UCD Console for UCD-400 UCD-411

User Manual

UNIGRAF

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Table of Contents

1. ABOUT THIS MANUAL

Purpose

This guide is User Manual of UCD-400 and UCD-411. They are USB-connected video interface test units for use with a PC with Windows® 10 Windows® 8 or Windows® 7 operating system.

All instructions in this manual are valid when using either UCD-400 and UCD-411 except the instructions for DisplayPort Sink (DP RX) functionality, which is only for UCD-400.

The purpose of this guide is to

- Provide an overview of the product and its features.
- Provide instructions for the user on how to install the software and the drivers.
- Provide instructions for the user on how to update the FW of the unit.
- Introduce the HW features of the UCD-400 and UCD-411 units.
- Provide instructions for the user on how to use UCD Console software.

All instructions in this manual are valid both for UCD-400 and UCD-411 except the instructions for DisplayPort Sink (DP RX) functionality.

Product and Driver Version

This manual explains features found in UCD Console Software Package **1.12.** 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.

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

2. INTRODUCTION

Product Description

UCD-400 is a high speed, USB 3.0 connected video interface test unit. *UCD Console* is the common graphical user interface (GUI) for Unigraf's UCD-400 and UCD-300 family units. The outlook and details of UCD Console will be different depending on the capabilities of the connected unit reflecting the features enabled.

UCD-400 units feature a high-level Software Development Kit (SDK) for use in automated testing. It is called Test Software Interface (TSI). 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

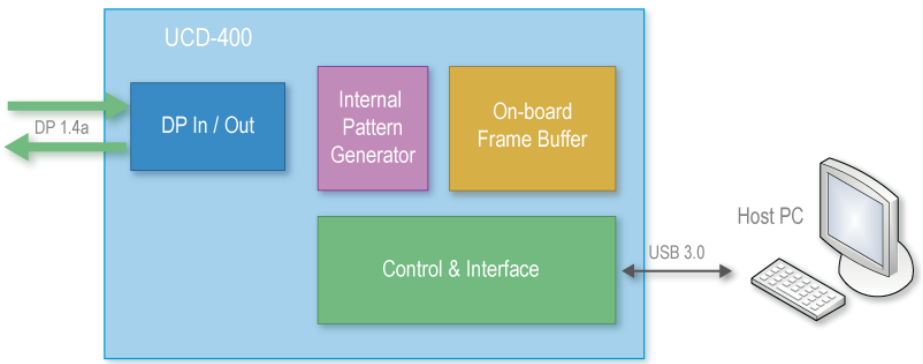
- UCD-400: Simultaneous DisplayPort 1.4a source and sink capability
- UCD-411: DisplayPort 1.4a source capability
- Supports HBR3 feature of DP 1.4a
- Supports Display Stream Compression, DSC
- High resolution video and audio capture up to 8K 30 Hz, 4K / UHD 120 Hz, 8K 60 Hz with DSC (UCD-411 N/A)
- Compatible with HDCP versions 1.3 and 2.3
- 2 GB on-board high-speed video buffer
- High speed USB 3.0 host PC interface

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

Functional Description

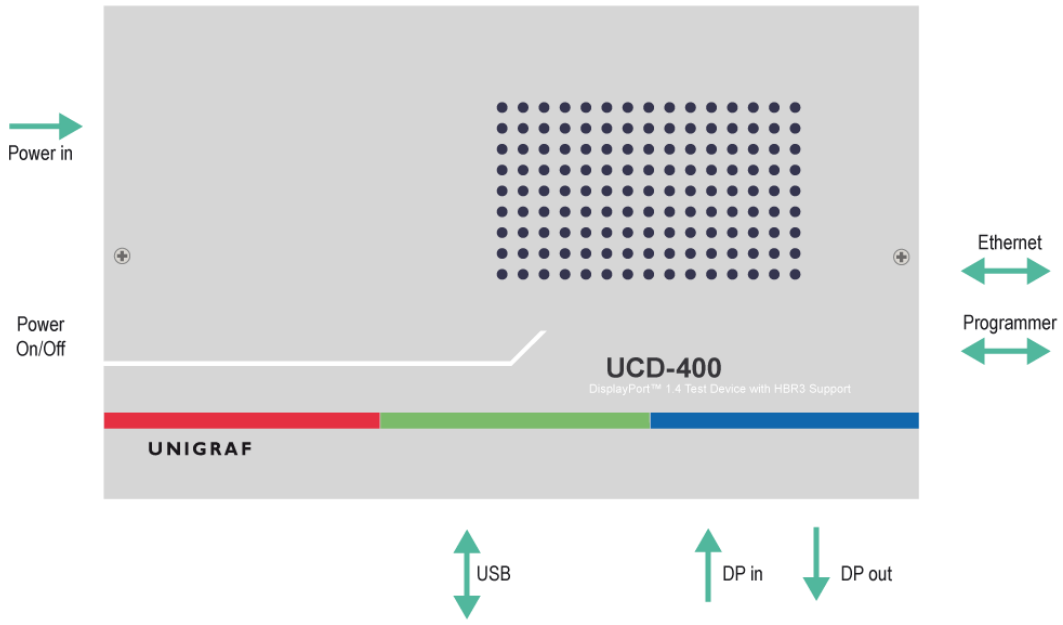
UCD-400 units consist of a multimedia signal input stage (UCD-411 N/A), an internal pattern generator, a control stage with on-board frame buffer and a PC interface stage. In the Input Stage the signal is conditioned and converted to desired format. The Interface and Control stages are either passing 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.

Please find below logical diagram of UCD-400 unit. UCD-411 contains only source functionality



UCD-400

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



Name	Description
DP in	DisplayPort™ 1.4a compliant input from the upstream Source. (UCD-411: N/A)
DP out	DisplayPort™ 1.4a compliant output to the downstream Sink
Power in	+12 Vdc Power Supply Input
Power On/Off	Rocker power switch
USB	USB 3.0 connection to the host PC
Programmer	USB interface for configuring the device FW (behind a cover)
Ethernet	Ethernet interface for updating the device FW (behind a cover)

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

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

USB Type-C Interface

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

Unpacking

The UCD-400 product shipment contains:

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

Installation Package

The UCD-400 software installation package can be obtained from Unigraf download page at https://www.unigraf.fi/downloads/

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

- Windows drivers (installed during set up)
- UCD Console software GUI (installed during set up)
- License Manager (installed during set up)
- DSC Test Content and DSC compression tools (optionally installed during set up)
- TSI SDK (optionally installed during set up)
- User Manuals including this document.

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

Note:	The software should be installed before connecting the UCD-400 unit in the PC.

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

Software Installation

▶ Start the installation by running **Unigraf Software Bundle Setup.exe**

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

▶ Click **Next** to continue. The next dialog you need to agree to Unigraf Software End User License and select the components installed.

Note	The size of the DSC Content Library Generator with supporting files is 2.6 Gbytes

▶ Next dialogs define the installation folder in your PC and the Start Menu folder used.

▶ When the selections are ready, click **Install** to start the installation.

▶ Click **Finish** to exit the installation dialog.

3. LICENSE MANAGER

Licensing

The features of UCD Console GUI are divided into groups based on the target use of the device. Some basic features can be used without licenses. Advanced feature groups have their dedicated licenses that open the related part of the GUI or enable the related control.

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 Unigraf **License Manager**. By default, shortcut to Unigraf License Manager can be found in Start Menu under: **All programs/Unigraf/UCD-400.**

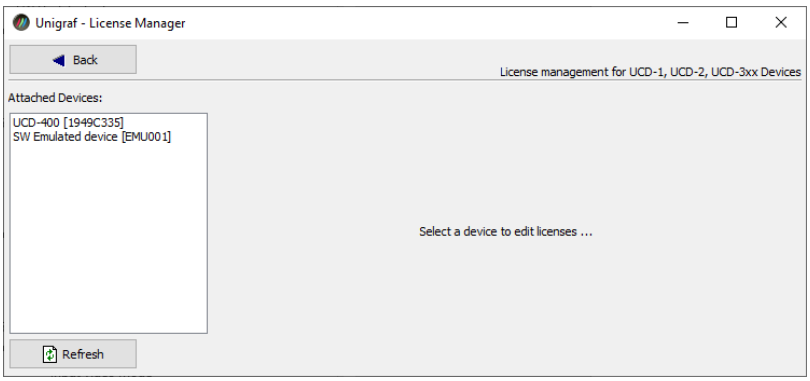
Please click **Yes** in the first dialog. License Manager can be run only with Administrator rights.

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. If no suitable device families are detected, License Manager will exit. Please first select one of the available device families by clicking one of the device family selector buttons.

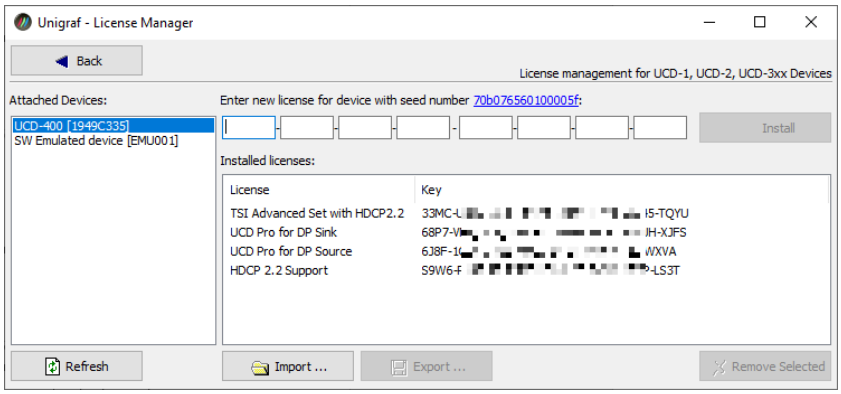
In the list of Attached Devices please select the device in question. The *serial number* and the *seed number* of your device are printed in a sticker attached to the bottom of the device.



The **Back** button opens the device family selection screen. The **Refresh** button will re-scan the system for installed hardware.

Managing Licenses

Seed Number



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

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

Adding New License Keys

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

Once the license key is fully entered, click the **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 seed number for the device.

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 notice, that characters that can't 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 currently installed licenses for the currently selected device. The list shows the actual license key, and what that key unlocks.

Remove Selected will uninstall selected licenses. To uninstall a license, click on the license and then click the Remove Selected button.

Export will allow all installed licenses for the currently selected device to be saved into an INI file for backup and distribution to other PCs. To export a license, click on the license and then click the Export button. Please notice that licenses from multiple devices can be exported into the same INI file.

Import will install licenses from an INI file for the currently selected device.

4. FIRMWARE UPDATE PROCEDURE

UCD Configuration Utility is used to load an updated firmware to the device. As an option, UCD Configuration Utility enables the user to select the operation roles present in the UCD-400 unit. The utility configures a firmware set for the selected operation roles and programs the firmware set to the device. Please contact Unigraf for details.

Updating from Earlier FW Versions

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

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

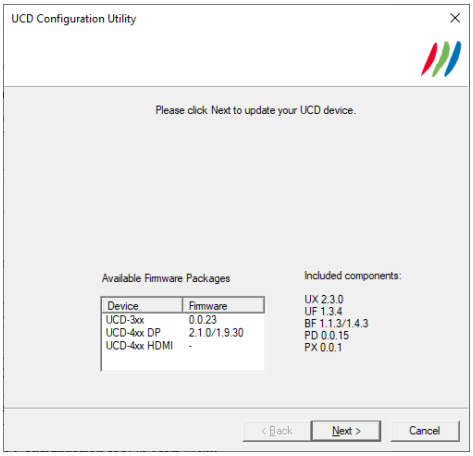
FW Update

To update the firmware or create a new configuration on a UCD-400 device, please perform the following steps:

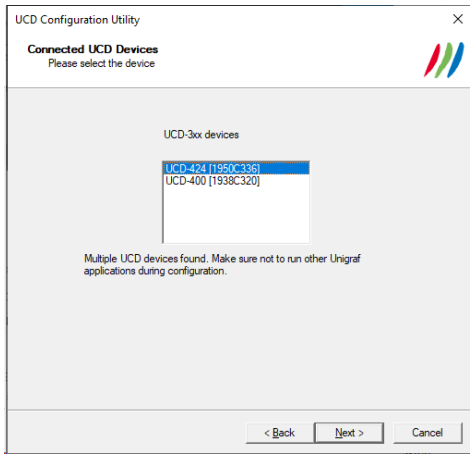
- Connect the UCD-400 unit to a power supply and connect the USB cable.
- Open UCD Console. Select Tools > Firmware update.

UCD Firmware Configuration tool can alternatively be launched in Start Menu.

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

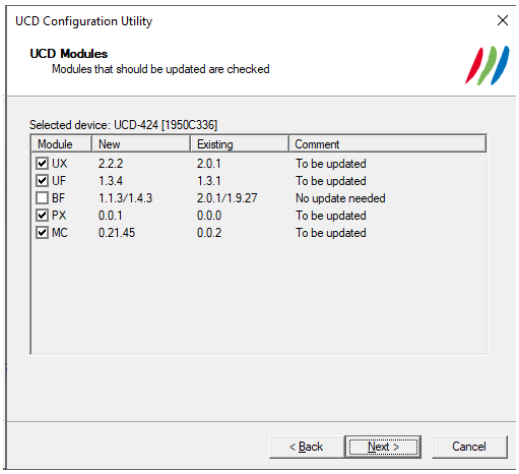


If several UCD units are connected to the PC, in next dialog please select the device to be updated. Click **Next**.



Updated Modules

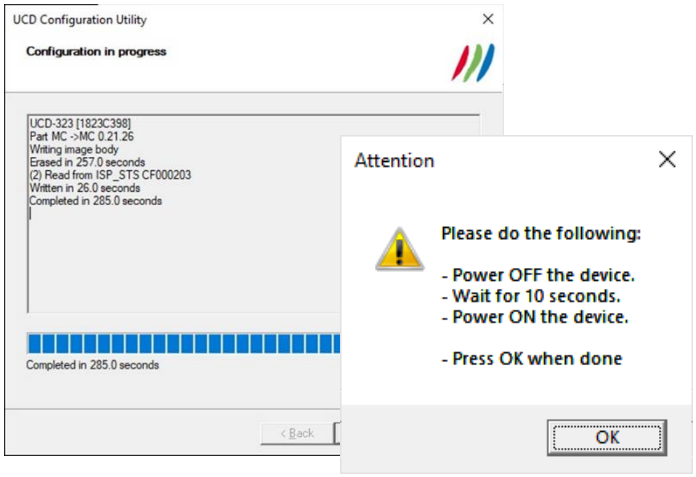
The tool indicates the firmware file to be used and prompts for selection of the firmware modules to be updated. It compares the modules in the selected device and omits the ones that are the same.



▶ When you are done, click Next.

Power Cycle

When updating certain parts of the firmware, the whole process cannot be done during one session and the UCD device need to be restarted between steps. Therefore, on certain point, user needs to **power cycle** the device (switch off power > wait for 10 seconds > turn on power).



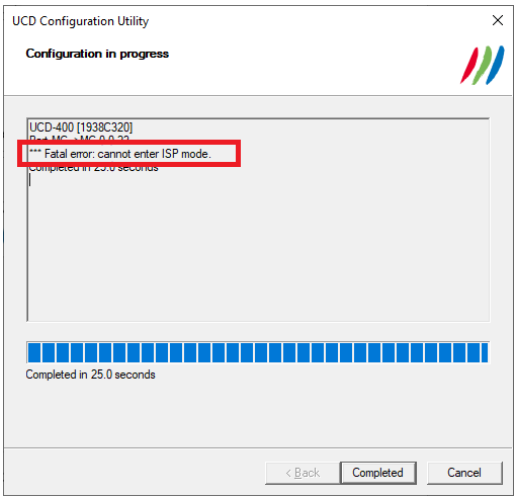
Click **OK** button on the dialog.

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

▶ Once the FW Update procedure has been completed, power cycle the device (switch off power > wait for 10 seconds > turn on power).

Recovering Failures in FW Procedure

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



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

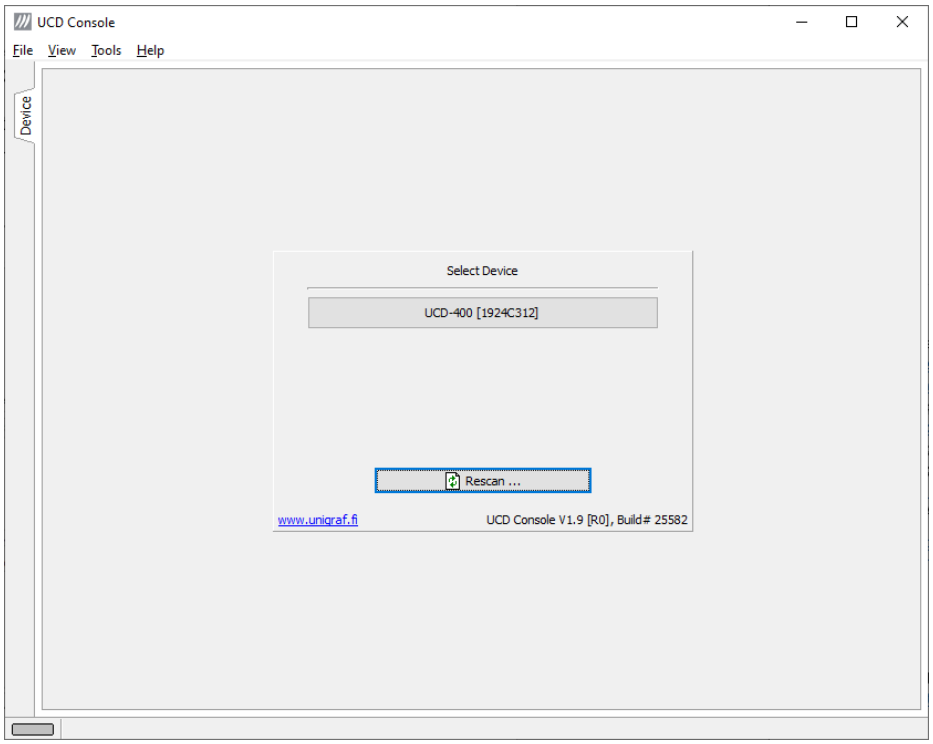
5. UCD CONSOLE

UCD Console is the graphical user interface (GUI) of UCD-400 for desktop use. It 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 the problem detection.

The various features of the UCD-400 are divided into interface specific screens and tabs. Each tab contains data and controls for a specific feature.

Device Selection

A shortcut of UCD Console can be found by default under Start Menu path **All programs/Unigraf/UCD-400.** Once UCD Console GUI is launched the dialog provides a list of UCD-400 devices connected in the PC. Please select the target device by clicking on the appropriate button. If your device cannot be found in the list, please confirm the power and USB connection to the device and click the **Rescan …** button.



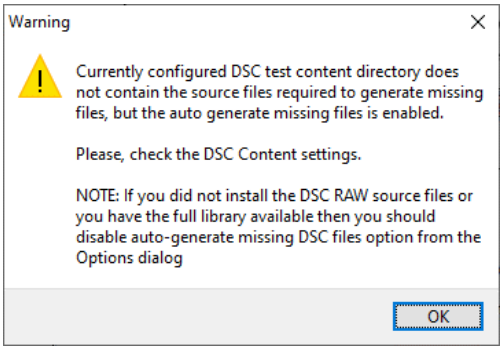
Analyzer and Pattern Generator Roles

The use of UCD-400 devices with UCD Console is divided by Analyzer (DisplayPort Sink), Pattern Generator (DisplayPort Source) and Event Logger (Event Log). The functionalities of the three roles can be found in tabs. This User Manual will explain all roles and their functionalities.

When using UCD-411 only Pattern Generator (DisplayPort Source) and Event Logger (Event Log) roles are available.

Warning about DSC Test Content

When running DSC Compliance Tests, UCD-400 needs to have access to DSC content used as test patterns. The content can be created from the source bitmap files downloaded during installation (optional) either with Unigraf DSC Content Creator or created by the Compliance Test Tool on-the-fly during the compliance test.

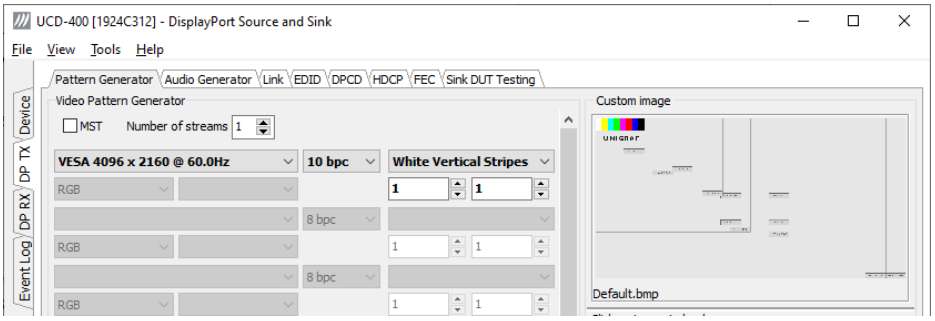


If *Automatically create missing content* is selected in Tools > Options menu, but the source files have not been installed a *Warning* dialog will open. Clicking **OK** will open the *Option* menu.

You can either re-install the whole SW package with DSC Content Library or deselect *Automatically create missing content* in Option menu.

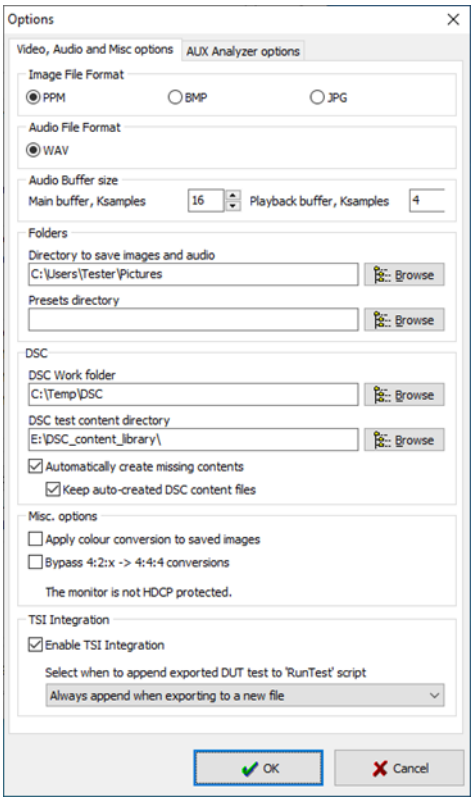
Applying Changes

In various UCD Console dialogues the user needs to update several parameter or fields to make the changes needed. In order to avoid false combinations of parameters the new parameters are applied to UCD-400 only after **Apply** is clicked. In UCD Console the situation that parameters have been changed but not applied is indicated by **bold values** of the parameter.



Options

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



Video Audio and Misc. Options

Image File Format

You can save the captured frames either in PPM, BMP or JPG 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

Audio Buffer size

Main buffer: Length of the buffer in the PC memory storing audio samples for monitoring audio format in DP RX / Audio tab. Increased buffer length will enable longer time span to be monitored.

Playback buffer: Length in the buffer in the PC for transferring captured audio to PC sound system. Increased buffer size will ensure a smooth audio output but will also increase the delay between the capture of the audio stream and its playback.

Folders

Please select the directories in the PC for saving the captured images and audio, the saved Presets

DSC

DSC Work folder: Folder for DSC Work files.

DSC test content directory: Folder where DSC source bitmap files, related configuration files and DSC conversion tools are stored.

Automatically create missing content: When selected, compliance test tool During execution of DSC Compliance Tests, the tool automatically creates the DSC compressed content used for testing the DUT.

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.

Misc. options

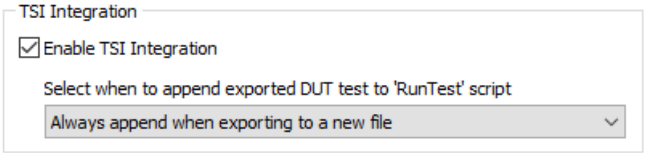
Apply color conversions to saved images: When saving captured frames, the Color Mode selected in *Video* tab will be applied also to saved images.

Bypass 4:2:x –> 4:4:4 conversions: 4:2:2 and 4:2:0 images are previewed and stored as received, without pixel doubling.

HDCP protected monitor: Text appearing if the monitor where UCD Console is viewed is HDCP compliant and HDCP is enabled. This feature enables preview of captured HDCP encrypted content in *Video* tab.

TSI Integration

Selections for generating a workspace for TSI usage.



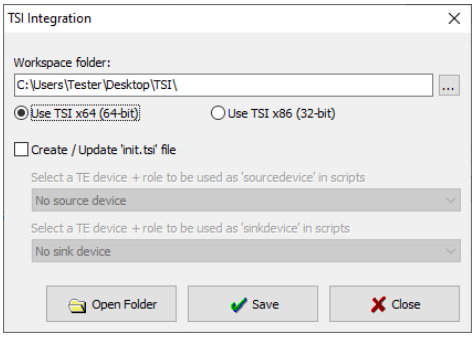
AUX Analyzer Options

Options for configuring the way data is presented in *AUX Analyzer* tab in *Event Log*.

Please find full description of the controls in chapter *Event Log / DP AUX Analyzer* later in this document.

TSI Integration

Tools > TSI Integration. Selections for generating a workspace for TSI usage.

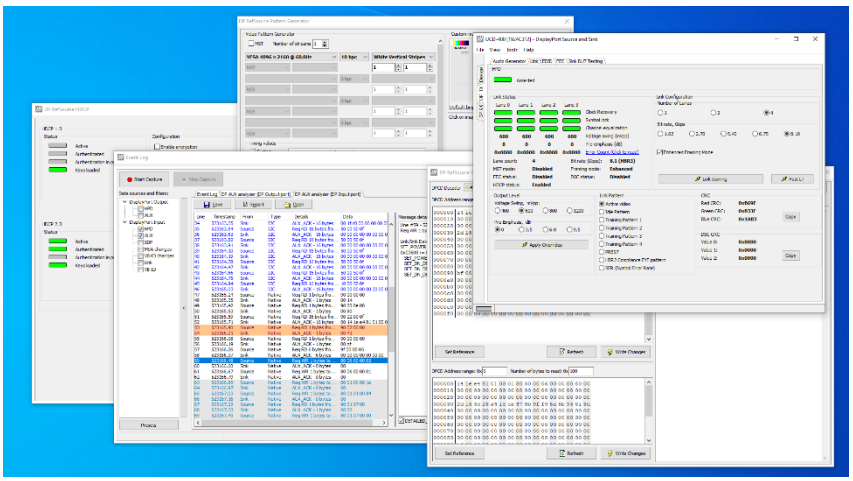


TSI Integration enables automatic creation of the necessary configuration files for executing tests exported from UCD Console's Sink DUT testing or Source DUT Testing.

Please refer to chapters *Source DUT Testing Tab* and *Sink DUT Testing Tab* later in this document for description about exporting tests.

Detaching 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 Page**. 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.



6. DISPLAYPORT REFERENCE SINK

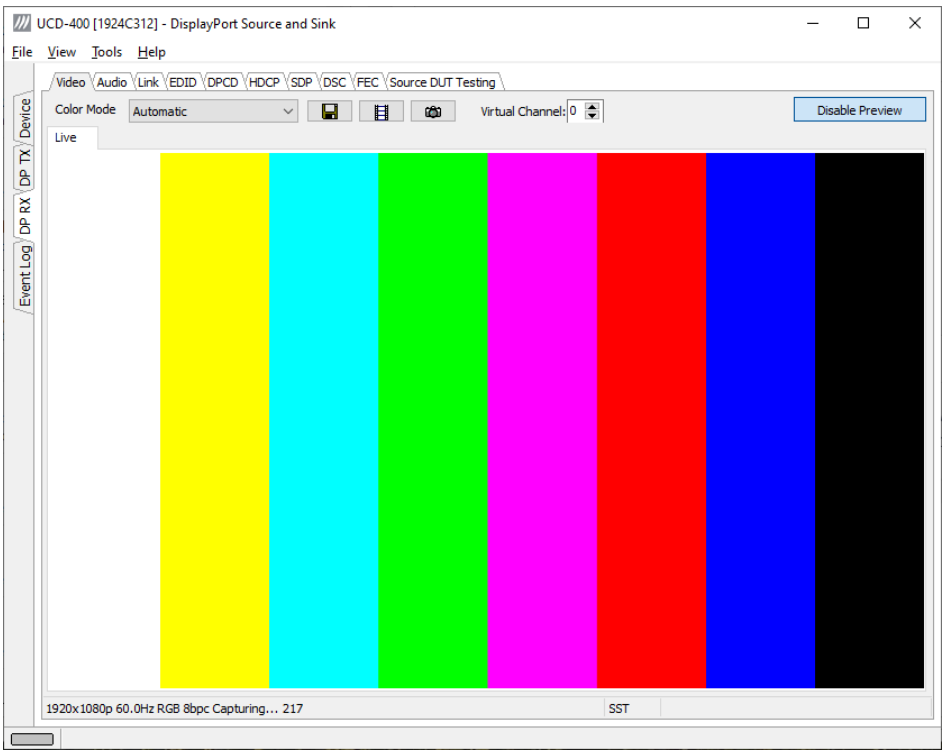
DP Sink functionality not available when using UCD-411.

DisplayPort Reference Sink dialog (DP RX) can be selected from the vertical tab on the left edge of the GUI. The horizontal tabs on the top of the GUI enable the various functions available for the input channel. Some of the tabs are enabled by default, some only when an applicable license is included. DPRX features the following functions.

