# UCD-422 Gen2, UCD-422 UCD-412

# User Manual

## UCD Console SW Version 3.8


UNIGRAF

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# Edition

UCD-422 UCD Console 3.8 User Manual, Rev 4

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# CE Mark

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

# Table of Contents

# 1. ABOUT THIS MANUAL

## Purpose

This guide is a User Manual of UCD-422 Gen2, UCD-422 and UCD-412 test devices, that are USB-connected video interface test units for use with a computer.

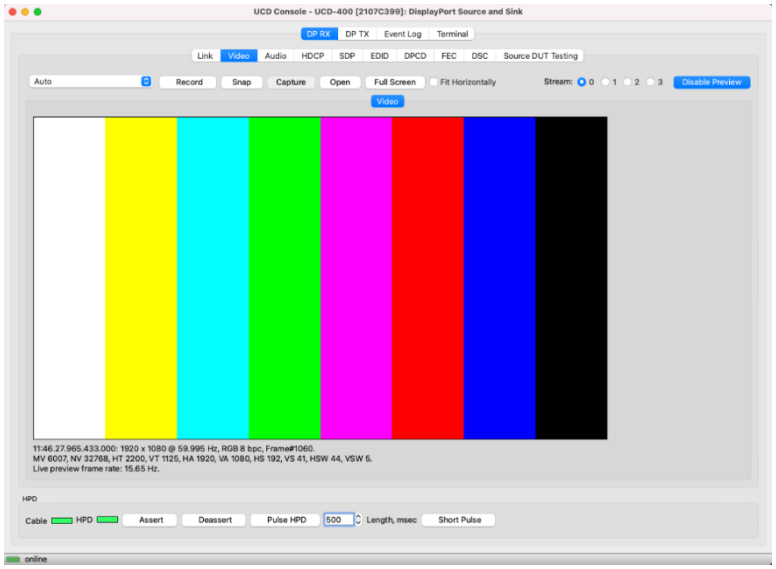
The purpose of this guide is to

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

## Product and Software Version

This manual explains features found in UCD Console SW Bundle **3.7.** 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 |

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

# 2. INTRODUCTION

## Product Description UCD-422 Gen2, UCD-422 and UCD-412

### Product Features

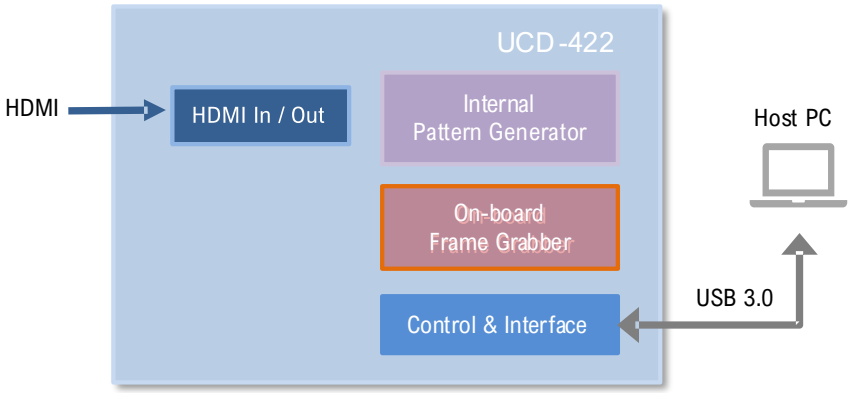
- UCD-422 Gen2, UCD-422: Reference Sink and Source for verifying HDMI connected devices.
- UCD-412: Reference Source for verifying HDMI connected sinks.
- HDMI 2.1 compatible. Supports FRL and TMDS signaling.
- Supports HDMI video and audio up to 10K@30 Hz, 8K@60 Hz (YCbCr 4:2:0), 4K@120 Hz (YCbCr 4:2:0)
- Supports Display Stream Compression (DSC), and Enhanced Audio Return Channel (eARC)
- Compatible with HDCP versions 1.4 and 2.3
- 2 GB on-board high-speed video frame buffer
- High speed USB 3.0 host PC interface

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

### Functional Description

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

Please find below logical diagram of UCD-422 unit

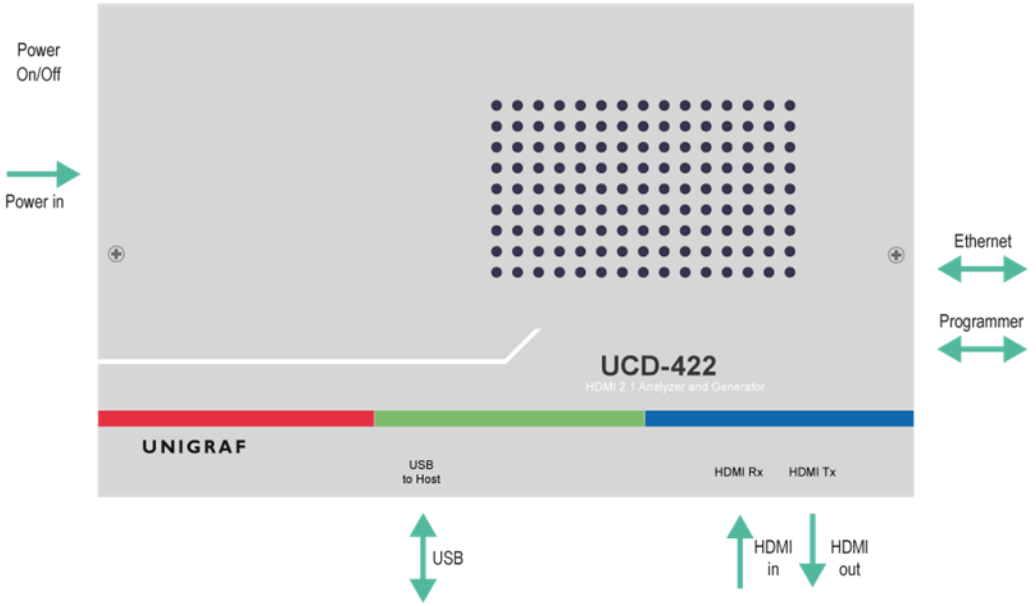



### Delivery Content

- Product shipment contains:
- The UCD-422 Gen2, UCD-422 or UCD-412 unit
- AC/DC Power supply (100 to 240 Vac 50/60 Hz input, +12 Vdc output)
- USB 3.0 compliant cable for host PC connection
- HDMI 2.1 grade HDMI cable
- Micro-USB type B compatible cable needed for FW programming.
- Ethernet cable needed for FW programming.

## Connections

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




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

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

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

# Safety and Operational Precautions

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

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

- Use only Unigraf provided AC/DC Power Adapter. Please make sure that connectors and cabling to the Power Adapter are intact. In case there are any doubts about the condition of the Adapter or cabling, stop using it immediately.
- It is important to ensure that the used AC input voltage is within the specified range (100 to 240 Vac 50/60 Hz) and the fuses in the AC lines are of the specified type. If in doubt, do not connect the device.
- UCD devices are rated for indoor use only. They are rated for Pollution Degree 2 as defined in IEC 61010-1. This classification corresponds to usage in a typical office or home environment. Under normal use, only dry, non-conductive pollution occurs. Occasionally, temporary conductivity caused by condensation can be expected. Temporary condensation occurs only when the product is out of service.
- When installing the unit, connect the Power Adapter to the UCD device first, after that connect the AC plug. Please disconnect the USB cable to the controlling PC and remove cabling to DUT while connecting the power input cables.
- It is forbidden to open the housing of the UCD device without written permission from Unigraf. Failure to comply with this rule will void the warranty of the unit.
- UCD devices are intended for use as Electrical Test Instrument only. Use for other purposes is forbidden.
- Use UCD equipment only in its specified ambient temperature and humidity.
- In order to ensure that the UCD device and associated SW will operate properly, please ensure that the PC used for controlling the UCD device complies with the minimum requirement set by Unigraf.
- Please keep UCD software updated by regularly checking the updates on Unigraf download page (https://www.unigraf.fi/downloads/). Please update the device firmware to match the installed software.

# 3. INSTALLATION

## Installation Package

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

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

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

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

| Note: | The software should be installed before connecting the UCD unit to the computer. |
|---|---|

| Note: | System administrator's privileges are required for performing installations. |
|---|---|

## Software Installation

### Windows

Install *.exe file from the package.

Start installation by running application **SoftwareBundle_X.X.XXXX.**

The welcome page is displayed and shows the software package release version.

The user is also asked if he/she wants to:

- Create a desktop shortcut
- Install the Visual C++ redistributable (needs to be present on Windows)
- Install Unigraf USB drivers

Confirm by selecting *Next* dialog button. Select *Install* to start the installation.

Select *Finish* to exit the installation dialog.

### macOS

Install *.pkg file from the package. This is a universal binary for ARM and Intel x86.

Start installation by running application **SoftwareBundle_X.X.XXXX.**

Confirm by selecting *Next* dialog button. Select *Install* to start the installation.

Select *Finish* to exit the installation dialog.

Note: If you are downgrading, please remove the *Unigraf UCD Tools* folder from the *Applications* folder before starting installation.

Note: If installation fails, remove the *Unigraf UCD Tools* folder and any possible copies from the *Applications* directory and try again.

## Linux

Linux extract the *.tar.gz file. You will find two install scripts (*install-libfuse.sh* and install.sh).

In the Files app select each script in turn, right click and select *Properties* to open the *Properties dialog*. Toggle the *Executable as Program* button.

In the Files app open a terminal window by unselecting any selected files and right clicking and selecting *Open in Terminal* to run the scripts (order is important).

In the terminal type: *sudo ./install-libfuse.sh*

You will be prompted for you password.

Type: *sudo ./install.sh*

You will be prompted with:

*Please proceed to 'Software & updates' application to tab 'Other Software' and uncheck checkboxes or remove 'cdrom' entry from /etc/apt/sources.list file. Otherwise you will have problems during UCD Console package installation. If you are already done, enter the key 'y'. If not - 'n'*

For Ubuntu just enter y. For debian follow instruction.

You will then be prompted again with:

*Please proceed to 'Software & updates' application to the first tab and set check box 'Officially supported (main)'. Otherwise you will have problems during UCD Console package installation. If you are already done, enter the key 'y'. If not - 'n'*

For Ubuntu just enter *y*. For debian follow instruction

Answer y for additional prompts.

The Ucd Tool Installer Setup app should now be running.

Select *Next>*

Select radio button for *Install for all users* or *Install just for me*.

You are asked to Choose Installation Directory. Do NOT choose the default (/root/Unigraf/Unigraf UCD Tools at time of writing). Select a directory that is easy to access and remember.

Note the warning: Installing in existing directory. It will be wiped on uninstallation.

Select *Next> Install* and *Finnish*.

Navigate to the *Unigraf UCD Tools* directory under the installation directory and double click the app you want to run (*UCDConsole.AppImage* for example).

# Firmware Update Procedures

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

## Updating from Earlier FW Versions

UCD Firmware versions prior to 1.8.52 (see Help > About on Consol) do not support the procedure described here. Follow the instructions in *Appendix G Firmware Recovery Procedure with Quartus Prime* in this manual.

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

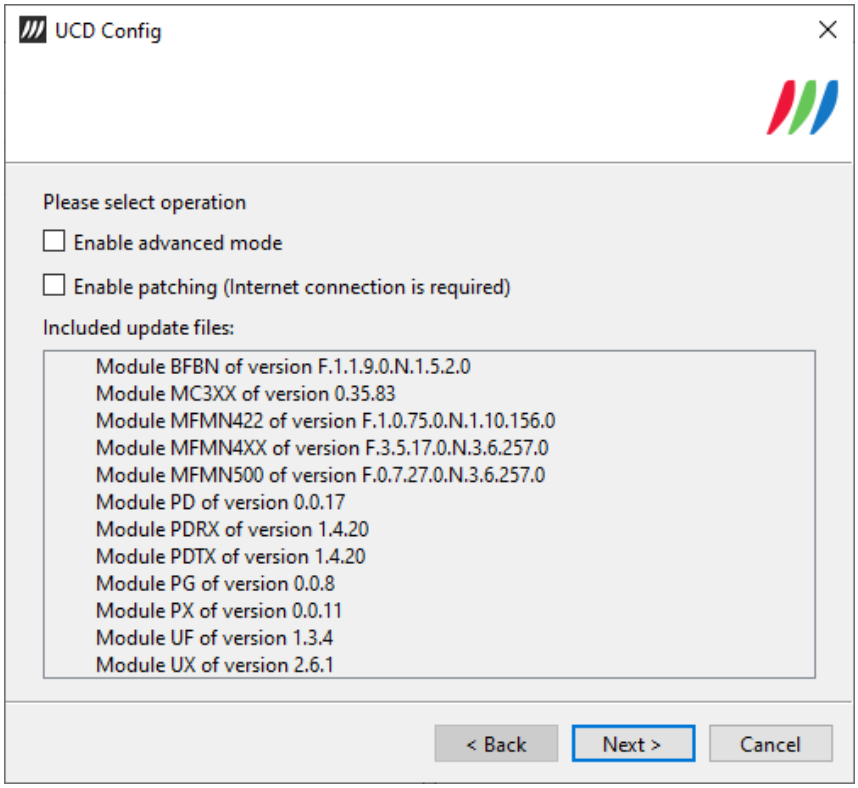
To update the firmware or create a new configuration on a UCD-4XX device, perform the following steps:

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

## UCD Config

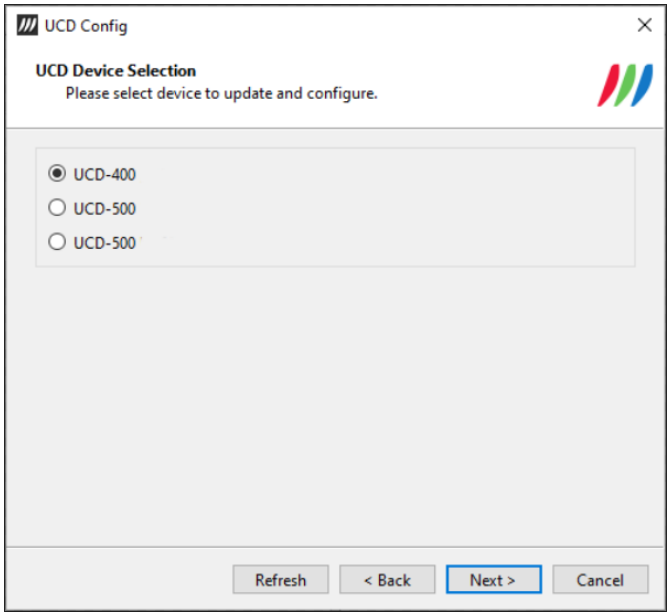
The first page of the utility indicates the firmware component versions present in the package. Select **Enable advanced mode** checkbox if you want to customize the installation (possibly to downgrade firmware for example). **Enable patching (Internet connection is required)** check box is not relevant for UCD-4XX devices.

Select ***Next*** to proceed.



## UCD Device Selection

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



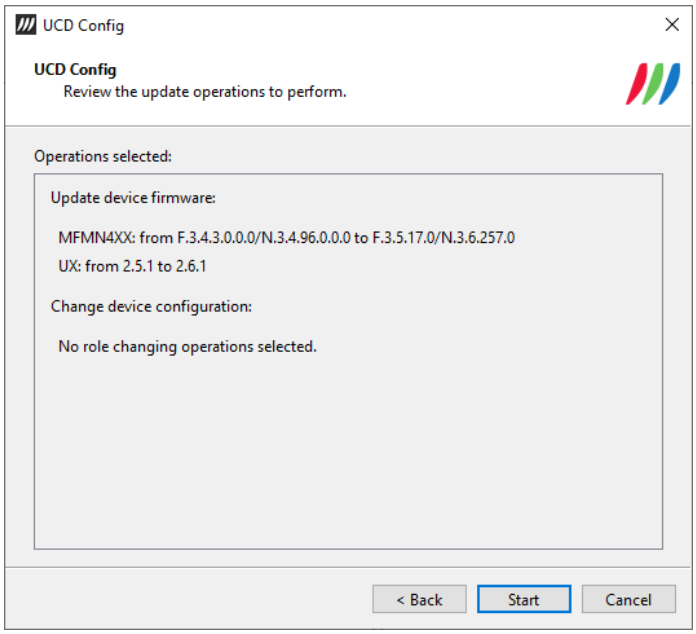

## Review updates

A new dialog lists:

- FW components available in the UCD device
- Current FW version (from)
- FW to be installed (to)

| Note: | Selecting individual components for update is only enabled in **Advanced Mode**. |
|---|---|

Click **Start** to start the FW update procedure.

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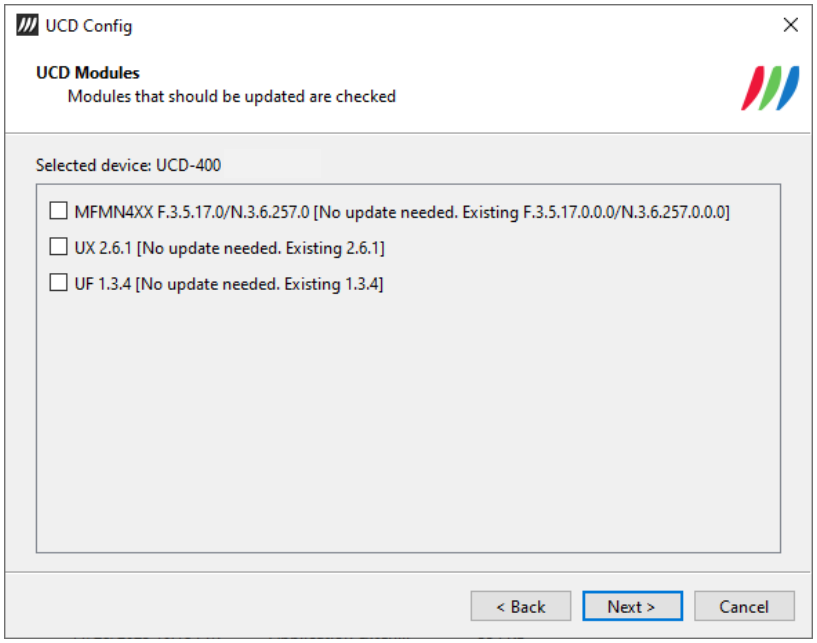
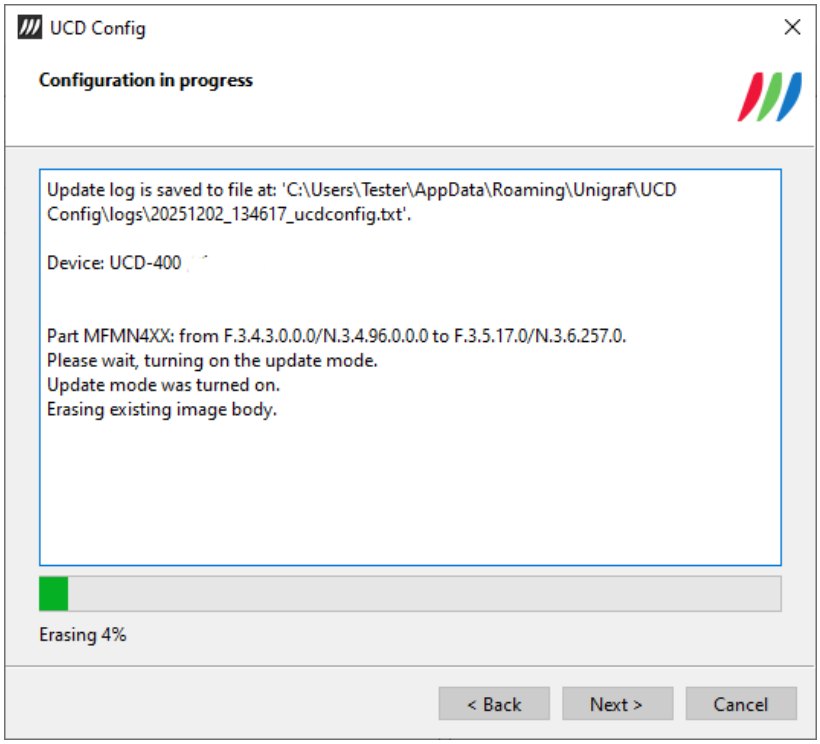
## Advanced Mode

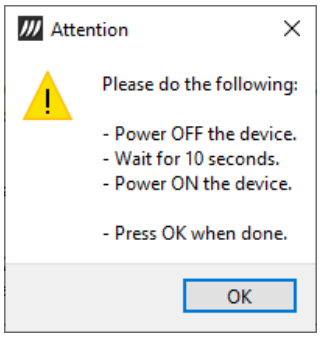
Advanced mode allows users to select individual components to update. Click **Next** to review the components and start the update procedure.




