						●			
Adaptive-Sync CTS****	4.8.1.1 – 4.8.1.2, 4.8.2.1 – 4.8.2.3							●		
DP 2.1 LTTPR CTS	4.9.1.1 – 4.9.1.21								●	
HDCP 2.3 CTS 1A Test Set	HDCP2.3 CTS 1A-01 – HDCP2.3 CTS 1A-12									●
HDCP 2.3 CTS 1B Test Set	HDCP2.3 CTS 1B-01 – HDCP2.3 CTS 1B-10									●
Link Config Tests	Link Training at All Supported Lane Counts and Link Rates	●								
Pixel Level Video Tests	Compare video frame sequence with a single reference	●								

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

***) Unigraf UCD-400 was used by VESA for TE correlation of the tests

****) Adaptive-Sync CTS is currently limited to 8b/10b link coding and SST mode. Unigraf UCD-400 was used by VESA for TE correlation of the tests.

Sink DUT Testing		Default	DP 1.4a LL CTS*	DP 1.4a DSC CTS*	DP 2.1 LL CTS*	DP 2.1 DSC CTS	DP 2.1 DisplayID & EDID CTS*	DP 21 Adaptive-Sync CTS DUT*	DP 2.1 LTTPR CTS*	HDCP 2.3 CTS*
DP 1.4 Link Layer CTS	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 1.4 DSC CTS	5.6.1.1 – 5.6.1.26, 5.6.2.1 – 5.6.2.14			●						
DP 2.1 Link Layer CTS	5.2.1.8 – 5.2.1.12, 5.2.2.1 – 5.2.2.9, 5.3.1.1 – 5.3.1.15, 5.3.2.1 – 5.3.2.2, 5.4.1.1 – 5.4.1.8, 5.4.2.1 – 5.4.2.2, 5.4.5.1 - 5.4.5.5, 5.5.1.1 – 5.5.1.7				●					
DP 2.1 DSC CTS	5.6.1.1 – 5.6.1.26, 5.6.2.1 – 5.6.2.16, 5.6.3.1 – 5.6.3.6					●				
DisplayID-EDID CTS***	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 – 5.7.3.4, 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						●			
Adaptive-Sync CTS****	5.8.1.1 – 5.8.1.3							●		
DP 2.1 LTTPR CTS	5.9.1.1 – 5.9.1.15								●	
HDCP 2.3 CTS 2C Test Set	HDCP2.3 CTS 2C-01 – HDCP2.3 CTS 2C-05									●

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

***) Unigraf UCD-400 was used by VESA for TE correlation of the tests

****) Adaptive-Sync CTS is currently limited to 8b/10b link coding and SST mode. Unigraf UCD-400 was used by VESA for TE correlation of the tests.

LTTPR and DP Tunnel Device Testing		Default	DP 2.1 LTTPR CTS for testing LTTPR Device
DP 2.1 LTTPR CTS for testing LTTPR Device	7.1.1.1 – 7.1.1.9, 7.1.2.1 – 7.1.2.9, 7.1.3.1-7.1.3.8, 7.1.4.1-7.1.4.8, 7.1.5.1-7.1.5.6, 7.1.6.1-7.1.6.7, 7.1.7.1-7.1.7.7, 7.1.8.1, 7.1.9.1, 7.1.10.1		●

Repeater DUT Testing		Default	HDCP 2.3 CTS*
HDCP 2.3 CTS 3A Test Set	HDCP2.3 CTS 3A-01 – HDCP2.3 CTS 3A-06		●
HDCP 2.3 CTS 3B Test Set	HDCP2.3 CTS 3B-01 – HDCP2.3 CTS 3B-07		●
HDCP 2.3 CTS 3C Test Set	HDCP2.3 CTS 3C-01 – HDCP2.3 CTS 3C-25		●

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

Compliance Tests

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-500.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.

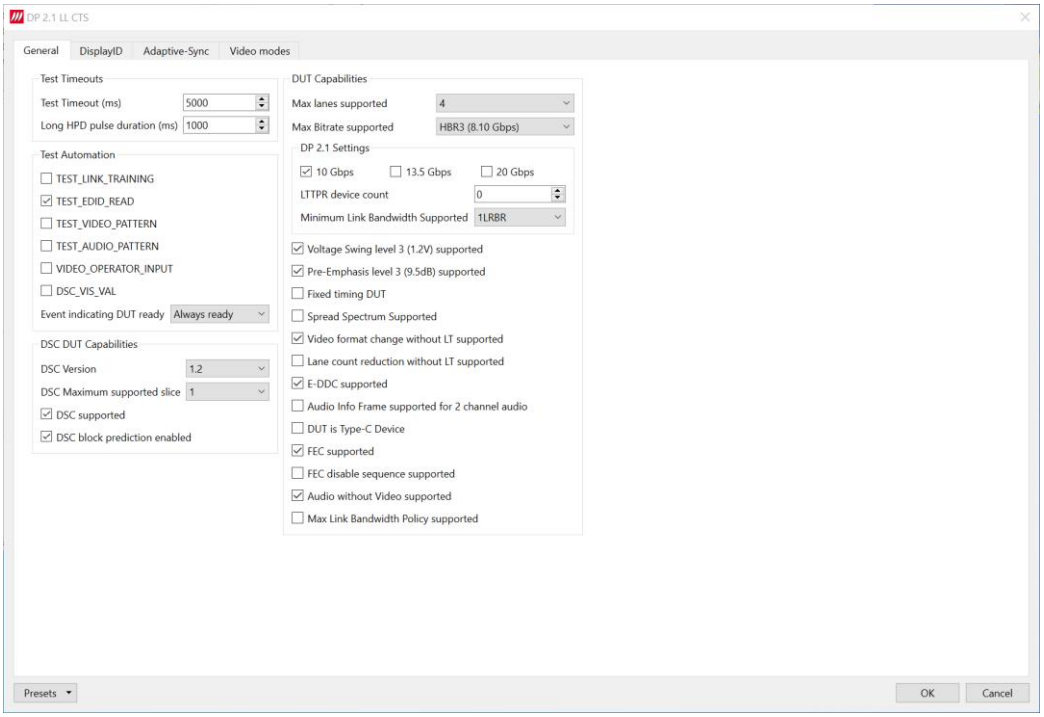
Compliance tests (CTS Tests) are part of tests included in **Source DUT Testing** tab of **DP RX** and **Sink DUT Testing** tab of **DP TX**.