- Video preview and saving (Video)
- Audio monitoring and saving (Audio)
- Status information and control of the upstream link (Link)
- EDID editor (EDID)
- DPCD editor (DPCD)
- HDCP status monitor and control (HDCP)
- SDP sent by the Source device (SDP)
- Display Stream Compression (DSC)
- FEC feature control and status (FEC)
- Source DUT Testing.

Video Tab

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



Input video mode

7680x4320p 30.0Hz RGB 8bpc Capturing... 76

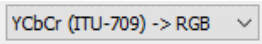
The measured input resolution, frame rate and color format are shown below the preview window. The indication of the number of frames captured to the PC indicates the pace of the image data transfer to the PC.

Disable / Enable Preview

Click here the button to start or stop capturing video frames.

The top ribbon of the tab has the following controls:

Color Mode for preview



- No Conversion: The captured color components are interpreted as R, G and B respectively. No color conversion will be done.
- Automatic: The color mode is selected based on the information in the MSA. If there is no color information available, “No Conversion” is used.
- YCbCr (ITU-709) - > RGB: The captured data components are interpreted as Y, Cb, and Cr respectively. Color conversion to RGB is done based on ITU-709 standard.
- SMPTE 170M - > RGB: The captured data components are interpreted as Y, U, and V respectively. Color conversion to RGB is done based on SMPTE 170M standard.

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.

Select Virtual Channel

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

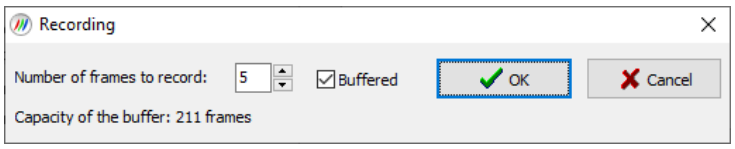
Save one frame

Capture and save one video frame as a bitmap file in the PC. The format and storage location can be selected in Tools > Options pull-down menu. The available bitmap formats are PPM, BMP and JPG.

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.

Sequence recording

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



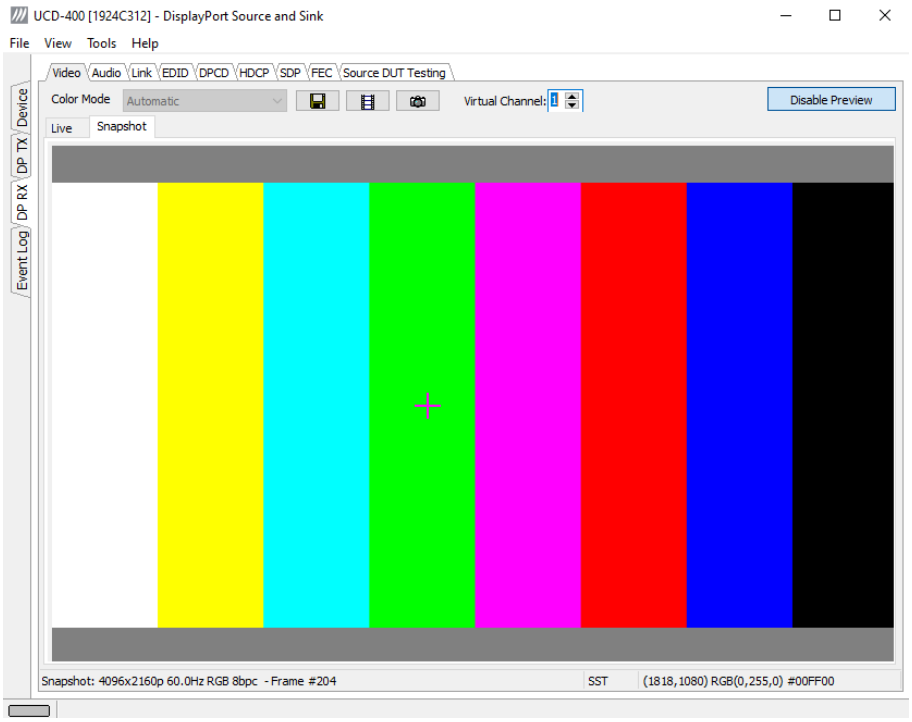
In buffered mode, all input frames are captured non-drop until the on-board frame buffer will be full. The dialog also informs the capacity of the buffer with the selected video mode.

In non-buffered mode, only one input frame is buffered at a time. Frames will be skipped if the transfer of the data to the PC is slower than the input data rate.

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

Snap preview

When clicked, one frame of the incoming video is captured and shown in a new *Snapshot* tab. The captured bitmap can be saved with **Save one frame** function described above.



Color Information of the Captured Bitmap can be evaluated by placing the mouse cursor on top of the preview image. The lower right-hand side ribbon of the GUI lists

- Location of the cross cursor on the bitmap
- The intensity of the Red, Green and Blue components of the pixel on the cursor location
- The HTML HEX color code of the pixel on cursor location

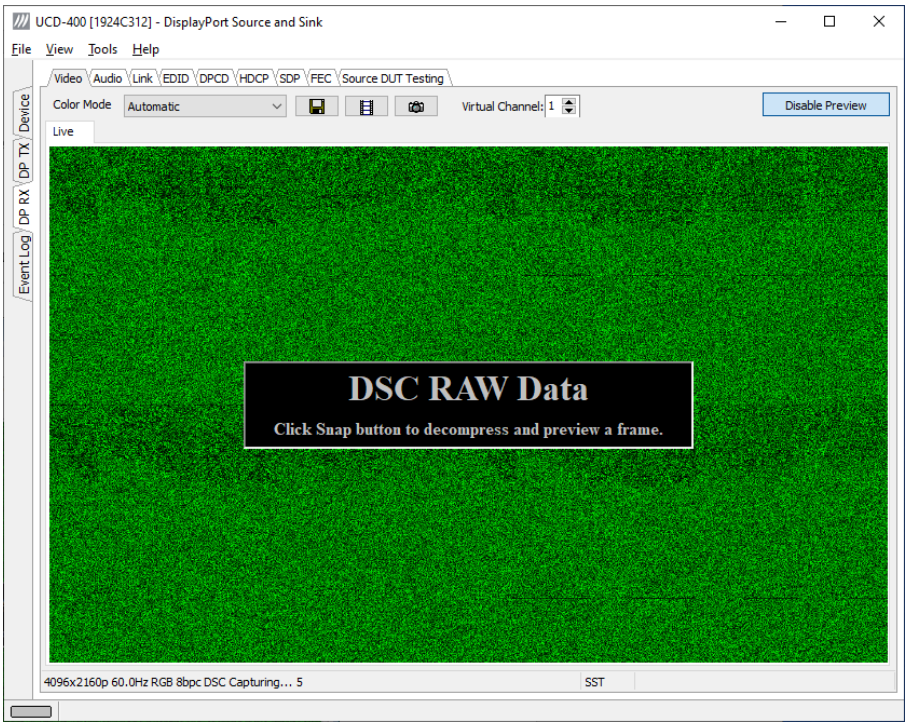
Zoom of the Preview Image can be altered by right clicking on top of the preview image and selecting between

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

While in the *Snap preview mode* clicking on the “Camera” icon will take additional snapshots

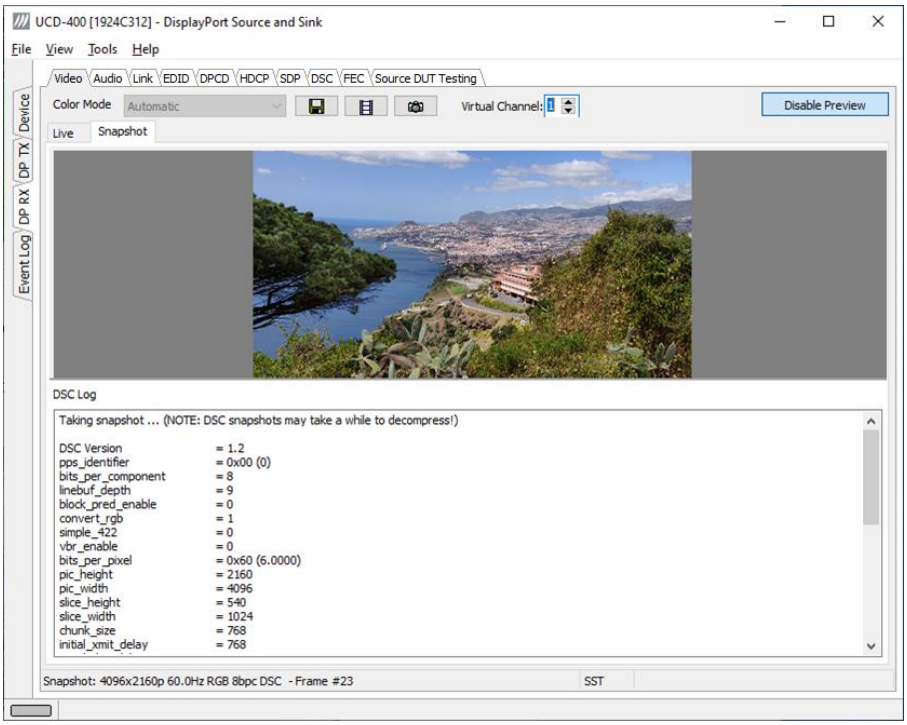
Preview DSC Decompressed Stream

In order to capture and preview DSC compressed video DSC must be enabled by selecting **DSC Capable** checkbox in *DSC* tab.



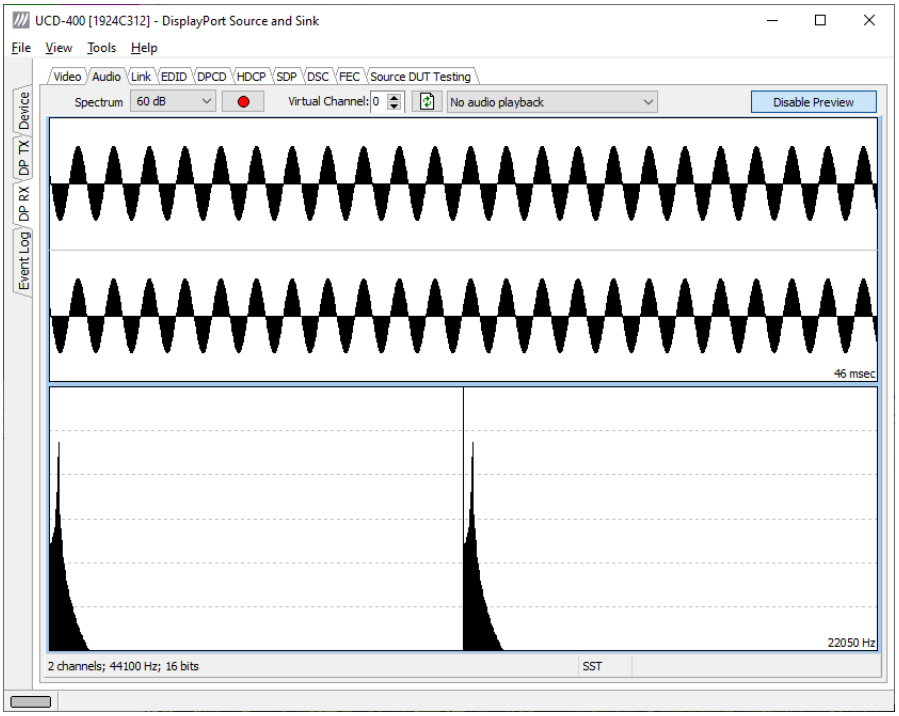
Select **Enable Preview** to verify that DSC compressed stream is received.

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



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 80 dB.
- The horizontal sound level indicator is in the bottom of the dialog.

The span of the preview window is defined with **Audio preview size** found in Tools > Options dialog. The value is given in ksamples (1024 samples). The relation between the preview window span in milliseconds (msec) and the value given in *Audio preview* size depends on the sampling frequency. Please do not exceed the *Audio buffer size* set in the same dialog.

Disable / Enable Preview

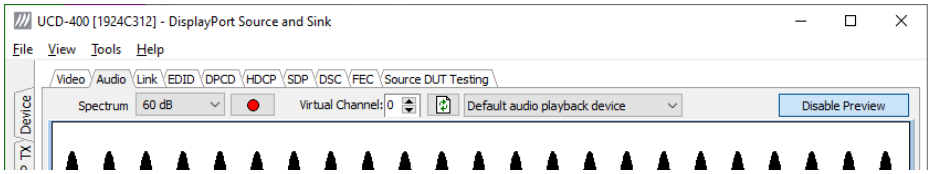
This button controls capturing the audio data.

Select Virtual Channel

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

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, the *No audio playback* is chosen.



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-400 EDID. Since UCD-400 is not performing any audio format conversion, it might occur that the source provides an audio format that the selected playback device is not supporting. In case a conflict occurs, please change manually the EDID content or disable audio playback to monitor the waveforms in UCD Console.

Refresh audio device list

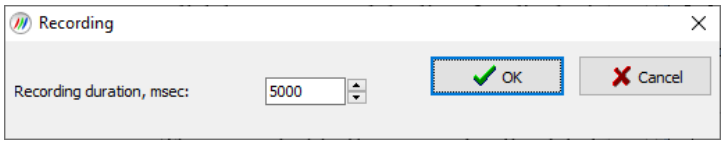
Click here to re-read the list of audio devices after making changes to the host PC configuration.

Audio Buffer Size

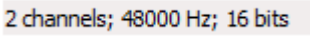
The amount of buffering used in the data transfer between the UCD-400 unit and the PC in **Audio buffer size** in Tools > Options dialog. Increased buffer size will ensure a smooth audio output but will also increase the delay between the capture of the audio stream and its playback.

Start audio recording

The captured audio can be recorded in the PC using Waveform Audio File Format, WAV (*.wav) format. The pop-up dialog defines recording duration. The folder where the audio file will be saved can be selected in File > Options.



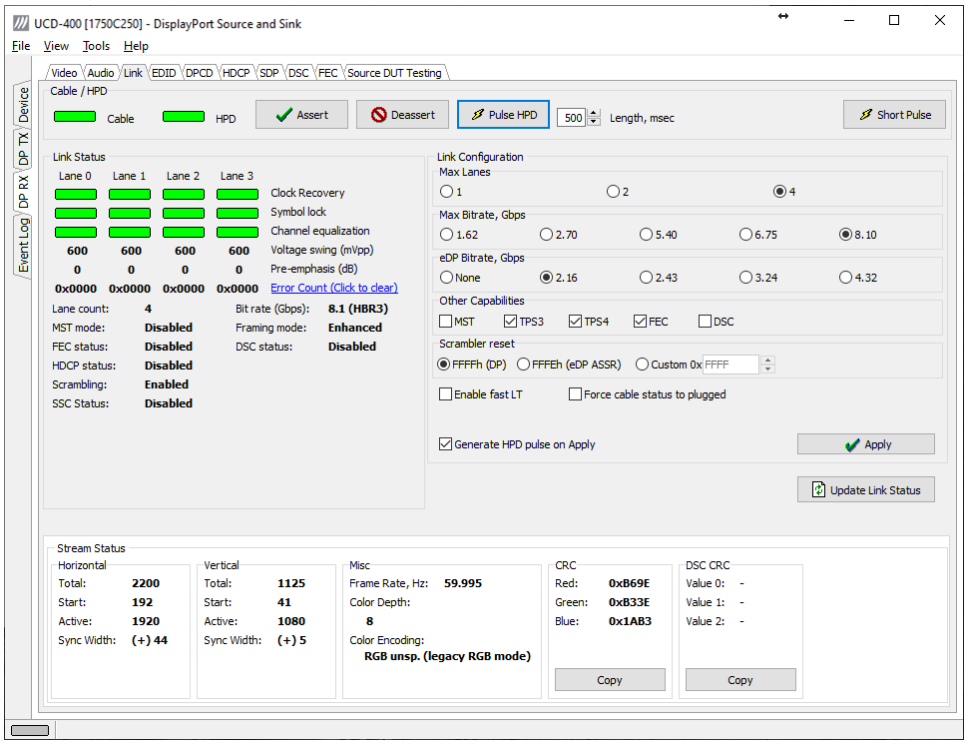
Input audio mode



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

Link Tab

Link tab contains four panels: Cable / HPD, Link Status, Link Configuration and Stream Status.



Cable / HPD

Indicator lights of the state of the cable. **Cable** indicates that the hardware has detected an upstream cable. **HPD** indicates that the HPD signal is Asserted (logical “high”).

Clicking the **Deassert** button will cause HPD line to be set to logical “low” (de-asserted) and hence no HPD pulse can be generated. Click the **Assert** to re-activate the HPD line (set to logical “high”).

To apply an HPD Pulse with programmable duration click **Pulse HPD**. The duration will be defined in the provided field.

For applying a short pulse click **Short Pulse**. Pulse duration is 1 ms.

Link Status

Link Status displays the status of the link training and the link parameters negotiated between UCD-400 Sink and the Upstream Source. The data is retrieved from the DPCD registers of the UCD-400 Sink. The status is updated automatically.

Link Configuration

Link Configuration allows the user to change the way the Sink capabilities are announced in the DPCD registers of the UCD-400 Sink. Maximum Lane Count, Maximum Bitrate and supported eDP Bitrate are set with their appropriate radio buttons.

To update the new status to the DPCD registers click **Apply**.

Note:	Please note that UCD Console Link Tab currently supports for announcing one bitrate from the pre-selected rates to be used with eDP protocol. The user can apply alternative schemes by editing DPCD register content in the DPCD Tab.

Other Capabilities
Enable or disable features like MST, FEC and DSC

Scrambler Reset

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

In **Auto** mode UCD verifies that connected DP Sink supports eDP and Alternate Scrambler Seed, and then applies FFFEh. If not, FFFFh will be used.

When **Force cable status to plugged** is checked, sink functionality is active regardless of a failure of upstream device detection e.g., due to incorrect AUX Channel electrical termination.

To apply a Hot-Plug Detect pulse automatically after updating the status, select **Generate HPD pulse on Apply**. HPD pulse duration will be defined in the *Pulse* HPD field.

Stream Status

Stream status is enabled with *UCD Pro for DP Sink* license.

Video Timing Details are retrieved from the Main-Stream Attributes (MSA) of the monitored stream. Frame rate is measured by UCD-400 Local Sink.

Note:	Please note that the MSA information used for Video Timing Details is provided by the Upstream Source, it is not measured by the UCD-400 Local Sink.

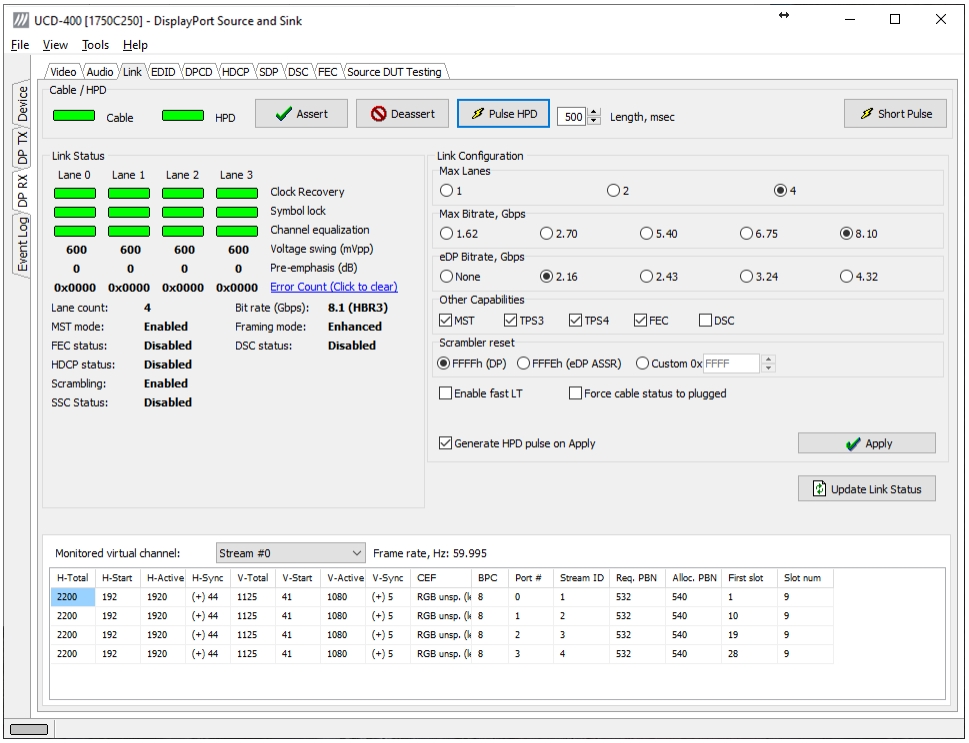
CRC

The 16-bit **CRC** (checksum, cyclic redundancy check) values of the three color components of the captured video frame; calculated by the Sink hardware. To re-calculate, click **Update Link Status**.

The 16-bit **DSC CRC** values of the captured DSC compressed frame. "**Value 0**" is calculated from 1st, 4th, 7th … byte, "**Value 1**" from 2nd, 5th, 8th … byte and "**Value 2**" from 3rd, 6th, 9th … byte.

Multistreaming

When Multistreaming (MST) is enabled, and the source sends a multi-stream signal the details of the received virtual channels is shown in a table in *Stream Status* field.



Port#: Port number where the virtual channel is directed.

Stream ID: Stream identification number of the virtual channel

Req. PBN: Requested PBN (payload Bandwith Number) value for the virtual channel

Alloc.PBN: PBN value allocated for the virtual channel

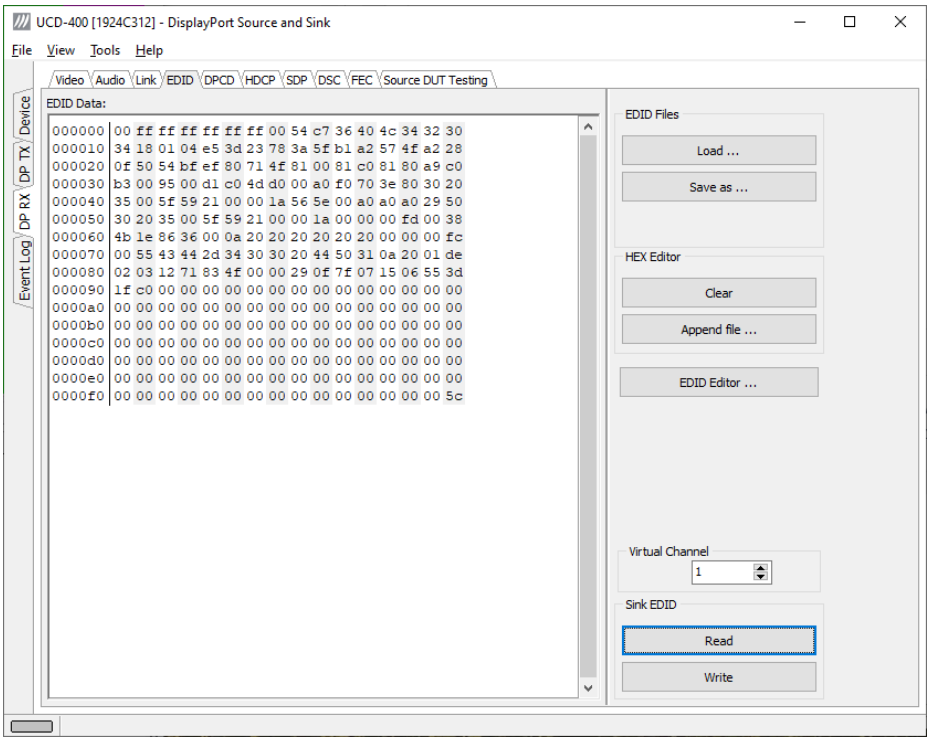
First slot: Time slot where the first VC Payload for the virtual channel is stored

Slot number: Number of VC Payload slots reserved for the virtual channel.

EDID Tab

EDID Tab provides tools for accessing the EDID of the UCD-400 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
- Program and read the contents of the EDID memory of up to four virtual MST Ports



EDID Files

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

Note

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

Currently the EDID Editor does not support Display ID. Hex EDID files can however be modified with the HEX Editor or externally generated hex EDID files that have Display ID content can be load and programmed into the hardware.

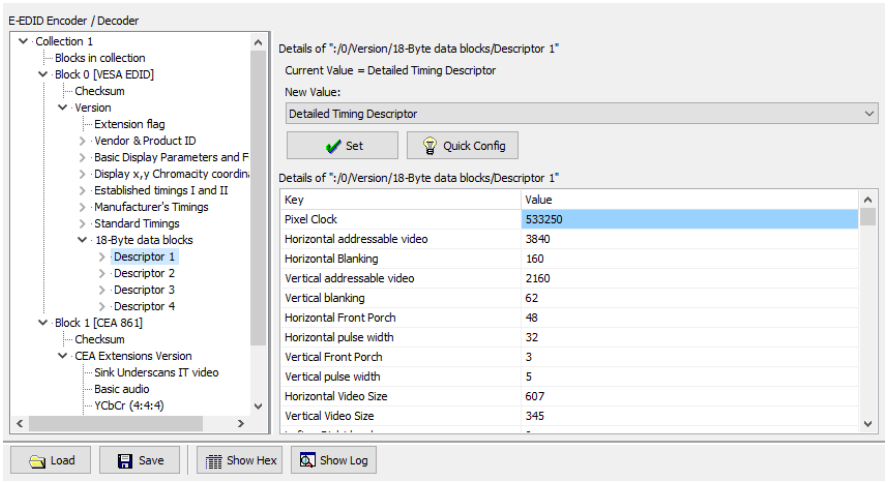
HEX Editor

When EDID content is either loaded from a file or read from the hardware EDID memory, it is shown in the *EDID Data* panel on the left hand side of the dialog. EDID contents can be edited by typing over the existing values. Altered content is highlighted with **RED**. Please note that Hex Editor itself does not alter the contents of the EDID data or verify its integrity.

After editing the data can either be saved to an *.ecd file in the PC with **Save as…** or programmed it to the hardware EDID memory with **Write**.

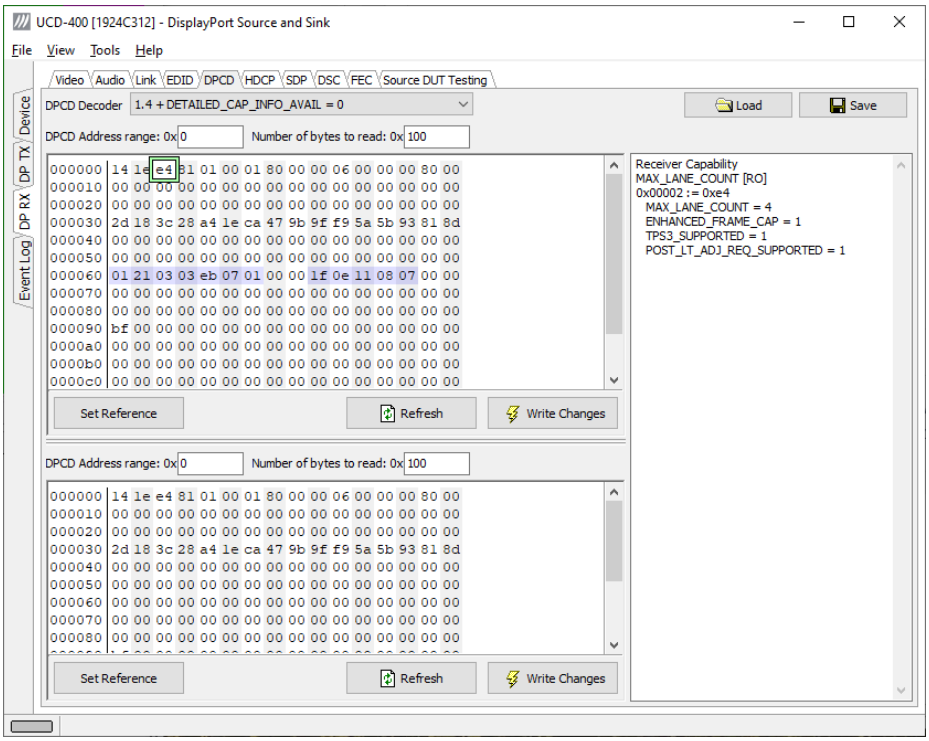
EDID Editor

EDID Editor is launched in a separate pop-up window. 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-400 Sink.



The tool consists of two independent monitoring and editing windows for the DPCD data. The user can freely select the the DPCD address areas shown on each panel.

The *DPCD Decoder* panel on the right hand side shows the interpretation of the DPCD byte selected on the monitoring windows. The selected byte is shown with a green outline.

The combo box above the DPCD Decoder window allows selection of how the DPCD data is interpreted. It can be either as *DP 1.4 DPCD*, or as *DP 1.4 DPCD* with *Detailed Capability Info* selected or not (DETAILED_CAP_INFO_AVAIL = 1/0).