## Configuration in progress



During the installation, you will be prompted to power cycle the device (power off, wait for 10 seconds and then power the device on again). Select *OK* to proceed.




After the update has finished, click **Next** to see a summary and select **Finish** to complete.

Please note that the update proceedure may take several minutes to complete.

## Recovering Failures in FW Update Procedure

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

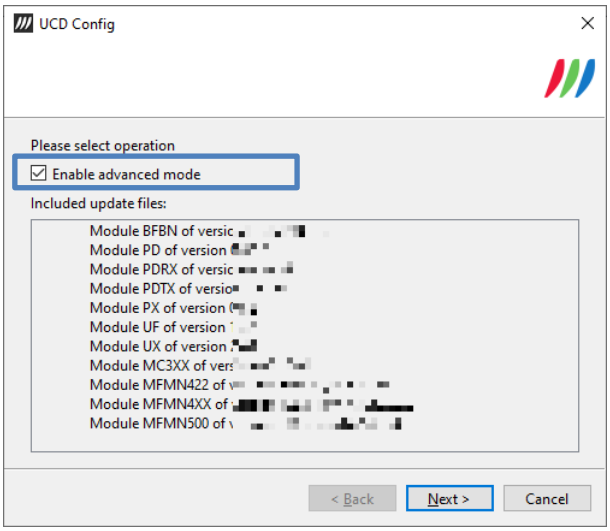
Once FW Recovery procedure has been done and a Firmware version supporting UCD Firmware Configuration tool has been installed, all future updates can be done using this tool.

# Firmware Downgrading

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

Please follow the procedure below:

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




8. Select the device. **Click Next.**
9. In **UCD Modules** select the module titled MFMN4XX F.X.X.X/N.X.X.X
10. Click **Next**. Click **Start** to start programming FW to the connected UCD Device

# License Manager

## Licensing

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

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

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

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

## License Manager GUI

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

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

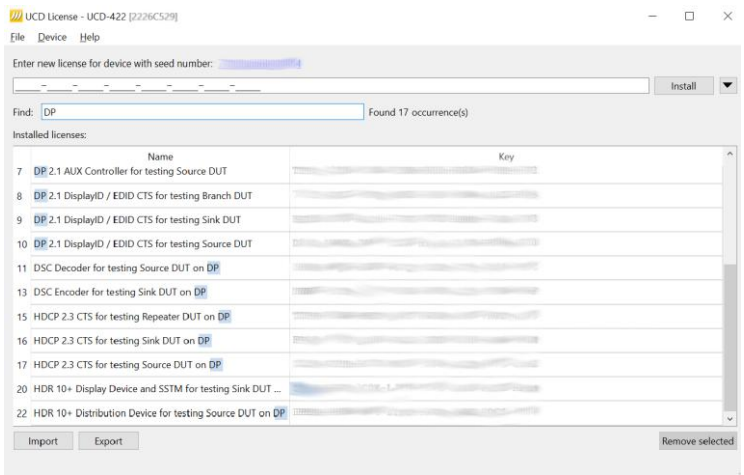
## Managing Licenses

### Seed Number

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

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

## Adding New License Keys




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

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

Click the Search inverted triangle at the upper right to view the *Find* edit control. Enter a search keyword: The license list is updated to show names that contain the keyword.

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

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

## Managing Installed Licenses

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

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

# UCD Console

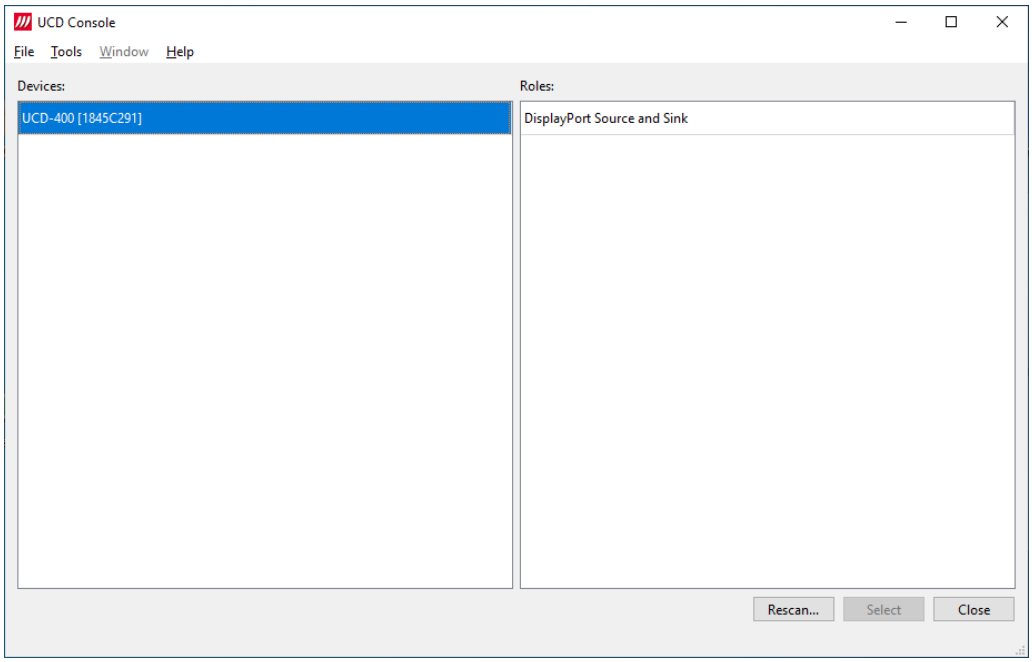
UCD Console SW is graphical user interface (GUI) for UCD family test equipment for desktop use. UCD Console provides the user access to all features of the unit. UCD Console also includes powerful debugging and analysis tools enabling the user to monitor the status of the display interfaces and assist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

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

## Device Selection

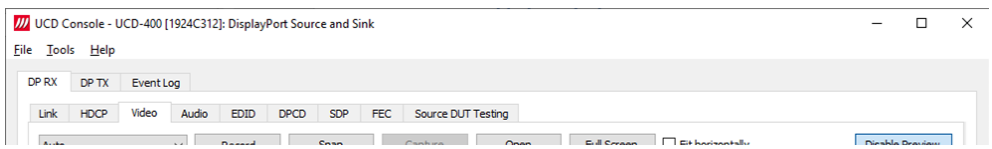
A shortcut of UCD Console can be found by default under Start Menu.

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



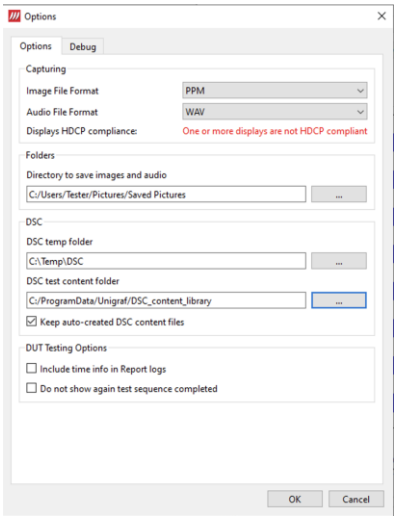

## Analyzer and Generator Operation

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



# Options

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




## Image File Format

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

## Audio File Format

Audio files are stored in WAV format.

## Displays HDCP Compliance

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

## Folders

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

## DSC

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

Warning

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

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

## DUT Testing Options

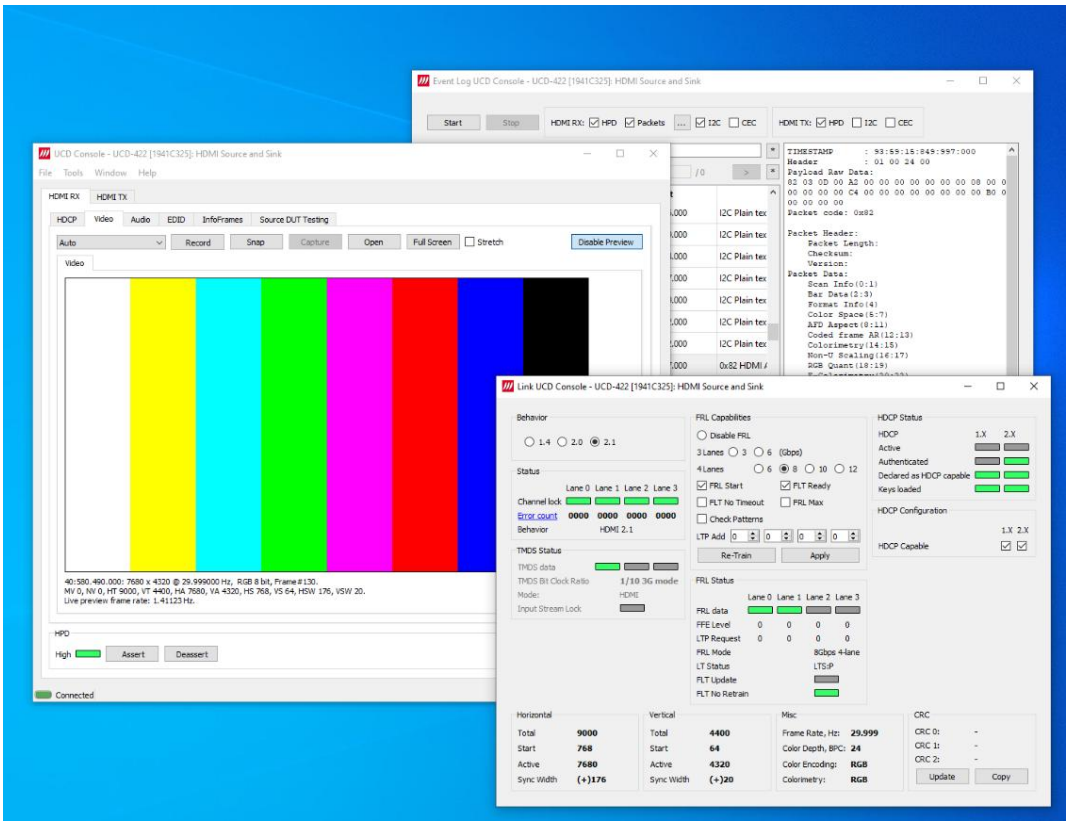
Configure DUT Testing reports.

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

# Detaching and Cloning Tabs

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

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



# 4. ANALYZER OPERATION

When used as an *Analyzer*, the UCD device acts as HDMI Sink or Receiver device.

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

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

## Functionality Tabs

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

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

### Functionality Tabs

Analyzer role features the following tabs:

- Video preview and saving (Video)
- Audio monitoring and saving (Audio)
- EDID editor (EDID)
- HDCP status monitor and control (HDCP)
- Source DUT Testing tab
- Event Log
- Status information and control of the upstream link (Link)
- Received InfoFrame packets (InfoFrame).

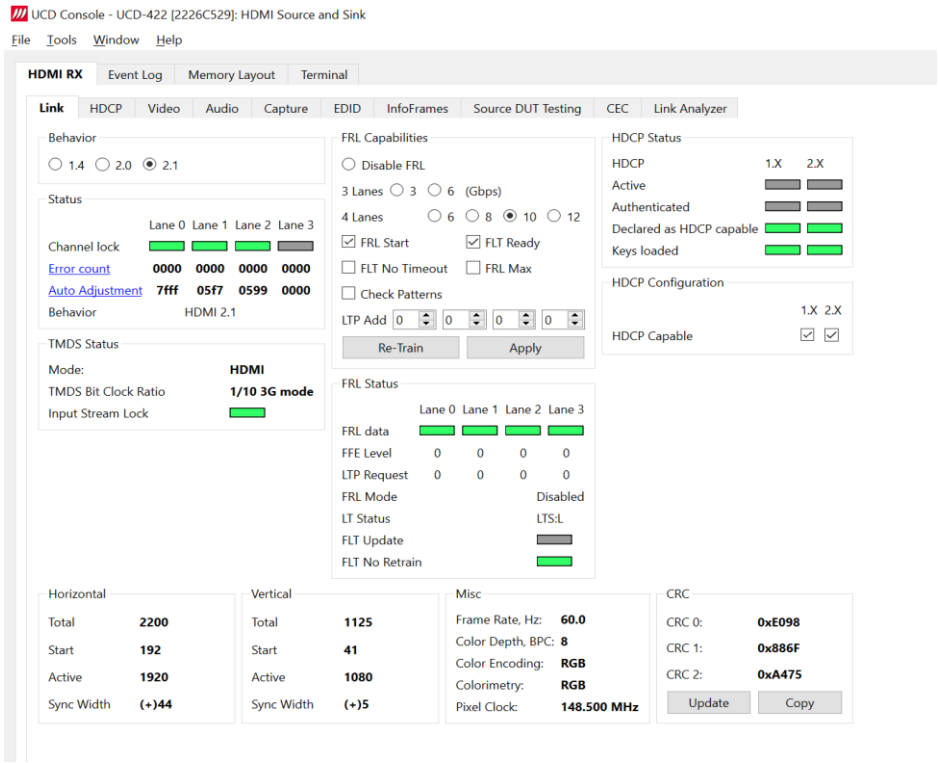
| Note: | Some of the tabs are enabled by default, some only when an applicable license is included. Please refer to Appendix B Licensing of this document for description of features and licensing. |
|---|---|

# Functionality Tabs

## Link Tab

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

### Behavior



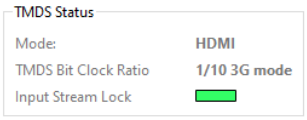

Selection of HDMI operation mode: HDMI 1.4, HDMI 2.0 or HDMI 2.1.

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

### Status

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

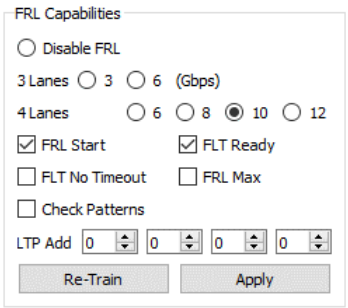
## TMDS Status (Only in TMDS Mode)




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

## FRL Capabilities (Only in FRL Mode)

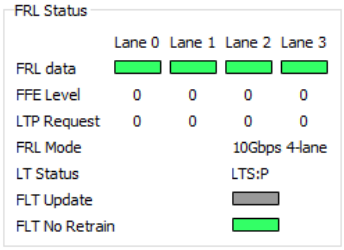
FRL Capabilities allows the user to change the way the Sink capabilities are announced in the SCDC capability registers of the UCD-422 Sink.




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

## FRL Status (Only in FRL Mode)

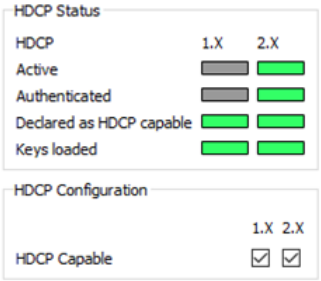
FRL Status displays the status of the link training and the link parameters negotiated between UCD-422 Sink and the Upstream Source. The status is updated automatically.




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

## HDCP Status

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

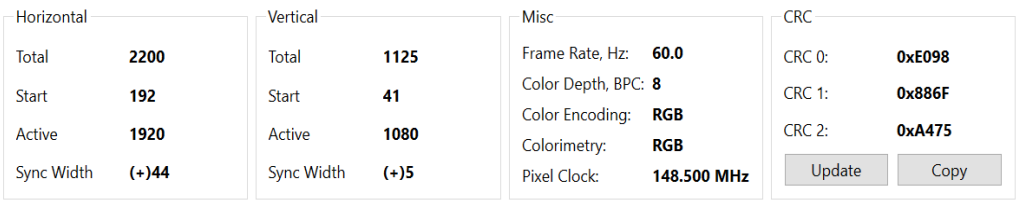



## HDCP Configuration

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

## Video Status

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

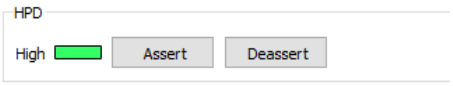



## CRC

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

### HPD

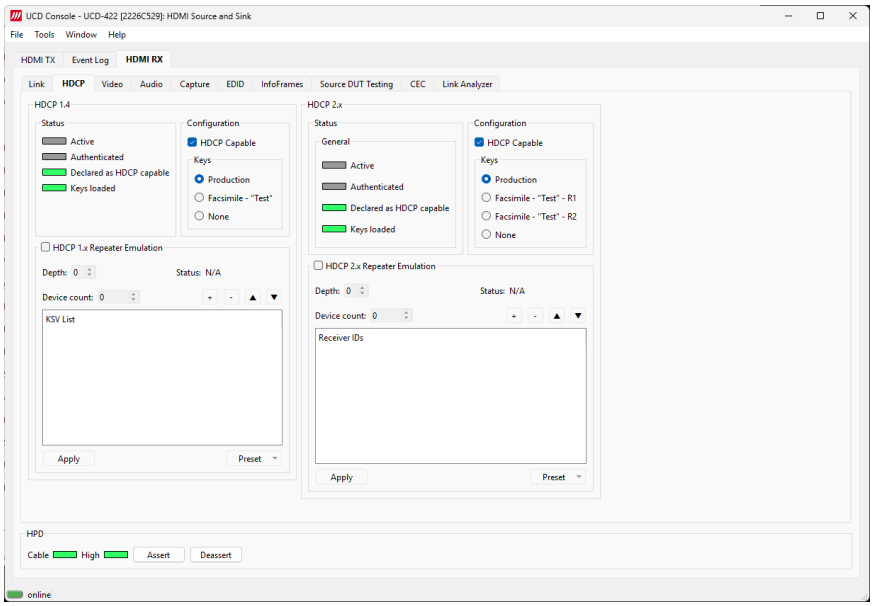
| | |
|---|---|
| *High:* | LED indicates that the HPD signal is Asserted (logical “high”). |
| *Deassert:* | Click button to set HPD line to logical “low” (de-asserted) and hence no HPD pulse can be generated. |
| *Assert:* | Click to re-activate the HPD line (set to logical “high”). |




# HDCP Tab

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

### Status



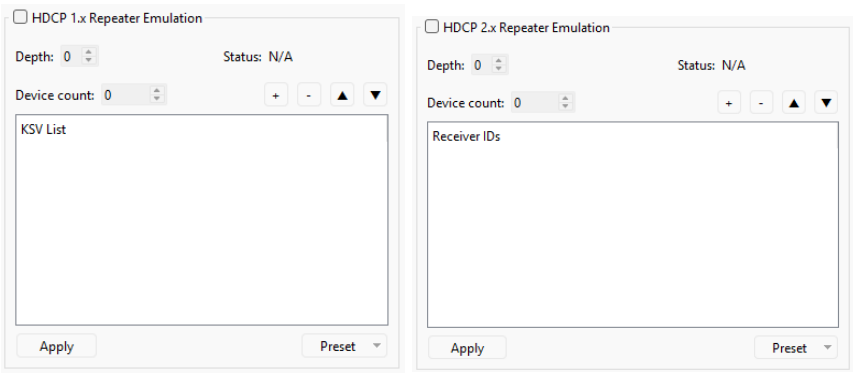

The status field indicates the HDCP status of the UCD device.

| | |
|---|---|
| *Active*: | The link between UCD and the upstream source has been encrypted. |
| *Authenticated*: | The HDCP handshake between the UCD and the sink unit has been completed successfully. |
| *Declared as HDCP capable*: | The UCD unit recognizes HDCP handshake messages. |
| *Keys loaded*: | The HDCP keys are loaded to the UCD unit. |
| *SST Mode Type* | Type when in SST mode (DP). |

### Configuration

| | |
|---|---|
| *HDCP Capable*: | To inform source DUTs that TE (UCD device) is HPCD capable or not. Uncheck to disable. |

## HDCP 1.x and HDCP 2.x Repeater Emulation




For HDMI the UCD device can simulate a HDCP repeater. Check the *Repeater Simulation* box to enable the rest of the controls.

| | |
|---|---|
| *Depth*: | Depth of *Repeater* (maximum 4). |
| *Device count*: | The number of devices that act as repeaters (maximum 32). |
| *KSV Value* | KSV value assigned to each device. |
| *Receiver IDs* | Receiver IDs |
| *Status* | Shows HDCP authentication of repeater. |

The *Device count* can be change via the spinbox or the +/- buttons.