The tests cases are divided into 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

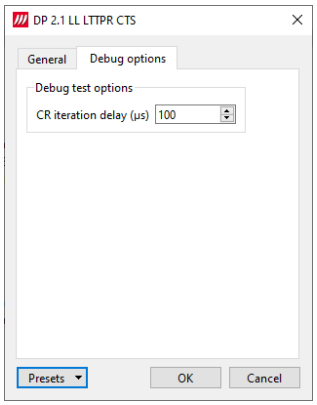
Before running the tests, capabilities of the DUT have to be defined for the test engine. Each test category has its dedicated test parameter dialog. Click **Configure** in *Source DUT Testing* or *Sink DUT Testing* tab to open the parameter dialog.

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



DP 2.1 LL LTTPR CTS CR iteration delay

Debug options allows users to manually set the CR iteration delay. To access debug options to set the CR iteration delay, select a test from DP 2.1 LL LTTPR CTS test set and click **Configure**.



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

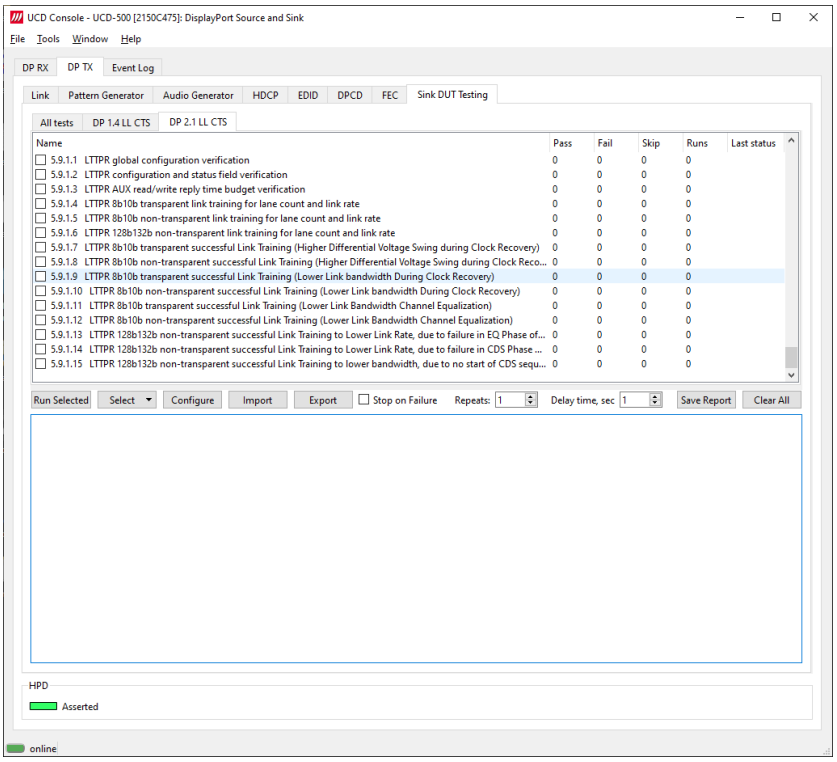
In Tools > Options menu you can define DSC Work folder and DSC test content directory.

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-5XX firmware implements the test according to the test specification.

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



Select the tests for execution by clicking the corresponding row. 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.

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 All	Clear the test log and the results matrix

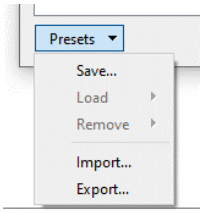
Saving Test Parameters

Test parameters can be saved in various ways.

- Export parameters in *Sink/Source DUT Testing* tab to a *.td file for later use in UCD Console or with TSI scripting or sharing.
- Export parameters in *Sink/Source 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 Console. Please find a description below.