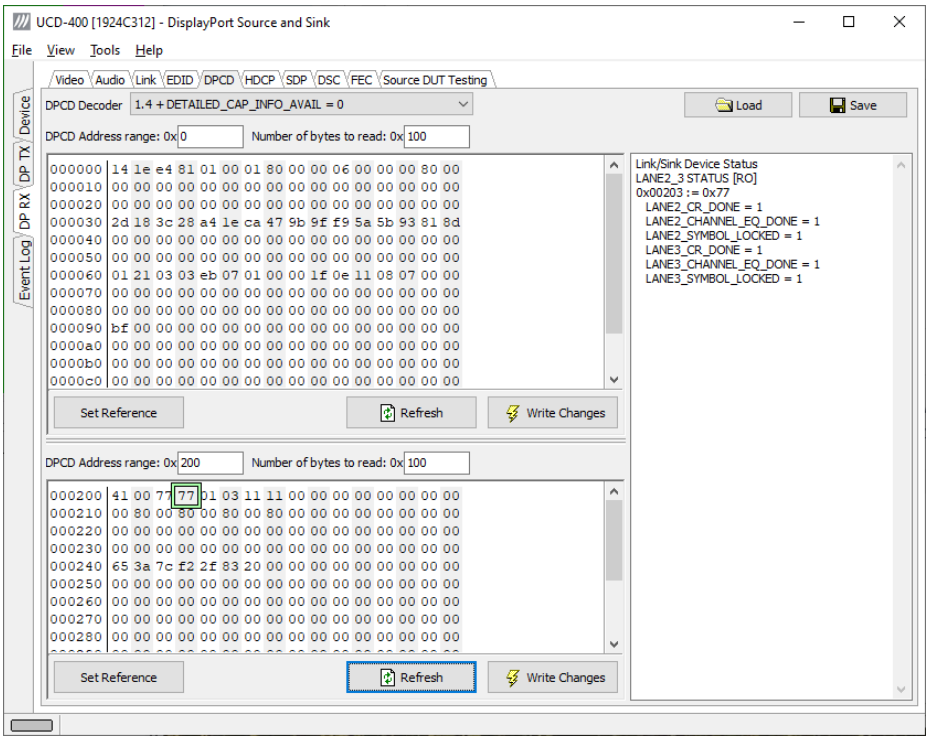
Click **Refresh** to re-read the data from the DPCD registers to the window in question.

Click **Write Changes** to write the portion of data shown in the window in question to the DPCD registers.

Click **Set Reference** to 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 gray background.

The fields edited by the user will be highligted with **red** color.



Saving and Loading DPCD Content

DPCD data in the selected address areas can be saved as a file in your PC. There are three alternative formats:

- Binary *DPCD Fata File* format (*.DPD). This is Unigraf proprietary format. You can also load the DPCD content stored in this format.
- *Comma Separated Values* (*.CSV) for loading the data to a spreadsheet.
- *HEX Dump* (*.HEX) in a human readable text format.

▶ Click **Save** to select the location and the format of the file.

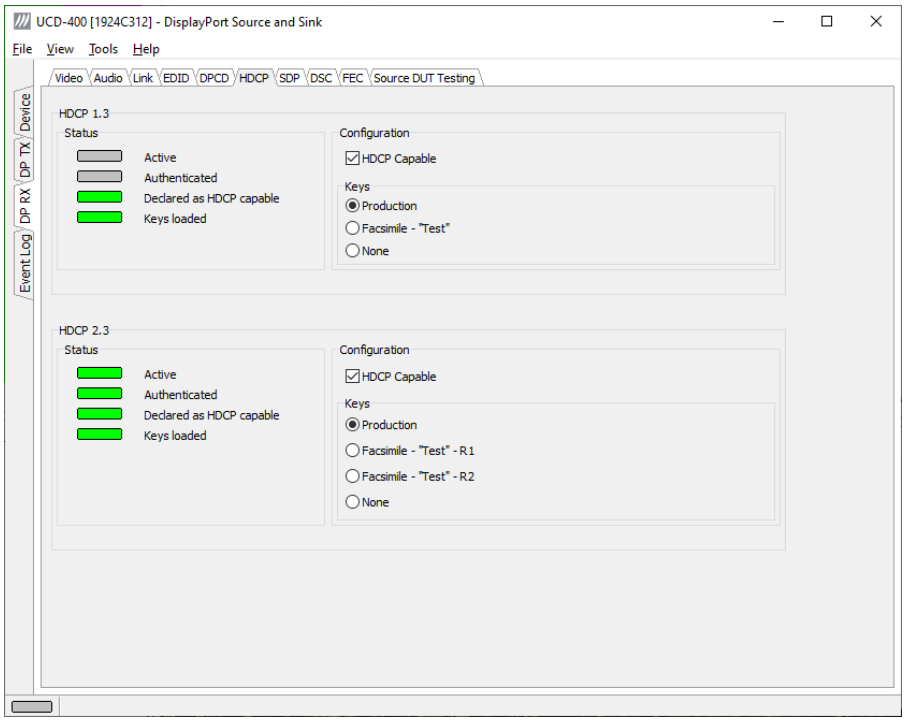
▶ Click **Load** to load DPCD data saved in *DPCD Data File* (*.DPD) format to the editor.

▶ To program the data into the DPCD registers of UCD-400 Local Sink click **Write Changes**.

Note	- Writing DPCD data to the DPCD registers of the UCD-400 Local Sink will potentially affect the status and capabilities of UCD-400 as seen by the upstream source. - User control like Link Training or mode changes will modify the content of the DPCD registers - During a reboot of UCD-400 the DPCD registers will be returned to their default values

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-400 device.



Status

The status field indicates the HDCP status of the UCD-400 device.

Active: The link between UCD-400 and the upstream source has been encrypted.

Authenticated: The HDCP handshake between the UCD-400 and the sink unit has been completed successfully.

Declared as HDCP capable: The UCD-400 unit recognizes HDCP handshake messages.

Keys loaded: The HDCP keys are loaded to the UCD-400 unit.

Configuration

HDCP Capable: To disable HDCP uncheck the box.

Keys

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

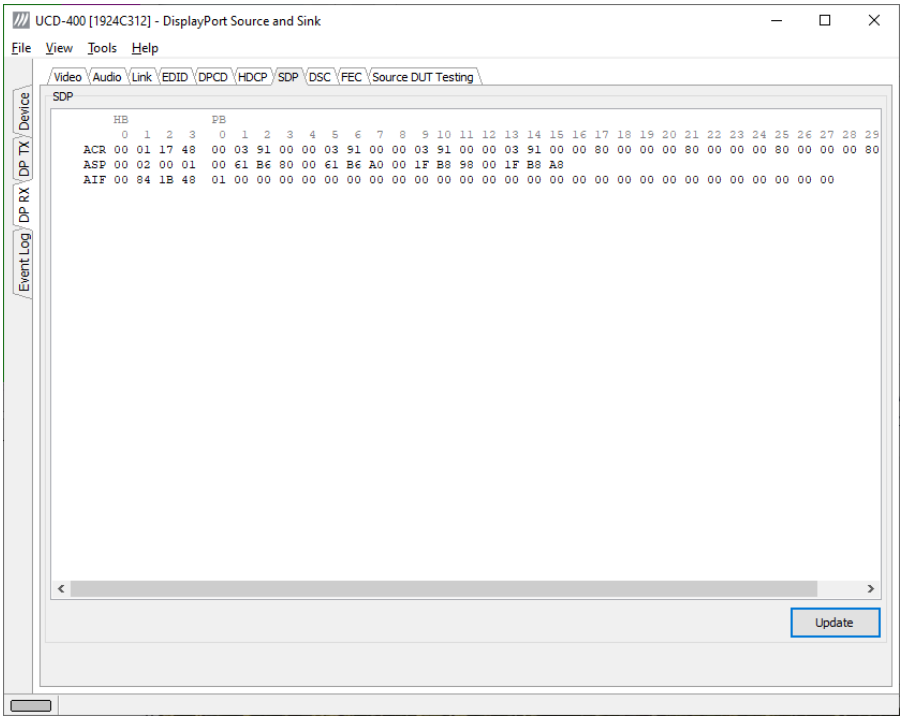
HDCP 1.3 vs. HDCP 2.3

UCD-400 devices support by default both HDCP 1.3 and HDCP 2.3 standard.

SDP Tab

SDP Tab is enabled with *UCD Pro for DP Sink* license.

In SDP Tab shows the *Secondary-Data Packets* sent by the Source device. Click **Update** to re-read the data.



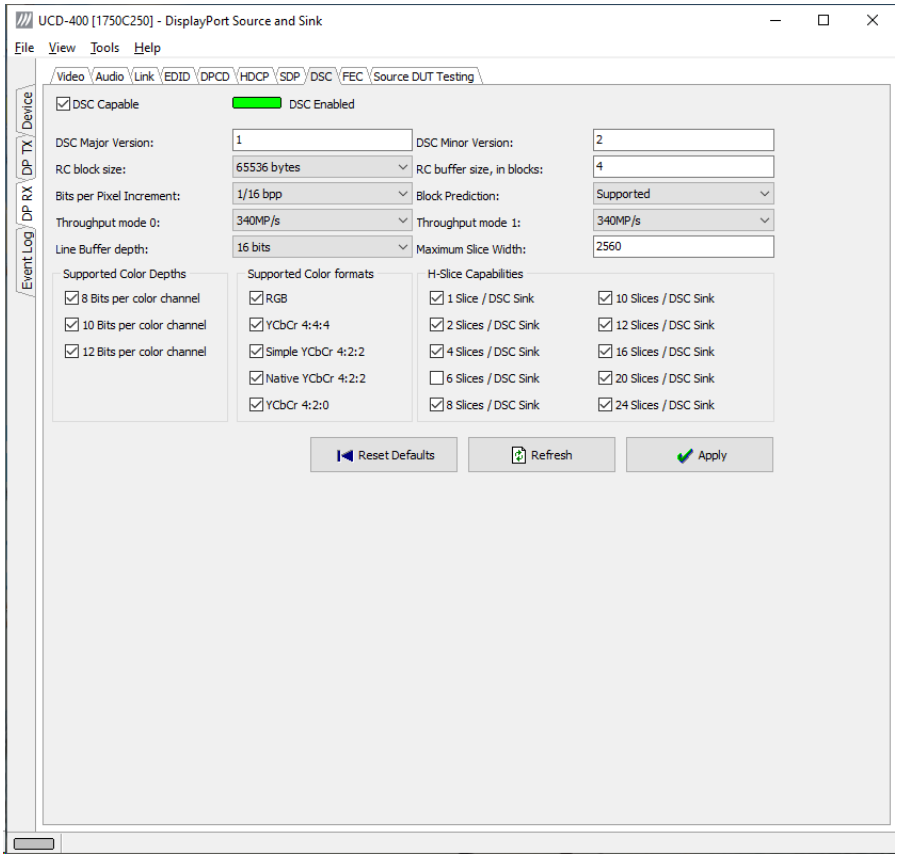
SDP Tab displays in hexadecimal format the following received SDP packets:

- 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)

DSC Tab

DSC Tab is enabled with *DSC Decoder* license.

DSC tab contains control of the Display Stream Compression (DSC) feature, and definition of DSC support capabilities that UCD-400 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 (0x00060) of UCD-400 sink to find out if DSC capability is declared.

DSC Capable: Control of UCD-400 DPCD register 0x00060 bit 0. Please click **Apply** to enable the change.

DSC Enabled: Connected source has enabled DSC

DSC Support Capabilities

The various controls in this tab change the content of UCD-400 sink DPCD register address range (0x00061 through 0x0006F) related to DSC. Please click **Apply** to enable the change.

Apply

Write changes to UCD-400 sink DPCD registers

Refresh

Re-read the content of UCD-400 sink DPCD and update the control status.

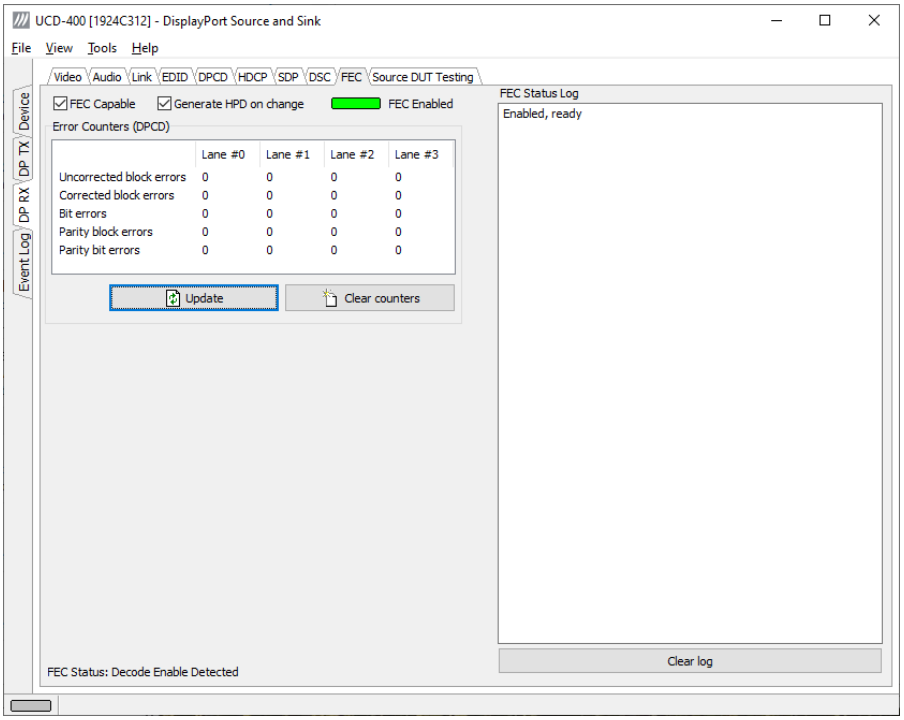
Reset Defaults

Reset the content of UCD-400 DSC related DPCD registers (0x00060 through 0x0006F) to the default values as defined in UCD-400 firmware.

FEC Tab

FEC Tab is enabled as a basic feature.

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



Enabling FEC

Enabling FEC feature is controlled by the source device. When connected, source verifies corresponding registers in sink DPCD to find out if sink is FEC capable. This register in UCD-400 sink can be controlled by **FEC Capable** checkbox.

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

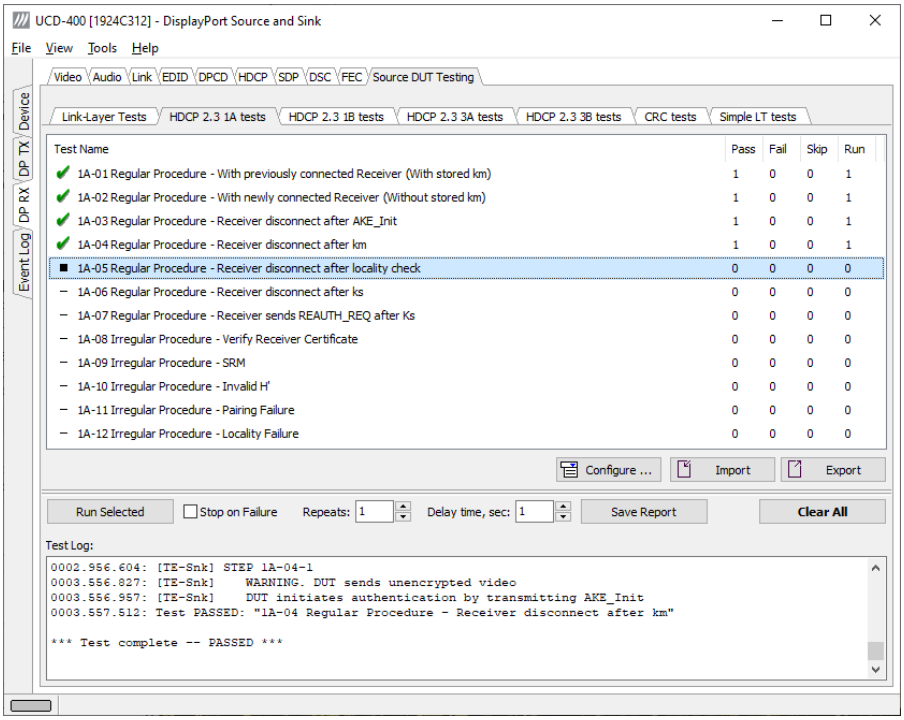
- Click **Update** to read the FEC Error Counters
- Click **Clear** to clear the counters.

FEC Status Log lists FEC events.

Source DUT Testing Tab

Source DUT Testing Tab is enabled with *UCD Pro for DP Sink* license.

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



Select the tests for execution by clicking the corresponding row.

Clicking **Configure…** opens a dialog for defining the test parameters for that set. Please refer to *Test Parameters* below for description.

Clicking Configure… opens a dialog for defining the test parameters for that set. Please refer to Test Parameters below for description.

- Tests are started by clicking **Run Selected**. By clicking **Abort** the sequence is stopped.

Test flow can be controlled with **Repeats** of the test sequence, **Delay time** between individual tests or **Stop on Failure** that stops the whole sequence if one of the tests fail.

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.

Click **Save Report** to generate a HTML report file for sharing the results with other parties for viewing without UCD Console.

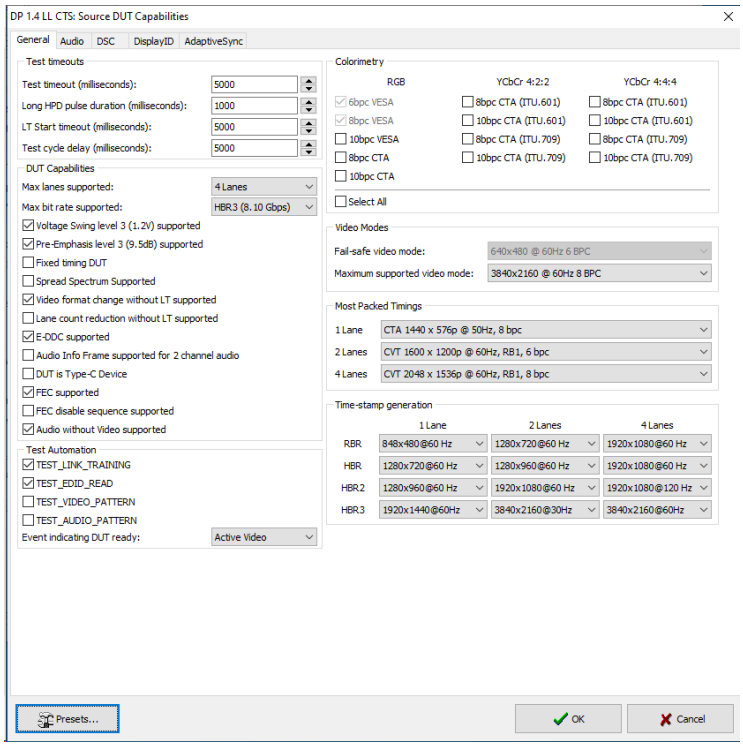
By clicking **Clear All** the test log and the results matrix are cleared.

Test Parameters

Each test set has its dedicated set of test parameters. Open a dialog for defining the parameters by clicking **Configure…**.

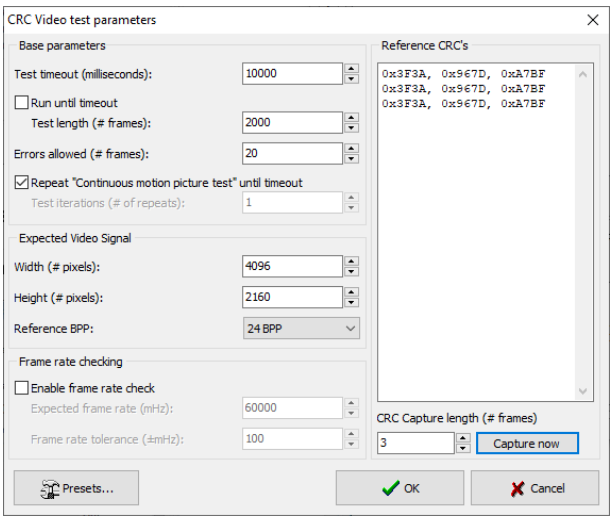
Parameters of Link Layer CTS

Link Layer CTS parameters includes DUT capabilities defined in *Source Device Capability Question List* in document *DisplayPort Link Layer Compliance Test Specification*. The capabilities are grouped into tabs based on the tested feature.



Parameters of CRC Test Set

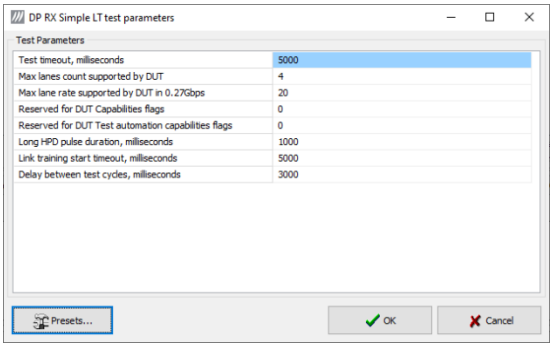
CRC Video test parameters dialog contains fields for defining the test duration, number of frames captured, errors allowed and expected video format.



Click **Capture now** to record *Reference CRCs*. Please define the number of frames used as reference – either one or the number of frames in the predefined test sequence.

Parameters of DP RX Simple LT Tests

The parameters for DP RX Simple LT test set is a subset of DUT capabilities.



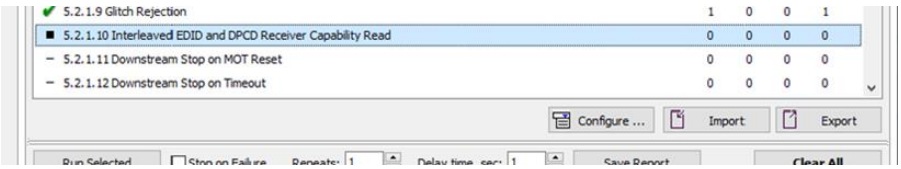
Presets

In all parameter dialogs the selected parameters can be saved as Presets. Please click **Presets…** to save or recall a configuration.

Exporting Tests for TSI

Unigraf UCD Console includes a feature rich Software Development Kit (SDK) for use in automated testing. The SDK is called Test Software Interface (TSI). 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 details.

The tests included in UCD Console's Source DUT Testing tab and Sink DUT Testing tab can be executed in TSI environment. A straightforward way is to use UCD Console's *Tools > TSI Integration* dialog to create the necessary files for TSI environment and use *Export* function in *DUT Testing* tabs to include the intended tests.



Export: Save parameters of the selected test to a file. If TSI Integration is enabled in Tools > Options, also the test is appended into 'Run Test' file in TSI workspace folder.

Import: Recall parameters from configuration file. If TSI Integration is enabled in Tools > Options, parameters are imported from a file in TSI workspace folder

7. DISPLAYPORT REFERENCE SOURCE

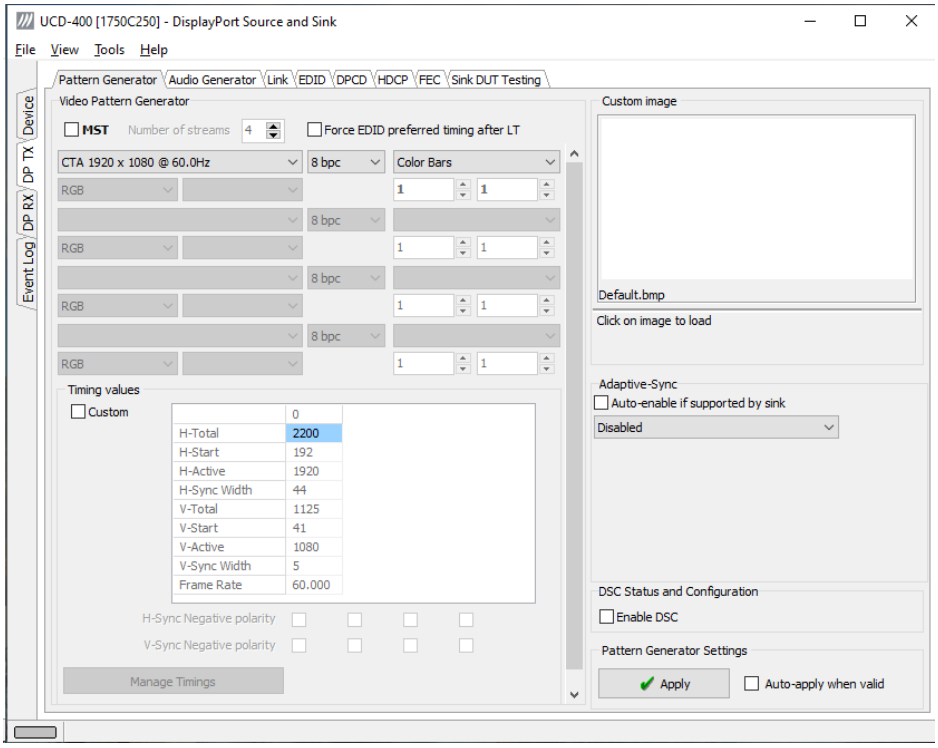
DP Source functionality available when using both UCD-400 and UCD-411.

DP Reference Source function is using one output channel, DisplayPort Source (DP TX). The corresponding vertical tab can be seen on the left edge of the GUI.

The horizontal tabs on the top of the GUI enable the various functions available for the output channel. Some of the tabs are enabled by default, some only when an applicable license is included. DPTX features the following functions.

- Video pattern generator (Pattern Generator)
- Audio generator (Audio Generator)
- Status information and control of the downstream link (Link)
- EDID editor (EDID)
- DPCD monitor (DPCD)
- HDCP status monitor and control (HDCP)
- FEC feature control and status (FEC)
- Sink DUT Testing Tab.

Pattern Generator Tab



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

Predefined Timings

UCD-400 includes a set of common predefined video timings. Please find a list of the timings with their major details in Appendix C of this document.

Force EDID Preferred Timing After LT

After Link Training (= plug-in) UCD applies the timing indicated as the Preferred Timing in VESA block of Sink device EDID.

The feature is disabled when MST mode is used.

Color Mode

RGB color mode with full range quantization levels will be used with all patterns except with *Color Square Pattern*. This pattern allows the user to select RGB, YCbCr 4:4:4, YCbCr 4:2:2 and YCbCr 4:2:0 color modes. When YCbCr is selected, the Colorimetry dropdown box is enabled and allows selection between ITU-709 and ITU-601. Please find a description of the available test patterns in Appendix D of this document.

Color Depth

You can set the color depth used. The available color depths are: 6, 8, 10, 12 and 16 bpc. Color depth 6 bpc is only available with RGB.

Predefined Video Patterns

UCD-400 has a set of predefined patterns and a possibility to user defined custom patterns. The predefined patterns are selected from the list in the combo box. By selecting **Disabled** you can have the links activated but no video data transferred.

Please find a description of the available predefined patterns in Appendix D of this document.

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

Custom Image Patterns

BMP, PNG, JPG and TIFF files can be loaded from the PC to be used as custom images. The bitmaps will be aligned to the top left hand side corner, displayed at the original resolution, no scaling, cropped to the active area.

MST Operation

Multi-streaming can be enabled from **MST** check box and selecting the number of streams. Please click **Apply** to enable.

Note	Please note that MST and DSC features and cannot be used simultaneously

Adaptive-Sync Control

User controls in the four Adaptive-Sync modes are the following.

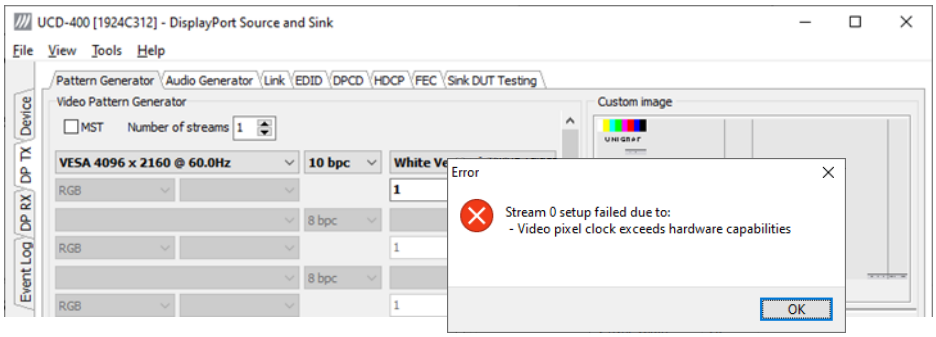
- **Adaptive Total, constant refresh rate**: Added blank lines.
- **Adaptive Total, Square pattern**: Added blank lines, min; Added blank lines, max; Period, frames.
- **Adaptive Vtotal, Zigzag pattern**: : Added blank lines, min; Added blank lines, max; Increase, lines; Decrease, lines.
- **Fixed Average VTotal:** Target refresh rate, Hz; Increase, lines; Decrease, lines.

Auto enabled if supported by Sink enables the feature based on connected Sink status.

Note	Please note that MST and Adaptive-Sync features and cannot be used simultaneously

Pattern Generator Settings

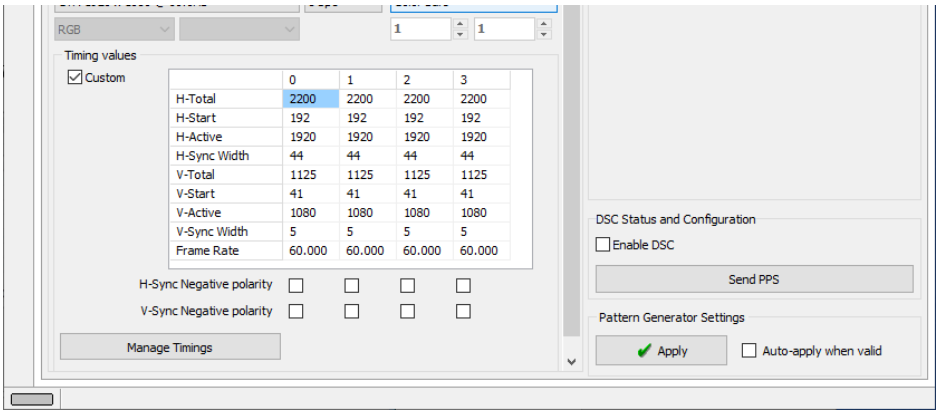
In order to avoid sourcing invalid video mode combinations new settings are being validated when the user is clicking **Apply**. Automatic validation will be applied when **Auto-apply when valid** is checked. The situation that parameters have been changed but not applied is indicated by **bold values** of the parameter. If new settings cannot be supported by e.g. the selected link configuration, an error dialog will be shown.