Inverted triangles are used to navigate the *KSV* rows.

Use the *Preset* dropdown to *Save, Load* and *Remove* named (saved internally) sets.

Use the *Import* and *Export* options to load and save to files.

Press *Apply* to apply settings.

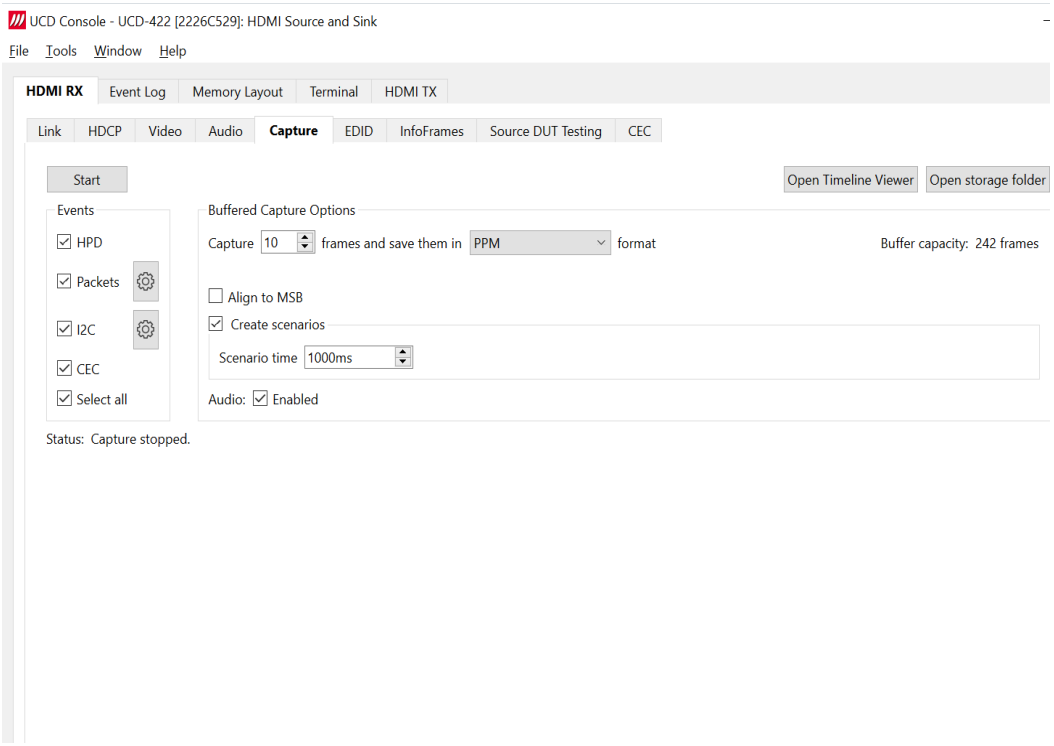
## Keys

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

# Capture Tab

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

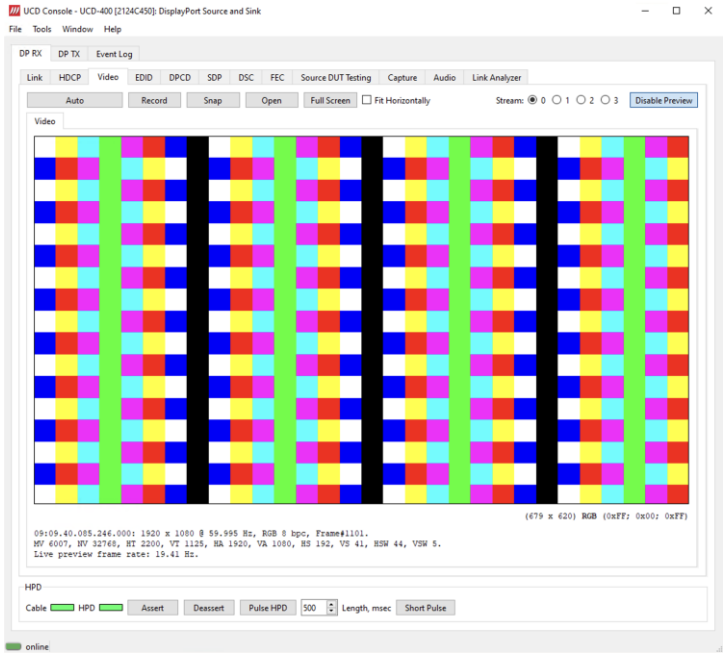
HDMI *Events* see *HDMI Link Analyser Tab Events.*




| | |
|---|---|
| *Start / Stop* | Start or stop capturing. Button label changes per action. |
| *Capture N frames:* | The number of video frames to capture. |
| *Format:* | Selection of the format of the saved video frame bitmaps. BIN, PPM, BMP, BIN + PPM, BIN + BMP. |
| *Buffer capacity:* | The number of video frames that can be stored to UCD frame buffer using current video signal format. |
| *Align to MSB* | Store binary data aligned to the Most Significant Bit (MSB).<br>When this is left unchecked the binary data is aligned to the Least Significant Bit (LSB). |
| *Create scenarios* | Define the length of the scenario. |
| *Events:* | Please refer to chapter *Event Log* for details of the captured events. |
| *Audio:* | Enable audio. |
| *Status:* | Status of the capture. |
| *Open Timeline Viewer* | Open Event Timeline Viewer to view the captured data. For detailed instructions refer to chapter seven of this manual. |
| *Open storage folder:* | Data save folder is defined in menu Tools > Options. Captured video, audio and data is saved in a subfolder of this folder. The name of the subfolder is “buffered_capture_yyyymmdd_hhmmss” (e.g., buffered_capture_20210301_130532). |

# Video Tab

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

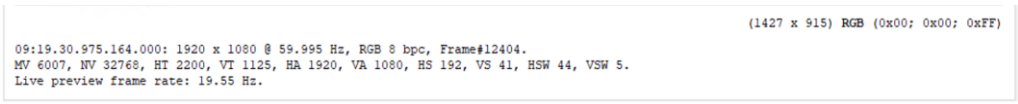



## Disable / Enable Preview

Click the button to start or stop capturing video frames.

## Video Status

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




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

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

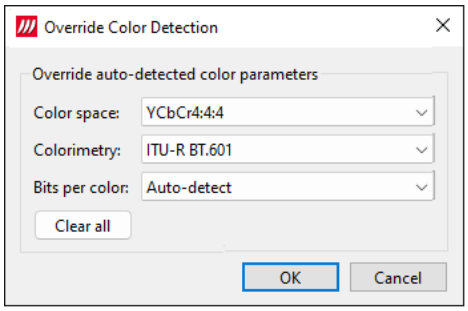
Please note that UCD test equipment are able to capture video at full frame rate.
*Live preview frame rate* indicates the rate of updating captured video on UCD Console preview screen. The rate is limited e.g by the USB communication between UCD test equipment and the PC.

## Override Color Detection

Auto

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

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



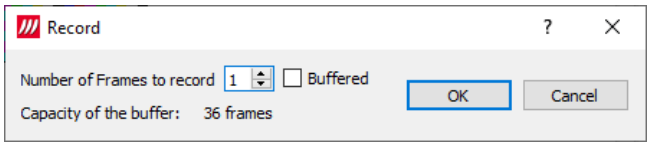

| | |
|---|---|
| *Color space:* | Define as which format captured data will be interpreted. (Auto-detect, RGB, YCbCr4:4:4, YCbCr4:2:2, YCbCr4:2:0) |
| *Colorimetry:* | Define as which colorimetry captured data will be interpreted. (ITU-R BT.601, ITU-R BT.709, ITU-R BT.2020) |
| *Bits per color* | Define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

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

## Frame recording

Record

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




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

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

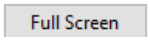
Recorded frames are stored by default in C:/Users/<Current user>/Pictures. Please refer to Tools > Options where the location of this folder can be customized.

## Open

Open

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

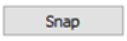
## Full Screen



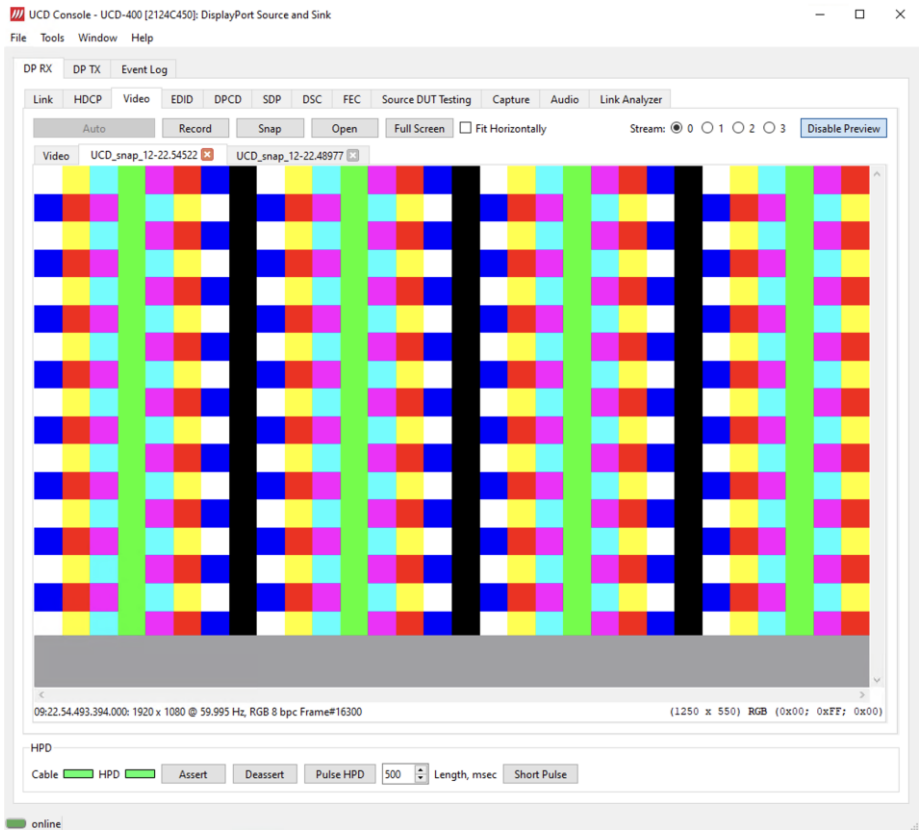

Preview captured video full screen, scaled to vertically fit the screen.

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

## Snap Frame




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




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

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

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

### Zoom

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

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

### Save Frame

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

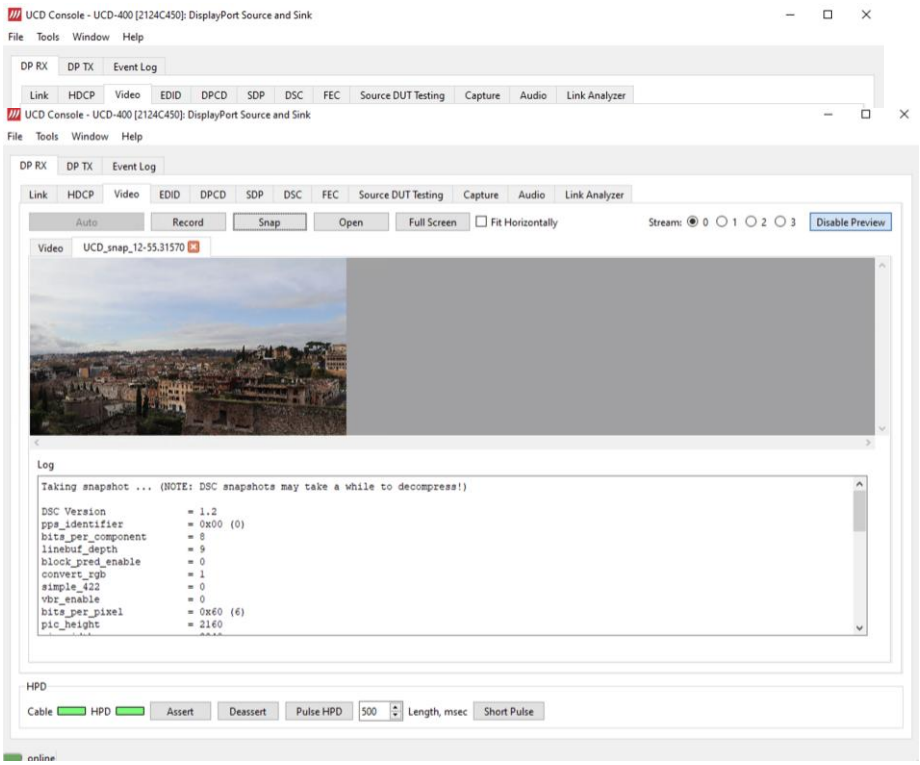
| Note: | In PPM format the files are stored with the captured color depth, with other formats the color depth is truncated to 8 bits per color. |
|---|---|

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

## Previewing DSC Decompressed Stream

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

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

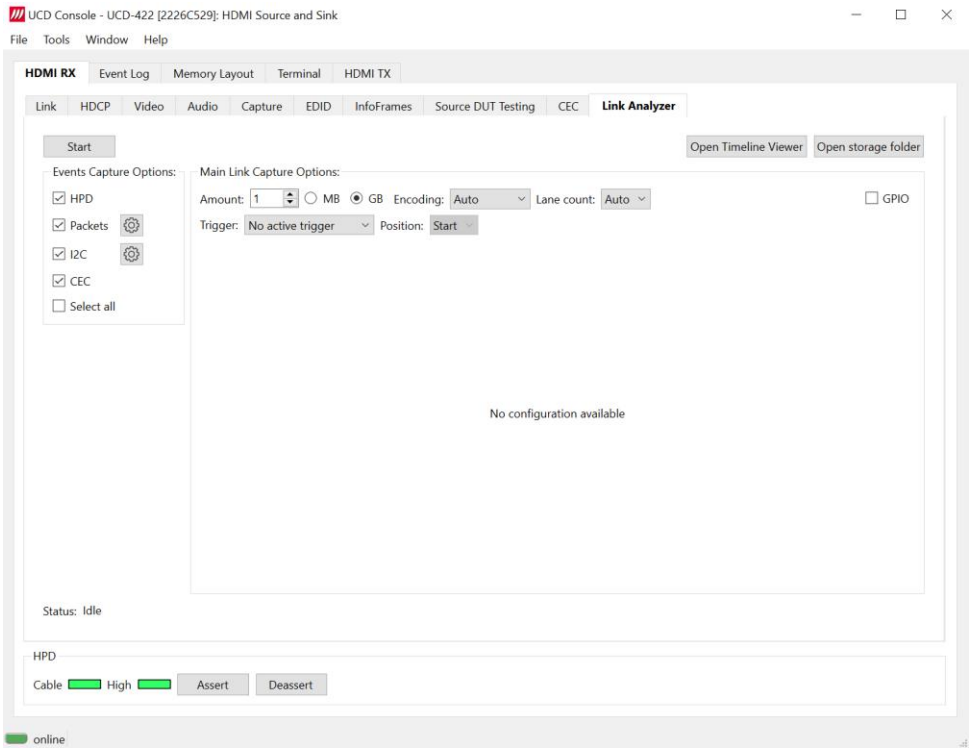



Click **Snap** button to capture one frame and start the decompressor (offline in the PC). Once the decompression is ready, the frame is shown, and *Log* lists the details of the compressed image. A snapped DSC image can be saved as a DSC-file.

# HDMI Link Analyzer Tab

Capture Data Events for analysis with *Link Timeline Viewer*. See chapter Link Timeline Viewer for details.

## Link Analyzer buttons




| | |
|---|---|
| *Start* | Start capturing main link data using *Main Link Capture Options.* |
| *Open Timeline Viewer* | Open Link Timeline Viewer. See Timeline Viewer. |
| *Open storage folder* | Open folder in the PC where capture data is stored. Folder is the video storage folder defined in *Tools* > *Options*.<br>Captured video, audio and data is saved in a subfolder of this folder. The name of the subfolder is “capture_yyyymmdd_hhmmss). (e.g. capture_20210215_093351). |

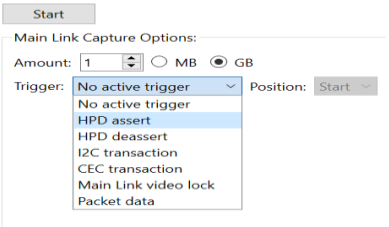
## Main Link Capture Options

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

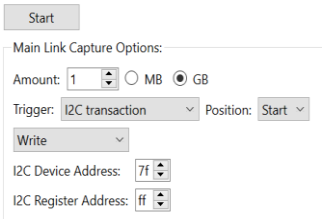
## Trigger Point Options

Data capture start can occur with or without defined trigger criteria.

*Trigger* criteria dropdown has four options: No active trigger, HDP assert, HDP deassert, I2C transaction, *CEC transaction*, *Main Link* video lock and *Packet data*.

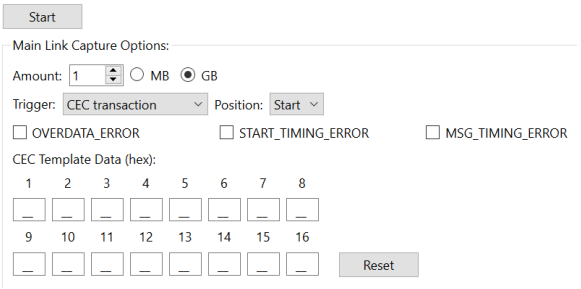


When *I2C transaction* is selected, a drop down list box is enabled and visible with options: *Write*, *Read* and *Any*. Two spinboxes are enabled for *I2C Device Address* and *I2C Register Address*.

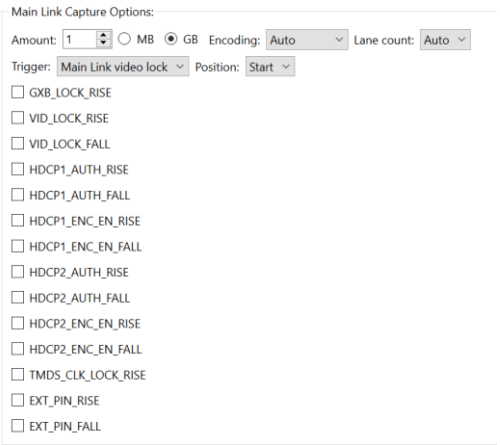



When *CEC transaction* trigger is selected, available trigger options are shown below.

Select trigger options via checkboxes *OVERDATA_ERROR, START_TIMING_ERROR* and/or by filling in the *CEC Template Data (hex)* values.




When the *Main Link video lock* trigger is selected, available checkboxes are *GXB_LOCK_RISE, VID_LOCK_RISE, VID_LOCK_FALL, HDCP1_AUTH_RISE, HDCP1_AUTH_FALL, HDCP1_ENC_EN_RISE, HDCP1_ENC_EN_FALL, HDCP2_AUTH_RISE, HDCP2_AUTH_FALL, HDCP2_ENC_EN_RISE, HDCP2_ENC_EN_FALL, TMDS_CLK_LOCK_RISE, EXT_PIN_RISE, EXT_PIN_FALL.*



When *Packet data* is selected: Checkbox *BCH_ERROR,* when checked, will start capture when a *BCH_ERROR* error occures (and only when one has occurred). Fill out *packet Template Data (hex)* to filter events to start capture*.* Shown below is a trigger for *AVI Infoframe*s in general.


## Position

Triggered capture timepoints available are: *Start, 25%, 50%, 75%, End*.

## Events

The following events can be selected via checkboxes:

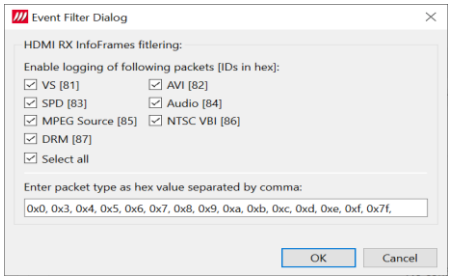
### HPD

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

### Packets

HDMI infoframes. Click the ⚙ button to open the *Event Filter Dialog*.