Presets

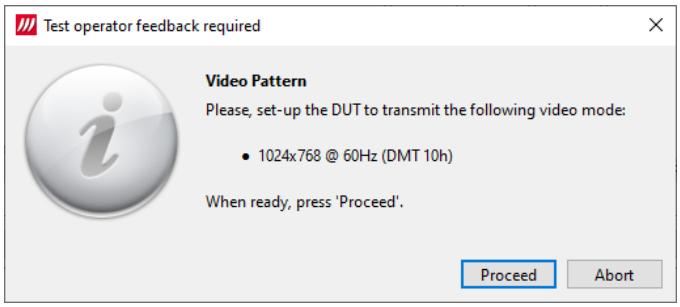
In all *Configure* dialogs the selected parameters can be saved as Presets. Please click **Presets…** to save or recall a configuration. Click Save first to assign the configuration a name, and after that you can e.g. Export it to a file.

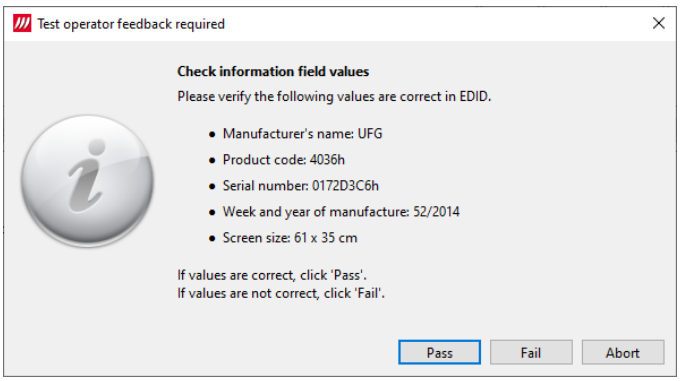


Operator Feedback

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.

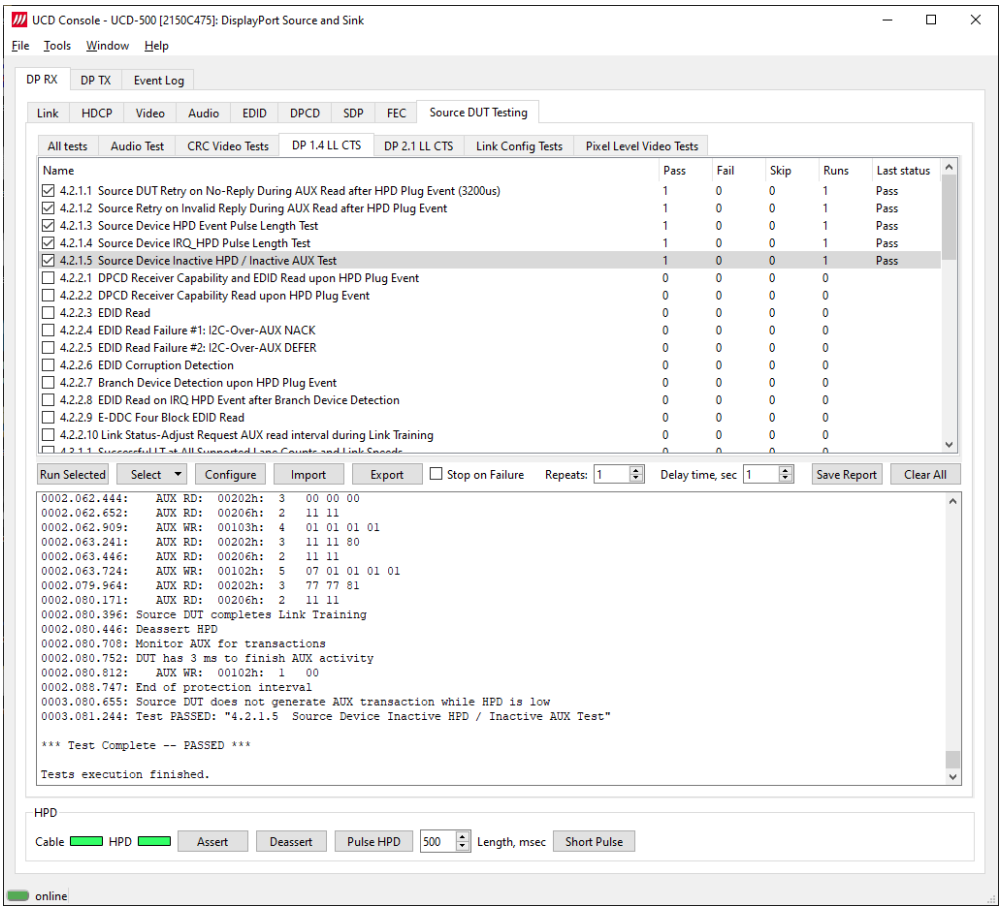
Clicking “Abort” stops execution of the test.





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.