Note	Please note that the changes in Pattern Generator tab will not be applied unless the user validates them by clicking **Apply** or when **Auto-apply when valid** is checked.

Custom Timing

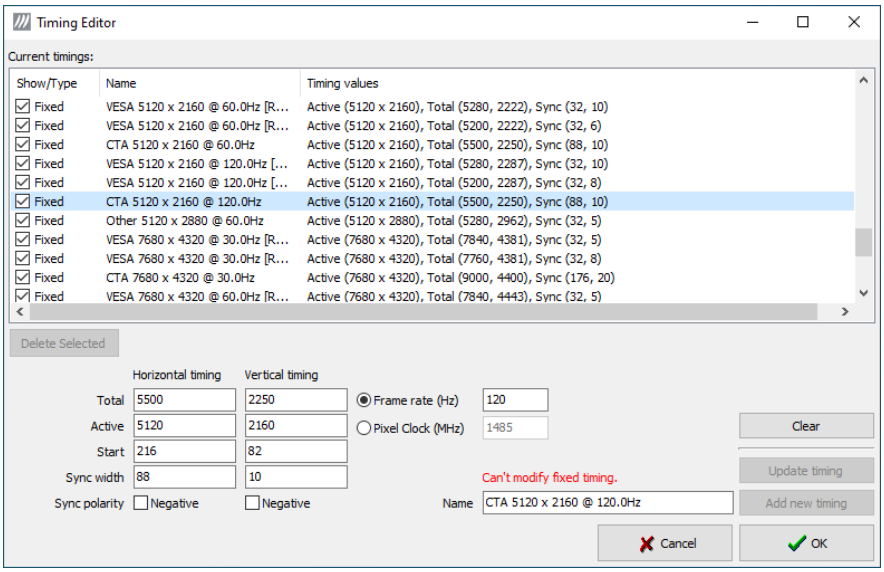
Custom Timing feature is enabled with *UCD Pro for DP Source* license.



The timing parameters can be modified by selecting the **Custom** check-box and editing the fields of the matrix. Enable the new parameters by clicking **Apply** button.

Manage Timings

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



- In order to create a new custom timing based on one of the standard fixed, timings select the fixed timing and change its name and click **Add new timing** to store**.**
- In order to modify an existing custom timing, select it, modify and click Update timing.

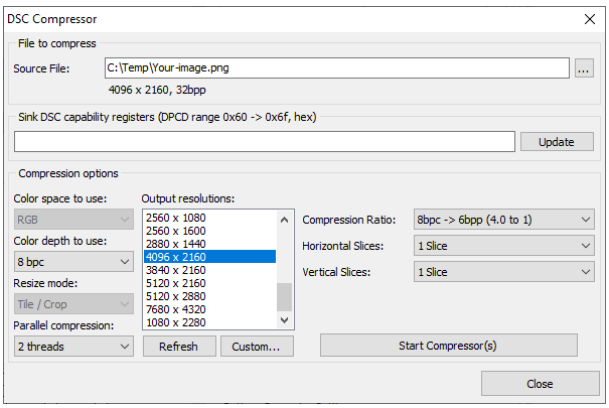
  The dialog will make a sanity check for the values entered and will warn the user for any combinations that cannot be used.

Customize Timings List

The timings are shown on the pull-down menu by un-checking the **Show** box. The timings will remain in the list and can be brought back to the pull-down menu, when needed.

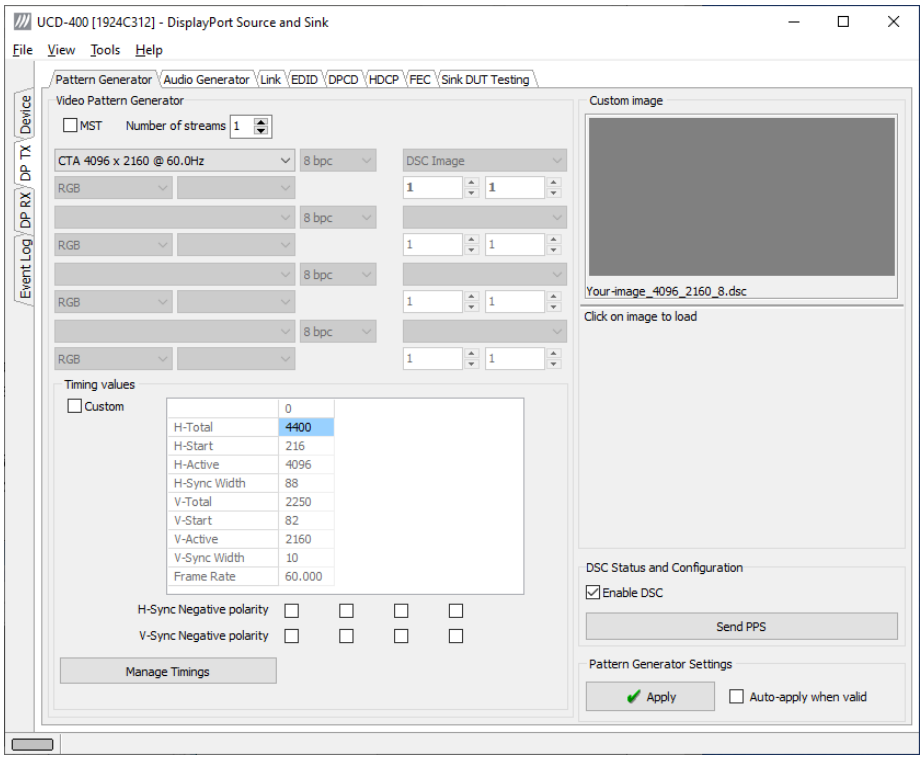
Sourcing DSC Compressed Patterns

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.
- Click Start Compressor(s).

  A DSC compressed file named e.g. *Your_Picture_4096_2160_8.dsc* will be created in the same folder are your source file *Your_Picture*. The selected resolution and bit depth will be added to the file name.



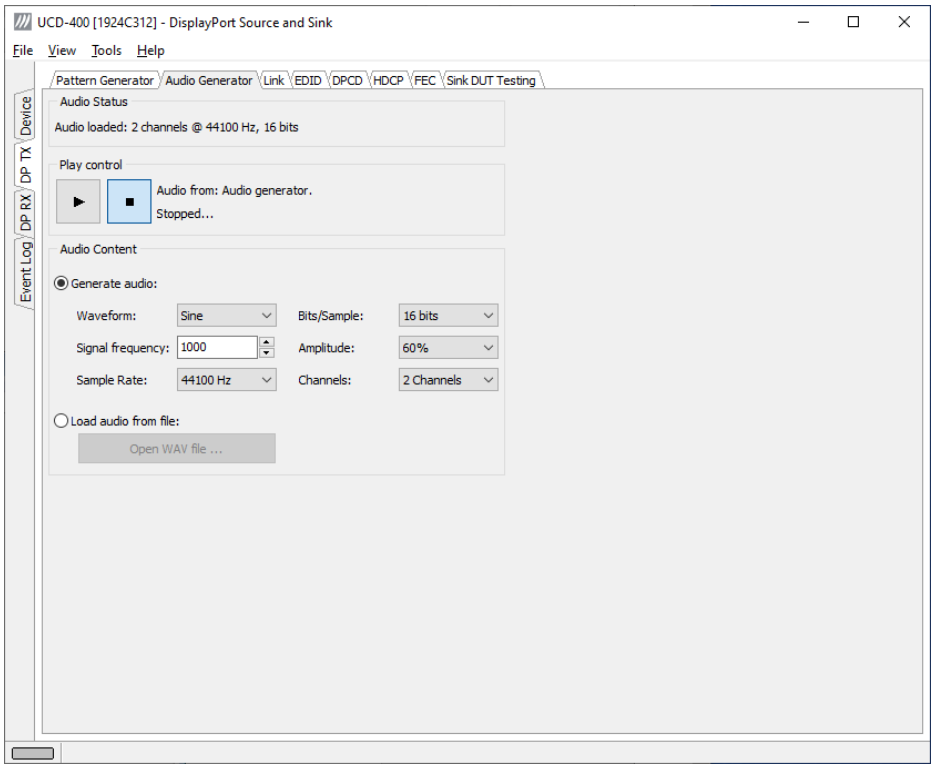
- Select Enable DSC and click Apply.

Note	Please note that the output resolution has to match the size of the used compressed DSC image.

Note	Please note that MST and DSC features and cannot be used simultaneously

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.

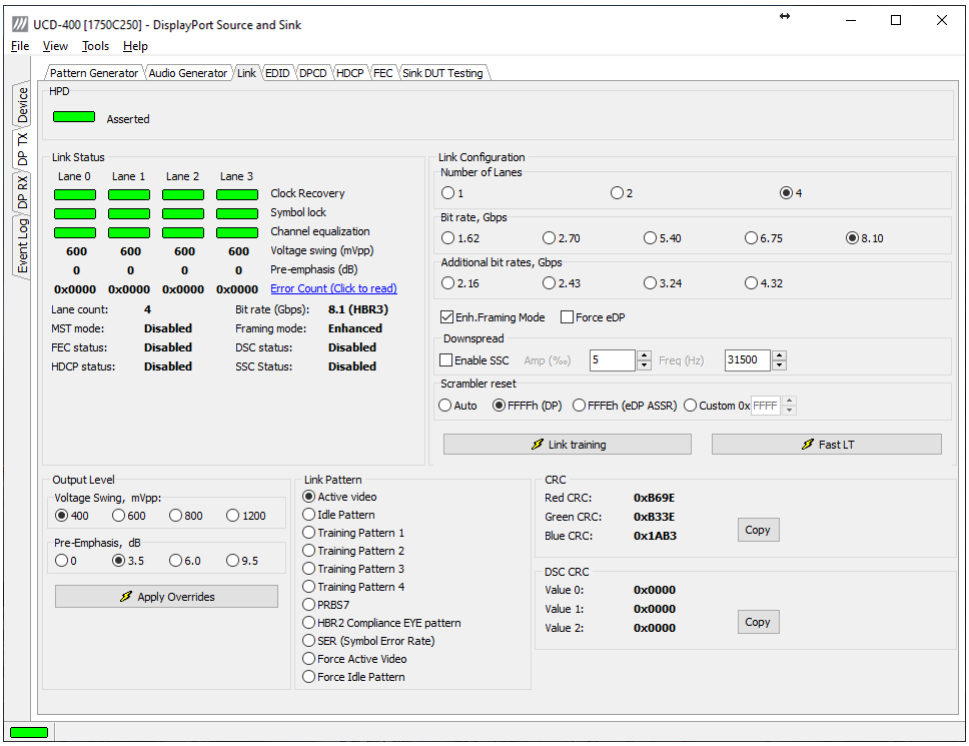
  Audio Status in the top of the tab indicates the type of the currently played audio content.

Link Tab

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

HPD

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



Link status

The panel shows the result of the link training with the connected downstream sink and status of connection features.

Output Level

Override output level and pre-emphasis values selected during link training. Click **Apply Overrides** to validate changes.

Note	Please note that connected Sink and Source actively maintain the link. If the override settings result in link failure, the link will be automatically re-trained and proper values set.

Link configuration

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

- Set the Number of Lanes used,
- Set the Link Rate, from standard DP link rates or Additional ‘eDP’ link rates
- Enable Enhanced Framing Mode
- Force eDP mode (If set, only link rates announced in SUPPORTED_LINK_RATES table (DPCD 00010h – 0001Fh) will be used when determining supported link rates.

Downspread

Select **Enable SSC** to enable down spreading of link frequency (SSC).

Set **Amp (‰)** to SSC Spreading Amplitude.
Allowed amplitude range is 1 to 10‰ (per mil, 0.1%) (It is mandatory for a DP Rx to support up to 0.5% down spread).

Set **Freq (Hz)** to SSC Modulation frequency. Allowed Frequency range is 30 to 35 kHz.

Scrambler Reset

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

In **Auto** mode UCD verifies that connected DP Sink supports eDP and Alternate Scrambler Seed, and then applies FFFEh. If not, FFFFh will be used.

Fast Link Training

Click **Fast LT** to initiate a link training without AUX transactions. The procedure will be the following:

1. Send idle for 10 µs
2. Send TPS1 for 1 ms
3. Send TPS2/3/4 for 1 ms
4. Send idle for 10 µs
5. Send video

Link Pattern

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

When **Force Active Video** option is selected, character error messages from sink will not interrupt video transmission.

When **Force Idle Pattern** is selected, Link Training and Active Video will not be initiated even after a re-plug.

Note	Please note that except *Active video*, the patterns do not carry video and audio. They are special bit combinations used for development purposes. When selecting **Active Video** (or **Force Active Video**) normal audio and video are being transmitted over the link.

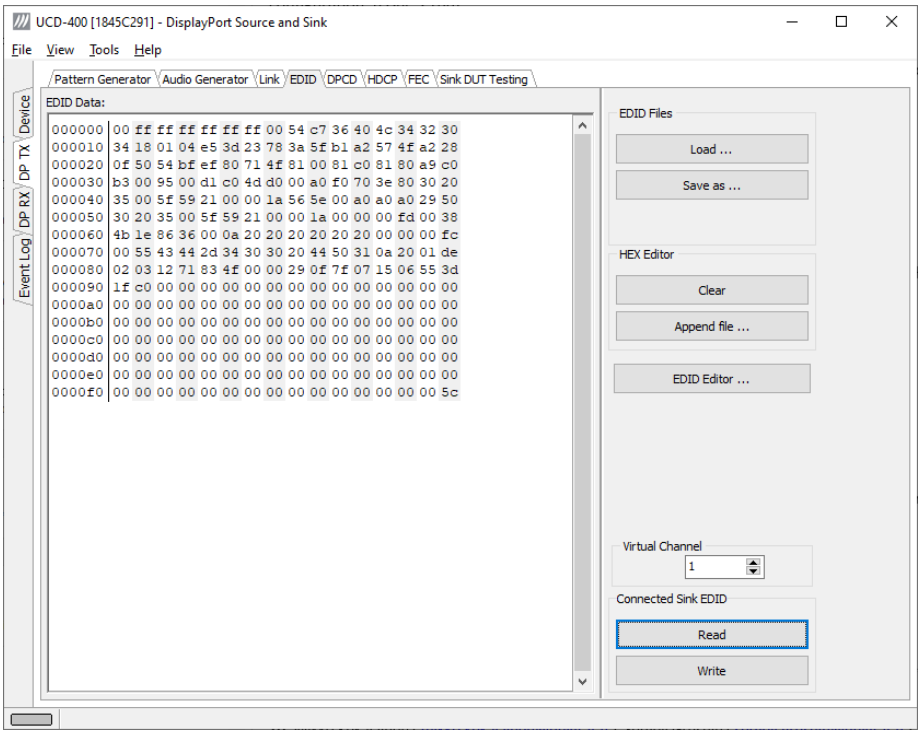
CRC

The 16-bit **CRC** (checksum, cyclic redundancy check) values of the three color components calculated by the Sink hardware.

The 16-bit **DSC CRC** values of the captured DSC compressed frame. "**Value 0**" is calculated from 1st, 4th, 7th … byte, "**Value 1**" from 2nd, 5th, 8th … byte and "**Value 2**" from 3rd, 6th, 9th … byte.

EDID Tab

EDID tab enables analyzing and saving the EDID read from the connected Sink device.



There are three basic functions:

- Read the contents of the EDID of the downstream sink over the DisplayPort link.
- Load and save EDID data files in the host PC
- Edit the EDID contents

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 is read. If the device is not supporting all four blocks, the non-supported area is replaced with zeroes.

Currently the EDID Editor does not support Display ID. Hex EDID files can however be modified with the HEX Editor or externally generated hex EDID files that have Display ID content can be load and programmed into the hardware.

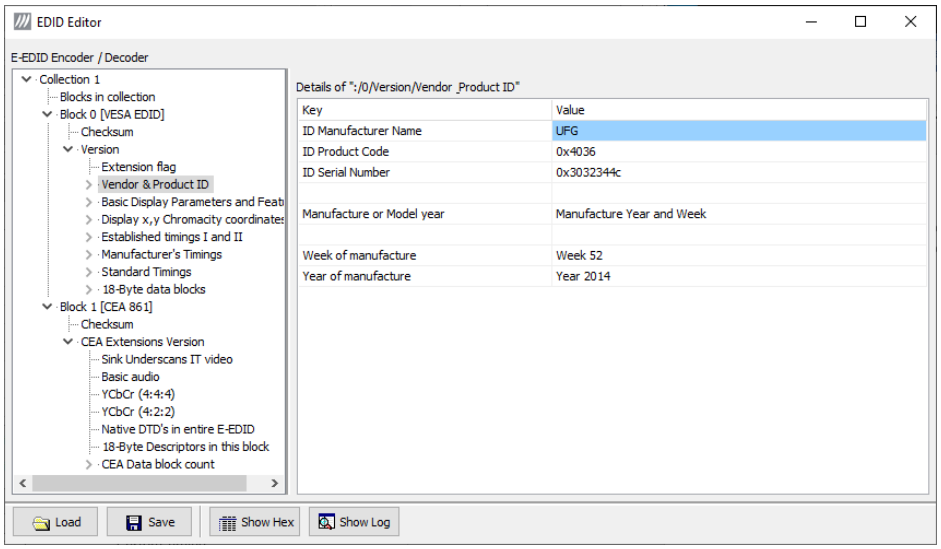
HEX Editor

When EDID content is either loaded from a file or read from the hardware EDID memory, it is shown in the *EDID Data* panel on the left hand side of the dialog. EDID contents can be edited by typing over the existing values. Altered content is highlighted with **RED**. Please note that Hex Editor itself does not alter the contents of the EDID data or verify its integrity.

After editing the data can either be saved to an *.ecd file in the PC with **Save as…** or programmed it to the hardware EDID memory with **Write**.

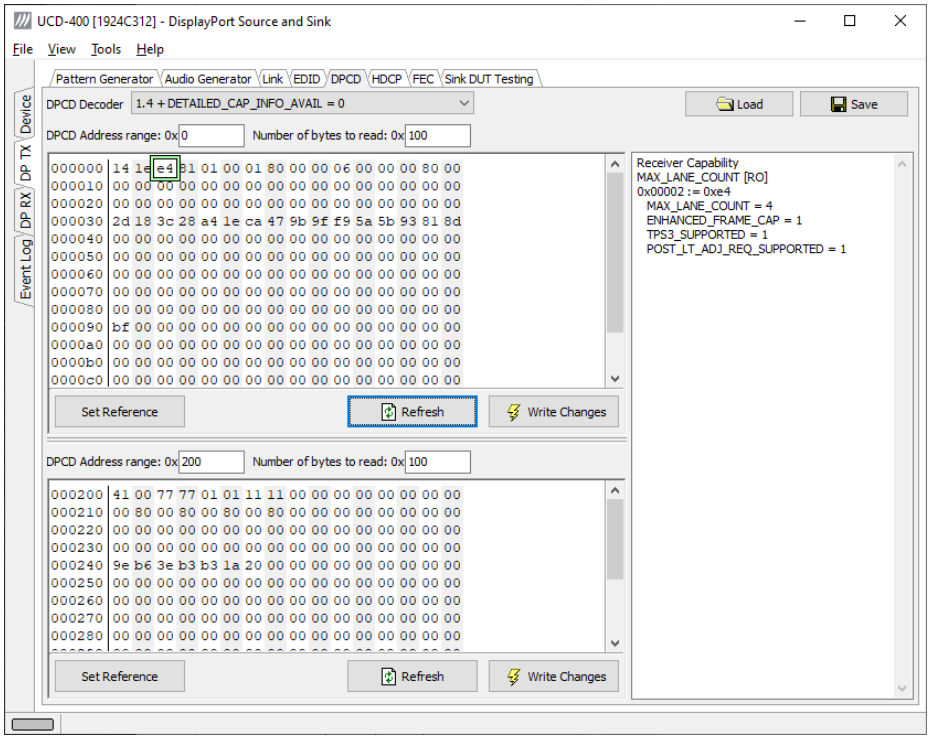
EDID Editor

EDID Editor is launched in a separate pop-up window. 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 connected Downstream Sink.



The tool consists of two independent monitoring and editing windows for the DPCD data. The user can freely select the the DPCD address areas shown on each panel.

The *DPCD Decoder* panel on the right hand side shows the interpretation of the DPCD byte selected on the monitoring windows. The selected byte is shown with a green outline.

In the combo box above the DPCD Decoder window you can select how the DPCD data is interpreted, either as *DP 1.1 DPCD*, or as *DP 1.2 DPCD* with *Detailed Capability Info* selected or not (DETAILED_CAP_INFO_AVAIL = 1/0).

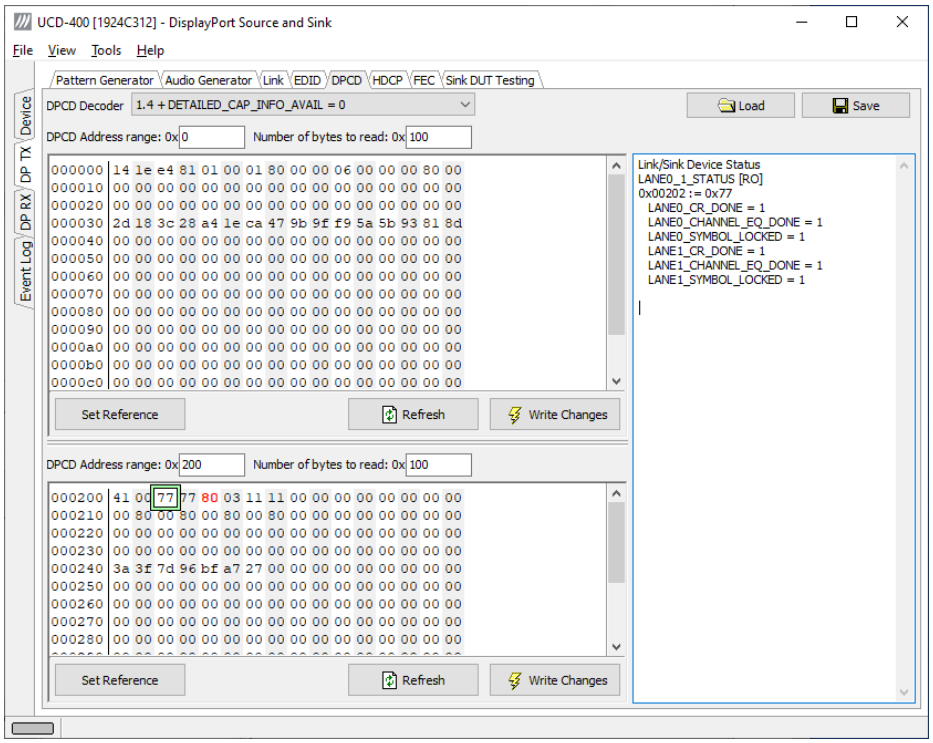
By clicking **Refresh** you can re-read the data from the DPCD registers to the window in question.

By clicking **Write Changes** you can write the portion of data shown in the window in question to the DPCD registers.

By clicking **Set Reference** you can store currently shown data as a reference for comparison.

When you refresh the data from the DPCD registers the changed bytes will be highlighted with gray background.

The fields edited by the user will be highligted with **red** color.



Saving and Loading DPCD Content

DPCD data in the selected address areas can be saved as a file in your PC. There are three alternative formats:

- Binary *DPCD Fata File* format (*.DPD). This is Unigraf proprietary format. You can also load the DPCD content stored in this format.
- *Comma Separated Values* (*.CSV) for loading the data to a spreadsheet.
- *HEX Dump* (*.HEX) in a human readable text format.

▶ Click Save to select the location and the format of the file.

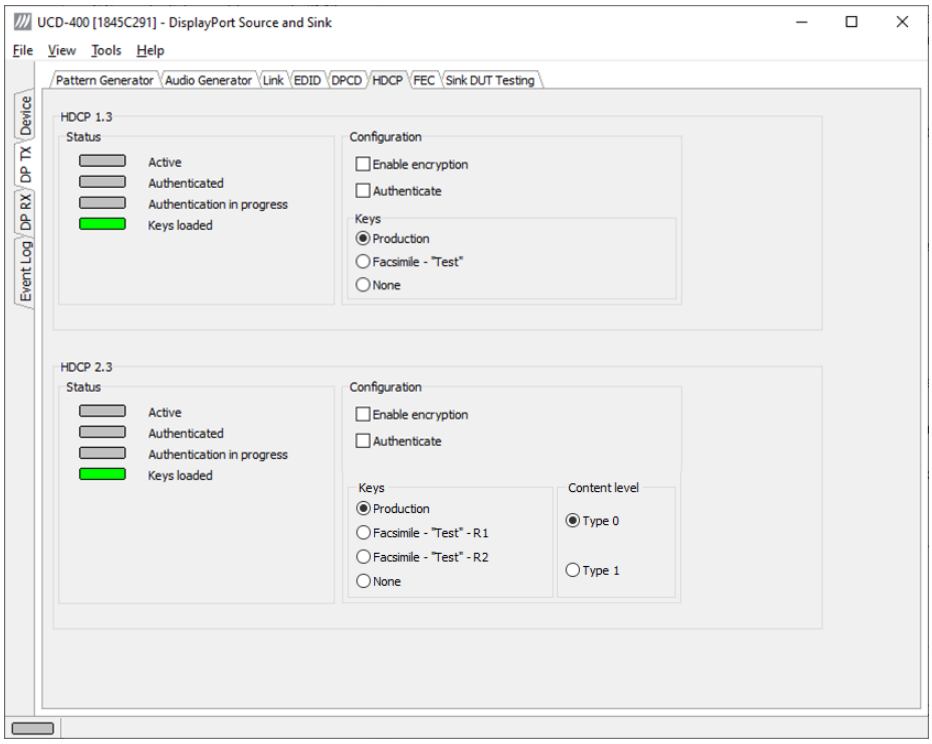
▶ Click Load to load DPCD data saved in DPCD Data File (*.DPD) format to the editor.

▶ To program the data into the DPCD registers of UCD-400 Local Sink click Write **Changes**.

Note	- Writing DPCD data to the DPCD registers of the Sink will potentially affect the status and capabilities of sink as seen by the source. - User control like Link Training or mode changes will modify the content of the DPCD registers

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 connected UCD-400 device.



Status

The status fields indicate the HDCP status of the connected UCD-400 device.

Active: The stream between UCD-400 and the downstream sink has been encrypted.

Authenticated: The HDCP handshake between the UCD-400 and the sink unit has been completed successfully.

Authentication in process: The HDCP handshake is in process between the UCD-400 and the downstream sink unit.

Keys loaded: The HDCP keys are loaded to the UCD-400 unit.

Configuration

Enable encryption: Check to enable the encryption of the stream between UCD-400 and the downstream sink.

Authenticate: Perform the HDCP initiation handshake between the UCD-400 and the sink unit.

Keys

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

Content level

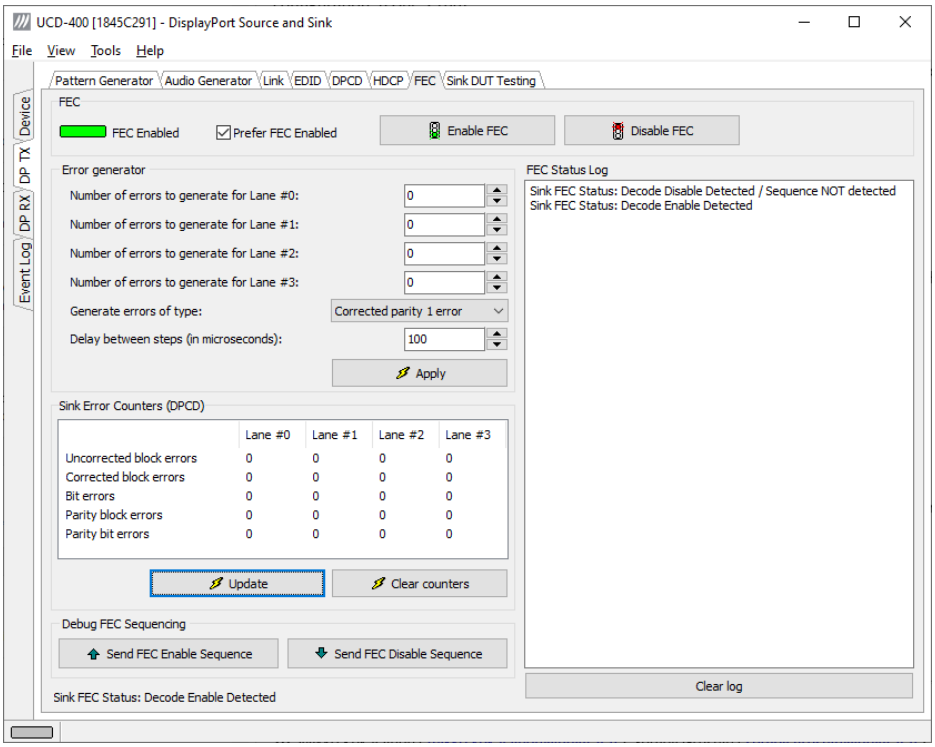
Selection of **Type 1** content ensures that content encryption is done with HDCP version 2.2 or higher.