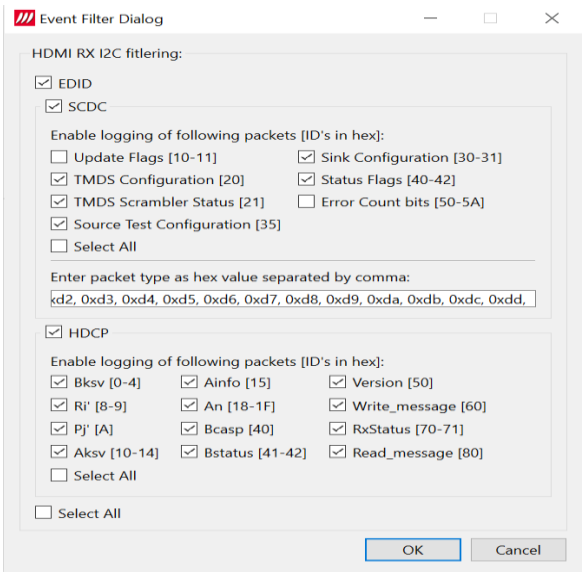
Packet events without checkboxes can be added via the *Enter packet type edit control (0x2 for audio sample for example).*




### I2C

Capture I2C communication. Click the ⚙ button to open the *Event Filter Dialog*.

Use edit control *Enter packet type as hex separated by comma:* to add packets manually.



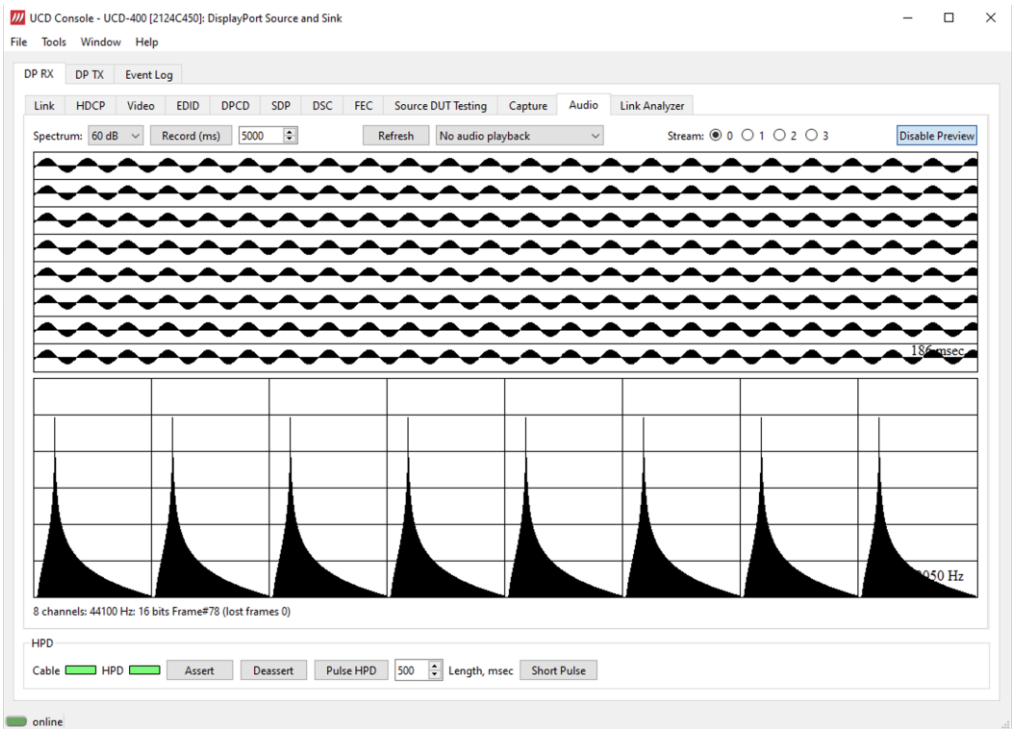

## CEC

Capture CEC communication.

# Audio Tab

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

The audio signal format is shown in three ways.




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

## Enable Preview / Disable Preview

This button controls capturing the audio data.

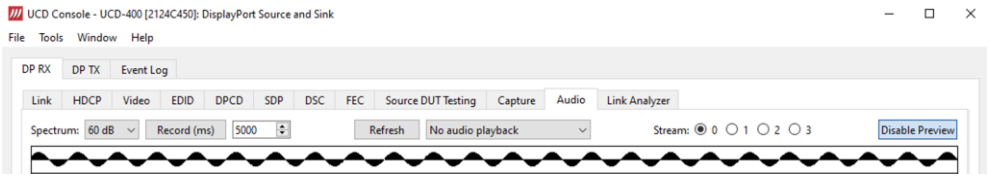
## Select Monitored Stream

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

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

## Playback device selection

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




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

## Refresh audio device list


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

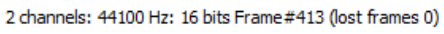
## Audio Buffer Size

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

## Start audio recording


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

## Input audio mode



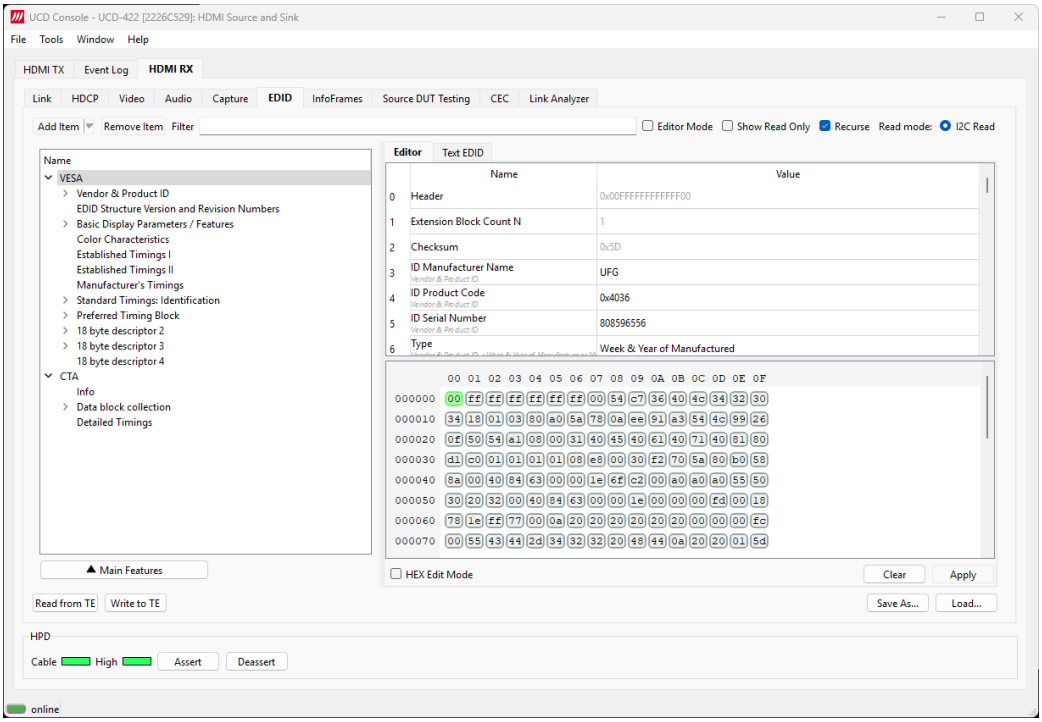

This field (in the bottom of the dialog) indicates detected audio mode in the input stream and the number of audio packets captured.

# EDID Tab

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

- Load and save data files on the host PC.
- Edit contents in *Editor Mode* or the *Hex Edit Mode*.
- Read and write to EDID memory for up to 4 virtual ports.

## EDID




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

Note: Four blocks (512 bytes) are read. If the device does not support all four blocks, the non-supported data is replaced with zeros.

## Text EDID

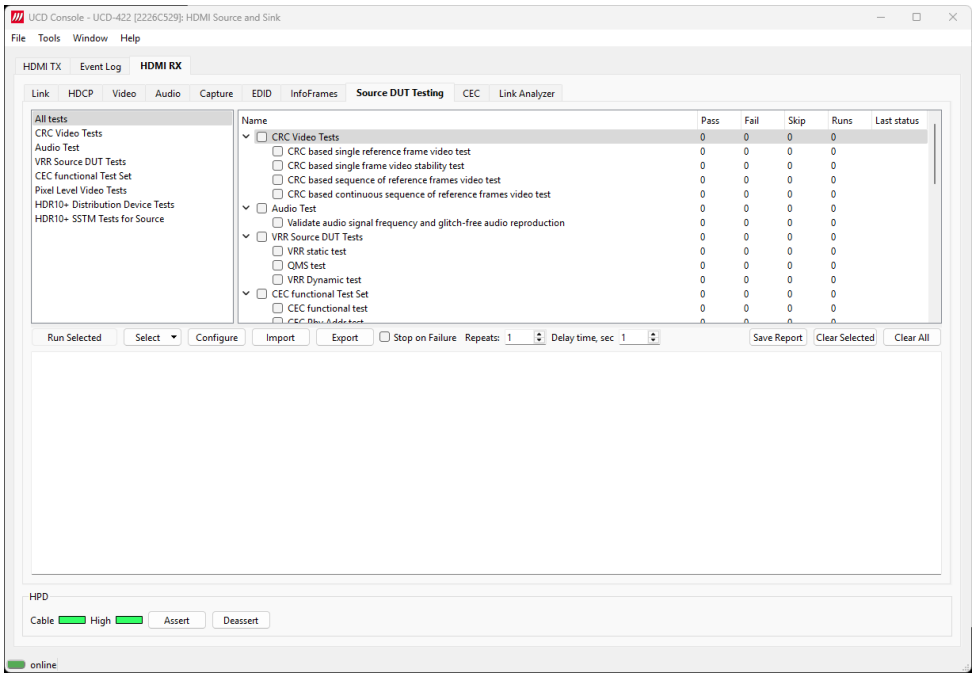
The *Text EDID* tabs allow viewing data in tree form.

## EDID Editor

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

# Source DUT Testing Tab

Please refer to *Appendix E* for descriptions of the tests available. The tests are presented in a split view, the right being test categories and the left being the tests in them.




Select the tests for execution by checking checkboxes or by clicking the test name. *All tests* item on the left hand side is really just for viewing all tests available. Select the desired test category when running tests.

| | |
|---|---|
| *Run/Run Checked:* | Select to start selected/checked tests. Once tests are running the *Run Checked* button is relabeled *Abort* to stop the test sequence if desired. |
| *Select:* | Includes three sets of options: *Select All, Clear All, Invert All* for changing the tests current selections; *Save* (checked items), *Load* (and check relevant items), *Remove* (named tests list) for handling named templates; *Import* (check all items contained in file) and *Export* (save all checked items to file) for loading and saving file-based templates. Do not confuse *Import and Export* with those below: These are for setting and saving tests to run. |
| *Configure:* | Opens a test parameters dialog for the selected test set. Make sure a test category other than *All* tests is selected. Refer to *Test Parameters* below for details. |
| *Import:* | Load saved test parameter files (*.td or *.json) for into UCD Console. Select *Configure* to see current parameters. Loading *.td files to UCD Console is currently unreliable. |
| *Export:* | Save test parameters for later use or for use in test automation. For saving parameters for later use in UCD Console, either format can be used. For saving parameters for TSI scripting, please use *.td files. For use with Python applications, use *.json files. |
| *Stop on Failure*: | Stops execution of tests if one fails. |
| *Repeats:* | Number of times to repeat the selected test sequence. |
| *Delay time:* | Delay in seconds between individual tests. |

On completion of each test the result of the test is displayed in the table columns on the right. For each test the table lists the number *Pass*, *Fail, Skips, Runs and Last Status* (status of last run).

| | |
|---|---|
| *Save Report:* | Select to generate a HTML report file. This will also open a tab in the default browser and display the results. |
| *Clear Selected* | Clear the test results of the **selected** (not checked) tests results. A subsequently saved report will not include these test results. |
| *Clear All:* | Clear the test log view and the outstanding results. |

## Test Parameters

Each test suite has a dedicated set of test parameters. Select *Configure* to launch the parameters dialog for the selected tests.

See Appendix E for parameter descritptions for each test category.

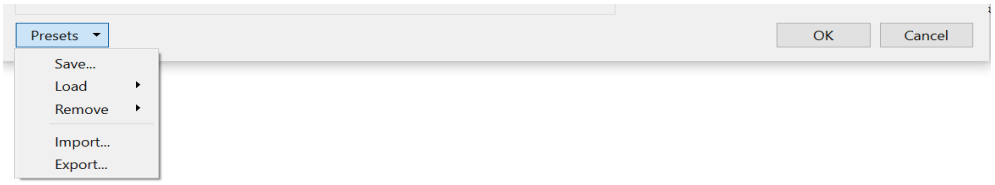
## Saving Test Parameters

Test parameters can be saved in various ways.

- Export parameters in *Sink DUT Testing* tab to a *.td file for later use in UCD Console, to run TSI scripts, or to share test parameters with someone. Presently importing *.td files into UCD Console is unreliable.
- Export parameters in *Sink DUT Testing* tab to a *.json file for later use in UCD Console, to run Python scripts, or to load test parameters into UCD Console.
- Save parameters in *Configure* dialog as Presets to be later used in UCD Console. See description below.

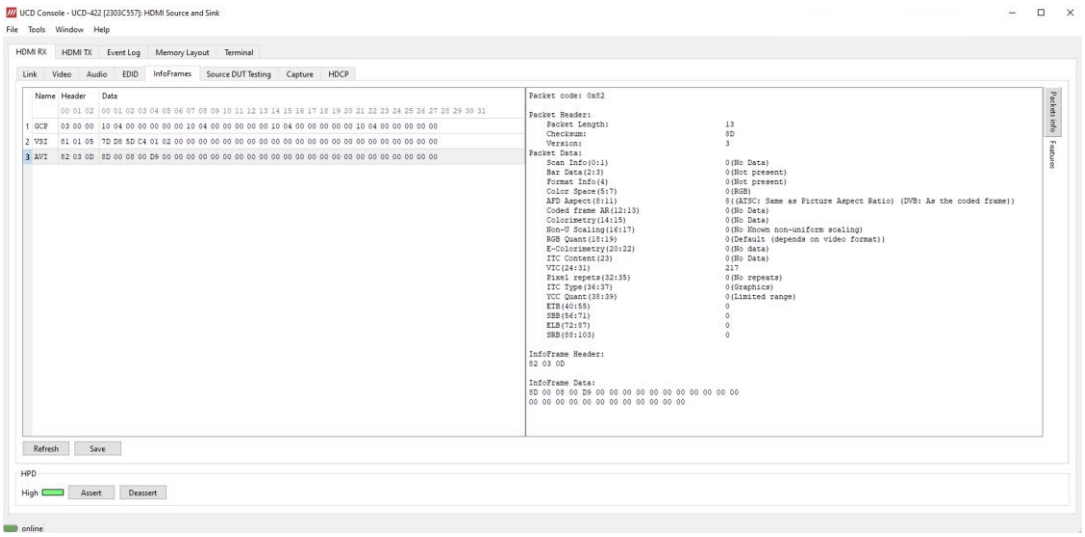
### Presets

All *Configure* dialogs selected parameters can be saved and loaded via *Presets* dropdown menu. Select *Save* or *Load* for named internal configuration parameter sets. Select *Remove* to delete a named internal set. Select *Import* and *Export* for loading and saving parameter sets from and to external files. Note that *Import*ing and *Export*ing *.json files here have a different format than importing those described above.



# InfoFrame Tab

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




## Received InfoFrames

InfoFrames tab displays in hexadecimal format the following received InfoFrames:

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

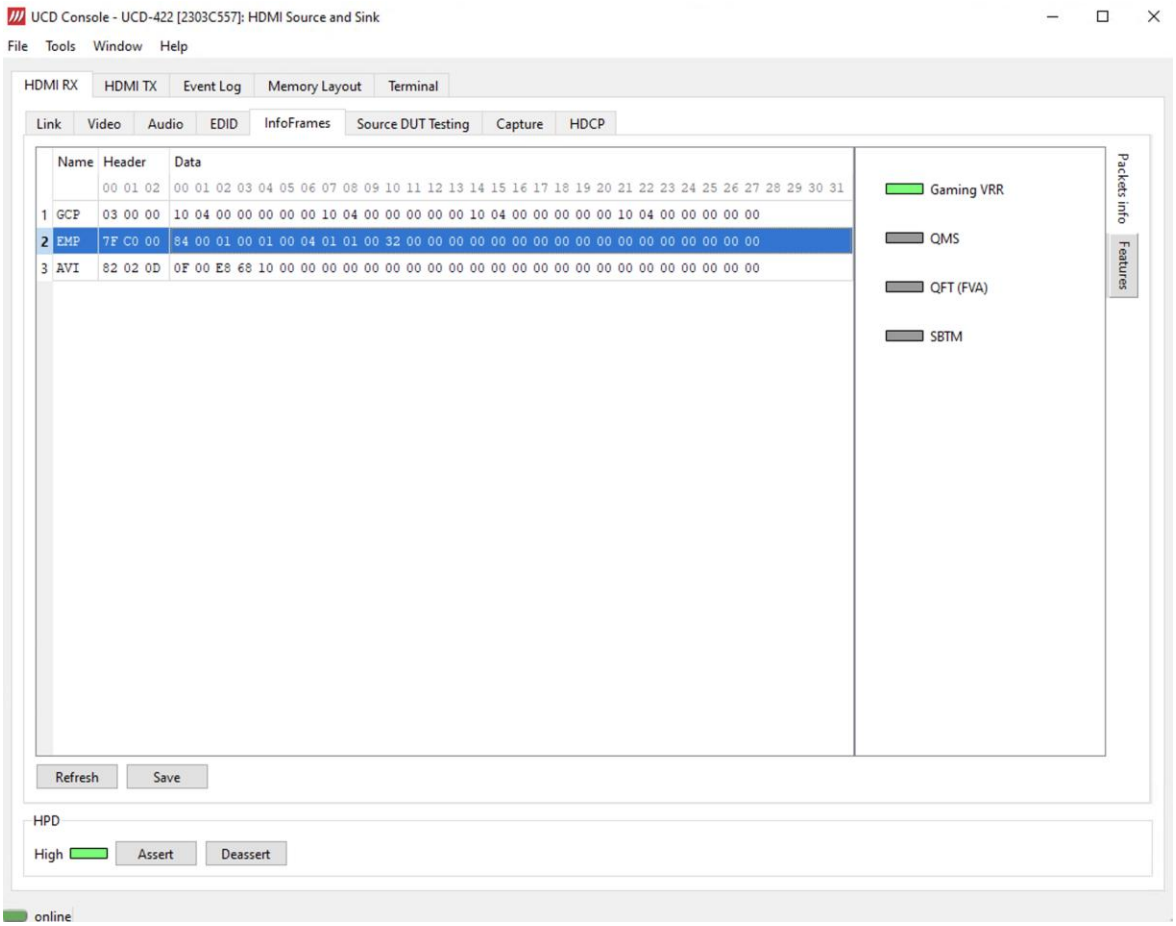
## Saving InfoFrames

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

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

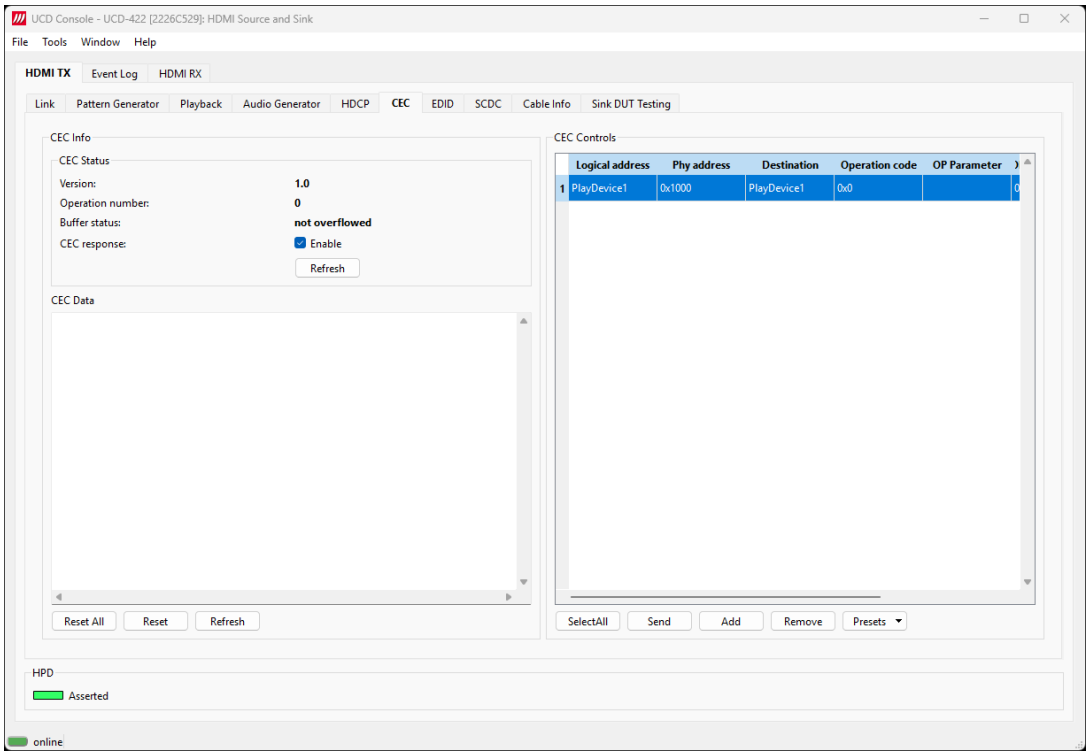
## Infoframe Features

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



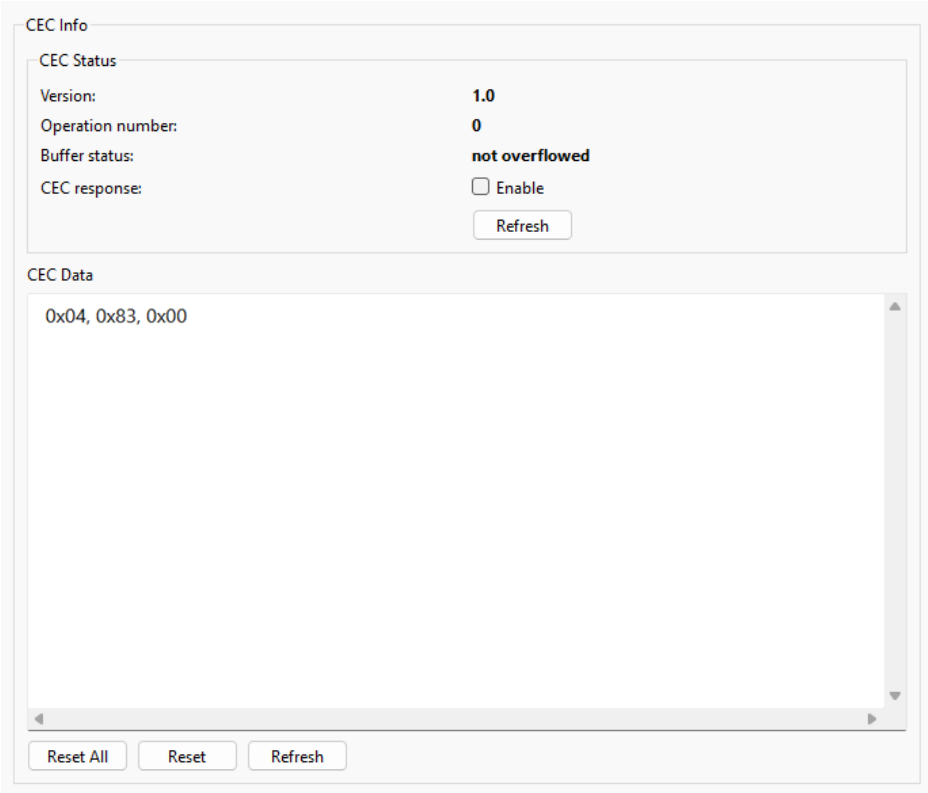
# CEC Tab

The *CEC Tab* is used for sending and receiving CEC (Consumer Electronics Control) protocol messages and data. The *CEC Tab* is grouped into two panels: *CEC Info and CEC Controls.*



## CEC Info

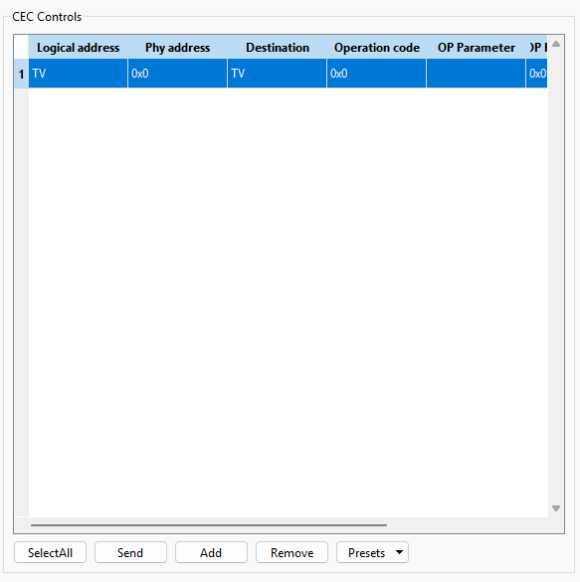
CEC data and received status can be seen in the *CEC info* panel.




| | |
|---|---|
| *Version:* | CEC version number |
| *Operation number:* | CEC operation number |
| *Buffer status:* | Shows buffer status |
| *CEC response:* | Enable CEC response. |
| *CEC data:* | Shows CEC data received |
| *Reset All:* | Remove all rows |
| *Reset:* | Remove selected rows |
| *Refresh:* | Check for new data |

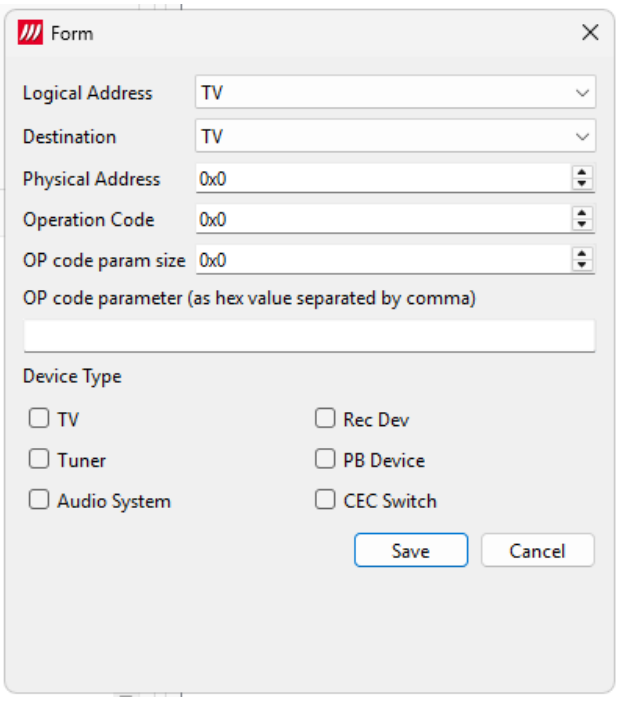
## CEC Controls

Use *CEC Controls* to send data a HDMI follower via CEC protocol.




| | |
|---|---|
| *Select all:* | Select all added items |
| *Send:* | Transmit via HDMI CEC protocol |
| *Add:* | Add an *Operation code* with parameters to be sent to various devices |
| *Remove:* | Remove selected items. |
| *Presets:* | Save, load, remove, import and export presets |

Add




| | |
|---|---|
| *Logical address:* | Initiator address |
| *Destination:* | Destination device |
| *Physical address:* | Physical address of device. Auto-filled by firmware |
| *Operation code:* | Opcode |
| *OP code param size:* | The size of operand(s). Minimum is 0x0, maximum is 0xE. |
| *OP code parameter (as hex value separated by comma)* | Operand(s) |
| *Device type* | Select device type |

| | |
|---|---|
| Note: | Event Log can also monitor the received CEC frames |

## Remote

The interface simulates the function of a remote control.


| | | | |
|---|---|---|---|
| | *Power Toggle* | | *Up* |
| | *Power on* | | *Down* |
| | *Power off* | | *Left* |
| | *Root menu* | | *RIght* |
| | *Exit* | | *Select* |
| CH | *Channel up*<br>*Channel down* | Vol | *Volume up*<br>*Volume down* |

### CEC Flow

| | |
|---|---|
| | *Logical address (initiator)* |
| | *Logical address (destination)* |
| *ADDR* | *Physical address* |

# 5. GENERATOR OPERATION

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

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

## Functionality Tabs

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

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

### Functionality Tabs

Analyzer role features the following tabs:

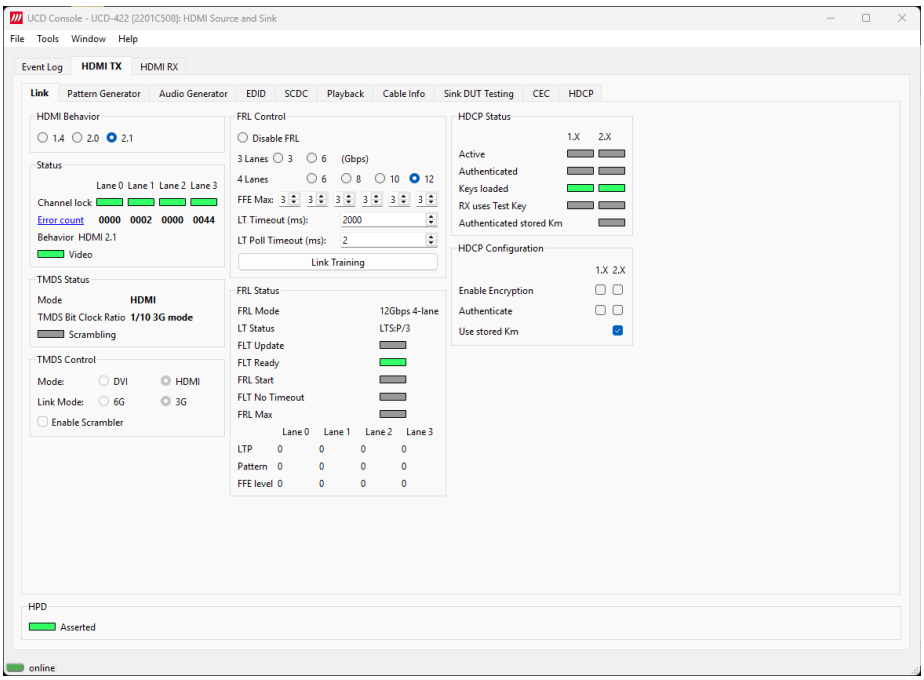
- Link (Link status and configuration)
- Video pattern generator (Pattern Generator).
- Content Playback (Playback)
- EDID editor (EDID)
- HDCP status monitor and control (HDCP)
- Sink DUT Testing
- Adaptive-Sync
- Status information and control of the downstream link (Link).
- SCDC monitor (SCDC)

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

# Functionality Tabs

## Link Tab

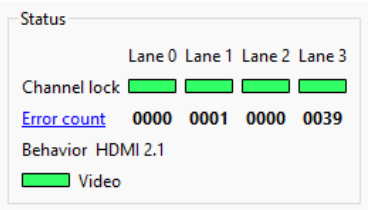
Link tab shows the status and control items for the HDMI link.




### HDMI Behavior

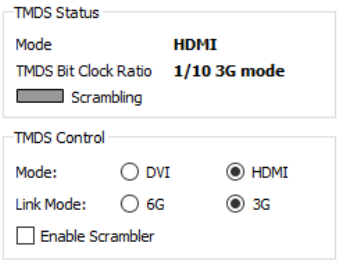
Selection of the HDMI version to be used (HDMI 1.4 / HDMI 2.0 / HDMI 2.1).

### Status




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

## TMDS Status (only in TMDS mode)

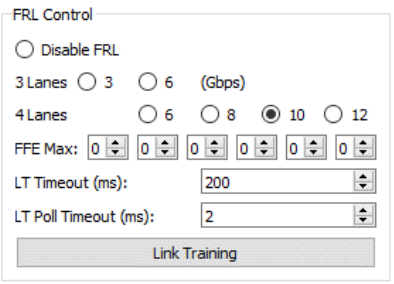



| | |
|---|---|
| *Mode:* | Status of the HDMI/TMDS mode (HDMI/DVI) |
| *TMDS Bit Clock Ratio:* | Status of TMDS_Bit_Clock_Ratio bit in SCDC – TMDS Configuration (1/10 or 1/40) |
| *Scrambling:* | Status of TMDS_Scrambler_Status bit in SCDC – TMDS Scrambler Status (1=LED on; 0=LED off) |

## TMDS Control (only in TMDS mode)

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

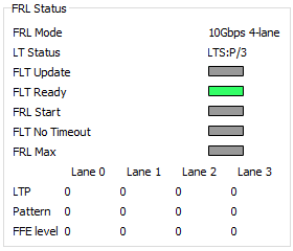
## FRL Control




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

Please click **Link Training** to apply

## FRL Status

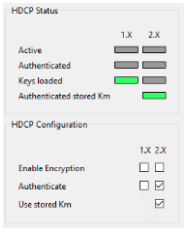



| | |
|---|---|
| *FRL Mode:* | FRL Mode used by UCD-4XX HDMI source |
| *LT Status:* | FRL link training status of UCD-4XX HDMI source |
| *FLT Update:* | Status of FLT_update flag in SCDC Update Flags register of the connected HDMI sink. |
| *FLT Ready:* | Status of FLT_ready flag in SCDC Status Flags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

## Lane Status Matrix

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

## HDCP Status




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

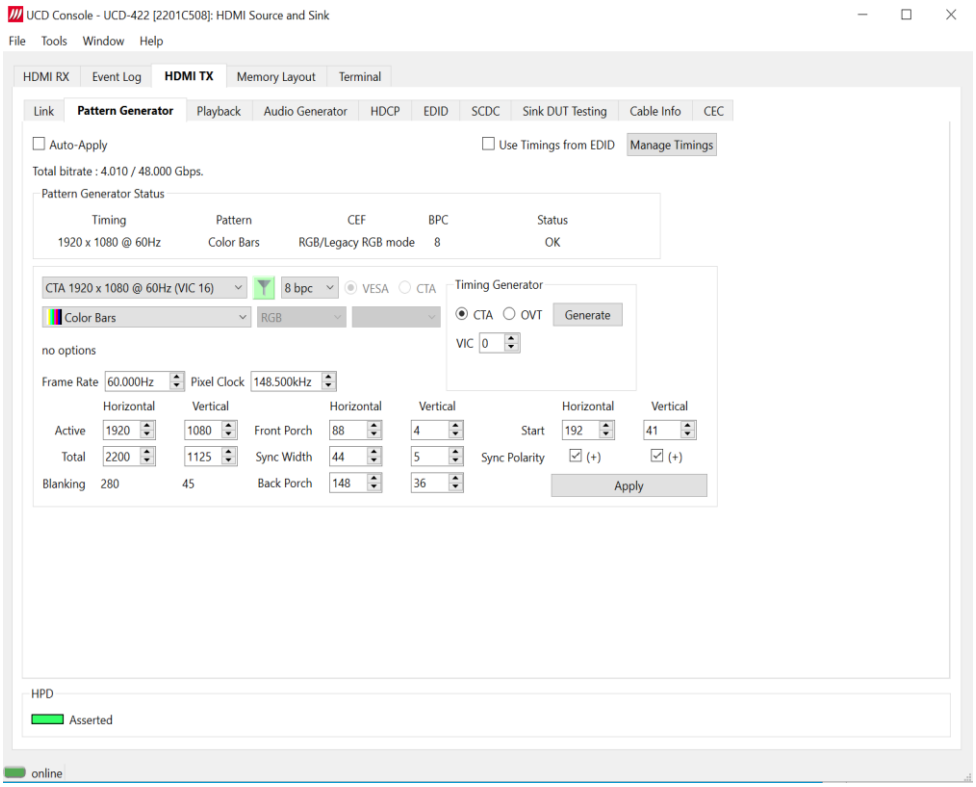
## HDCP Configuration

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

## HPD (Bottom panel)

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

# Pattern Generator Tab



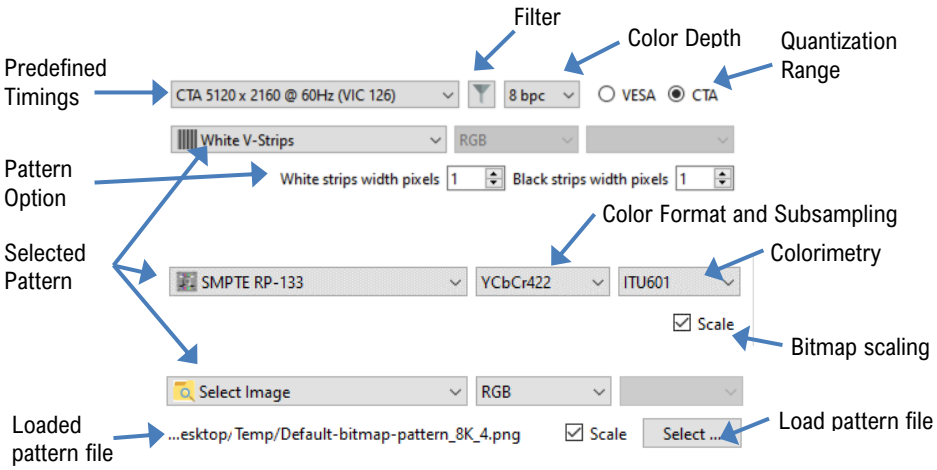

| | |
|---|---|
| *Force EDID preferred timing after LT* | UCD reads the EDID of the connected Sink and after next LT enables to Stream 0 the timing listed in 18-byte descriptor 1 in VESA block of the sink's EDID. |
| *Use timings from EDID* | UCD reads the EDID of the connected Sink and lists only timings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

*Pattern Generator Status* panel shows the *Timing*, *Pattern* (Name), *CEF* (color format and subsampling and colorimetry), *BPC* (bits per color), *Status*, and *CRC* value, for each active stream.

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

## Pattern

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




### Predefined Timings

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

### Color Depth

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

### Video Pattern

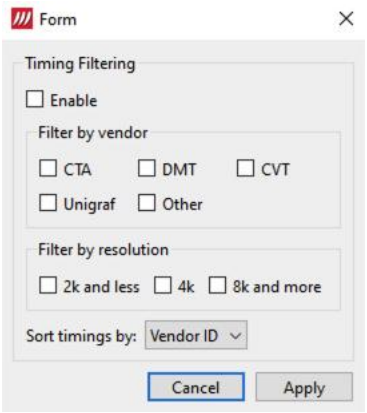
The selection includes a set of predefined patterns and a possibility to load user defined custom patterns. Please find a description of the available predefined patterns in Appendix D of this document. By selecting **Disabled** you can have the links activated but no video data transferred.

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

### Filter

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

HDMI timings are sorted by VIC number by default.




### Custom Image Patterns

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

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

### Bitmap Scaling

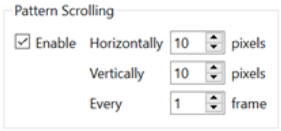
When bitmap patterns are used, they can be used either in their original resolution, aligned to left top corner (=un-check *Scale*), or upscaled or downscaled to match the selected video resolution (=check *Scale*).