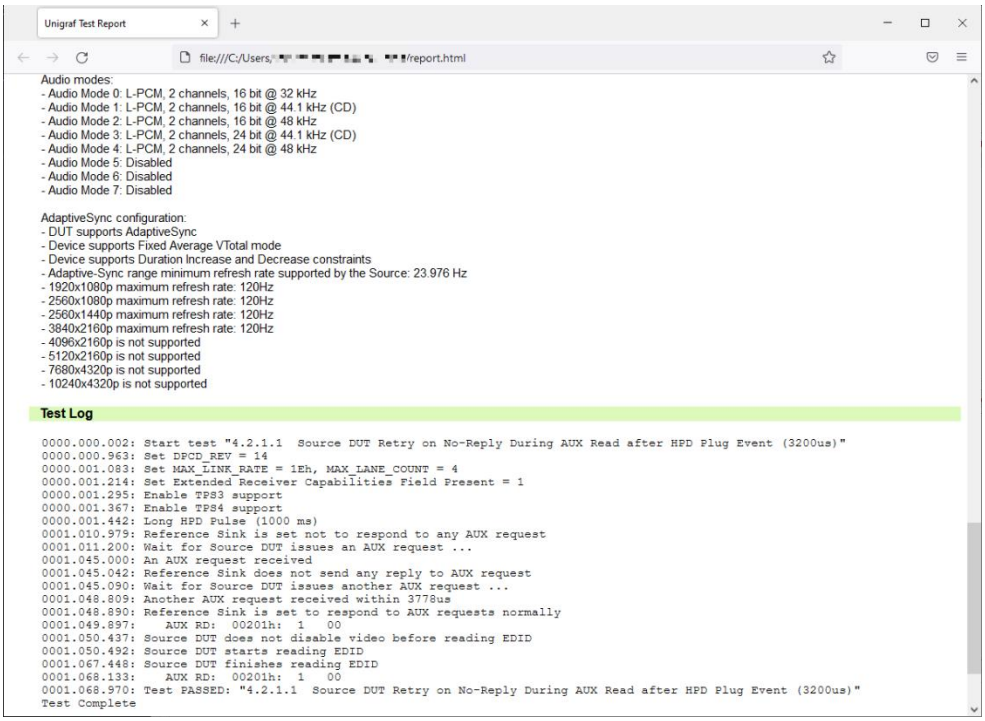
At the completion of each test the result of the test is indicated in the matrix on the right hand side of the test panel. For each test the matrix lists the number of occurrences of each result and the number of tries performed.

Test Report

Results of the test can be saved as a report in HTML format.

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, and individual tests.



DUT Testing Options

Please refer to Tools > Options earlier in this manual for control on including system date and time in the beginning of each event line in created reports.

Audio Test Set

Validate audio signal frequency and glitch-free audio reproduction

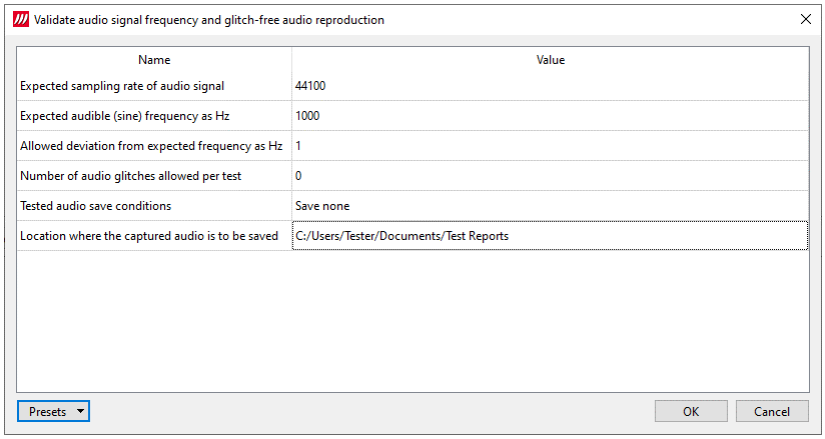
Perform frequency check on the digital audio content and verify the content to be glitch-free. This test assumes that a pure sine-wave audio signal content is being transmitted to the test equipment.

The test will first capture a 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.

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

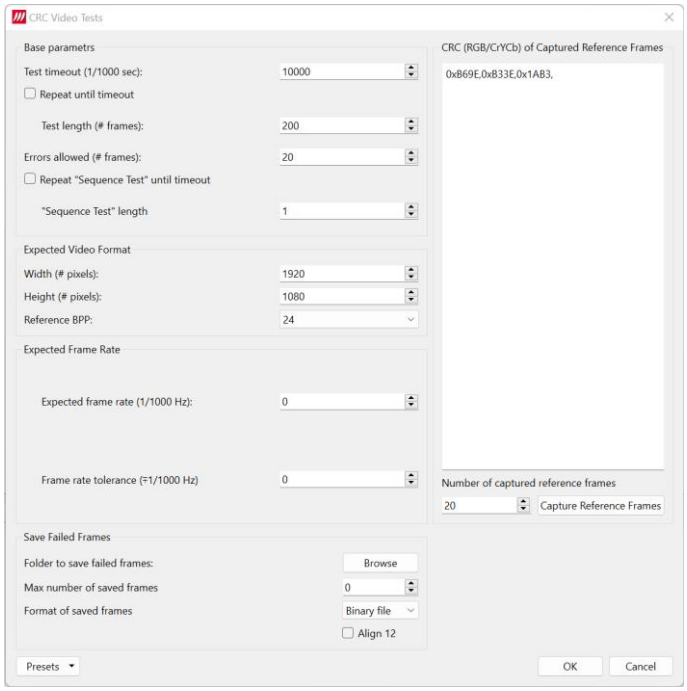
- Expected sampling rate of audio signal (default 44 100 s/sec)
- Expected audible (sine) frequency in Hz (default 1000 Hz)
- Allowed deviation from expected frequency in Hz (default 1 Hz)
- Number of audio glitches allowed per test (default 0)
- Tested audio save conditions (Save none / Save failed / Save all)