HDCP 1.3 vs. HDCP 2.3

UCD-400 devices support by default HDCP 1.3 and HDCP 2.3.

FEC Tab

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



FEC

Clicking **Enable FEC** UCD-400 will verify if connected sink supports FEC and begins the handshake for enabling FEC.

Clicking **Disable FEC** UCD-400 will start the FEC disable handshake.

If **Prefer FEC Enabled** is selected and the connected sink supports FEC, UCD-400 will start the FEC Enable Sequence after a successful connection.

Error Generator

Generate errors of type: selection 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
- Corrected parity 1 error

Note:	FEC must be enabled and running before errors can be added.

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

Clicking **Apply** will start error injection.

Clicking **Update** will read sink DPCD FEC error counter registers.

Clicking **Clear counters** will clear sink DPCD FEC error counter registers.

Note:	Link training will reset sink FEC error counters.

Debug FEC Sequencing

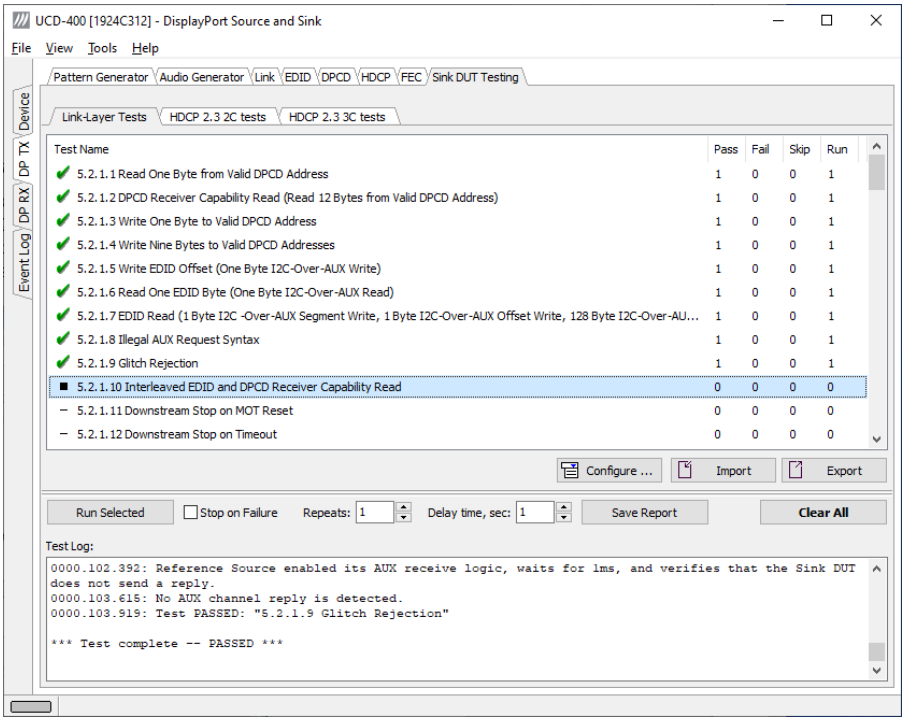
When clicking **Send FEC Enable Sequence** UCD-400 will start adding *FEC Enable Sequence* in its main link data.

When clicking **Send FEC Disable Sequence**, UCD-400 will start adding *FEC Disable Sequence* in its main link data.

Sink DUT Testing Tab

Sink DUT Testing Tab is enabled with *UCD Pro for DP Source* license.

Please refer to **Appendix E** later in this document for description of the tests available. Sink DUT Testing enables the execution of HDCP 2.3 Compliance Tests for a DP Sink DUT. Sink DUT Testing enables testing of a DP Sink DUT. Please refer to **Appendix E** of this document to get a full definition of the Test Cases and test parameters.



Select the tests for execution by clicking the corresponding row.

Clicking **Configure…** opens a dialog for defining the test parameters for that set. Please refer to Test Parameters below for description.

Parameters from Test descriptor files can be loaded with Import and stored with Export. Please refer to chapter *Exporting Tests for TSI* later in this document.

- Tests are started by clicking **Run Selected**. By clicking Abort the sequence is stopped.

Test flow can be controlled with **Repeats** of the test sequence, **Delay** between individual tests or **Stop on Failure** that stops the whole sequence if one of the tests fail.

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.

Click **Save Report** to generate a HTML report file for sharing the results with other parties for viewing without UCD Console.

By clicking **Clear All** the test log and the results matrix are cleared.

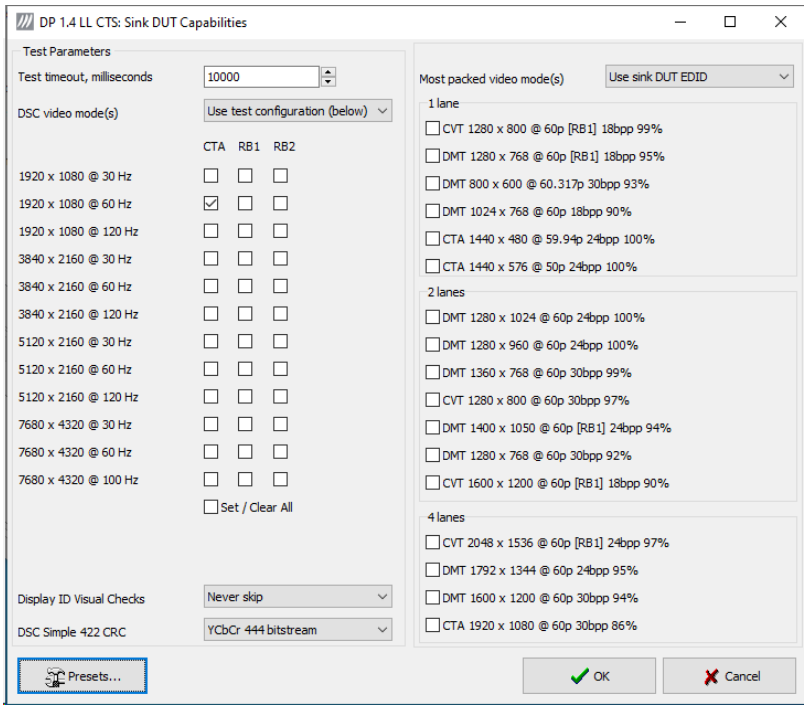
Test Parameters

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

Parameters of LL CTS Tests

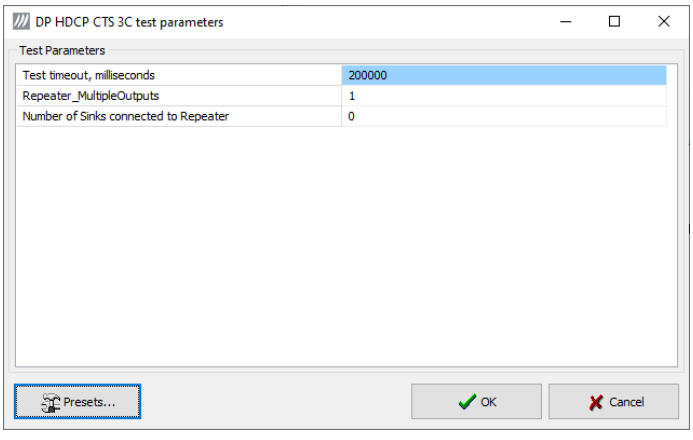
Link-Layer Tests parameter panel defines which resolutions and video modes are used for testing.

They can be defined in the matrix in the dialog by selecting **Use test configuration (below)** or determined by evaluating content of DUT EDID by selecting **Use sink DUT EDID**.



Parameters of HDCP CTS Tests

HDCP CTS Tests have their own parameter dialog.



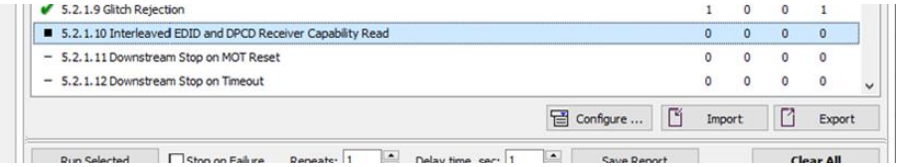
Saving and Loading Presets

In all parameter dialogs the selected parameters can be saved as Presets. Please click **Presets…** to save or recall a configuration.

Exporting Tests for TSI

Unigraf UCD Console includes a feature rich Software Development Kit (SDK) for use in automated testing. The SDK is called Test Software Interface (TSI). 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 details.

The tests included in UCD Console's Source DUT Testing tab and Sink DUT Testing tab can be executed in TSI environment. A straightforward way is to use UCD Console's *Tools > TSI Integration* dialog to create the necessary files for TSI environment and use *Export* function in *DUT Testing* tabs to include the intended tests.



Export: Save parameters of the selected test to a file. If TSI Integration is enabled in Tools > Options, also the test is appended into 'Run Test' file in TSI workspace folder.

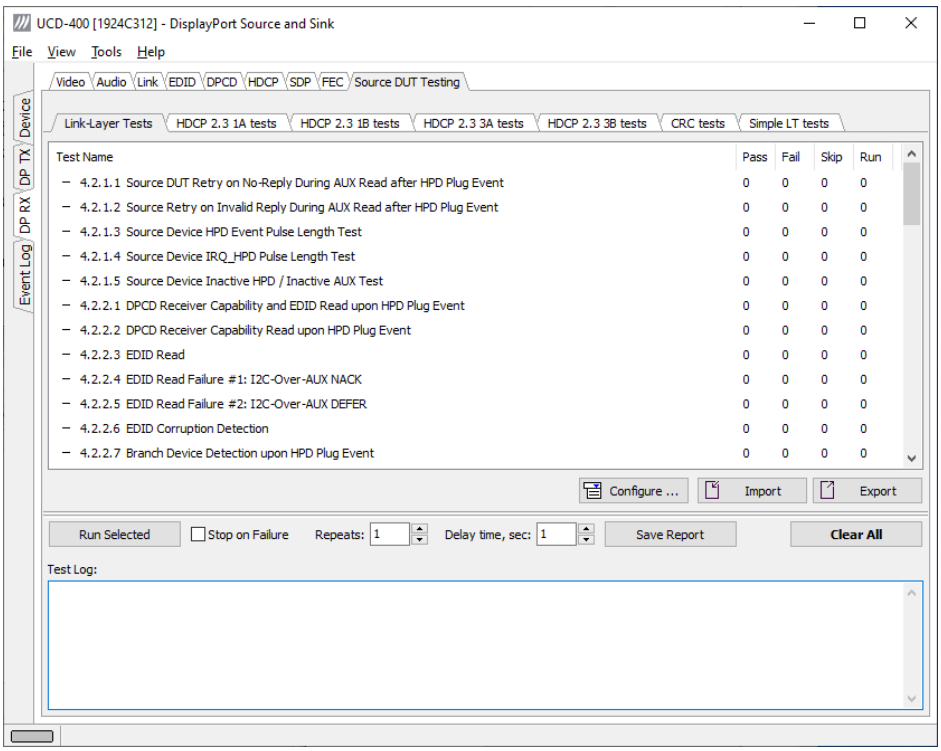
Import: Recall parameters from configuration file. If TSI Integration is enabled in Tools > Options, parameters are imported from a file in TSI workspace folder

8. COMPLIANCE TESTS

Compliance test functionality 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 *DisplayPort Compliance Test Tool Options for* UCD-400. 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**. **Source DUT Testing** tab is not available when using UCD-411.



The tests cases are divided to test categories as described in *Appendix E* of this document. Each test category can be found in its dedicated sub-tab. The sub-tabs as in turn enabled by the licenses present in user's PC. Please refer to chapter 3 *License Manager* earlier in this document.

DSC Test Content

When running DSC Compliance Tests, UCD-400 needs to have access to DSC content used as test patterns. The content can be created from the source bitmap files downloaded during installation (optional) either with Unigraf DSC Content Creator or created by the Compliance Test Tool on-the-fly during the compliance test.

Options

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

When *Automatically create missing content*, is selected automatically create the DSC compressed content used for testing the DUT.

You can also *Keep auto-created DSC content files:* By default, the DSC compressed content is deleted after use. If selected, the content not deleted.

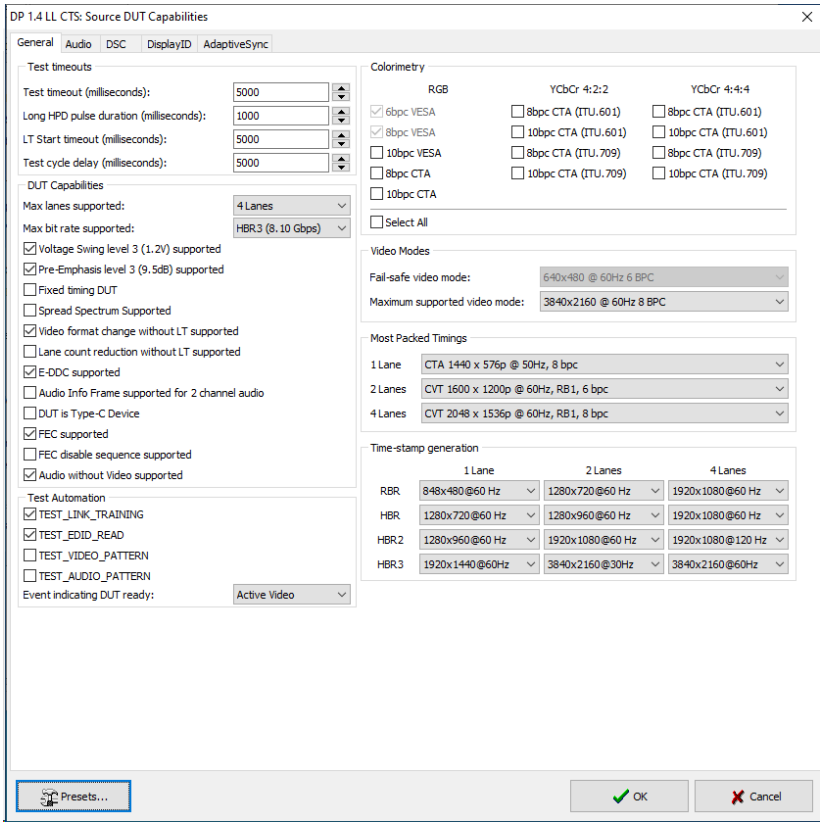
Warning

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.

Test Parameters

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



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

Note

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

Saving Test Parameters

Test parameters can be saved for later use in two ways: internally or externally in a file.

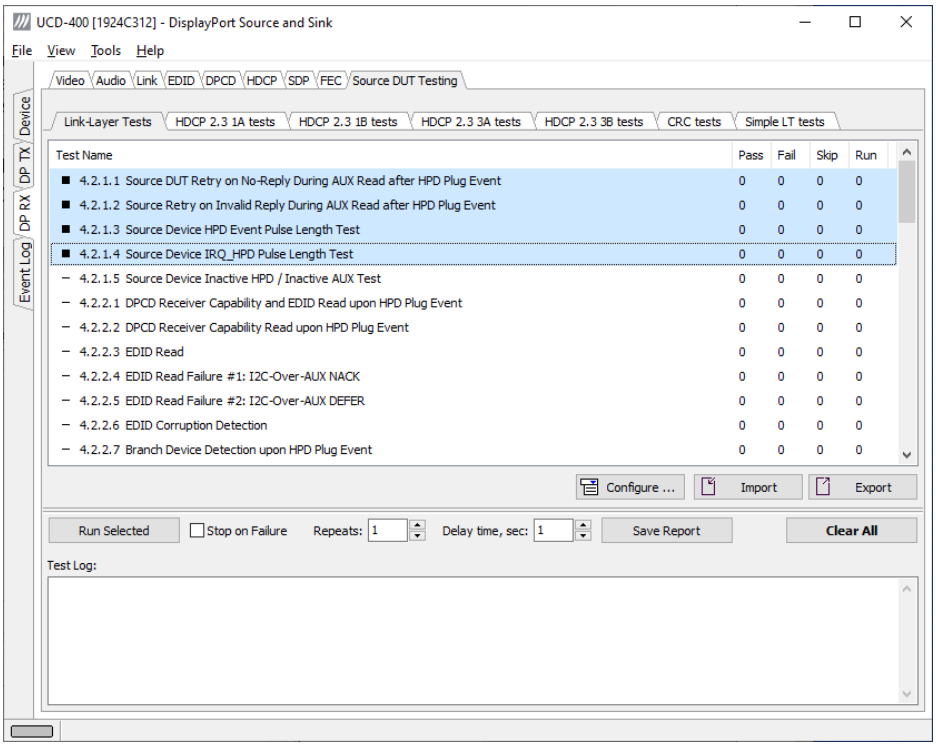
In *parameter dialog* the parameter set can be saved as an internal **Preset**.

In *Source* or *Sink DUT Testing* tab **Export** saves test definitions of each selected test in a separate file. **Import** loads the parameters back to UCD Console. They can be run with Unigraf TSI. Please refer to chapter *7.3.6 Running Tests* in document *TSI-X_Reference.pdf* in UCD Console release package.

Running CTS Tests

Source DUT Testing (UCD-411 N/A) and *Sink DUT Testing* tabs include the tests enabled with the set of licenses present in UCD Console. The tests are grouped in test set tabs. In tabs the tests are listed by the test name and reference number as presented in applicable compliance test specification. UCD-400 firmware implements the test according to the test specification.

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



Repeats defines number of test-runs and the **Delay time** delay between the tests. 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.

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

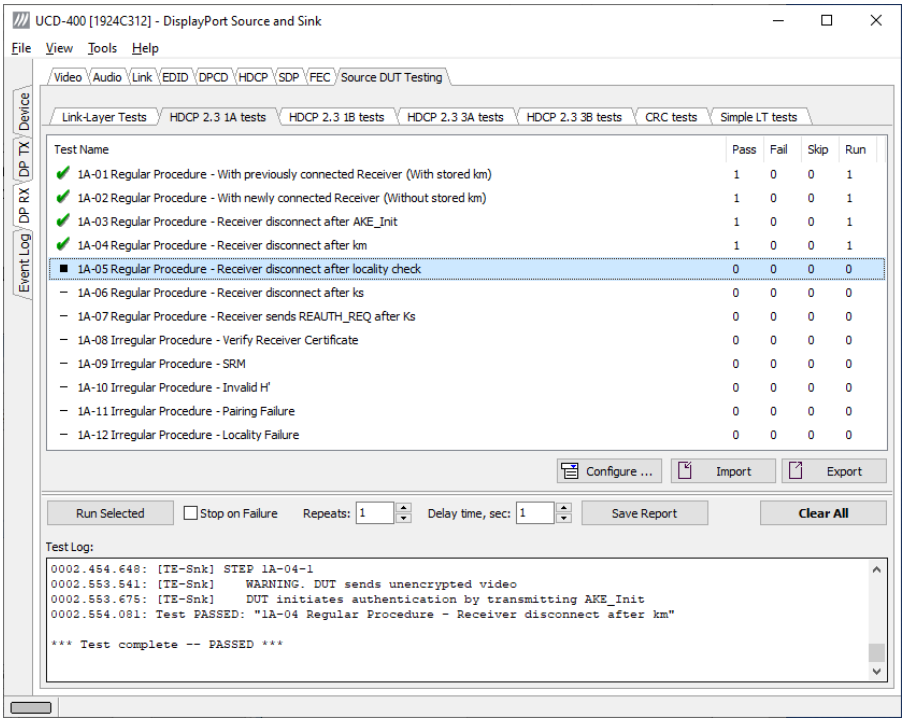
Selecting **Stop on Failure** stops execution of a series of tests in case a failure is found.

For clearing the Status Log and the Results matrix, click **Clear All.**

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.

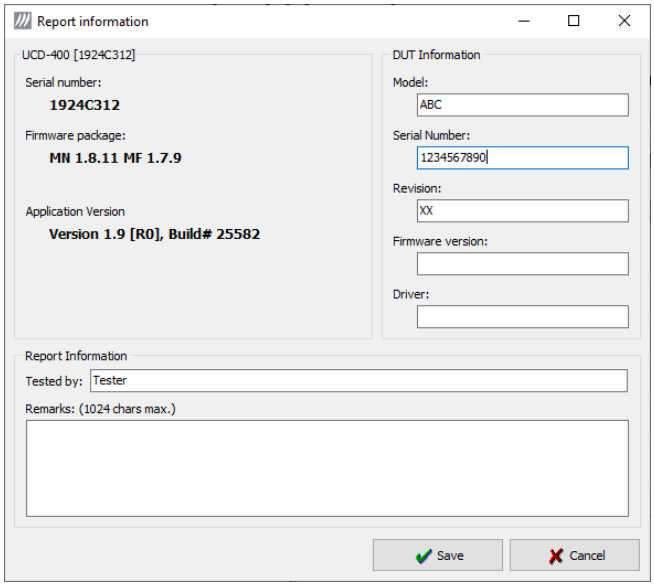
At the completion of each test the result of the test is indicated in the matrix on the right hand side of the test panel. For each test, the matrix lists the number of occurrences of each result and the number of tries performed.



Test Report

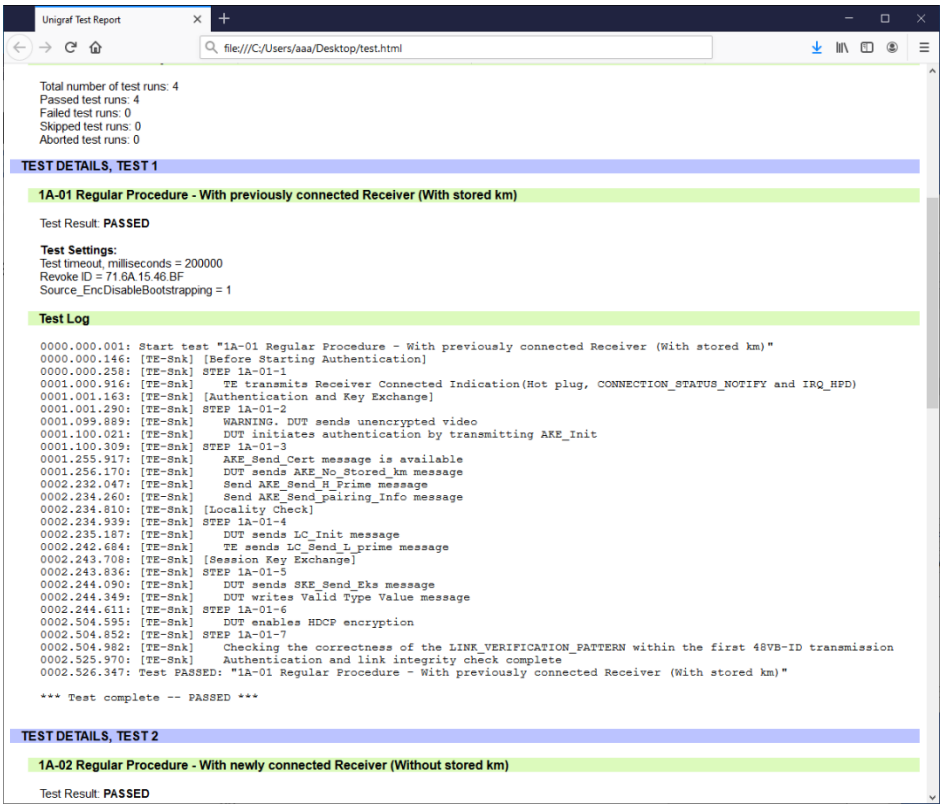
Results of the test can be saved as a report in HTML format.

Click **Save Report** in UCD Console. A dialog will open where information about the DUT and remarks about the test can be included in the report. Details of the used test equipment and the software and firmware version will be added automatically.



Viewing the CTS Test Report

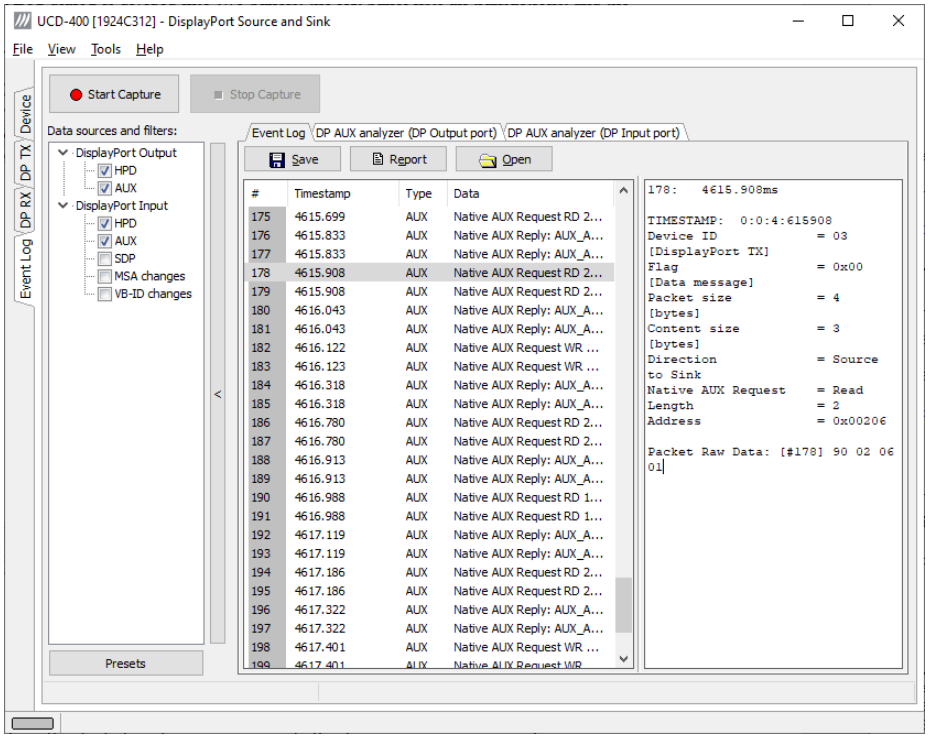
The report file can be viewed with any HTML browser. The report has built-in views for Report Summary, Test Summary, and individual Test Logs.



9. EVENT LOG

Event Logger (Event Log) vertical tab can be seen on the left edge of the GUI. Event Log is enabled with *UCD Pro for DP Sink* (UCD-411 N/A) or *UCD Pro for DP Source* license.

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.



Event Logger captures the following items (DP RX not available in UCD-411)

- HPD status (DP TX and DP RX)
- AUX transaction (DP TX and DP RX)
- DP SDP messages (DP RX)
- Changes in MSA (DP RX)
- Changes in VB-ID (DP RX)

Each item line includes Time stamp, Type indication, Message source, and raw message data. The right panel lists the content of one message. Messages belonging together with the selected one are shown in red color.

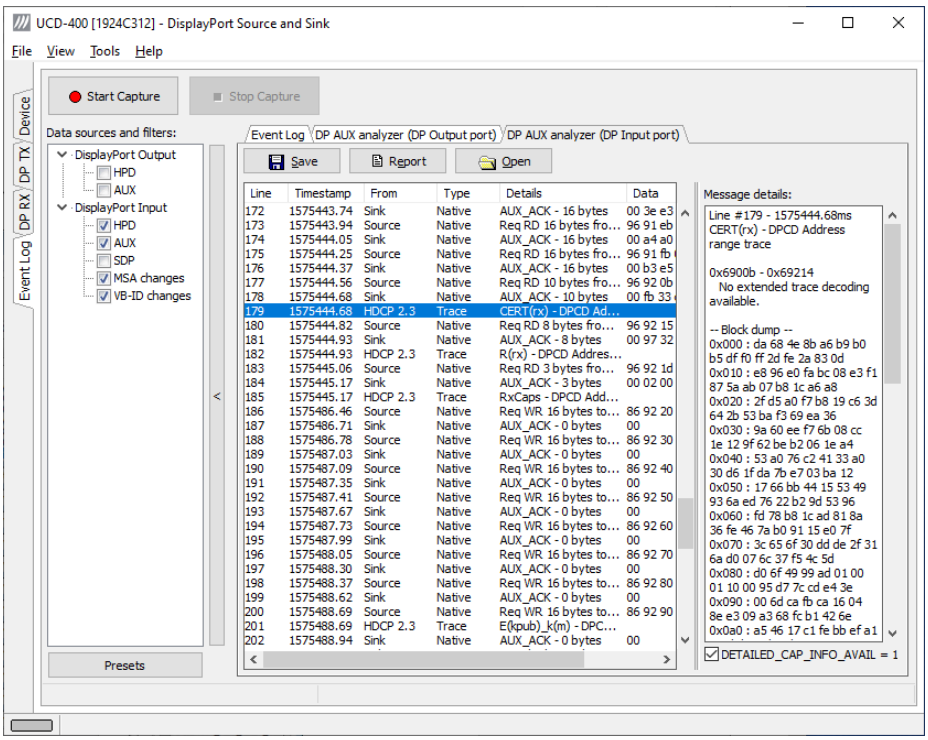
▶ Start event logging by clicking **Start Capture** and stop it by clicking **Stop Capture.**

▶ The transactions can be saved in binary *.evt Event Log files by clicking **Save**. Saved Event Log files can be recalled by clicking **Open**.

▶ Clicking **Report** stores event logs as html reports to be shared and viewed with any web browser. The save dialog allows inclusion of detailed information about the DUT and the test in free-text *Report information*.

DP AUX Analyzer

DP AUX Analyzer functionality is enabled in UCD-400 and UCD-411 by default.



The AUX Analyzer tabs collect AUX Channel Transactions from the Event Log in the *Transaction list.* The user can parse the content of each transaction by clicking the corresponding *transaction line*. The parsed content is in the *Message Details* panel on the right.