### Pattern Options

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

## Pattern Scrolling

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

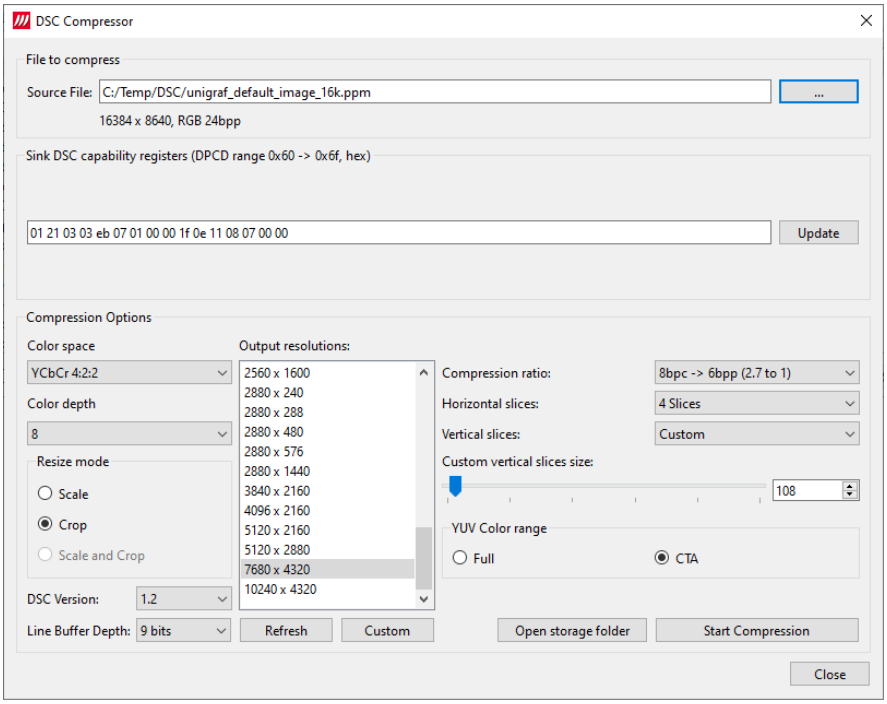



| | |
|---|---|
| *Enable:* | Enable or disable pattern scrolling |
| *Horizontally X pixels:* | Horizontal step of the pattern movement in pixels<br>(values in range -127…0…128, for YCbCr 4:2:2 even values).<br>0 = no movement, positive values = pattern moves to the right. |
| *Vertically Y pixels:*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

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

## Sourcing DSC Compressed Patterns

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



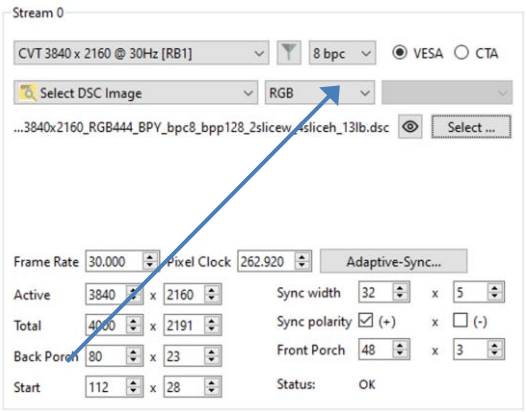

Select the source bitmap file in Source File field. Define the Output Resolution, the color depth, compression ratio and number of horizontal and vertical slices in the frame.

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

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

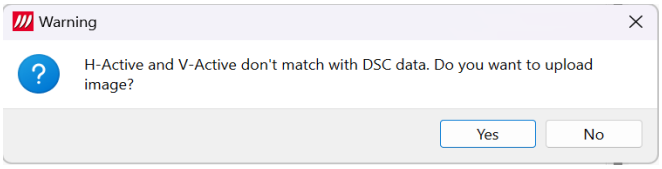
Example:
unigraf_default_image_16k.ppm >>
unigraf_default_image_16k_1920x1080_YUV422_FULL_bpc8_bpp6.dsc

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




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

When *Select DSC Image* pattern is being transmitted and incompatible *Horizontal and Vertical Active* timings are set (Via *Apply* or *Apply All*), the user is presented with a dialog: *H-Active and V-Active don't match with DSC data. Do you want to upload image?*




Above, "*Do you want to upload image?"* is misleading and will be changed to "*Continue to transmit image?".*

If you select *No*, the new settings will not be applied.

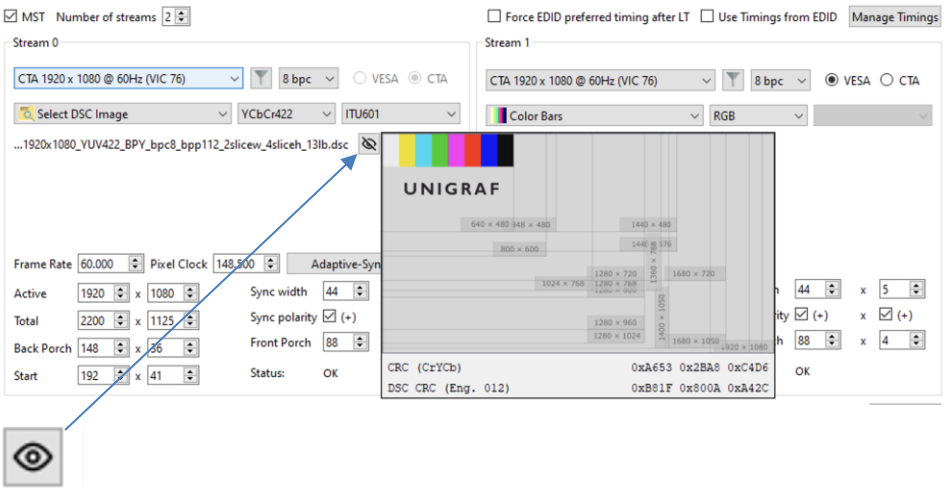
If you select *Yes*, the Pattern will continue to be transmitted. DSC data is transferred in the active window. To transfer all DSC data without loss, active video should be large enough for DSC compressed data (DSC_pic_height * DSC_pic_lenght / compression_ratio). MSA H-active should also not be less than DSC pic_height.

MSA V-active parameters can be reduced without DSC corruption until active video area is no longer large enough to pass all DSC data.

MSA V-active and H-active can be increased until HW limitation (pixel clock limit) and link bandwidth are reached.

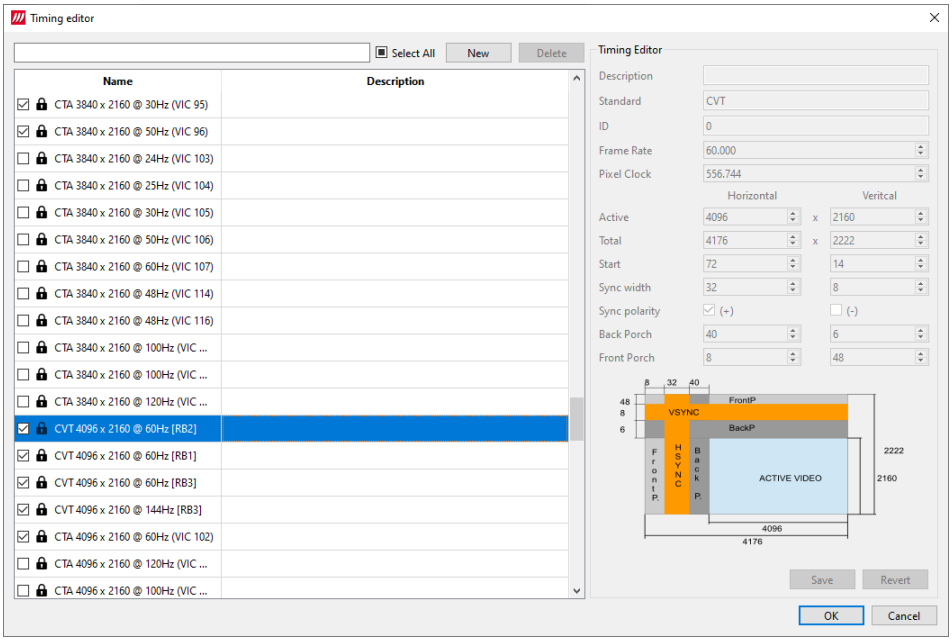
## Preview DSC image

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



## Manage Timings

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




### Customizing Timings List

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

### Editing Timings

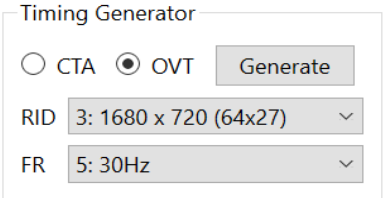
Video timing Name and Description are shown in the list. Lock icon indicates that a timing is a fixed timing which cannot be edited or deleted. Custom timings are indicated with a head icon .

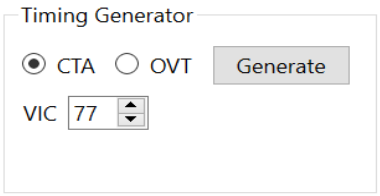
| | |
|---|---|
| *New:* | Create a new custom timing based on the selected fixed timing. |
| *Delete:* | Delete the selected custom timing |
| *Save:* | Save changes in the selected custom timing. |
| *Revert:* | Undo all changes |

The dialog parameters will be sanity checked and will warnings issued for illegal combinations.

### HDMI Timing Generator

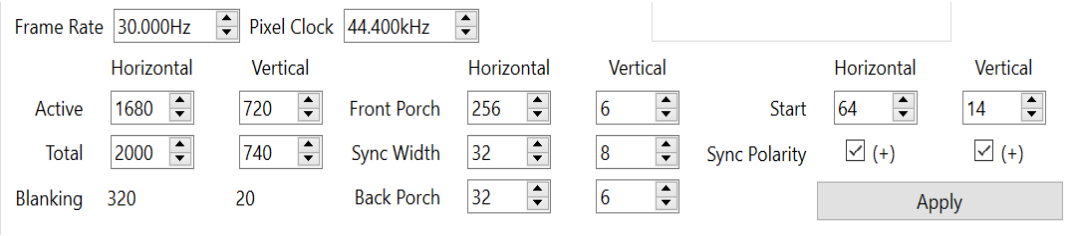
HDMI Timings can be generated and applied via the *Timing Generator* group.





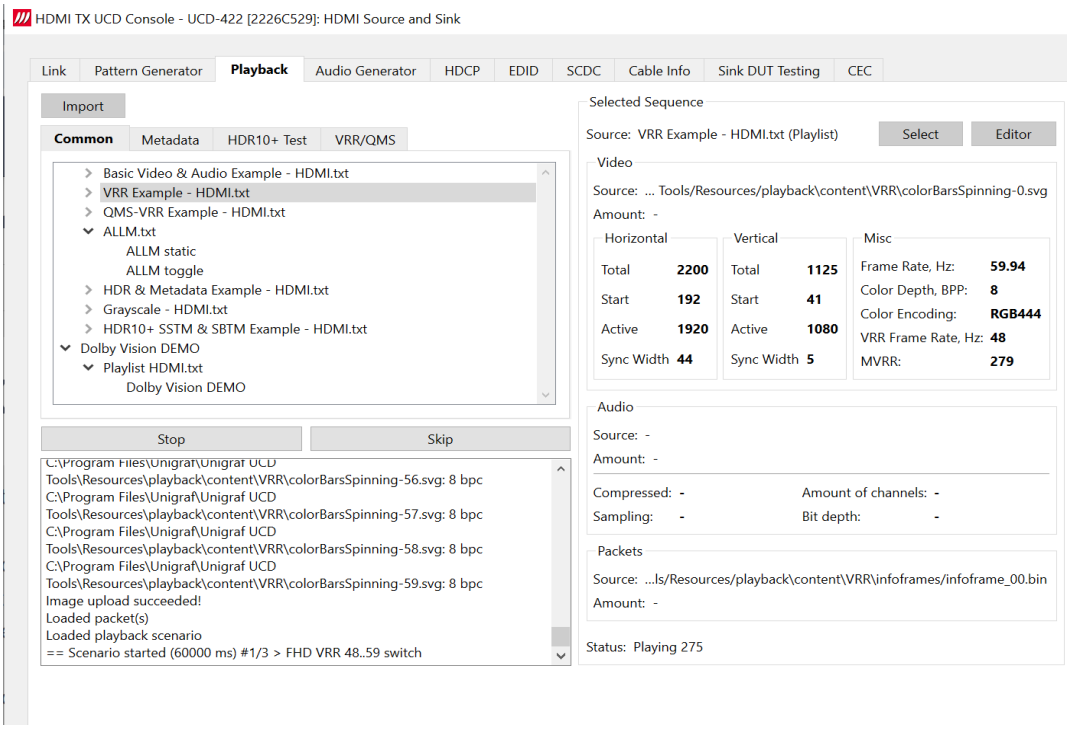

To do this select *CTA* or *OVT* timings radio button. Select desire *RID* and *FR* or *VIC* in combo boxes and then click the *Generate* button.

The generated values will be reflected in the Frame parameters. Click *Apply* to set timing.



# Playback Tab

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




| Term | Functionality |
|---|---|
| Playlist | *Playlists* (text files) specify the UCD devices and output protocol for transmission. It lists *scenarios* to be transmitted. |
| Scenario | Scenarios (text files) allow users to select video frames, metadata packets and audio to be transmitted and their order. |
| Advanced Playlists | Unigraf UCD devices can also be used as a compatibility test tools for dedicated standards such as Dolby Vision™ and HDR10+. Contact Unigraf for details. |

Note: Note that Playlists and Scenarios are protocol dependent.

## Common Tab

The *Import* button is for importing *.json files into the *common* tab treeview. Sample content on windows can abe found at C:\Program Files\Unigraf\Unigraf UCD Tools\Resources\playback\basic_library.json. Be **warned** that once imported, items cannot at present be removed. Actually you can but it involves using *Windows Register Editor* to remove values from (uninstall will not help):

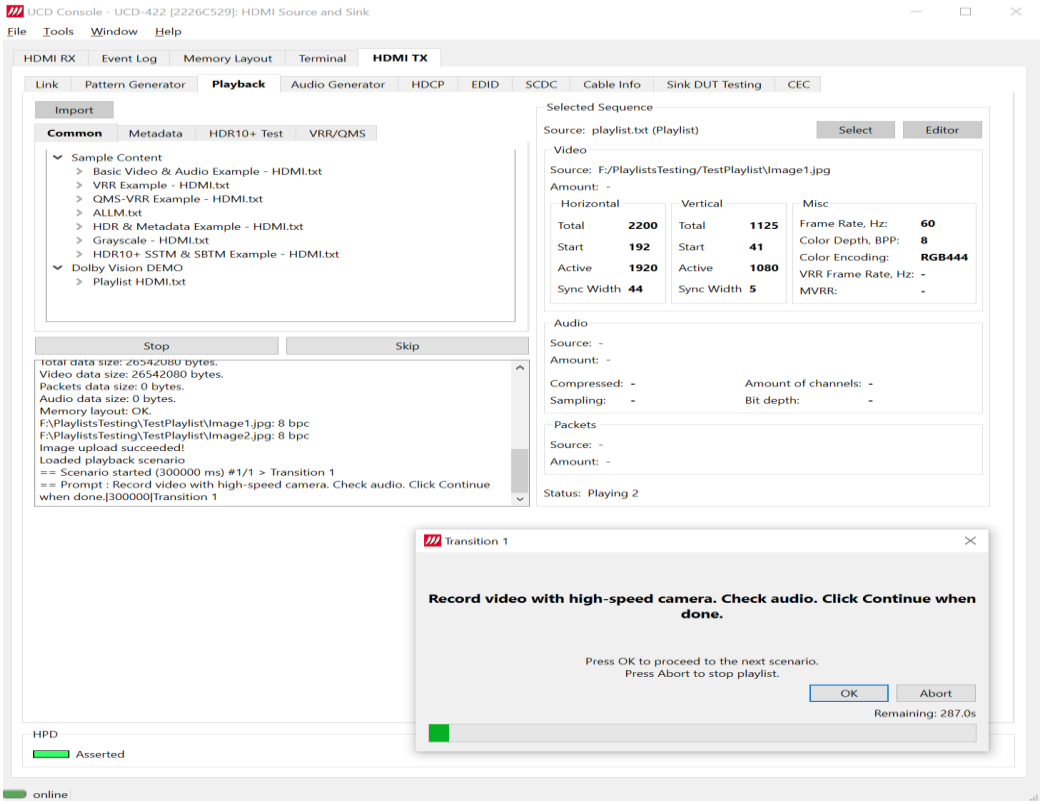
Computer\HKEY_CURRENT_USER\SOFTWARE\Unigraf\UCD Console\Playback

Computer\HKEY_CURRENT_USER\SOFTWARE\Unigraf\UCD Console\MetadataScenario

Sample playlists are included in UCD Console. Select a sequence (a scenario) from the playlists and press *Run* (or double click it) to play.

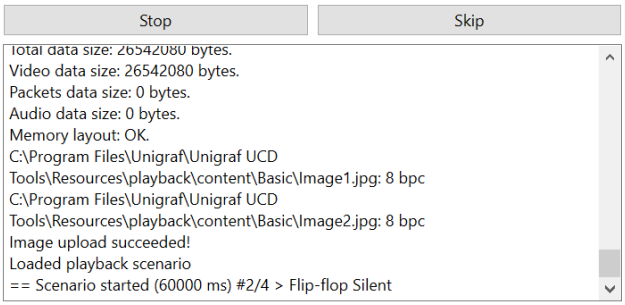
The *Run* button lable changes to *Stop* as a *Scenarios* run. Press *Stop* to stop playing the scenario. Press *Skip* to skip to next scenario (available when there are multiple scenarios in a playlist) while playing. While the *scenario* is loading the *Run* button lable changes to *Cancel* to allow cancelation.

Figure below shows a playlist being run that contains a *prompt* command which pops up a dialog.




## Status Log

Scenario commands are listed in the *Status Log* as they are run.



## Selected Sequence

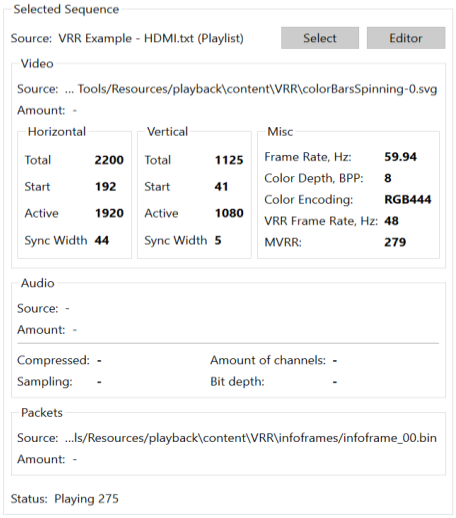
Running scenario video and audio details and their sources are shown in the *Selected Sequence* group panel.

Note that the triggered scenario or playlist to be run is the last selected: If an item was selected via the *treeview*, it is the triggered item to be run. If the *Select* button was used to select an item, it is the triggered item to be run (regardless of what is selected in the tree control).

Press the *Select* button to load a *playlist* or *scenario* to be run (selecting a sample from the *Sample Content treeview* will load them as the *playlist* or *scenario* to be run). Also it will be the *scanario* used as a template if the *Scenario Editor* is launched: default scenario values will be set if a playlist is selected.

Press the *Editor* button to launch the *Scenario Editor* (see below).

The *Selected Sequence* parameters are the transmission stream parameters.



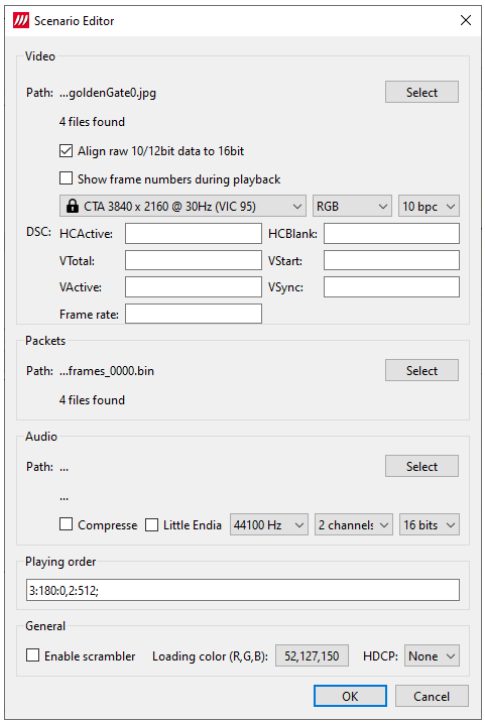
## Scenario Editor

Press the *Select* button above to select the scenario desired to use as a template for creating a new scenario. Press the *Editor* button to launch the *Scenario Editor*. The the dialog paramaters will be generated from the scenario file shown under the panel *Source* label (*Philips FHD.txt* as seen above).

Press the *Path :…*for setting the *Video, Packets or* Audio paths.