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

CRC Based Video Test Set

Role:	Product:
DP Reference Sink (DP RX)	UCD-500 and Gen 2

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)

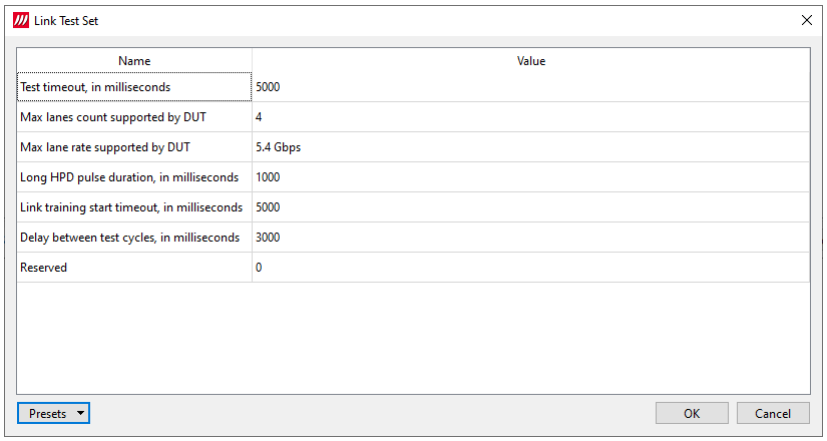
Note: Please note that in order for the TE to maintain the sequence, all CRCs in the reference frame list should be different.

Link Config Tests

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.



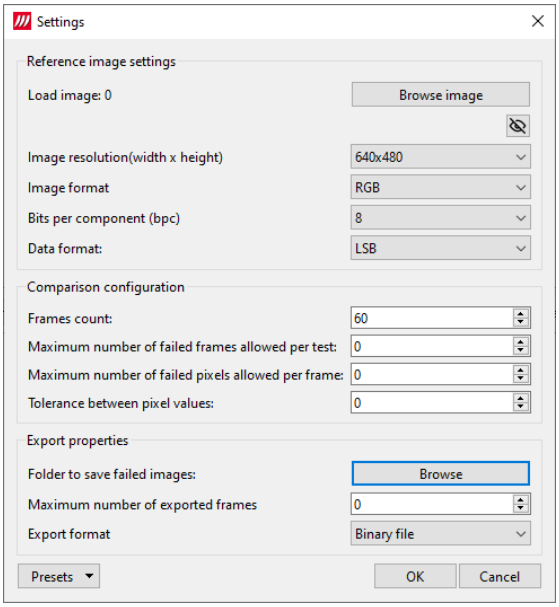
Parameters in use

- 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)

Pixel Level Video Tests

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.

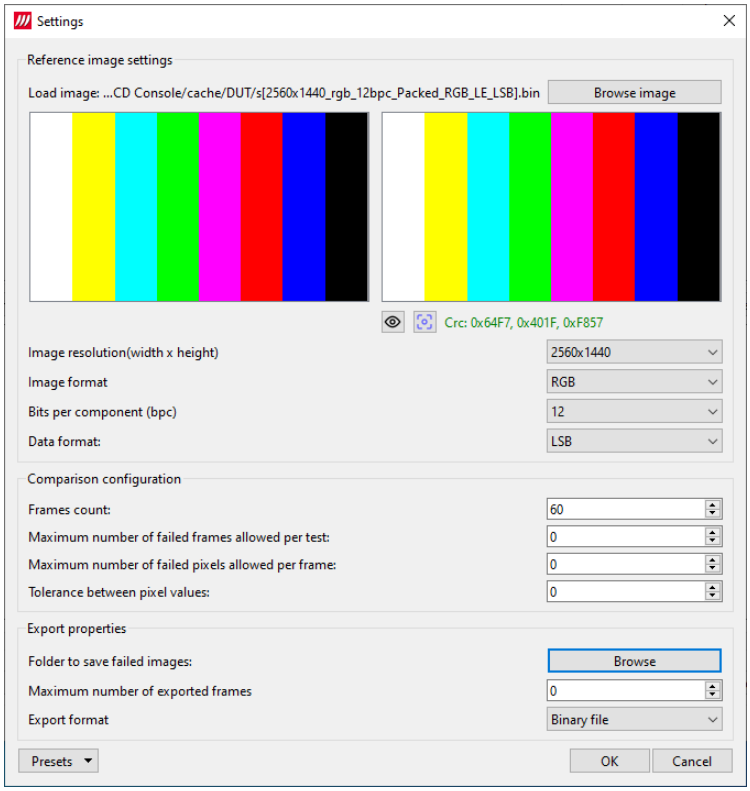
- The color component values of each pixel in the captured frame is compared to the corresponding pixels in the reference image.
- If the difference is larger than the provided tolerance, the pixel is considered failed.
- If the number of failed pixels in a frame is larger than the provided tolerance, 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:	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 saved to PC
Export format:	Format of saved failed frames: Binary file, PPM image, BMP image
Presets:	Store and recall settings

Capturing Reference Image

Users 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, the stability of the video is verified with a CRC stability check. Captured CRC can also be verified by the user.