Please refer to chapter *Customizing the Main Window* below for details on how to modify the content and look of the *Transaction list*.

Lines

The data is organized in lines, each numbered starting from 1 and marked with a timestamp. There are four kinds of lines:

1. Information lines
   Identified by the text “INFO” in their Type column, they provide some useful information like the time acquisition has started and stopped or the logical state of the inputs, etc.
2. Transaction lines
   Identified by the text “Native” or “I2C” in their Type column, they report an AUX channel data transfer, either a data Request or a data Reply.
3. Event lines
   Identified by the text “Event” in their Type column, they signal the state change in one or more of the monitored inputs.
4. Sideband Channel Messages
   The Isochronous Transport Service uses the sideband communications over sideband channel (AUX CH and HPD) for the management of topology/virtual channel connection/Main Link and performs Main Link symbol mapping.

5. Error lines
   A line Type reading “Error” marks the detection of an illegal AUX channel data packet. An irregular start condition, an irregular stop condition or transfer of a number of bits which is not a multiple of 8 are all conditions that cause an error line.
6. Trace lines
   Combines the data from several lines of a HDCP related message to one entry in *Message details* panel for easier readability.

Columns

The data on each line is ordered in columns. Each column provides additional information about the data line, facilitating its viewing and interpretation:

Line

This column displays the line number, starting from 1, and cannot be hidden.

Timestamp

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.

From

This column indicates the originator of the data line:

- “**Source**” and “**Sink**” for an AUX channel transaction, respectively a data Request and a data Reply.
- “**Source Trace**” and “**Sink Trace**” respectively for Sideband Message data Request and Reply.
- “**DPA-400**” for error and information lines.
- “**Unknown**” for signal state change events.

Type

This column provides additional information about the type of the line:

- “**Native**” marks Native AUX channel Requests and Replies.
- “**I2C**” marks I2C AUX channel Requests and Replies.
- “**Sideband Request**” and “**Sideband Reply**” to mark the Sideband Channel messages
- “**Event**” is used for signal state change events.
- “**INFO**” is used with information lines.
- “**Error**” is used for illegal conditions detected on the AUX channel.

Details

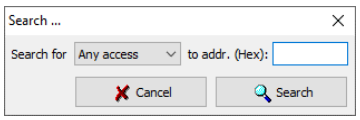
This column contains an abbreviated description of the line content in textual form.

Data

The binary data exchanged during AUX channel transactions, in hexadecimal notation.

Find

To locate an access to a DPCD location right-click on the list and select **Find…** or select **Ctrl+F** from keyboard. To **Find again** select **F3**.



Message Details

The *Message details* panel is used to provide a detailed explanation of the line currently selected in the *Transaction list*. For AUX channel transaction lines, for each of the DPCD memory locations affected, the panel lists:

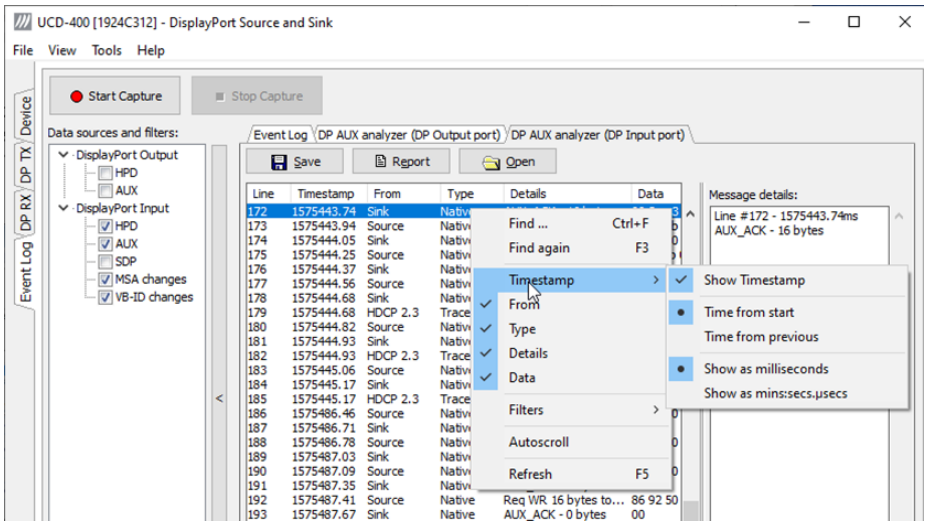
- All data bytes read or written.
- All DPCD memory locations affected.
- The name of the locations and of each of their bit fields.
- All bit field's numeric and binary values, together with their decoded value.
- The Replies outcome (AUX_ACK, AUX_NACK, I2C_DEFER, etc.).

Customizing the Main Window

Format of the data shown in the *Transaction list* and the *Message details* panels can be altered in order to highlight the details of your interest.

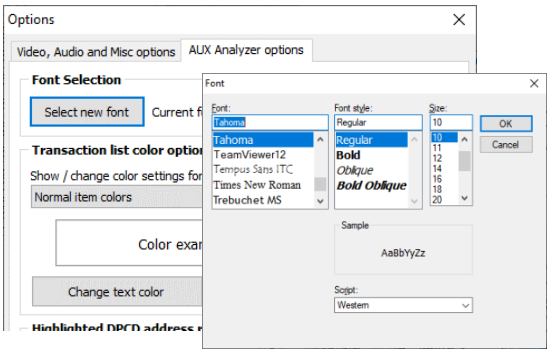
Selecting Data Columns

The *Transaction list* can be customized by right-clicking over the list. The pop-up menu allows choosing which columns to display, the style of the timestamp and switch between absolute and relative timestamps. *Filters* limit the transactions shown in the list. Please see *Filtering* later in this document.



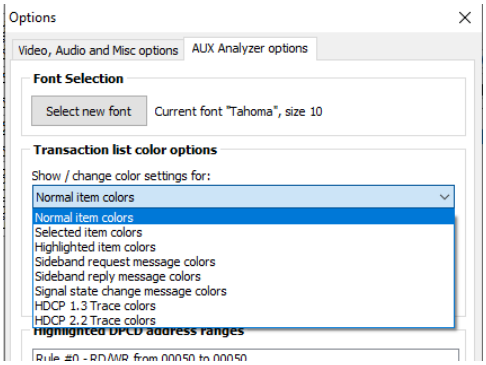
Selecting Font and Colors

Select **Tools > Options > AUX Analyzer options** tab. Click **Select new font** and choose the font and size used for displaying the *Transaction list* and the *Message details*.



Transaction List Color Options

Select the colors for the font and background of various items.



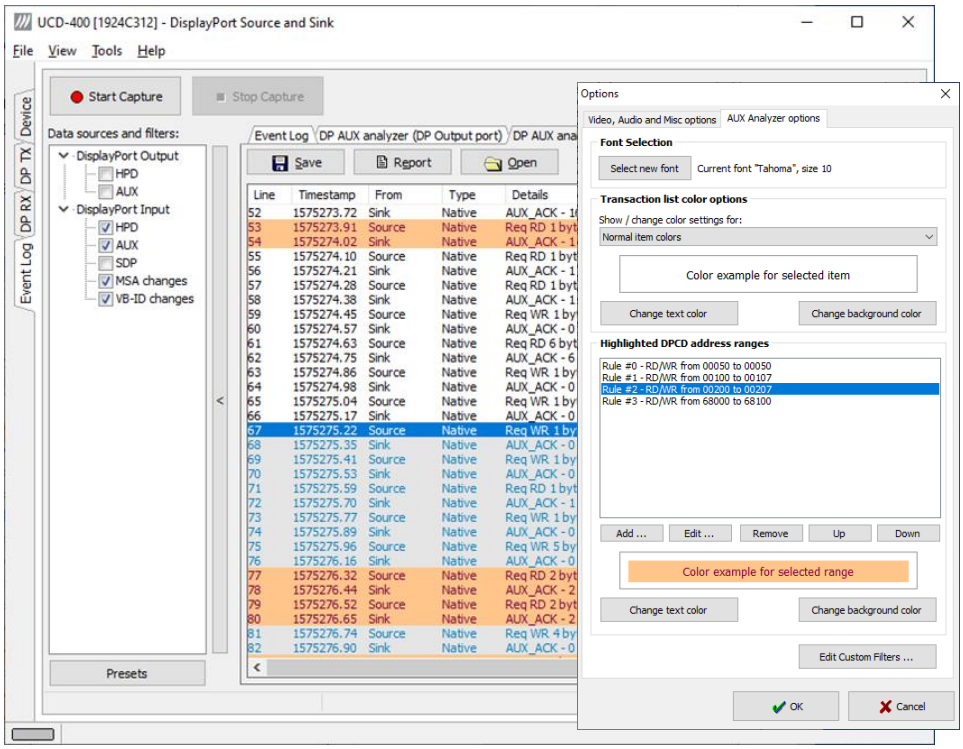
Highlighted DPCD Address Ranges

In order to improve the readability of the *Transaction list*, you can mark the AUX channel transactions where a certain DPCD register address or address range is highlighted with a color of choice.

Click **Add…**, select the access type, start DPCD address and end DPCD address of the range in Hex. Click **Accept**.

Select the range you just created from the **Highlighted DPCD addresses ranges** list and click the **Change test color** and **Change background color** buttons to select the colors desired.

You can create multiple simultaneous coloring rules to help you get a better view of the data captured.

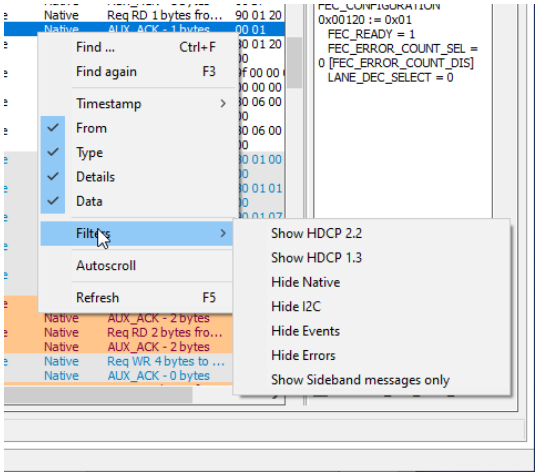


Filtering

Transactions lines shown in the transaction list can be limited by *Filtering*. The shown lines can be selected by:

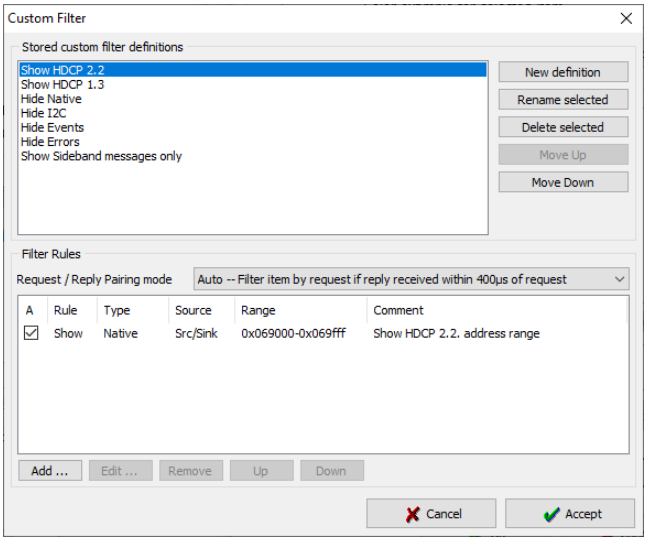
- The type of data line
- The origin of the message
- The DPCD address range

Right click > *Filters* drop down menu lists a set of pre-programmed filters.



Editing Filters

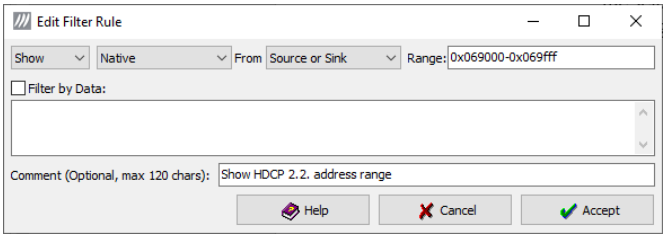
From *Custom Filter* dialog (Tools > Options > Edit Custom Filters …) allows for adding and modifying filters. The pre-programmed filters are listed in the dialog. Their structure can be copied as bases of your custom filters. It is advisable not to modify the pre-programmed filters directly but make copies of them.



In the *Stored custom filter definitions* panel, lists currently defined Filters. On the right hand side buttons, you can define new Filters, rename, or delete them. Their appearance in the *Filters* pull-down menu can also be altered.

In the *Filter Rules* panel lower in the dialog, you can review and change the *Rules* in the selected *Filter*. **Add…** creates new rules, **Edit…** enables review and editing existing Filters and **Remove** deletes from the Filter definition.

When clicking Add… or Edit… *Edit Filter Rule* dialog opens. The dialog defines the action of the rule, events, and event details.



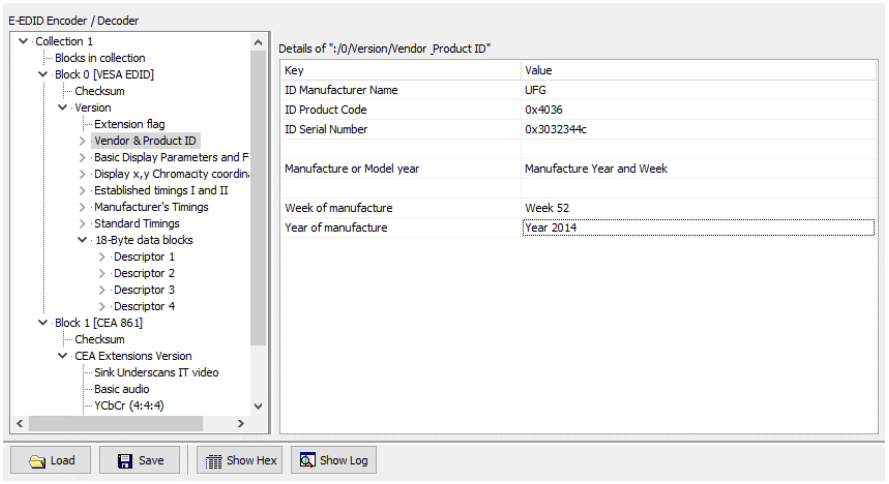
Click **Help** to show "Help" text also attached to Appendix F of this document.

Note	Please note that Filters are a very powerful tool. They can however unintentionally hide valuable data from you. Please be careful when applying custom filters. A good practice is to start from an existing filter and gradually add new rules while testing their performance.

Note	Filtering and selecting the columns for display do not affect the actual data acquisition. All transactions and their full data are always captured.

10. EDID EDITOR

The *EDID Editor* main window is divided into three logical areas. The bottom part of the



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

Command Buttons

Load: Load an EDID block collection file from disk.
Save: Save the current block collection to a disk file.
Show Hex: Show or Hide the HEX view.
Show Log: Show or Hide the Log view.

EDID Editor Features

The EDID Editor currently supports VESA E-EDID block versions 1.3 and 1.4. As the standard defines, the versions 1.0, 1.1 and 1.2 are supposed to be backward compatible, and therefore the VESA E-EDID decoder will also show their contents. However, in these cases it should be noted that the error checking is not compliant with restrictions given in these older versions of the standard. In addition to VESA E-EDID block, the CEA-861 versions 1, 2 and 3 EDID blocks are also fully supported as well as the VESA Block Map Extension blocks.

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.

HEX View: An optional HEX data display of all blocks in the collection. The view also shows the latest changes highlighted.

LOG View: An optional LOG view, which will contain log prints generated by the editor. Mostly it will list values that have been automatically updated due to edits.

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.

- **Enter** key will apply text-edit values and combo-box selection.
- To apply new setting to *binary* values (ones that show a check-box), please click the **Set** button.
- When you see a **Quick Config** button appear below an editor, you can access a configuration menu that allows you to quickly select one of multiple pre-defined setup options.
- In CEA-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". Unfortunately re-arranging the descriptors and CEA data blocks is not supported yet, so you need to be careful when editing these.
- 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 check-box if you want the new value applied.

Note	It is recommended that you back up the un-edited EDID contents to a file before editing and writing it to the card.

Saving EDID Data

When you are done with editing you can either save the EDID contents to a file in the PC or bring it in the *HEX Editor*.

For saving the data to a file in your PC click **Save**.

For bringing the data to the HEX Editor close the EDID Editor window by clicking the **Window Close** button in the top right-hand corner of the window. You will be asked if you would like to copy and replace the EDID data in the HEX Editor. Click **Yes** to replace the data, click **No** to discard the modifications.

When you are back in the *HEX Editor*, the bytes that the *EDID Editor* changed are highlighted with **BLUE BACKGROUND**.

APPENDIX A. PRODUCT SPECIFICATION

UCD-400 / UCD-411

Input	UCD-400: DisplayPort™ 1.4a compliant (DP Rx) UCD-411: Not available
Output	UCD-400 & UCD-411: DisplayPort™ 1.4a compliant (DP Tx)
Max video mode	7680 × 4320 p30 input and output 3840 × 2160 p120 input and output
Audio	LPCM, 2 – 8 channels, 44.1 to 192 kHz
Content Protection	HDCP 2.3, HDCP 1.3
DSC Capability	DSC Sink with off-line decompression (UCD-411 N/A) DSC Source using pre-compressed content DSC 1.2a support. Support RGB / YCbCr up to 12 bits per component. 24 slices, max width 7680 pixels Up to 8K@60 Hz
Additional features	MST, FEC, LTTPR DP 1.4a LL CTS, DP DSC CTS HDCP 2.3 CTS
Computer interface	USB 3.0
Software	Windows 10, 8 and 7 compatible software drivers, UCD Console application for Windows. TSI API with interface specific Test Sets.
Power supply	+12 Vdc 100 to 240 Vac 50/60 Hz AC/DC converter included
Module Size	272 × 170 × 60 mm
Weight	1.2 kg w/o power supply

APPENDIX B. LICENSING

The following tables provide detailed explanation of the functions and their availability and licensing.

DPRX functionality is not available when using UCD-411.

UCD Console & TSI: DisplayPort Reference Sink (DPRX)

Tab	Function	Basic*	TSI Basic**	DSC Decoder	DP 1.4a LL CTS for testing Source DUT	HDCP 2.3 CTS for testing Source DUT	HDCP 2.3 CTS for testing Repeater DUT
Video							
	Preview, Capture, Snap preview	●	●				
	Status	●	●				
Audio							
	Monitor, Capture, and graphical preview	●	●				
	Status	●	●				
Link							
	Link Status, Link Configuration	●	●				
	Stream Status (video, audio)	●	●				
	HPD Status, HPD Assert / De-assert, HPD Long Pulse, HPD Short Pulse	●	●				
	MST Feature (up to 4 streams)	●	●				
	FEC Feature	●	●				
	DSC Decoder, DSC Control			■			
EDID							
	Read / Write, Save / Load	●	●				
	EDID Editor	●					
DPCD							
	Read/Write, Save/Load	●	●				
	DPCD Decoder	●					
HDCP							
	HDCP 1.3 and HDCP 2.3 Support	●	●				
	Authentication status, Encryption status	●	●				
Event Log							
	Event Log	●	●				
	DP AUX Analyzer	●					
Source DUT Testing							
	Execute TSI Tests	●	●				
	Execute DP LL, Audio and FEC CTS				■		
	Execute DSC CTS			■			
	HDCP 2.3 CTS for testing DP Source DUT					■	■
	HDCP 2.3 CTS for testing DP Repeater DUT						■

*) UCD-400 is delivered by default with *UCD Console Pro DP Sink*, *UCD Console Pro DP Source* and *HDCP 2.3 support* enabling license keys. UCD-411 is delivered by default with *UCD Console Pro DP Source* and *HDCP 2.3 support* enabling license keys.

**) UCD-400 and UCD-411 are delivered by default with *TSI SDK Advanced with HDCP 2.3* support key

UCD Console & TSI: DisplayPort Reference Source (DPTX)

Tab	Function	Basic*	TSI Basic**	DSC Encoder	LTTPR	DP 1.4a LL CTS for testing Sink DUT	HDCP 2.3 CTS for testing Sink DUT	HDCP 2.3 CTS for testing Repeater DUT
Pattern Generator								
	Fixed and custom Video Timings	●	●					
	Fixed and custom Video Patterns	●	●					
	Adaptive-Sync Feature	●	●					
Audio Generator								
	Play audio files	●	●					
Link								
	Link Status	●	●					
	HPD Status: (Asserted / De-asserted)	●	●					
	Link Configuration: (Lane count, Link Rate, Framing mode, Clock mode)	●	●					
	MST Feature (up to 4 streams)	●	●					
	FEC Feature	●	●					
	DSC Encoder			■				
	LTTPR Feature				■			
EDID								
	Read / Write, Save / Load	●	●					
	EDID Editor	●						
DPCD								
	Read / Write, Save / Load	●	●					
	DPCD Decoder	●						
HDCP								
	HDCP 1.3 Support	●	●					
	Control: (Enable / Disable, authenticate only, Encryption Enable / Disable)	●	●					
	Status: (Authentication status, Encryption status)	●	●					
	HDCP 2.3 Support	●	●					
Event Log								
	Event Log	●	●					
	DP AUX Analyzer	●						
Sink DUT Testing								
	Execute TSI Tests	●	●					
	Execute DP LL, Audio and FEC CTS					■		
	Execute DSC CTS			■				
	HDCP 2.3 CTS for testing DP Sink DUT						■	■
	HDCP 2.3 CTS for testing DP Repeater DUT							■

*) UCD-400 is delivered by default with *UCD Console Pro DP Sink*, *UCD Console Pro DP Source* and *HDCP 2.3 support* enabling license keys. UCD-411 is delivered by default with *UCD Console Pro DP Source* and *HDCP 2.3 support* enabling license keys.
**) UCD-400 and UCD-411 are delivered by default with *TSI SDK Advanced with HDCP 2.3* support key

APPENDIX C: PREDEFINED TIMINGS

DisplayPort Sink and Source Capability (RGB) (4 lanes capability)

Description	TSI*	H active	V active	H total	V total	Frame rate	RGB 4:4:4				
							6	8	10	12	16
VESA 640 x 480 @ 60Hz	0	640	480	800	525	60	●	●	●	●	●
VESA 800 x 600 @ 60Hz	1	800	600	1056	628	60	●	●	●	●	●
VESA 848 x 480 @ 60Hz	2	848	480	1088	517	60	●	●	●	●	●
VESA 1024 x 768 @ 60Hz	3	1024	768	1344	806	60	●	●	●	●	●
CTA 1280 x 720 @ 60Hz	4	1280	720	1650	750	60	●	●	●	●	●
VESA 1280 x 768 @ 60Hz	5	1280	768	1664	798	60	●	●	●	●	●
VESA 1280 x 960 @ 60Hz	6	1280	960	1800	1000	60	●	●	●	●	●
VESA 1280 x 800 @ 60Hz [RB1]	7	1280	800	1440	823	60	●	●	●	●	●
VESA 1280 x 800 @ 60Hz	8	1280	800	1680	831	60	●	●	●	●	●
VESA 1280 x 768 @ 60Hz	9	1280	768	1440	790	60	●	●	●	●	●
VESA 1280 x 1024 @ 60Hz	10	1280	1024	1688	1066	60	●	●	●	●	●
VESA 1360 x 768 @ 60Hz	11	1360	768	1792	795	60	●	●	●	●	●
VESA 1400 x 1050 @ 60Hz	12	1400	1050	1560	1080	60	●	●	●	●	●
VESA 1600 x 1200 @ 60Hz [RB1]	13	1600	1200	1760	1235	60	●	●	●	●	●
VESA 1600 x 1200 @ 60Hz	14	1600	1200	2160	1250	60	●	●	●	●	●
VESA 1680 x 1050 @ 60Hz	15	1680	1050	2240	1089	60	●	●	●	●	●
VESA 1680 x 1050 @ 60Hz [RB1]	16	1680	1050	1840	1080	60	●	●	●	●	●
VESA 1792 x 1344 @ 60Hz	17	1792	1344	2448	1394	60	●	●	●	●	●
VESA 1920 x 1080 @ 30Hz [RB1]	18	1920	1080	2080	1096	30	●	●	●	●	●
VESA 1920 x 1080 @ 30Hz [RB2]	19	1920	1080	2000	1096	30	●	●	●	●	●
CTA 1920 x 1080 @ 30Hz	20	1920	1080	2200	1125	30	●	●	●	●	●
VESA 1920 x 1080 @ 60Hz [RB1]	21	1920	1080	2080	1111	60	●	●	●	●	●
VESA 1920 x 1080 @ 60Hz [RB2]	22	1920	1080	2000	1111	60	●	●	●	●	●
CTA 1920 x 1080 @ 60Hz	23	1920	1080	2200	1125	60	●	●	●	●	●
VESA 1920 x 1080 @ 120Hz [RB1]	24	1920	1080	2080	1144	120	●	●	●	●	●
VESA 1920 x 1080 @ 120Hz [RB2]	25	1920	1080	2000	1144	120	●	●	●	●	●
CTA 1920 x 1080 @ 120Hz	26	1920	1080	2200	1125	120	●	●	●	●	●
VESA 1920 x 1440 @ 60Hz	27	1920	1440	2600	1500	60	●	●	●	●	●
VESA 2048 x 1536 @ 60Hz	28	2048	1536	2208	1580	60	●	●	●	●	●
VESA 2560 x 1440 @ 60Hz	29	2560	1440	2720	1481	60	●	●	●	●	●
VESA 2560 x 1080 @ 60Hz	30	2560	1080	3424	1120	60	●	●	●	●	●
VESA 2560 x 1080 @ 60Hz [RB1]	31	2560	1080	2720	1111	60	●	●	●	●	●
VESA 2560 x 1600 @ 60Hz	32	2560	1600	3504	1658	60	●	●	●	●	●
VESA 2560 x 1600 @ 60Hz [RB1]	33	2560	1600	2720	1646	60	●	●	●	●	●
Other 2880 x 1440 @ 60Hz	34	2880	1440	2976	1456	60	●	●	●	●	●
VESA 4096 x 2160 @ 60Hz	35	4096	2160	4176	2222	60	●	●	●	■	▲
VESA 3840 x 2160 @ 30Hz [RB1]	36	3840	2160	4000	2191	30	●	●	●	●	●
VESA 3840 x 2160 @ 30Hz [RB2]	37	3840	2160	3920	2191	30	●	●	●	●	●
CTA 3840 x 2160 @ 30Hz	38	3840	2160	4400	2250	30	●	●	●	●	●
CTA 3840 x 2160 @ 50Hz	39	3840	2160	5280	2250	50	●	●	■	■	▲
CTA 4096 x 2160 @ 50Hz	40	4096	2160	5280	2250	50	●	●	■	■	▲
VESA 3840 x 2160 @ 60Hz [RB1]	41	3840	2160	4000	2222	60	●	●	●	■	■
VESA 3840 x 2160 @ 60Hz [RB2]	42	3840	2160	3920	2222	60	●	●	●	■	■
CTA 3840 x 2160 @ 60Hz	43	3840	2160	4400	2250	60	●	●	■	■	▲
CTA 4096 x 2160 @ 60Hz	44	4096	2160	4400	2250	60	●	●	■	■	▲

● Supported ■ Supported with HBR3 ▲ Supported with DSC

DisplayPort Sink and Source Capability (RGB) (4 lanes capability) contd.