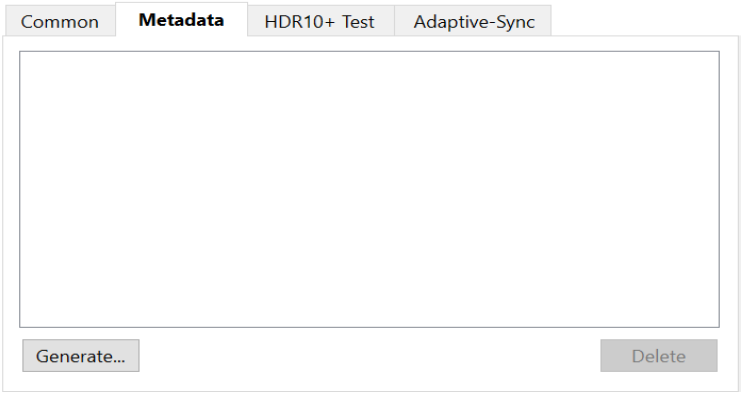
Press *OK* to save. Your are presented with a save dialog. You need to navigate to a directory you can save to. Run Conssole 2 with **administration rights** if you want to save to default locations on windows such as: C:\Program Files\Unigraf\Unigraf UCD Tools\Resources\playback\content.

Refer to *Appendix H: Playlists and Scenarios* later in this manual for details.

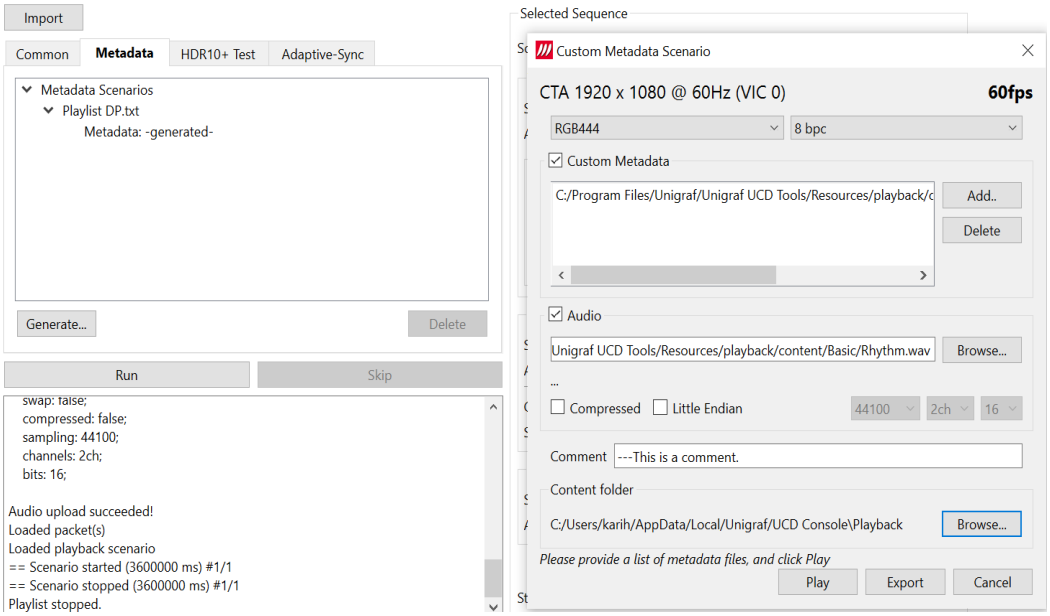


## Metadata Tab

The *Metadata tab* is for creating scenarios with metadata.




Select the *Delete* button to delete a *scenario* or the *Generate* button to launch the *Custom Metadata Scenario* dialog (shown below).




Current *Pattern Generator* timing details are shown at the top. You can change the color mode (RGB444, YUV444, YUV422, YUV420) and color depth (8 bpc, 10 bpc, 12 bpc, 16 bpc) via the dropdown combo boxes.

Select the *Add* or *Delete* buttons to add or remove metadata from the scenareio.

Check the *Audio* checkbox and then the *Browse…* button to add an audio file. Sampling, channels and bits can be selected via the combo boxes.

The *scenario Comment* can be added in line edit box after the three dashes (---).

Use the *Content folder Browse…* button to select save location.

You can press Play to run the *scenario*, *Export* to save it or *Cancel* to cancel.

*Export* will create a folder something like Metadata1920x1080@60-RGB444-8bpc in the *Content folder*. In it you will find generated files frame.svg (displaed while running), the metadata files you selected and a scenario.txt file. You may edit and rename these files.

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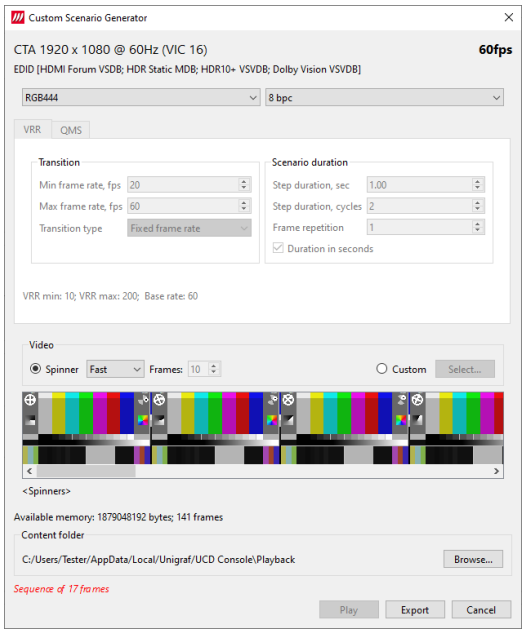
## HDR10+ Test Tab

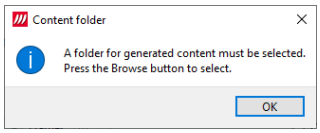
Please refer to HDR10+ CTS User Manual for detailed description of the tab.

## VRR/QMS tab

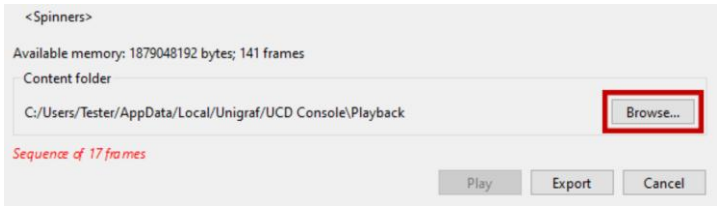

Click *Generate* to generate custom VRR and QMS scenarios. Custom Scenario Generator window will open.




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

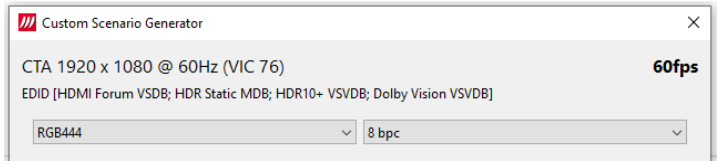



Click *Browse…* to select the folder.



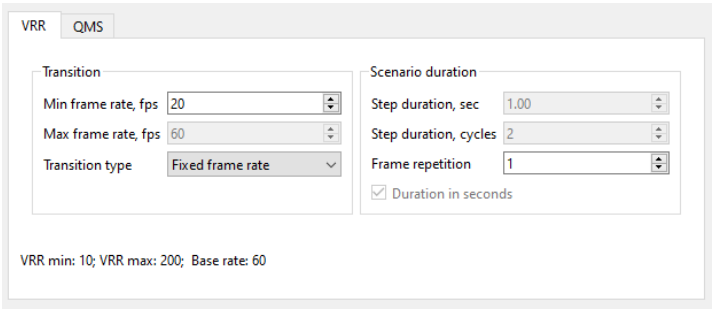

### Timing details

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

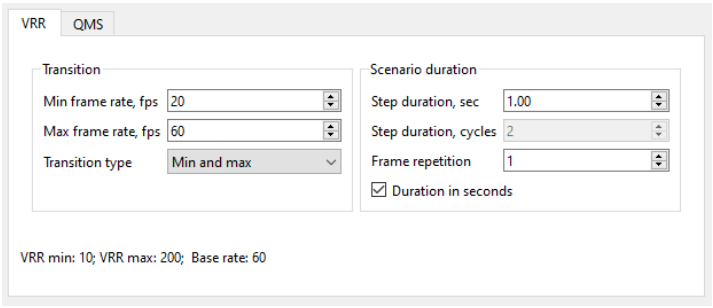


## VRR settings

In the VRR tab you can set the transition and scenario duration parameters. Different transition types are Fixed frame rate, Min and max and Gradual. When *fixed frame rate* is selected, the scenario is played at the minimum frame rate set in the first field. Please, note that when the fixed frame rate is selected, you can only select the number of times the frame is repeated.

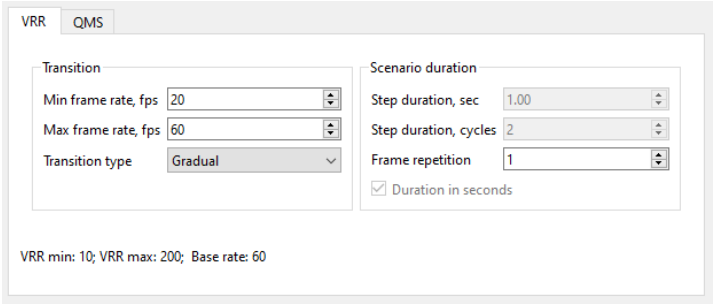



When *min and max* is selected, the output sceario will alter the framerate between the specified values. You can also set the duration for step in seconds and select how many times frames are repeated.



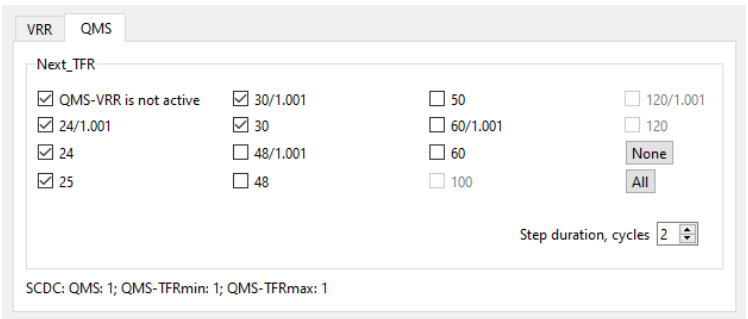

When *gradual* is selected, the frame rate is changed with each frame. For example, when min frame rate is set at 20 and max is set at 60 and the scenario has 40 frames, frame rate would be incremented by 1 with each frame.

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

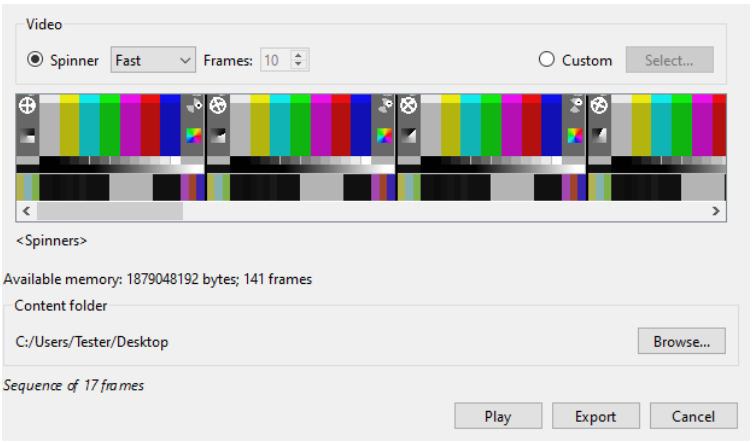



## QMS settings

In the QMS settings dialogue you find all the frame rates included in the QMS specification. Select which frame rates you want to inlcude in your scenario. Also select the step duration in cycles. In the lower left corner details of the scenario as shown.



### Video



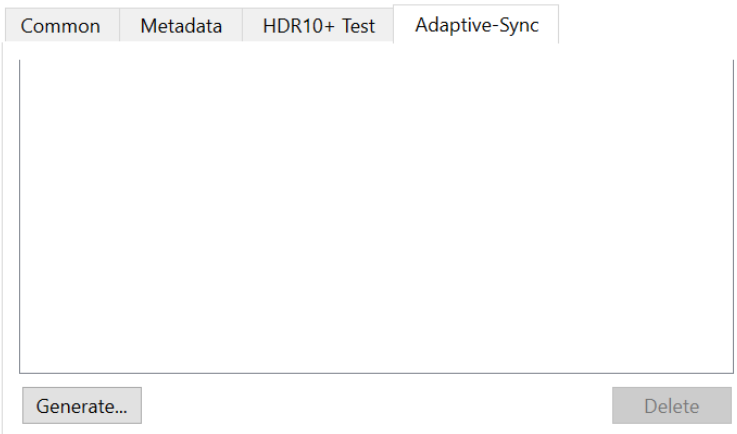

The section at the bottom shows details of the output video. The default pattern is a spinner. You can select the speed of the spinner video from the predefined options in the drop-down menu or you can set a number of frames it takes for the spinner to rotate a full circle. You can also select a custom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

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

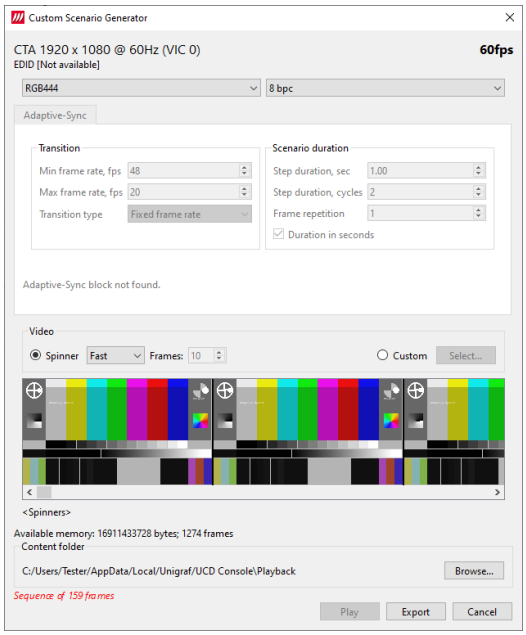
You can export the scenario by clicking *Export.* When exporting, you are asked to select a location for the export. The content folder will be automatically created in the chosen location. The folder inlcudes the image files, packets and scenario parameters.

You can play the scenario by clicking *Play.* When the scenario is ready for playing, the scenario generator window will close. You can now inspect the progress in the log in the playback tab as shown below.

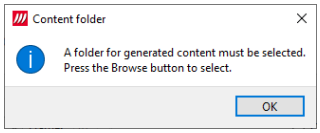
## Adaptive-Sync tab



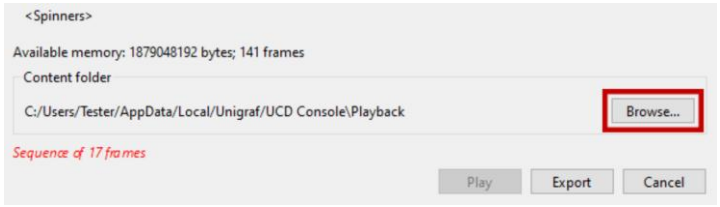

Click *Generate* to generate custom Adaptive-Sync scenarios. Custom Scenario Generator window will open.




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

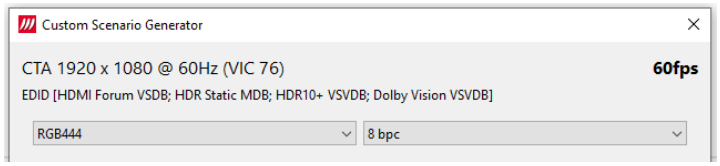



Click *Browse…* to select the folder.




## Timing details

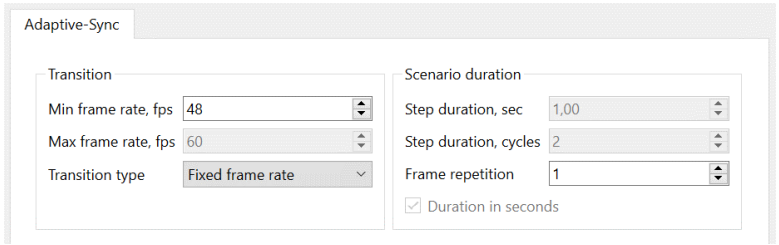
The uppermost part of the window shows the timing details. Please, note that the timing is set on the pattern generator tab. You can change the color mode (RGB444, YUV444, YUV422, YUV420) and color depth (8 bpc, 10 bpc, 12 bpc, 16 bpc).



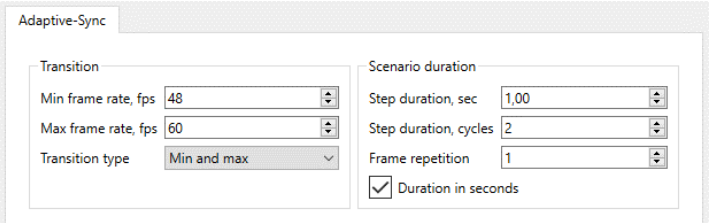

## Adaptive-Sync settings

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

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

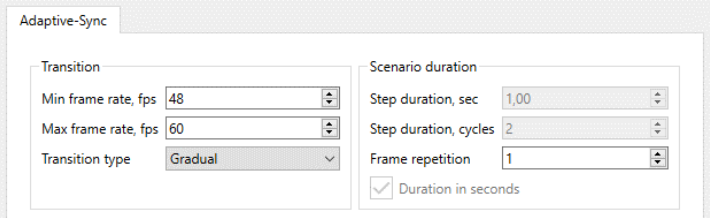


When *min and max* is selected, the output scenario will alter the framerate between the two values set in the drop down menus. You can also set the duration for step in seconds and select how many times frames are repeated.

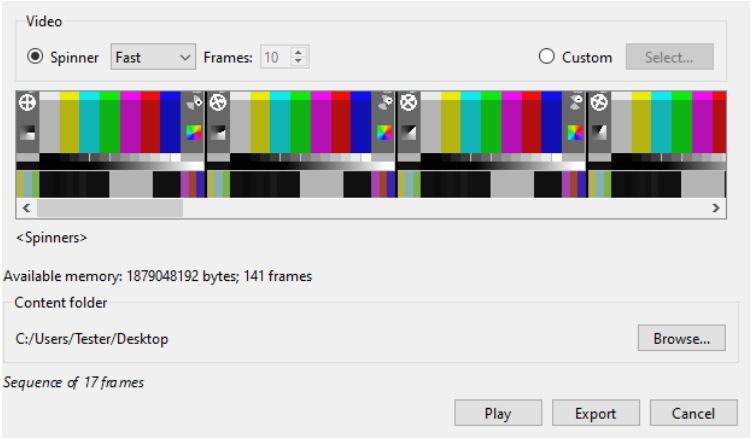



When *gradual* is selected, the frame rate is changed with each frame. For example, when min frame rate is set at 20 and max is set at 60 and the scenario has 40 frames, frame rate would be incremented by 1 with each frame.