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 provides 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:

- VTP is a text-based, interpreted language.
- Commands, variables, and constant names are not case-sensitive.
- All text at the right of a semicolon (‘;’) is treated as comment.
- All strings are delimited by quotation marks (“a string”). Quote and backslash characters must be prefixed by the backslash symbols (“ a quote \” and “ a backslash \\”).
- 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 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
```

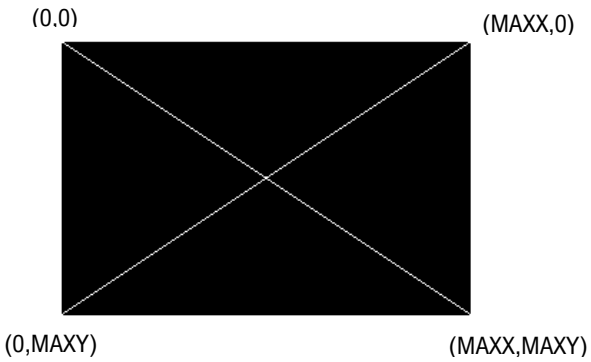
Draws a line from point (x1,y1) to point (x2,y2).

Example:

You can draw a white diagonal cross using either ABSOLUTE or 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

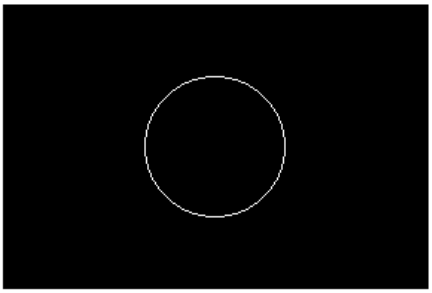
```
Syntax: CIRCLE x y r
```

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:

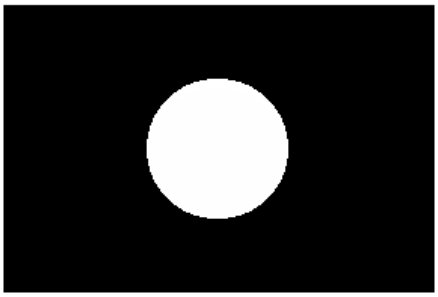


FCIRCLE