Description	TSI*	H active	V active	H total	V total	Frame rate	RGB 4:4:4				
							6	8	10	12	16
VESA 3840 x 2160 @ 120Hz [RB1]	45	3840	2160	4000	2287	120	■	▲	▲	▲	▲
VESA 3840 x 2160 @ 120Hz [RB2]	46	3840	2160	3920	2287	120	■	▲	▲	▲	▲
CTA 3840 x 2160 @ 120Hz	47	3840	2160	4400	2250	120	■	▲	▲	▲	▲
VESA 5120 x 2160 @ 30Hz [RB1]	48	5120	2160	5280	2191	30	●	●	●	●	●
VESA 5120 x 2160 @ 30Hz [RB2]	49	5120	2160	5200	2191	30	●	●	●	●	●
CTA 5120 x 2160 @ 30Hz	50	5120	2160	6000	2200	30	●	●	●	●	■
VESA 5120 x 2160 @ 60Hz [RB1]	51	5120	2160	5280	2222	60	●	●	■	■	▲
VESA 5120 x 2160 @ 60Hz [RB2]	52	5120	2160	5200	2222	60	●	●	■	■	▲
CTA 5120 x 2160 @ 60Hz	53	5120	2160	5500	2250	60	●	■	■	▲	▲
VESA 5120 x 2160 @ 120Hz [RB1]	54	5120	2160	5280	2287	120	▲	▲	▲	▲	▲
VESA 5120 x 2160 @ 120Hz [RB2]	55	5120	2160	5200	2287	120	■	▲	▲	▲	▲
CTA 5120 x 2160 @ 120Hz	56	5120	2160	5500	2250	120	▲	▲	▲	▲	▲
Other 5120 x 2880 @ 60Hz	57	5120	2880	5280	2962	60	●	■	▲	▲	▲
VESA 7680 x 4320 @ 30Hz [RB1]	58	7680	4320	7840	4381	30	■	■	▲	▲	▲
VESA 7680 x 4320 @ 30Hz [RB2]	59	7680	4320	7760	4381	30	■	■	▲	▲	▲
CTA 7680 x 4320 @ 30Hz	60	7680	4320	9000	4400	30	■	▲	▲	▲	▲
VESA 7680 x 4320 @ 60Hz [RB1]	61	7680	4320	7840	4443	60	▲	▲	▲	▲	
VESA 7680 x 4320 @ 60Hz [RB2]	62	7680	4320	7760	4443	60	▲	▲	▲	▲	
CTA 7680 x 4320 @ 60Hz		7680	4320	9000	4400	60	▲	▲	▲		
VESA 7680 x 4320 @ 100Hz [RB1]		7680	4320	7840	4529	100	▲				
VESA 7680 x 4320 @ 100Hz [RB2]		7680	4320	7760	4529	100	▲				
CTA 7680 x 4320 @ 100Hz		7680	4320	10560	4500	100					

● Supported ■ Supported with HBR3 ▲ Supported with DSC

*) TSI Timing ID

DisplayPort Sink and Source Capability (YCbCr) (4 lanes capability)

Description	TSI*	H active	V active	H total	V total	Frame rate	YCbCr 4:2:2 (bpc)				YCbCr 4:2:0 (bpc)			
							8	10	12	16	8	10	12	16
VESA 640 x 480 @ 60Hz	0	640	480	800	525	60	●	●	●	●	●	●	●	●
VESA 800 x 600 @ 60Hz	1	800	600	1056	628	60	●	●	●	●	●	●	●	●
VESA 848 x 480 @ 60Hz	2	848	480	1088	517	60	●	●	●	●	●	●	●	●
VESA 1024 x 768 @ 60Hz	3	1024	768	1344	806	60	●	●	●	●	●	●	●	●
CTA 1280 x 720 @ 60Hz	4	1280	720	1650	750	60	●	●	●	●	●	●	●	●
VESA 1280 x 768 @ 60Hz	5	1280	768	1664	798	60	●	●	●	●	●	●	●	●
VESA 1280 x 960 @ 60Hz	6	1280	960	1800	1000	60	●	●	●	●	●	●	●	●
VESA 1280 x 800 @ 60Hz [RB1]	7	1280	800	1440	823	60	●	●	●	●	●	●	●	●
VESA 1280 x 800 @ 60Hz	8	1280	800	1680	831	60	●	●	●	●	●	●	●	●
VESA 1280 x 768 @ 60Hz	9	1280	768	1440	790	60	●	●	●	●	●	●	●	●
VESA 1280 x 1024 @ 60Hz	10	1280	1024	1688	1066	60	●	●	●	●	●	●	●	●
VESA 1360 x 768 @ 60Hz	11	1360	768	1792	795	60	●	●	●	●	●	●	●	●
VESA 1400 x 1050 @ 60Hz	12	1400	1050	1560	1080	60	●	●	●	●	●	●	●	●
VESA 1600 x 1200 @ 60Hz [RB1]	13	1600	1200	1760	1235	60	●	●	●	●	●	●	●	●
VESA 1600 x 1200 @ 60Hz	14	1600	1200	2160	1250	60	●	●	●	●	●	●	●	●
VESA 1680 x 1050 @ 60Hz	15	1680	1050	2240	1089	60	●	●	●	●	●	●	●	●
VESA 1680 x 1050 @ 60Hz [RB1]	16	1680	1050	1840	1080	60	●	●	●	●	●	●	●	●
VESA 1792 x 1344 @ 60Hz	17	1792	1344	2448	1394	60	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 30Hz [RB1]	18	1920	1080	2080	1096	30	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 30Hz [RB2]	19	1920	1080	2000	1096	30	●	●	●	●	●	●	●	●
CTA 1920 x 1080 @ 30Hz	20	1920	1080	2200	1125	30	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 60Hz [RB1]	21	1920	1080	2080	1111	60	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 60Hz [RB2]	22	1920	1080	2000	1111	60	●	●	●	●	●	●	●	●
CTA 1920 x 1080 @ 60Hz	23	1920	1080	2200	1125	60	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 120Hz [RB1]	24	1920	1080	2080	1144	120	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 120Hz [RB2]	25	1920	1080	2000	1144	120	●	●	●	●	●	●	●	●
CTA 1920 x 1080 @ 120Hz	26	1920	1080	2200	1125	120	●	●	●	●	●	●	●	●
VESA 1920 x 1440 @ 60Hz	27	1920	1440	2600	1500	60	●	●	●	●	●	●	●	●
VESA 2048 x 1536 @ 60Hz	28	2048	1536	2208	1580	60	●	●	●	●	●	●	●	●
VESA 2560 x 1440 @ 60Hz	29	2560	1440	2720	1481	60	●	●	●	●	●	●	●	●
VESA 2560 x 1080 @ 60Hz	30	2560	1080	3424	1120	60	●	●	●	●	●	●	●	●
VESA 2560 x 1080 @ 60Hz [RB1]	31	2560	1080	2720	1111	60	●	●	●	●	●	●	●	●
VESA 2560 x 1600 @ 60Hz	32	2560	1600	3504	1658	60	●	●	●	●	●	●	●	●
VESA 2560 x 1600 @ 60Hz [RB1]	33	2560	1600	2720	1646	60	●	●	●	●	●	●	●	●
Other 2880 x 1440 @ 60Hz	34	2880	1440	2976	1456	60	●	●	●	●	●	●	●	●
VESA 4096 x 2160 @ 60Hz	35	4096	2160	4176	2222	60	●	●	●	■	●	●	●	●
VESA 3840 x 2160 @ 30Hz [RB1]	36	3840	2160	4000	2191	30	●	●	●	●	●	●	●	●
VESA 3840 x 2160 @ 30Hz [RB2]	37	3840	2160	3920	2191	30	●	●	●	●	●	●	●	●
CTA 3840 x 2160 @ 30Hz	38	3840	2160	4400	2250	30	●	●	●	●	●	●	●	●
CTA 3840 x 2160 @ 50Hz	39	3840	2160	5280	2250	50	●	●	●	■	●	●	●	●
CTA 4096 x 2160 @ 50Hz	40	4096	2160	5280	2250	50	●	●	●	■	●	●	●	●
VESA 3840 x 2160 @ 60Hz [RB1]	41	3840	2160	4000	2222	60	●	●	●	●	●	●	●	●
VESA 3840 x 2160 @ 60Hz [RB2]	42	3840	2160	3920	2222	60	●	●	●	●	●	●	●	●
CTA 3840 x 2160 @ 60Hz	43	3840	2160	4400	2250	60	●	●	●	■	●	●	●	●
CTA 4096 x 2160 @ 60Hz	44	4096	2160	4400	2250	60	●	●	●	■	●	●	●	●

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DisplayPort Sink and Source Capability (YCbCr) (4 lanes capability) contd.

Description	TSI*	H active	V active	H total	V total	Frame rate	YCbCr 4:2:2 (bpc)				YCbCr 4:2:0 (bpc)			
							8	10	12	16	8	10	12	16
VESA 3840 x 2160 @ 120Hz [RB1]	45	3840	2160	4000	2287	120	■	■	▲	▲	●	●	■	▲
VESA 3840 x 2160 @ 120Hz [RB2]	46	3840	2160	3920	2287	120	■	■	▲	▲	●	●	■	▲
CTA 3840 x 2160 @ 120Hz	47	3840	2160	4400	2250	120	■	■	▲	▲	●	■	■	▲
VESA 5120 x 2160 @ 30Hz [RB1]	48	5120	2160	5280	2191	30	●	●	●	●	●	●	●	●
VESA 5120 x 2160 @ 30Hz [RB2]	49	5120	2160	5200	2191	30	●	●	●	●	●	●	●	●
CTA 5120 x 2160 @ 30Hz	50	5120	2160	6000	2200	30	●	●	●	●	●	●	●	●
VESA 5120 x 2160 @ 60Hz [RB1]	51	5120	2160	5280	2222	60	●	●	●	■	●	●	●	●
VESA 5120 x 2160 @ 60Hz [RB2]	52	5120	2160	5200	2222	60	●	●	●	■	●	●	●	●
CTA 5120 x 2160 @ 60Hz	53	5120	2160	5500	2250	60	●	●	■	■	●	●	●	■
VESA 5120 x 2160 @ 120Hz [RB1]	54	5120	2160	5280	2287	120	■	▲	▲	▲	■	■	▲	▲
VESA 5120 x 2160 @ 120Hz [RB2]	55	5120	2160	5200	2287	120	■	▲	▲	▲	●	■	■	▲
CTA 5120 x 2160 @ 120Hz	56	5120	2160	5500	2250	120	■	▲	▲	▲	■	■	▲	▲
Other 5120 x 2880 @ 60Hz	57	5120	2880	5280	2962	60	●	■	■	▲	●	●	●	■
VESA 7680 x 4320 @ 30Hz [RB1]	58	7680	4320	7840	4381	30	●	■	■	▲	●	●	■	■
VESA 7680 x 4320 @ 30Hz [RB2]	59	7680	4320	7760	4381	30	●	■	■	▲	●	●	■	■
CTA 7680 x 4320 @ 30Hz	60	7680	4320	9000	4400	30	■	■	▲	▲	●	■	■	▲
VESA 7680 x 4320 @ 60Hz [RB1]	61	7680	4320	7840	4443	60	▲	▲	▲	▲	■	▲	▲	▲
VESA 7680 x 4320 @ 60Hz [RB2]	62	7680	4320	7760	4443	60	▲	▲	▲	▲	■	▲	▲	▲
CTA 7680 x 4320 @ 60Hz		7680	4320	9000	4400	60	▲	▲	▲		▲	▲	▲	▲
VESA 7680 x 4320 @ 100Hz [RB1]		7680	4320	7840	4529	100	▲	▲			▲	▲	▲	
VESA 7680 x 4320 @ 100Hz [RB2]		7680	4320	7760	4529	100	▲	▲			▲	▲	▲	
CTA 7680 x 4320 @ 100Hz		7680	4320	10560	4500	100					▲	▲		

● Supported ■ Supported with HBR3 ▲ Supported with DSC

*) TSI Timing ID

DisplayPort Sink and Source Capability (RGB) (2 lanes capability)

Description	TSI*	H active	V active	H total	V total	Frame rate	RGB 4:4:4				
							6	8	10	12	16
VESA 640 x 480 @ 60Hz	0	640	480	800	525	60	●	●	●	●	●
VESA 800 x 600 @ 60Hz	1	800	600	1056	628	60	●	●	●	●	●
VESA 848 x 480 @ 60Hz	2	848	480	1088	517	60	●	●	●	●	●
VESA 1024 x 768 @ 60Hz	3	1024	768	1344	806	60	●	●	●	●	●
CTA 1280 x 720 @ 60Hz	4	1280	720	1650	750	60	●	●	●	●	●
VESA 1280 x 768 @ 60Hz	5	1280	768	1664	798	60	●	●	●	●	●
VESA 1280 x 960 @ 60Hz	6	1280	960	1800	1000	60	●	●	●	●	●
VESA 1280 x 800 @ 60Hz [RB1]	7	1280	800	1440	823	60	●	●	●	●	●
VESA 1280 x 800 @ 60Hz	8	1280	800	1680	831	60	●	●	●	●	●
VESA 1280 x 768 @ 60Hz	9	1280	768	1440	790	60	●	●	●	●	●
VESA 1280 x 1024 @ 60Hz	10	1280	1024	1688	1066	60	●	●	●	●	●
VESA 1360 x 768 @ 60Hz	11	1360	768	1792	795	60	●	●	●	●	●
VESA 1400 x 1050 @ 60Hz	12	1400	1050	1560	1080	60	●	●	●	●	●
VESA 1600 x 1200 @ 60Hz [RB1]	13	1600	1200	1760	1235	60	●	●	●	●	●
VESA 1600 x 1200 @ 60Hz	14	1600	1200	2160	1250	60	●	●	●	●	●
VESA 1680 x 1050 @ 60Hz	15	1680	1050	2240	1089	60	●	●	●	●	●
VESA 1680 x 1050 @ 60Hz [RB1]	16	1680	1050	1840	1080	60	●	●	●	●	●
VESA 1792 x 1344 @ 60Hz	17	1792	1344	2448	1394	60	●	●	●	●	■
VESA 1920 x 1080 @ 30Hz [RB1]	18	1920	1080	2080	1096	30	●	●	●	●	●
VESA 1920 x 1080 @ 30Hz [RB2]	19	1920	1080	2000	1096	30	●	●	●	●	●
CTA 1920 x 1080 @ 30Hz	20	1920	1080	2200	1125	30	●	●	●	●	●
VESA 1920 x 1080 @ 60Hz [RB1]	21	1920	1080	2080	1111	60	●	●	●	●	●
VESA 1920 x 1080 @ 60Hz [RB2]	22	1920	1080	2000	1111	60	●	●	●	●	●
CTA 1920 x 1080 @ 60Hz	23	1920	1080	2200	1125	60	●	●	●	●	●
VESA 1920 x 1080 @ 120Hz [RB1]	24	1920	1080	2080	1144	120	●	●	●	■	▲
VESA 1920 x 1080 @ 120Hz [RB2]	25	1920	1080	2000	1144	120	●	●	●	■	▲
CTA 1920 x 1080 @ 120Hz	26	1920	1080	2200	1125	120	●	●	■	■	▲
VESA 1920 x 1440 @ 60Hz	27	1920	1440	2600	1500	60	●	●	●	●	■
VESA 2048 x 1536 @ 60Hz	28	2048	1536	2208	1580	60	●	●	●	●	■
VESA 2560 x 1440 @ 60Hz	29	2560	1440	2720	1481	60	●	●	●	■	■
VESA 2560 x 1080 @ 60Hz	30	2560	1080	3424	1120	60	●	●	●	●	■
VESA 2560 x 1080 @ 60Hz [RB1]	31	2560	1080	2720	1111	60	●	●	●	●	■
VESA 2560 x 1600 @ 60Hz	32	2560	1600	3504	1658	60	●	●	■	■	▲
VESA 2560 x 1600 @ 60Hz [RB1]	33	2560	1600	2720	1646	60	●	●	●	■	■
Other 2880 x 1440 @ 60Hz	34	2880	1440	2976	1456	60	●	●	●	■	■
VESA 4096 x 2160 @ 60Hz	35	4096	2160	4176	2222	60	■	▲	▲	▲	▲
VESA 3840 x 2160 @ 30Hz [RB1]	36	3840	2160	4000	2191	30	●	●	●	■	■
VESA 3840 x 2160 @ 30Hz [RB2]	37	3840	2160	3920	2191	30	●	●	●	■	■
CTA 3840 x 2160 @ 30Hz	38	3840	2160	4400	2250	30	●	●	■	■	▲
CTA 3840 x 2160 @ 50Hz	39	3840	2160	5280	2250	50	■	▲	▲	▲	▲
CTA 4096 x 2160 @ 50Hz	40	4096	2160	5280	2250	50	■	▲	▲	▲	▲
VESA 3840 x 2160 @ 60Hz [RB1]	41	3840	2160	4000	2222	60	■	■	▲	▲	▲
VESA 3840 x 2160 @ 60Hz [RB2]	42	3840	2160	3920	2222	60	■	■	▲	▲	▲
CTA 3840 x 2160 @ 60Hz	43	3840	2160	4400	2250	60	■	▲	▲	▲	▲
CTA 4096 x 2160 @ 60Hz	44	4096	2160	4400	2250	60	■	▲	▲	▲	▲

● Supported ■ Supported with HBR3 ▲ Supported with DSC

DisplayPort Sink and Source Capability (RGB) (2 lanes capability) contd.

Description	TSI*	H active	V active	H total	V total	Frame rate	RGB 4:4:4				
							6	8	10	12	16
VESA 3840 x 2160 @ 120Hz [RB1]	45	3840	2160	4000	2287	120	▲	▲	▲		
VESA 3840 x 2160 @ 120Hz [RB2]	46	3840	2160	3920	2287	120	▲	▲	▲		
CTA 3840 x 2160 @ 120Hz	47	3840	2160	4400	2250	120	▲	▲	▲		
VESA 5120 x 2160 @ 30Hz [RB1]	48	5120	2160	5280	2191	30	●	●	■	■	▲
VESA 5120 x 2160 @ 30Hz [RB2]	49	5120	2160	5200	2191	30	●	●	■	■	▲
CTA 5120 x 2160 @ 30Hz	50	5120	2160	6000	2200	30	●	■	■	▲	▲
VESA 5120 x 2160 @ 60Hz [RB1]	51	5120	2160	5280	2222	60	■	▲	▲	▲	▲
VESA 5120 x 2160 @ 60Hz [RB2]	52	5120	2160	5200	2222	60	■	▲	▲	▲	▲
CTA 5120 x 2160 @ 60Hz	53	5120	2160	5500	2250	60	▲	▲	▲	▲	▲
VESA 5120 x 2160 @ 120Hz [RB1]	54	5120	2160	5280	2287	120	▲	▲			
VESA 5120 x 2160 @ 120Hz [RB2]	55	5120	2160	5200	2287	120	▲	▲			
CTA 5120 x 2160 @ 120Hz	56	5120	2160	5500	2250	120	▲	▲			
Other 5120 x 2880 @ 60Hz	57	5120	2880	5280	2962	60	▲	▲	▲	▲	
VESA 7680 x 4320 @ 30Hz [RB1]	58	7680	4320	7840	4381	30	▲	▲	▲	▲	
VESA 7680 x 4320 @ 30Hz [RB2]	59	7680	4320	7760	4381	30	▲	▲	▲	▲	
CTA 7680 x 4320 @ 30Hz	60	7680	4320	9000	4400	30	▲	▲	▲		
VESA 7680 x 4320 @ 60Hz [RB1]	61	7680	4320	7840	4443	60	▲				
VESA 7680 x 4320 @ 60Hz [RB2]	62	7680	4320	7760	4443	60	▲				
CTA 7680 x 4320 @ 60Hz		7680	4320	9000	4400	60					
VESA 7680 x 4320 @ 100Hz [RB1]		7680	4320	7840	4529	100					
VESA 7680 x 4320 @ 100Hz [RB2]		7680	4320	7760	4529	100					
CTA 7680 x 4320 @ 100Hz		7680	4320	10560	4500	100					

● Supported ■ Supported with HBR3 ▲ Supported with DSC

*) TSI Timing ID

DisplayPort Sink and Source Capability (YCbCr) (2 lanes capability)

Description	TSI*	H active	V active	H total	V total	Frame rate	YCbCr 4:2:2 (bpc)				YCbCr 4:2:0 (bpc)			
							8	10	12	16	8	10	12	16
VESA 640 x 480 @ 60Hz	0	640	480	800	525	60	●	●	●	●	●	●	●	●
VESA 800 x 600 @ 60Hz	1	800	600	1056	628	60	●	●	●	●	●	●	●	●
VESA 848 x 480 @ 60Hz	2	848	480	1088	517	60	●	●	●	●	●	●	●	●
VESA 1024 x 768 @ 60Hz	3	1024	768	1344	806	60	●	●	●	●	●	●	●	●
CTA 1280 x 720 @ 60Hz	4	1280	720	1650	750	60	●	●	●	●	●	●	●	●
VESA 1280 x 768 @ 60Hz	5	1280	768	1664	798	60	●	●	●	●	●	●	●	●
VESA 1280 x 960 @ 60Hz	6	1280	960	1800	1000	60	●	●	●	●	●	●	●	●
VESA 1280 x 800 @ 60Hz [RB1]	7	1280	800	1440	823	60	●	●	●	●	●	●	●	●
VESA 1280 x 800 @ 60Hz	8	1280	800	1680	831	60	●	●	●	●	●	●	●	●
VESA 1280 x 768 @ 60Hz	9	1280	768	1440	790	60	●	●	●	●	●	●	●	●
VESA 1280 x 1024 @ 60Hz	10	1280	1024	1688	1066	60	●	●	●	●	●	●	●	●
VESA 1360 x 768 @ 60Hz	11	1360	768	1792	795	60	●	●	●	●	●	●	●	●
VESA 1400 x 1050 @ 60Hz	12	1400	1050	1560	1080	60	●	●	●	●	●	●	●	●
VESA 1600 x 1200 @ 60Hz [RB1]	13	1600	1200	1760	1235	60	●	●	●	●	●	●	●	●
VESA 1600 x 1200 @ 60Hz	14	1600	1200	2160	1250	60	●	●	●	●	●	●	●	●
VESA 1680 x 1050 @ 60Hz	15	1680	1050	2240	1089	60	●	●	●	●	●	●	●	●
VESA 1680 x 1050 @ 60Hz [RB1]	16	1680	1050	1840	1080	60	●	●	●	●	●	●	●	●
VESA 1792 x 1344 @ 60Hz	17	1792	1344	2448	1394	60	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 30Hz [RB1]	18	1920	1080	2080	1096	30	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 30Hz [RB2]	19	1920	1080	2000	1096	30	●	●	●	●	●	●	●	●
CTA 1920 x 1080 @ 30Hz	20	1920	1080	2200	1125	30	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 60Hz [RB1]	21	1920	1080	2080	1111	60	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 60Hz [RB2]	22	1920	1080	2000	1111	60	●	●	●	●	●	●	●	●
CTA 1920 x 1080 @ 60Hz	23	1920	1080	2200	1125	60	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 120Hz [RB1]	24	1920	1080	2080	1144	120	●	●	●	■	●	●	●	●
VESA 1920 x 1080 @ 120Hz [RB2]	25	1920	1080	2000	1144	120	●	●	●	■	●	●	●	●
CTA 1920 x 1080 @ 120Hz	26	1920	1080	2200	1125	120	●	●	●	●	●	●	●	●
VESA 1920 x 1440 @ 60Hz	27	1920	1440	2600	1500	60	●	●	●	●	●	●	●	●
VESA 2048 x 1536 @ 60Hz	28	2048	1536	2208	1580	60	●	●	●	●	●	●	●	●
VESA 2560 x 1440 @ 60Hz	29	2560	1440	2720	1481	60	●	●	●	●	●	●	●	●
VESA 2560 x 1080 @ 60Hz	30	2560	1080	3424	1120	60	●	●	●	●	●	●	●	●
VESA 2560 x 1080 @ 60Hz [RB1]	31	2560	1080	2720	1111	60	●	●	●	●	●	●	●	●
VESA 2560 x 1600 @ 60Hz	32	2560	1600	3504	1658	60	●	●	●	■	●	●	●	●
VESA 2560 x 1600 @ 60Hz [RB1]	33	2560	1600	2720	1646	60	●	●	●	●	●	●	●	●
Other 2880 x 1440 @ 60Hz	34	2880	1440	2976	1456	60	●	●	●	●	●	●	●	●
VESA 4096 x 2160 @ 60Hz	35	4096	2160	4176	2222	60	■	■	▲	▲	●	●	■	▲
VESA 3840 x 2160 @ 30Hz [RB1]	36	3840	2160	4000	2191	30	●	●	●	●	●	●	●	●
VESA 3840 x 2160 @ 30Hz [RB2]	37	3840	2160	3920	2191	30	●	●	●	●	●	●	●	●
CTA 3840 x 2160 @ 30Hz	38	3840	2160	4400	2250	30	●	●	●	■	●	●	●	●
CTA 3840 x 2160 @ 50Hz	39	3840	2160	5280	2250	50	■	■	▲	▲	●	■	■	▲
CTA 4096 x 2160 @ 50Hz	40	4096	2160	5280	2250	50	■	■	▲	▲	●	■	■	▲
VESA 3840 x 2160 @ 60Hz [RB1]	41	3840	2160	4000	2222	60	●	■	■	▲	●	●	■	■
VESA 3840 x 2160 @ 60Hz [RB2]	42	3840	2160	3920	2222	60	●	■	■	▲	●	●	■	■
CTA 3840 x 2160 @ 60Hz	43	3840	2160	4400	2250	60	■	■	▲	▲	●	■	■	▲
CTA 4096 x 2160 @ 60Hz	44	4096	2160	4400	2250	60	■	■	▲	▲	●	■	■	▲

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DisplayPort Sink and Source Capability (YCbCr) (2 lanes capability) contd.

Description	TSI*	H active	V active	H total	V total	Frame rate	YCbCr 4:2:2 (bpc)				YCbCr 4:2:0 (bpc)			
							8	10	12	16	8	10	12	16
VESA 3840 x 2160 @ 120Hz [RB1]	45	3840	2160	4000	2287	120	▲	▲	▲	▲	▲	▲	▲	▲
VESA 3840 x 2160 @ 120Hz [RB2]	46	3840	2160	3920	2287	120	▲	▲	▲	▲	▲	▲	▲	▲
CTA 3840 x 2160 @ 120Hz	47	3840	2160	4400	2250	120	▲	▲	▲		▲	▲	▲	▲
VESA 5120 x 2160 @ 30Hz [RB1]	48	5120	2160	5280	2191	30	●	●	●	■	●	●	●	●
VESA 5120 x 2160 @ 30Hz [RB2]	49	5120	2160	5200	2191	30	●	●	●	■	●	●	●	●
CTA 5120 x 2160 @ 30Hz	50	5120	2160	6000	2200	30	●	●	■	■	●	●	●	■
VESA 5120 x 2160 @ 60Hz [RB1]	51	5120	2160	5280	2222	60	■	▲	▲	▲	●	■	■	▲
VESA 5120 x 2160 @ 60Hz [RB2]	52	5120	2160	5200	2222	60	■	▲	▲	▲	●	■	■	▲
CTA 5120 x 2160 @ 60Hz	53	5120	2160	5500	2250	60	■	▲	▲	▲	■	■	▲	▲
VESA 5120 x 2160 @ 120Hz [RB1]	54	5120	2160	5280	2287	120	▲	▲	▲		▲	▲	▲	▲
VESA 5120 x 2160 @ 120Hz [RB2]	55	5120	2160	5200	2287	120	▲	▲	▲		▲	▲	▲	▲
CTA 5120 x 2160 @ 120Hz	56	5120	2160	5500	2250	120	▲	▲	▲		▲	▲	▲	▲
Other 5120 x 2880 @ 60Hz	57	5120	2880	5280	2962	60	▲	▲	▲	▲	■	▲	▲	▲
VESA 7680 x 4320 @ 30Hz [RB1]	58	7680	4320	7840	4381	30	▲	▲	▲	▲	■	▲	▲	▲
VESA 7680 x 4320 @ 30Hz [RB2]	59	7680	4320	7760	4381	30	▲	▲	▲	▲	■	▲	▲	▲
CTA 7680 x 4320 @ 30Hz	60	7680	4320	9000	4400	30	▲	▲	▲		▲	▲	▲	▲
VESA 7680 x 4320 @ 60Hz [RB1]	61	7680	4320	7840	4443	60	▲				▲	▲	▲	
VESA 7680 x 4320 @ 60Hz [RB2]	62	7680	4320	7760	4443	60	▲				▲	▲	▲	
CTA 7680 x 4320 @ 60Hz		7680	4320	9000	4400	60					▲	▲		
VESA 7680 x 4320 @ 100Hz [RB1]		7680	4320	7840	4529	100								
VESA 7680 x 4320 @ 100Hz [RB2]		7680	4320	7760	4529	100								
CTA 7680 x 4320 @ 100Hz		7680	4320	10560	4500	100								

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*) TSI Timing ID

DisplayPort Sink and Source Capability (RGB) (1 lane capability)

Description	TSI*	H active	V active	H total	V total	Frame rate	RGB 4:4:4				
							6	8	10	12	16
VESA 640 x 480 @ 60Hz	0	640	480	800	525	60	●	●	●	●	●
VESA 800 x 600 @ 60Hz	1	800	600	1056	628	60	●	●	●	●	●
VESA 848 x 480 @ 60Hz	2	848	480	1088	517	60	●	●	●	●	●
VESA 1024 x 768 @ 60Hz	3	1024	768	1344	806	60	●	●	●	●	●
CTA 1280 x 720 @ 60Hz	4	1280	720	1650	750	60	●	●	●	●	●
VESA 1280 x 768 @ 60Hz	5	1280	768	1664	798	60	●	●	●	●	●
VESA 1280 x 960 @ 60Hz	6	1280	960	1800	1000	60	●	●	●	●	■
VESA 1280 x 800 @ 60Hz [RB1]	7	1280	800	1440	823	60	●	●	●	●	●
VESA 1280 x 800 @ 60Hz	8	1280	800	1680	831	60	●	●	●	●	●
VESA 1280 x 768 @ 60Hz	9	1280	768	1440	790	60	●	●	●	●	●
VESA 1280 x 1024 @ 60Hz	10	1280	1024	1688	1066	60	●	●	●	●	■
VESA 1360 x 768 @ 60Hz	11	1360	768	1792	795	60	●	●	●	●	●
VESA 1400 x 1050 @ 60Hz	12	1400	1050	1560	1080	60	●	●	●	●	■
VESA 1600 x 1200 @ 60Hz [RB1]	13	1600	1200	1760	1235	60	●	●	●	●	■
VESA 1600 x 1200 @ 60Hz	14	1600	1200	2160	1250	60	●	●	●	■	■
VESA 1680 x 1050 @ 60Hz	15	1680	1050	2240	1089	60	●	●	■	■	▲
VESA 1680 x 1050 @ 60Hz [RB1]	16	1680	1050	1840	1080	60	●	●	■	■	▲
VESA 1792 x 1344 @ 60Hz	17	1792	1344	2448	1394	60	●	●	●	●	■
VESA 1920 x 1080 @ 30Hz [RB1]	18	1920	1080	2080	1096	30	●	■	■	▲	▲
VESA 1920 x 1080 @ 30Hz [RB2]	19	1920	1080	2000	1096	30	●	●	●	●	●
CTA 1920 x 1080 @ 30Hz	20	1920	1080	2200	1125	30	●	●	●	●	●
VESA 1920 x 1080 @ 60Hz [RB1]	21	1920	1080	2080	1111	60	●	●	●	■	▲
VESA 1920 x 1080 @ 60Hz [RB2]	22	1920	1080	2000	1111	60	●	●	●	■	■
CTA 1920 x 1080 @ 60Hz	23	1920	1080	2200	1125	60	●	●	■	■	▲
VESA 1920 x 1080 @ 120Hz [RB1]	24	1920	1080	2080	1144	120	■	▲	▲	▲	▲
VESA 1920 x 1080 @ 120Hz [RB2]	25	1920	1080	2000	1144	120	■	▲	▲	▲	▲
CTA 1920 x 1080 @ 120Hz	26	1920	1080	2200	1125	120	■	▲	▲	▲	▲
VESA 1920 x 1440 @ 60Hz	27	1920	1440	2600	1500	60	●	■	▲	▲	▲
VESA 2048 x 1536 @ 60Hz	28	2048	1536	2208	1580	60	●	■	■	▲	▲
VESA 2560 x 1440 @ 60Hz	29	2560	1440	2720	1481	60	■	■	▲	▲	▲
VESA 2560 x 1080 @ 60Hz	30	2560	1080	3424	1120	60	●	■	▲	▲	▲
VESA 2560 x 1080 @ 60Hz [RB1]	31	2560	1080	2720	1111	60	●	■	■	▲	▲
VESA 2560 x 1600 @ 60Hz	32	2560	1600	3504	1658	60	■	▲	▲	▲	▲
VESA 2560 x 1600 @ 60Hz [RB1]	33	2560	1600	2720	1646	60	■	■	▲	▲	▲
Other 2880 x 1440 @ 60Hz	34	2880	1440	2976	1456	60	■	■	▲	▲	▲
VESA 4096 x 2160 @ 60Hz	35	4096	2160	4176	2222	60	▲	▲	▲		
VESA 3840 x 2160 @ 30Hz [RB1]	36	3840	2160	4000	2191	30	■	■	▲	▲	▲
VESA 3840 x 2160 @ 30Hz [RB2]	37	3840	2160	3920	2191	30	■	■	▲	▲	▲
CTA 3840 x 2160 @ 30Hz	38	3840	2160	4400	2250	30	■	▲	▲	▲	▲
CTA 3840 x 2160 @ 50Hz	39	3840	2160	5280	2250	50	▲	▲	▲		
CTA 4096 x 2160 @ 50Hz	40	4096	2160	5280	2250	50	▲	▲	▲		
VESA 3840 x 2160 @ 60Hz [RB1]	41	3840	2160	4000	2222	60	▲	▲	▲		
VESA 3840 x 2160 @ 60Hz [RB2]	42	3840	2160	3920	2222	60	▲	▲	▲	▲	
CTA 3840 x 2160 @ 60Hz	43	3840	2160	4400	2250	60	▲	▲	▲		
CTA 4096 x 2160 @ 60Hz	44	4096	2160	4400	2250	60	▲	▲	▲		

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DisplayPort Sink and Source Capability (RGB) (1 lane capability) contd.