```
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
```

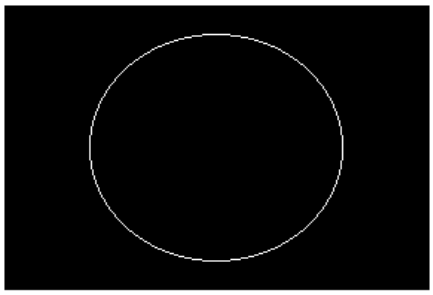
Draws an ellipse with center point at (x,y), horizontal radius hr and vertical radius vr.

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

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 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 always have positive integers or zero value. When an expression is evaluated 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 RECOVERY

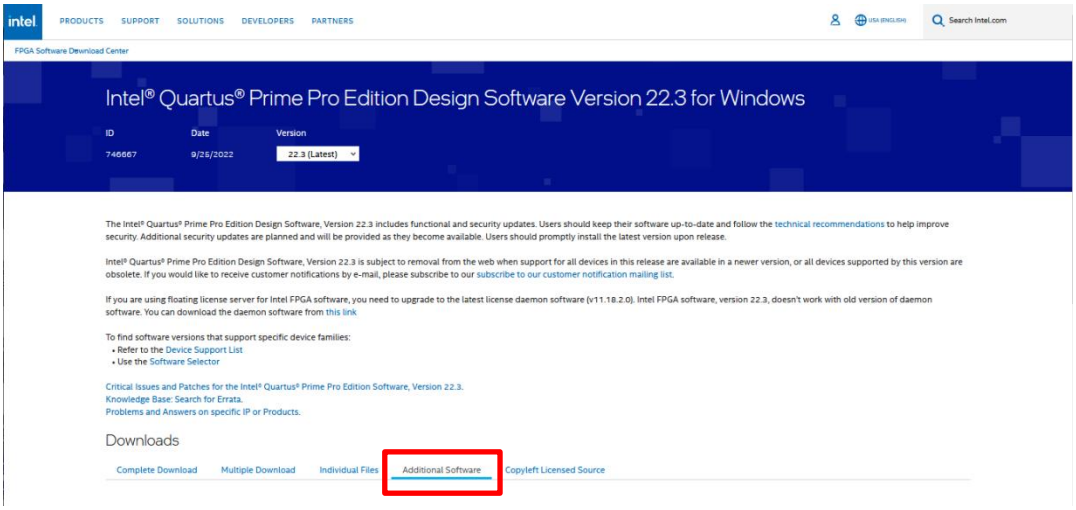
The chapter below describes a procedure for recovering Firmware of UCD-5XX unit in a case when e.g., the normal FW Update procedure failed because of a critical error.

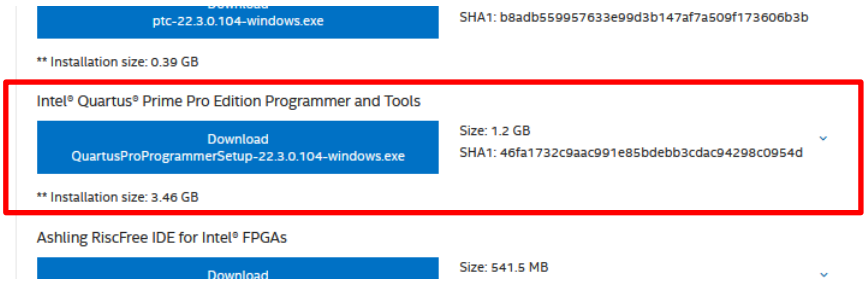
Note	The firmware recovery procedure is only available for Windows operating system.

Downloading Tools

The Recovery patch is programmed to UCD Device with a separate tool called **Intel® Quartus® Prime Pro Edition Programmer and Tools**. The tool can be downloaded from **Intel® FPGA** website:
https://www.intel.com/content/www/us/en/software-kit/746667/intel-quartus-prime-pro-edition-design-software-version-22-3-for-windows.html

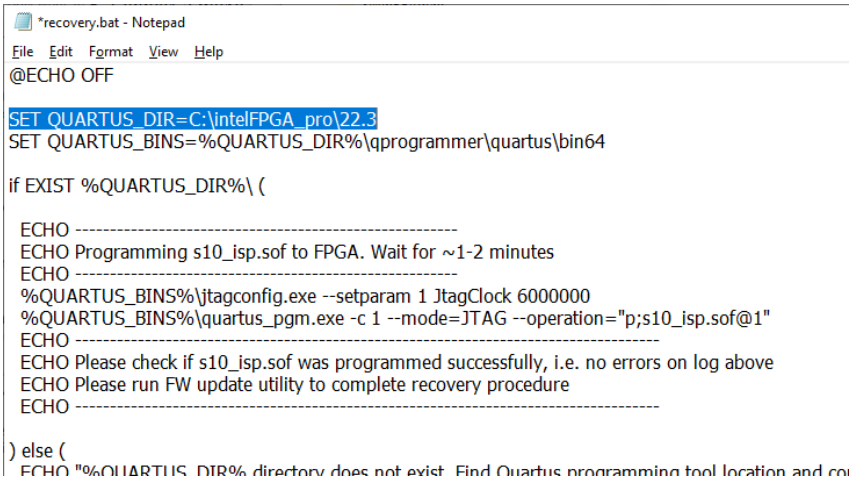
1. On the download page, please select section "**Additional Software**". Please download the software under "**Intel® Quartus® Prime Pro Edition Programmer and Tools**".
2. Please download and install the tool using default option in the PC.





Step 1

1. Connect the UCD device to the power supply and switch on power.
2. Connect the UCD device with a USB cable to the PC through USB connector (Please refer to chapter **Product Description** > **Connections** earlier in this document)
3. Please locate the *UCD-5xx_recovery.*zip file. By default the file is stored in C:\Program Files\Unigraf\Unigraf UCD Tools\recovery
4. Extract the content of the ZIP file in a folder in your PC, e.g., C:\Temp
5. Open Windows **Command Prompt** application
6. Change current directory to where the ZIP file was extracted (e.g. *cd \Temp*)
7. Connect a micro-USB cable to **JTAG** connector in the UCD device (Please refer to chapter **Product Description** > **Connections** earlier in this document).
8. In the directory where the ZIP file was extrected (e.g. c:\Temp) please edit file **recovery.bat**
9. On line three (3) parameter "QUARTUS_DIR" is set to point to the folder where the Qartus Programmer was installed (by default **C:\intelFPGA_pro\22.3**). If needed, please edit line three to match. Please save the file.



10. In Windows **Command Prompt** application please make sure that current directory is still the same (e.g. C:\temp)
11. Launch batch **recovery.bat**
12. Please wait until the batch file has been completed (may take up to several minutes).

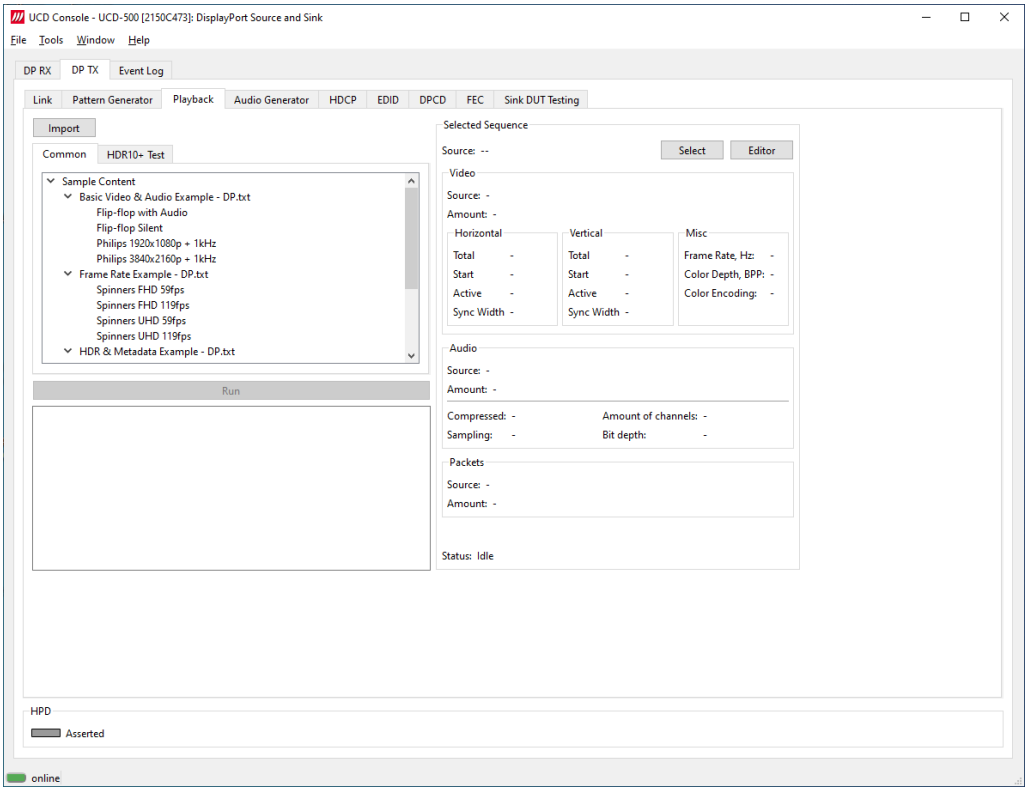
Step 2

Perform FW update procedure as described in section **Installation > Firmware Update Procedure** earlier in this manual.

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 the 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-5XX devices feature a 16 GBytes frame buffer memory. This frame buffer enables loading up to 320 pcs 4K video frames or 80 pcs 8K video frames. 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\Resources\playback\content*. It is advisable to create a 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 a 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' 'SDR - HDR'
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'

Scenarios

A Scenario is an operating structure that allows the user to determine a specific sequence of video frames, events and audio that are going to be played in a certain order. In addition, scenarios determine the 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 a 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/Adaptive-Sync 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	Not used with UCD-5XX	'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/Adaptive-Sync is enabled. In order to enable VRR/Adaptive-Sync, the corresponding event must be included in this step. The parameter is always in format of 'vXX', where 'XX' states frame rate. The parameter is provided after 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.

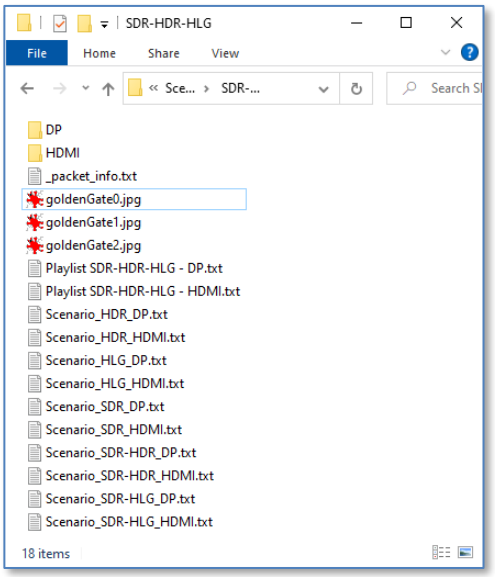
For example, parameter for YCbCr 4:4:4, 10 bits is (2 × 256 + 1) = 513.

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 the description of Playlist SDR-HDR-HLG – DP.



Playlist file (Playlist SDR-HDR-HLG - DP.txt)

Playlist item and example content	Description
[Device]	Start of device section
Serialnumber = *	Only one UCD device present.
Connectortype = DisplayPort Out	DisplayPort output
[Scenario]	Start of Scenario 1
caption = SDR	Scenario title “SDR”
period = 10000	Duration 10 sec
path = Scenario_SDR_DP.txt	Scenario file: Scenario_SDR_DP.txt in current folder
[Scenario]	Start of Scenario 2
caption = HDR	Scenario title “HDR”
period = 10000	Duration 10 sec
path = Scenario_HDR_DP.txt	Scenario file: Scenario_HDR_DP.txt in current folder
[Scenario]	Start of Scenario 3
caption = HLG	Scenario title “HLG”
period = 10000	Duration 10 sec
path = Scenario_HLG_DP.txt	Scenario file: Scenario_HLG_DP.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_DP.txt	Scenario file: Scenario_SDR-HDR_DP.txt in current folder
[Scenario]	Start of Scenario 5
caption = SDR – HLG	Scenario title “SDR – HLG”
period = 10000	Duration 10 sec
path = Scenario_HDR_DP.txt	Scenario file: Scenario_SDR-HLG_DP.txt in current folder

Scenario File (Scenario_SDR-HDR-DP.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=DP\Infoframes_0000.bin	Packet files in folder DP\, 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:)
linkRate=0	
linkRateMin=	
dscFrameRate=60	DSC Timing: Frame rate [fps] × 1000
dscHcactive=7840	DSC Timing: Horizontal active
dscHcblank=100	DSC Timing: Horizontal blank
dscVtotal=2250	DSC Timing: Vertical total
dscVsync=10	DSC Timing: Vertical sync
dscVstart=82	DSC Timing: Vertical start
dscVactive=2160	DSC Timing: Vertical active