Description	TSI*	H active	V active	H total	V total	Frame rate	RGB 4:4:4				
							6	8	10	12	16
VESA 3840 x 2160 @ 120Hz [RB1]	45	3840	2160	4000	2287	120					
VESA 3840 x 2160 @ 120Hz [RB2]	46	3840	2160	3920	2287	120					
CTA 3840 x 2160 @ 120Hz	47	3840	2160	4400	2250	120					
VESA 5120 x 2160 @ 30Hz [RB1]	48	5120	2160	5280	2191	30	■	▲	▲	▲	▲
VESA 5120 x 2160 @ 30Hz [RB2]	49	5120	2160	5200	2191	30	■	▲	▲	▲	▲
CTA 5120 x 2160 @ 30Hz	50	5120	2160	6000	2200	30	▲	▲	▲	▲	
VESA 5120 x 2160 @ 60Hz [RB1]	51	5120	2160	5280	2222	60	▲	▲			
VESA 5120 x 2160 @ 60Hz [RB2]	52	5120	2160	5200	2222	60	▲	▲			
CTA 5120 x 2160 @ 60Hz	53	5120	2160	5500	2250	60	▲	▲			
VESA 5120 x 2160 @ 120Hz [RB1]	54	5120	2160	5280	2287	120					
VESA 5120 x 2160 @ 120Hz [RB2]	55	5120	2160	5200	2287	120					
CTA 5120 x 2160 @ 120Hz	56	5120	2160	5500	2250	120					
Other 5120 x 2880 @ 60Hz	57	5120	2880	5280	2962	60	▲				
VESA 7680 x 4320 @ 30Hz [RB1]	58	7680	4320	7840	4381	30	▲				
VESA 7680 x 4320 @ 30Hz [RB2]	59	7680	4320	7760	4381	30	▲				
CTA 7680 x 4320 @ 30Hz	60	7680	4320	9000	4400	30					
VESA 7680 x 4320 @ 60Hz [RB1]	61	7680	4320	7840	4443	60					
VESA 7680 x 4320 @ 60Hz [RB2]	62	7680	4320	7760	4443	60					
CTA 7680 x 4320 @ 60Hz		7680	4320	9000	4400	60					
VESA 7680 x 4320 @ 100Hz [RB1]		7680	4320	7840	4529	100					
VESA 7680 x 4320 @ 100Hz [RB2]		7680	4320	7760	4529	100					
CTA 7680 x 4320 @ 100Hz		7680	4320	10560	4500	100					

● Supported ■ Supported with HBR3 ▲ Supported with DSC

*) TSI Timing ID

DisplayPort Sink and Source Capability (YCbCr) (1 lane capability)

Description	TSI*	H active	V active	H total	V total	Frame rate	YCbCr 4:2:2 (bpc)				YCbCr 4:2:0 (bpc)			
							8	10	12	16	8	10	12	16
VESA 640 x 480 @ 60Hz	0	640	480	800	525	60	●	●	●	●	●	●	●	●
VESA 800 x 600 @ 60Hz	1	800	600	1056	628	60	●	●	●	●	●	●	●	●
VESA 848 x 480 @ 60Hz	2	848	480	1088	517	60	●	●	●	●	●	●	●	●
VESA 1024 x 768 @ 60Hz	3	1024	768	1344	806	60	●	●	●	●	●	●	●	●
CTA 1280 x 720 @ 60Hz	4	1280	720	1650	750	60	●	●	●	●	●	●	●	●
VESA 1280 x 768 @ 60Hz	5	1280	768	1664	798	60	●	●	●	●	●	●	●	●
VESA 1280 x 960 @ 60Hz	6	1280	960	1800	1000	60	●	●	●	●	●	●	●	●
VESA 1280 x 800 @ 60Hz [RB1]	7	1280	800	1440	823	60	●	●	●	●	●	●	●	●
VESA 1280 x 800 @ 60Hz	8	1280	800	1680	831	60	●	●	●	●	●	●	●	●
VESA 1280 x 768 @ 60Hz	9	1280	768	1440	790	60	●	●	●	●	●	●	●	●
VESA 1280 x 1024 @ 60Hz	10	1280	1024	1688	1066	60	●	●	●	●	●	●	●	●
VESA 1360 x 768 @ 60Hz	11	1360	768	1792	795	60	●	●	●	●	●	●	●	●
VESA 1400 x 1050 @ 60Hz	12	1400	1050	1560	1080	60	●	●	●	●	●	●	●	●
VESA 1600 x 1200 @ 60Hz [RB1]	13	1600	1200	1760	1235	60	●	●	●	●	●	●	●	●
VESA 1600 x 1200 @ 60Hz	14	1600	1200	2160	1250	60	●	●	●	■	●	●	●	●
VESA 1680 x 1050 @ 60Hz	15	1680	1050	2240	1089	60	●	●	●	■	●	●	●	●
VESA 1680 x 1050 @ 60Hz [RB1]	16	1680	1050	1840	1080	60	●	●	●	●	●	●	●	●
VESA 1792 x 1344 @ 60Hz	17	1792	1344	2448	1394	60	●	●	■	▲	●	●	●	■
VESA 1920 x 1080 @ 30Hz [RB1]	18	1920	1080	2080	1096	30	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 30Hz [RB2]	19	1920	1080	2000	1096	30	●	●	●	●	●	●	●	●
CTA 1920 x 1080 @ 30Hz	20	1920	1080	2200	1125	30	●	●	●	●	●	●	●	●
VESA 1920 x 1080 @ 60Hz [RB1]	21	1920	1080	2080	1111	60	●	●	●	■	●	●	●	●
VESA 1920 x 1080 @ 60Hz [RB2]	22	1920	1080	2000	1111	60	●	●	●	●	●	●	●	●
CTA 1920 x 1080 @ 60Hz	23	1920	1080	2200	1125	60	●	●	●	■	●	●	●	●
VESA 1920 x 1080 @ 120Hz [RB1]	24	1920	1080	2080	1144	120	■	■	▲	▲	●	●	■	▲
VESA 1920 x 1080 @ 120Hz [RB2]	25	1920	1080	2000	1144	120	■	■	▲	▲	●	●	■	▲
CTA 1920 x 1080 @ 120Hz	26	1920	1080	2200	1125	120	■	■	▲	▲	●	■	■	▲
VESA 1920 x 1440 @ 60Hz	27	1920	1440	2600	1500	60	●	■	■	▲	●	●	●	■
VESA 2048 x 1536 @ 60Hz	28	2048	1536	2208	1580	60	●	●	■	▲	●	●	●	■
VESA 2560 x 1440 @ 60Hz	29	2560	1440	2720	1481	60	●	■	■	▲	●	●	■	■
VESA 2560 x 1080 @ 60Hz	30	2560	1080	3424	1120	60	●	■	■	▲	●	●	●	■
VESA 2560 x 1080 @ 60Hz [RB1]	31	2560	1080	2720	1111	60	●	●	■	■	●	●	●	■
VESA 2560 x 1600 @ 60Hz	32	2560	1600	3504	1658	60	■	▲	▲	▲	●	■	■	▲
VESA 2560 x 1600 @ 60Hz [RB1]	33	2560	1600	2720	1646	60	●	■	■	▲	●	●	■	■
Other 2880 x 1440 @ 60Hz	34	2880	1440	2976	1456	60	●	■	■	▲	●	●	■	■
VESA 4096 x 2160 @ 60Hz	35	4096	2160	4176	2222	60	▲	▲	▲	▲	▲	▲	▲	▲
VESA 3840 x 2160 @ 30Hz [RB1]	36	3840	2160	4000	2191	30	●	■	■	▲	●	●	■	■
VESA 3840 x 2160 @ 30Hz [RB2]	37	3840	2160	3920	2191	30	●	■	■	▲	●	●	■	■
CTA 3840 x 2160 @ 30Hz	38	3840	2160	4400	2250	30	■	■	▲	▲	●	■	■	▲
CTA 3840 x 2160 @ 50Hz	39	3840	2160	5280	2250	50	▲	▲	▲		▲	▲	▲	▲
CTA 4096 x 2160 @ 50Hz	40	4096	2160	5280	2250	50	▲	▲	▲		▲	▲	▲	▲
VESA 3840 x 2160 @ 60Hz [RB1]	41	3840	2160	4000	2222	60	▲	▲	▲	▲	■	▲	▲	▲
VESA 3840 x 2160 @ 60Hz [RB2]	42	3840	2160	3920	2222	60	▲	▲	▲	▲	■	▲	▲	▲
CTA 3840 x 2160 @ 60Hz	43	3840	2160	4400	2250	60	▲	▲	▲		▲	▲	▲	▲
CTA 4096 x 2160 @ 60Hz	44	4096	2160	4400	2250	60	▲	▲	▲		▲	▲	▲	▲

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DisplayPort Sink and Source Capability (YCbCr) (1 lane capability) contd.

Description	TSI*	H active	V active	H total	V total	Frame rate	YCbCr 4:2:2 (bpc)				YCbCr 4:2:0 (bpc)			
							8	10	12	16	8	10	12	16
VESA 3840 x 2160 @ 120Hz [RB1]	45	3840	2160	4000	2287	120	▲				▲	▲		
VESA 3840 x 2160 @ 120Hz [RB2]	46	3840	2160	3920	2287	120	▲				▲	▲		
CTA 3840 x 2160 @ 120Hz	47	3840	2160	4400	2250	120					▲	▲		
VESA 5120 x 2160 @ 30Hz [RB1]	48	5120	2160	5280	2191	30	■	▲	▲	▲	●	■	■	▲
VESA 5120 x 2160 @ 30Hz [RB2]	49	5120	2160	5200	2191	30	■	▲	▲	▲	●	■	■	▲
CTA 5120 x 2160 @ 30Hz	50	5120	2160	6000	2200	30	■	▲	▲	▲	■	■	▲	▲
VESA 5120 x 2160 @ 60Hz [RB1]	51	5120	2160	5280	2222	60	▲	▲	▲		▲	▲	▲	▲
VESA 5120 x 2160 @ 60Hz [RB2]	52	5120	2160	5200	2222	60	▲	▲	▲		▲	▲	▲	▲
CTA 5120 x 2160 @ 60Hz	53	5120	2160	5500	2250	60	▲	▲	▲		▲	▲	▲	▲
VESA 5120 x 2160 @ 120Hz [RB1]	54	5120	2160	5280	2287	120					▲			
VESA 5120 x 2160 @ 120Hz [RB2]	55	5120	2160	5200	2287	120					▲			
CTA 5120 x 2160 @ 120Hz	56	5120	2160	5500	2250	120					▲			
Other 5120 x 2880 @ 60Hz	57	5120	2880	5280	2962	60	▲	▲			▲	▲	▲	
VESA 7680 x 4320 @ 30Hz [RB1]	58	7680	4320	7840	4381	30	▲				▲	▲	▲	
VESA 7680 x 4320 @ 30Hz [RB2]	59	7680	4320	7760	4381	30	▲				▲	▲	▲	
CTA 7680 x 4320 @ 30Hz	60	7680	4320	9000	4400	30					▲	▲		
VESA 7680 x 4320 @ 60Hz [RB1]	61	7680	4320	7840	4443	60								
VESA 7680 x 4320 @ 60Hz [RB2]	62	7680	4320	7760	4443	60								
CTA 7680 x 4320 @ 60Hz		7680	4320	9000	4400	60								
VESA 7680 x 4320 @ 100Hz [RB1]		7680	4320	7840	4529	100								
VESA 7680 x 4320 @ 100Hz [RB2]		7680	4320	7760	4529	100								
CTA 7680 x 4320 @ 100Hz		7680	4320	10560	4500	100								

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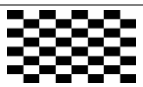
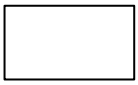
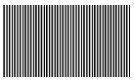
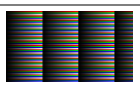
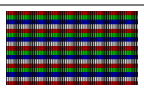
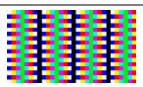
*) TSI Timing ID

APPENDIX D: PREDEFINED PATTERNS

Selection	TSI *	Pattern	Description
Disabled		N/A	The links are activated but no video data transferred
Color Bar	0		100% intensity color bars of all primaries and mixed combinations.
Chessboard	1		8 by 8 chessboard with black (0%) and 100% intensity white
Solid Black	2		0% luminance
Solid White	3		100% white
Solid Red	4		100% red
Solid Green	5		100% green
Solid Blue	6		100% blue
White Vertical Stripes	7		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 0 to 5000.
Gradient Vertical Stripes	8		16 pixels high horizontal red green, blue and white stripes. Intensity is increased from 0 to 100% with steps defined by the given parameter (n). (step = n*color_depth/256). “n” range 0 to 5000 (default 120).
Color Ramp	9		Color Ramp test pattern defined by VESA DisplayPort Link Layer Compliance Test Specification.
Color Square	10		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)
White Square			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).
Motion Pattern	11		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)
Custom Image			Bitmap image uploaded by the user. Click on the **Custom Images** panel to browse.

*) TSI Pattern ID

More test patterns can be downloaded e.g. from https://sid.org/Publications/ICDM.aspx#7327477-test-patterns

APPENDIX E: SINK, SOURCE AND REPEATER DUT TESTS

.

Source DUT Testing (UCD-411 N/A)		Default	DP 1.4a LL CTS*	DP DSC Decoder CTS*	DisplayID CTS*	Adaptive Sync CTS*	DP HDCP 2.3 CTS*
CRC based Video Test Set	CRC based single frame reference video test	✓					
	CRC based single frame stability test	✓					
	CRC based sequence of frames reference video test	✓					
	CRC based continuous sequence of frames reference video test	✓					
Link Test Set	Link Training at All Supported Lane Counts and Link Rates	✓					
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			✓			
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				✓		
Adaptive-Sync CTS	4.8.1.1 – 4.8.1.2, 4.8.2.1 – 4.8.2.2,					✓	
HDCP 2.3 CTS 1A Test Set	HCDP2.3 CTS 1A-01 – HCDP2.3 CTS 1A-13						✓
HDCP 2.3 CTS 1B Test Set	HCDP2.3 CTS 1B-01 – HCDP2.3 CTS 1B-10						✓

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

Sink DUT Testing		Default	DP 1.4a LL CTS*	DP DSC Encoder CTS*	DisplayID CTS*	Adaptive Sync CTS*	DP HDCP 2.3 CTS*
DP 1.4a 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 1.4a DSC CTS	5.6.1.1. – 5.6.1.26, 5.6.2.1 – 5.6.2.14			✓			
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, 5.7.2.1 – 5.7.2.3.5, 5.7.2.4.1 – 5.7.2.4.2, 5.7.2.5.1 – 5.7.2.5.2, 5.7.2.6.1 – 5.7.2.6.2, 5.7.2.7.1, 5.7.2.8, 5.7.3.1 – 5.7.3.5, 5.7.4.1 – 5.7.4.3, 5.7.4.5, 5.7.5.1 – 5.7.5.2, 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				✓		
Adaptive Sync CTS	5.8.1.1 – 5.8.1.3					✓	
HDCP 2.3 CTS 2C Test Set	HCDP2.3 CTS 2C-01 – HCDP2.3 CTS 2C-06						✓

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

Repeater DUT Testing		Default			DP HDCP 2.3 CTS*
HDCP 2.3 CTS 3A Test Set	HCDP2.3 CTS 3A-01 – HCDP2.3 CTS 3A-06				✓
HDCP 2.3 CTS 3B Test Set	HCDP2.3 CTS 3B-01 – HCDP2.3 CTS 3B-07				✓
HDCP 2.3 CTS 3C Test Set	HCDP2.3 CTS 3C-01 – HCDP2.3 CTS 3C-25				✓

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

CRC Based Video Test Set – DP RX

DisplayPort Sink (DP RX) functionality is not available when using UCD-411

CRC Based Single Reference Frame Video Test

The test compares captured frames to a provided reference.

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 100 000 ms)
- Total number of frames (default 2 000 ms)
- Number of bad frames allowed (default 2)
- Reference width (default 1920)
- Reference height (default 1080)
- Reference BPP (default 24)
- Expected frame rate (mHz)
- Frame rate tolerance (mHz)
- 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 100 000 ms)
- Total number of frames (default 2 000 ms)
- Number of bad frames allowed (default 2)

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 100 000 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)
- Frame rate tolerance (mHz)
  - 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 100 000 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)
- Frame rate tolerance (mHz)
- 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 Test Set – DP RX

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.

Parameters in use

- Test Timeout (default 5 000 ms)
- Max lane count supported by DUT (default 4)
- Max lane rate supported by DUT as multiple of 0.27 Gbps.
  (valid settings 6, 10 and 20; default 20)
- Long HPD pulse duration (default 1 000 ms)
- Link training start timeout (default 5 000 ms)
- Delay between test cycles (default 3 000 ms)

APPENDIX F: ADVANCED FILTERS

This the description of the advanced methods for filtering transactions in *DP AUX analyzer* in *Event Log*. The following help text can be seen as well by clicking the Help button of the *Edit Filter Rule* dialog.

Note	Please note that Filters are a very powerful tool. They can however unintentionally hide valuable data from you. Please be careful when applying custom filters. A good practice is to start from an existing filter and gradually add new rules while testing their performance.

Note	Filtering and selecting the columns for display do not affect the actual data acquisition. All transactions and their full data are always captured.

Data pattern expressions

A data-pattern expression is a string that describes how to determine if a data-block should be considered as "matched" or "unmatched". The syntax used with data-pattern expressions in Aux Channel Analyzer is described below

The data-block must be covered completely by the data-pattern expression. If the data block is shorter, or longer than the expression, then the data block is determined as "not matched". The '*' wildcard can be used to allow data blocks of any size to match.

Whitespaces and new-lines are ignored and are allowed anywhere; White spaces and new-lines can be used strategically to make the expression more readable.

For example: "*!(10)??(10)" is the same as "* ! (10) ? ? (10)"

Comment blocks:

Comments must be written enclosed in curly-braces '{' and '}'.

Wildcards

Wildcards used are '*' and '?'

? = Match any single data byte only.

* = Match any number of any data bytes. (including the possibility of matching NO data bytes)

For data matching, the byte value must be enclosed in braces '(' and ')'. Use prefixes '$' to indicate HEX value, '%' to indicate BIN. No prefix indicates DEC.

Examples:

* ($10) ($00) : Matches any data pattern that has the bytes $10, $00 at end of data.

? ($10) ($00) : Matches 3-byte data pattern that has $10 as second byte and $00 as third byte.

* ($10) * ($00) : Matches any data pattern that has $10 and ending to a $00 byte.

* ($10) * ($00) * : Matches any data pattern that has $10 and $00 after it.

($10) ? * ($20) * : Matches any data pattern that has $10 as first byte, followed by $20 with at least one other byte in between. (i.e. will not match $10, $20)

Use '!' to invert the match:

!($00) = Match any data byte that isn't $00.

Use '?' within HEX or BIN value to ignore that bit in comparison:

($??) = ? = Any data Byte.

($?0) = Any data byte with bits 0-3 cleared.

(%1???????) = Any data byte with bit 7 set.

(%0??????1) = Any data byte with bit 7 cleared and bit 0 set.

The '!' inversion can still be used:

!(%??????00) = Matches any data byte ending to %10, %11, %01 but not %00.

To match a single data byte with more than one value, separate the values with comma ',':

(0, 1, 100, 200, 254) : Matches a data byte whose value is 0, 1, 100, 200 or 254.

Invert the value group match with '!'. Value wildcard '?' is also allowed.

Example:

!(1, 2, 3) : Match any data byte other than 1, 2 or 3.

!($?f, $f?) : Don't match data bytes with bits 0-3 set to 1, or data bytes that have bits 7-4 set.

APPENDIX G: FIRMWARE RECOVERY PROCEDURE WITH QUARTUS PRIME

FW Update Tool

The chapter below describes a procedure for updating UCD-400 or UCD-411 Firmware in a case when e.g. the normal FW Update procedure failed because a critical error.

- Download the latest UCD-300/400 SW Bundle version from Unigraf website https://www.unigraf.fi/downloads/ and install it. Please do not launch UCD Console yet.
- *Recovery.zip* file will be by default installed in C:\Program Files (x86)\Unigraf\TSI\UCD-400\Recovery. Perform the *Recovery* procedure according to the instruction in the following pages.
- Without removing power from the UCD-400 device perform FW update procedure as described in section 4 FIRMWARE UPDATE PROCEDURE earlier in this manual.

Note

The FW patch loaded in the UCD device during Recovery procedure is stored in a temporary memory. When power is removed from UCD device, the content of the temporary memory will be erased. Therefore, please do not power down the UCD device after performing the *Recovery* before instructed in the end of the FW Update procedure.

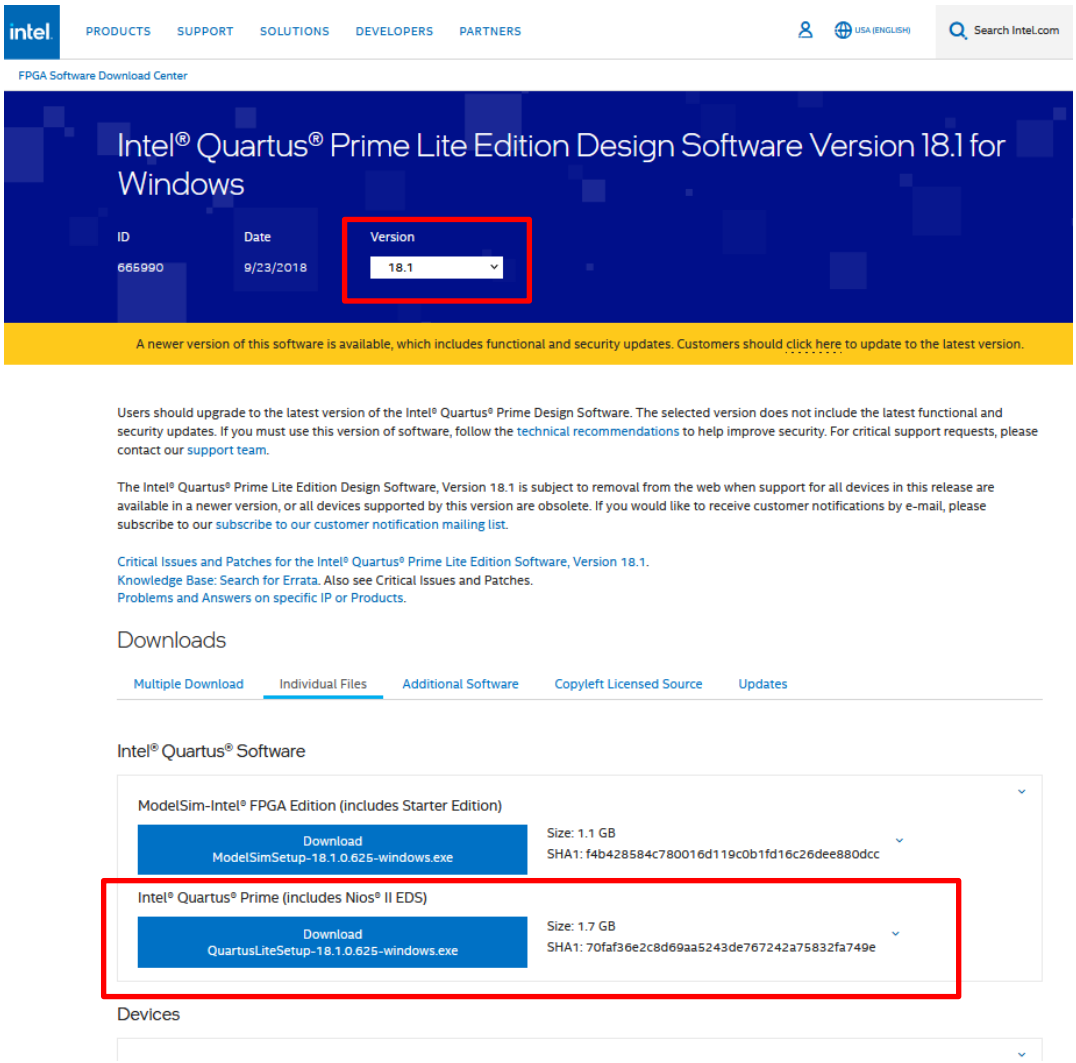
If power will accidentally be removed before the FW Update procedure, Recovery procedure needs to be re-initiated.

The Recovery patch is programmed to UCD Device with a separate tool called **Quartus Prime (includes Nios II EDS)**. The tool can be downloaded from **Intel® FPGA** website:
https://www.intel.com/content/www/us/en/software-kit/665990/intel-quartus-prime-lite-edition-design-software-version-18-1-for-windows.html

On the download page, please **Select release 18.1.** Please download **Quartus Prime (includes Nios II EDS)**.

Note:	Registering is needed for the download.

Please download and install the tool in the PC.



Connect to the UCD-400 Unit

- Power on the UCD-400.
- Connect UCD-400 with a USB cable to the PC through Programmer connector. (Pls refer to page 8 of this document)

Programming the FW

Please locate the *Recovery.zip* file. It is by default installed in C:\Program Files (x86)\Unigraf\TSI\UCD-400\Recovery. Extract the content of the zip file in a folder in your PC, e.g., c:\Temp

- Run **Nios II 18.1 Command Shell** application as Administrator

---

Note — Nios II 18.1 Command Shell application needs to be run as Administrator (Right click with mouse and select **Run as Administrator)**

Hint — Right click on the top edge of *Command Shell* and select **Edit > Paste** to paste the commands below

---

- Select the folder location where the content of the *Recovery.zip* file was extracted. For example (c:\Temp)

```
cd /cygdrive/c/Temp
```

- Run the loader.

```
source recovery.sh
```

This instruction will load a temporary patch to the FW of the UCD Device to enable normal FW Update procedure

- Once the upload has completed, please close the commend shell.
- Launch UCD Console and initiate FW Update by selecting Tools > Firmware update. Please follow the instructions given in section 4 FIRMWARE UPDATE PROCEDURE earlier in this manual.

Note — The FW patch loaded in the UCD device during Recovery procedure is stored in a temporary memory. When power is removed from UCD device, the content of the temporary memory will be erased. Therefore, please do not power down the UCD device after performing the Recovery before instructed in the end of the FW Update procedure.

If power will accidentally be removed before the FW Update procedure, Recovery procedure needs to be re-initiated.

- Once FW update procedure has completed, cycle power on the UCD Device (switch off power > wait for 10 seconds > turn on power).

Note — Please cycle the power on the UCD-400 unit to enable the FW update (switch off power > wait for 10 seconds > turn on power).

After Recovery procedure has been completed, you can delete the files stored in e.g., C:/Temp.