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




## Video

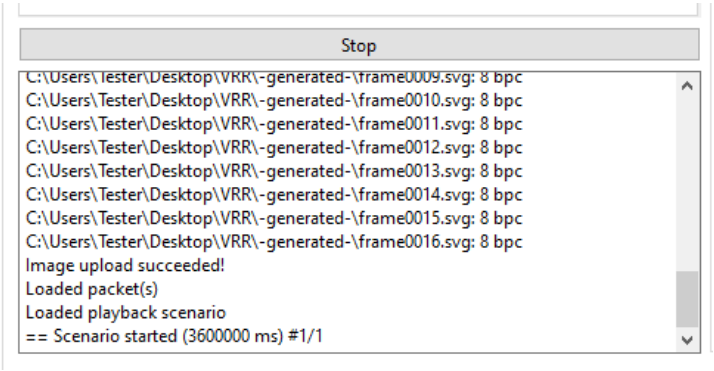


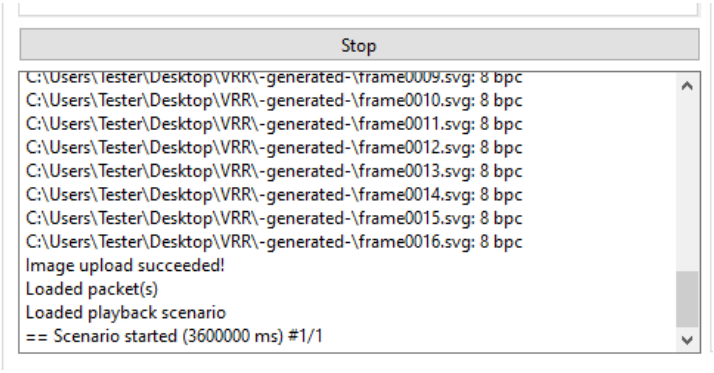

The section at the bottom shows details of the output video. The default pattern is a spinner. You can select the speed of the spinner video from the predefined options in the drop-down menu or you can set a number of frames it takes for the spinner to rotate a full circle. You can also select a custom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

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

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

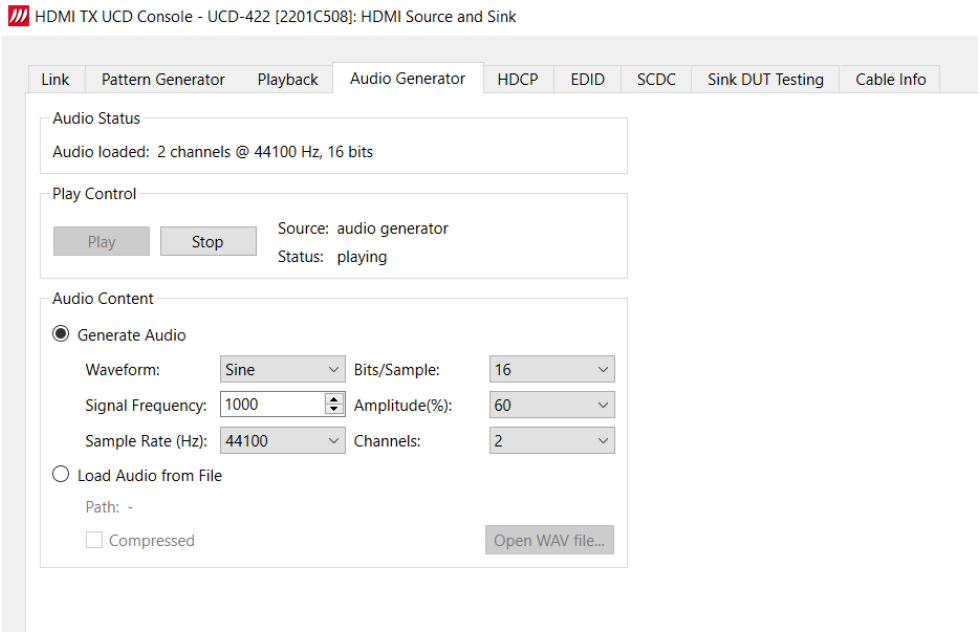
You can play the scenario by clickin *Play.* When the scenario starts playing, the scenario generator window will close. You can now inspect the progress in the log in the palyback tab as shown below.




# Audio Generator Tab

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




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

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

The *Compressed* checkbox indicates that the audio loaded from the selected file is compressed.

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

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

*Audio Status* displays current audio content status.

### Audio Content

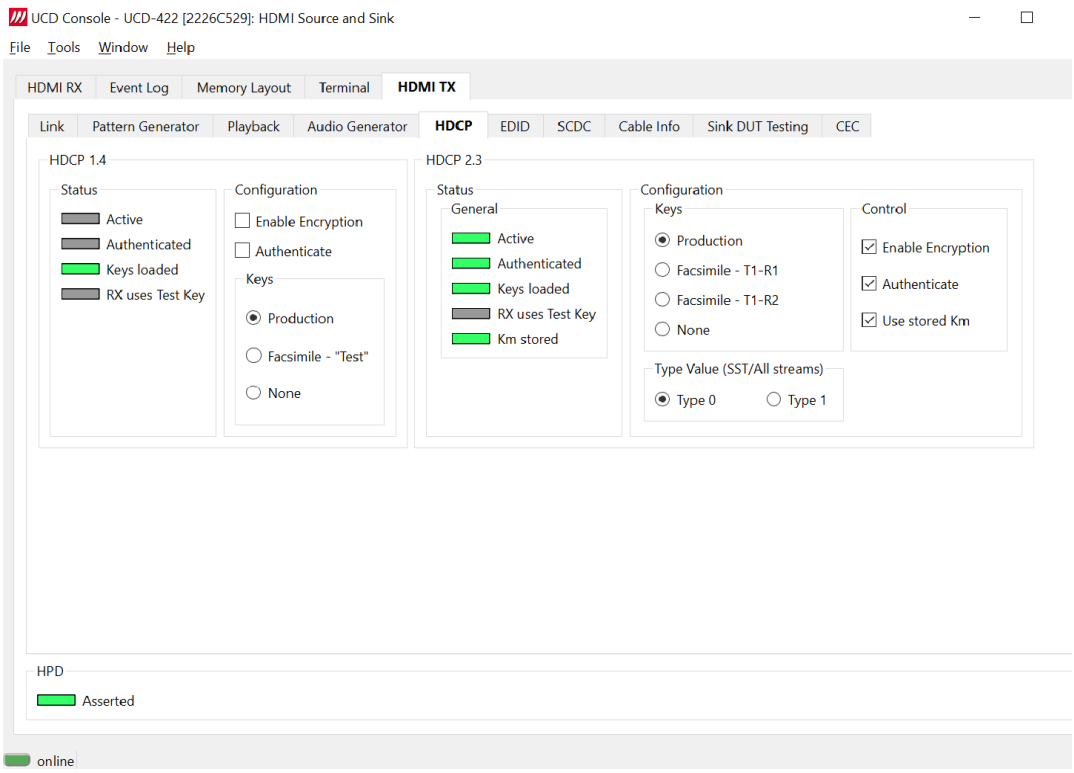
Sent audio can be generated internally or used a WAV file loaded from the PC.

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

| | |
|---|---|
| *Waveform* | Selection of audio waveform: Sine, Sawtooth, Square, or Incremental |
| *Signal Frequency* | Setting audio signal frequency in Hz. |
| *Sample Rate (Hz)* | Selection of audio sampling rate: 32000, 44100 (default), 48000, 88200, 96000, 176400, 192000. |
| *Bits/Sample* | Selection of sample bit depth: 16, 20, 24. |
| *Amplitude(%)* | Selection of audio amplitude: 10%, 20%, …, 90%, 100%. |
| *Channels* | Audio channels available: 1, 2, …, 7, 8.<br>Channels transmit LPCM (uncompressed) Audio. |

## HDCP Tab

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



### Status General

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

| | |
|---|---|
| *Active*: | The stream between UCD and the downstream sink has been encrypted. |
| *Authenticated*: | HDCP handshake between the UCD and the sink unit has been completed successfully. |
| *Keys loaded:* | HDCP keys are loaded to the UCD unit. |
| *Km is stored:* | Master Key (Km) is stored. |
| *SST Mode Type* | Type when in SST mode. |

### Status By stream

Stream status (DP) shows HDCP status on each stream.

### Configuration Control

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

### Configuration type

Select to configure HDCP (DP) or All streams at once or By stream.

### By stream

Select and configure streams (DP).

### Type Value

Select Type 0 or Type 1. Type 1 ensures that content encryption is done with HDCP version 2.2 or higher.

### Configuration Keys

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

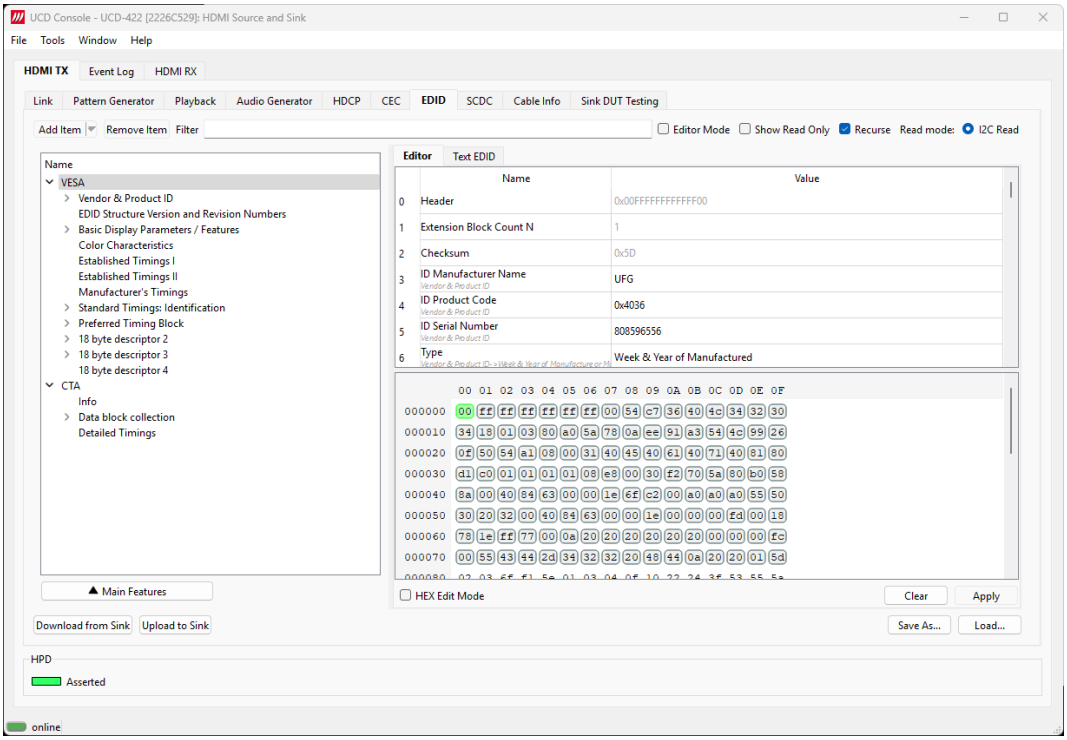
# EDID Tab

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

- Load and save the data files in the host PC.
- Edit the data contents either in Editor Mode or in Hex Edit Mode.
- Read and write data to the connected sink. Up to 4 virtual channels can be accessed.

## EDID Files

With *Load…* and *Save As…* a file can be read into the editor or written to a file from the PC.




The contents of the device EDID file are not modified, or integrity checked during load and save operations.

| Note: | Four blocks (512 bytes) of EDID code are read. If the device does not support all four blocks, the non-supported data values are set to zero. |
|---|---|

## Text EDID

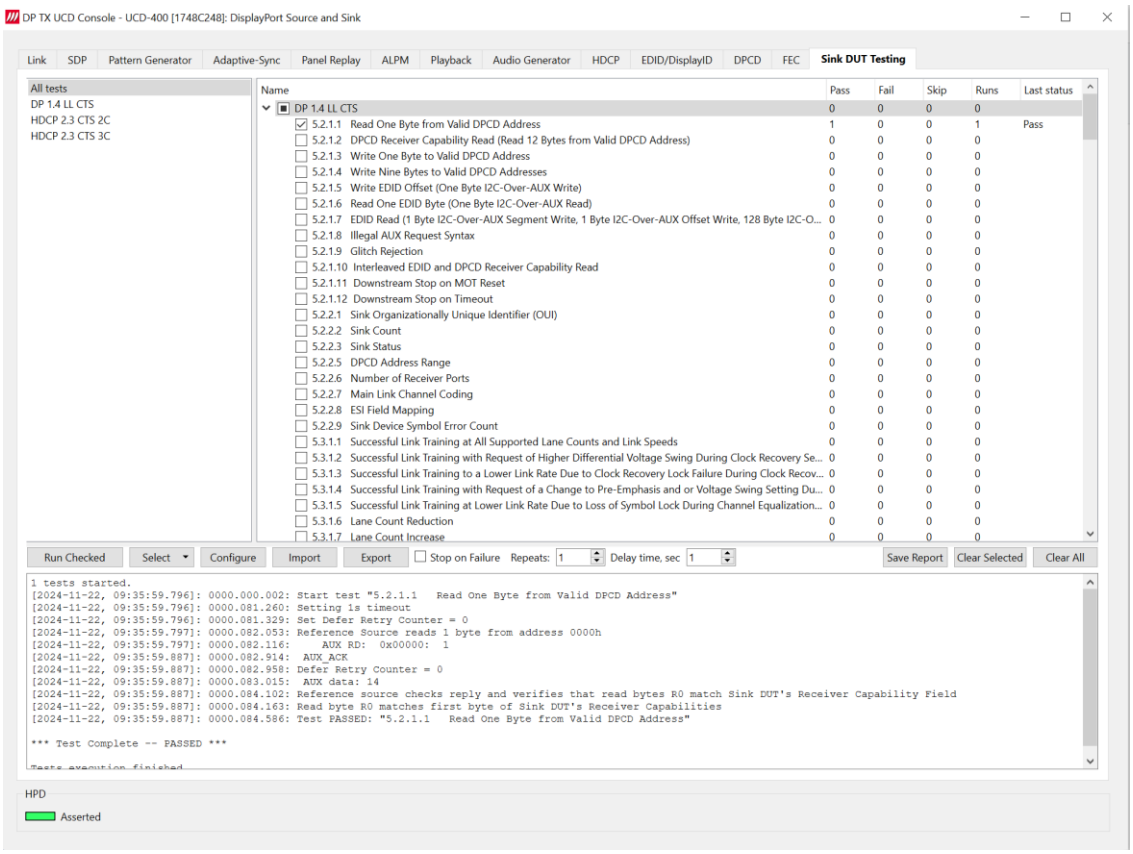
In the Editor Panes (upper right pane), the *Text EDID* tabs allow viewing data in tree form.

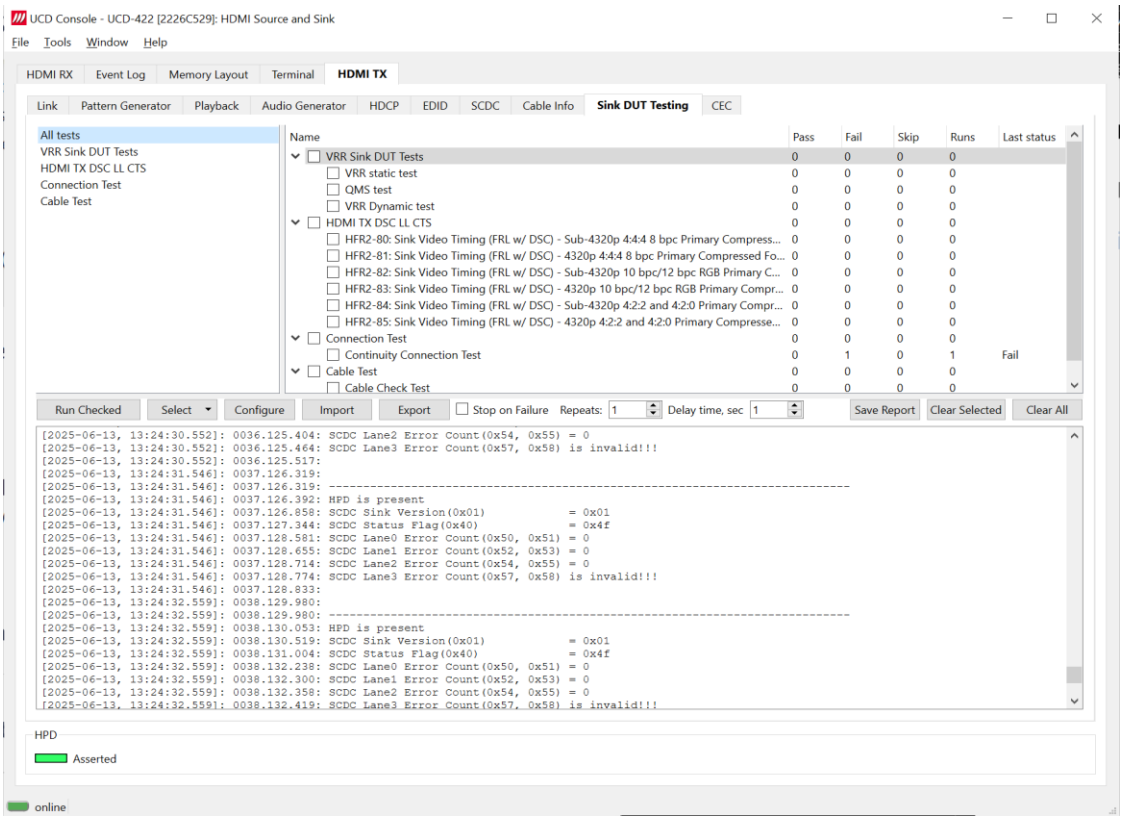
## EDID/DisplayID Editor

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

# Sink DUT Testing Tab

Refer to *Appendix E* for descriptions of the tests available. The tests are presented in a split view, the left being test categories and the right being the tests within.



Select the tests for execution by checking checkboxes or by clicking the test name. *All tests* item on the left hand side is really just for viewing all tests available. Select the desired test category (ex. *DP 1 .4 LL CTS*) when running tests.

| | |
|---|---|
| *Run/Run Checked:* | Select to start selected/checked tests. Once tests are running the *Run Checked* button is relabeled *Abort* to stop the test sequence if desired. |
| *Select:* | Includes three sets of options: *Select All, Clear All, Invert All* for changing the tests current selections; *Save* (checked items)*, Load* (and check relevant items)*, Remove* (named tests list) for handling named templates; *Import* (check all items contained in file) and *Export* (save all checked items to file) for loading and saving file-based templates. Do not confuse *Import and Export* with those below: These are for setting and saving tests to run. |
| *Configure:* | Opens a test parameters dialog for the selected test set. Make sure a test category other than *All* tests is selected. Refer to *Test Parameters* below for details. |
| *Import:* | Load saved test parameter files (*.td or *.json) for into UCD Console. Select *Configure* to see current parameters. Loading *.td files to UCD Console is currently unreliable. |
| *Export:* | Save test parameters for later use or for use in test automation. For saving parameters for later use in UCD Console, either format can be used. For saving parameters for TSI scripting, please use *.td files. For use with Python applications, use *.json files. |
| *Stop on Failure*: | Stops execution of tests if one fails. |
| *Repeats:* | Number of times to repeat the selected test sequence. |
| *Delay time:* | Delay in seconds between individual tests. |

On completion of each test the result of the test is displayed in the table columns on the right. For each test the table lists the number *Pass*, *Fail, Skips, Runs and Last Status* (status of last run).

| | |
|---|---|
| *Save Report:* | Select to generate a HTML report file. This will also open a tab in the default browser and display the results. |
| *Clear Selected* | Clear the test results of the *selected* (not checked) tests results. A subsequently saved report will not include these test results. |
| *Clear All:* | Clear the test log view and the outstanding results. |

## Test Parameters

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

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

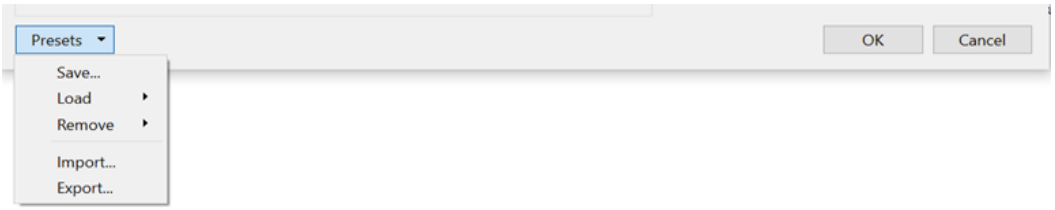
## Saving Test Parameters

Test parameters can be saved in various ways.

- Export parameters in *Sink DUT Testing* tab to a *.td file for later use in UCD Console, to run TSI scripts, or to share test parameters with someone. Presently importing *.td files into UCD Console is unreliable.
- Export parameters in *Sink DUT Testing* tab to a *.json file for later use in UCD Console, to run Python scripts, or to load test parameters into UCD Console.
- Save parameters in *Configure* dialog as Presets later to be used in UCD Console. See description below.

### Presets

All *Configure* dialogs selected parameters can be saved and loaded via *Presets* dropdown menu. Select *Save* or *Load* for named internal configuration parameter sets. Select *Remove* to delete a named internal set. Select *Import* and *Export* for loading and saving parameter sets from and to external files. Note that *import*ing and *Export*ing *.json files here have a different format than importing those described above.



# 6. HDMI LINK TIMELINE VIEWER

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

*HDMI Link Timeline Viewer* is a tool for evaluating the content and timing of data captured via HDMI *Link Analyzer* functionality of UCD Console.

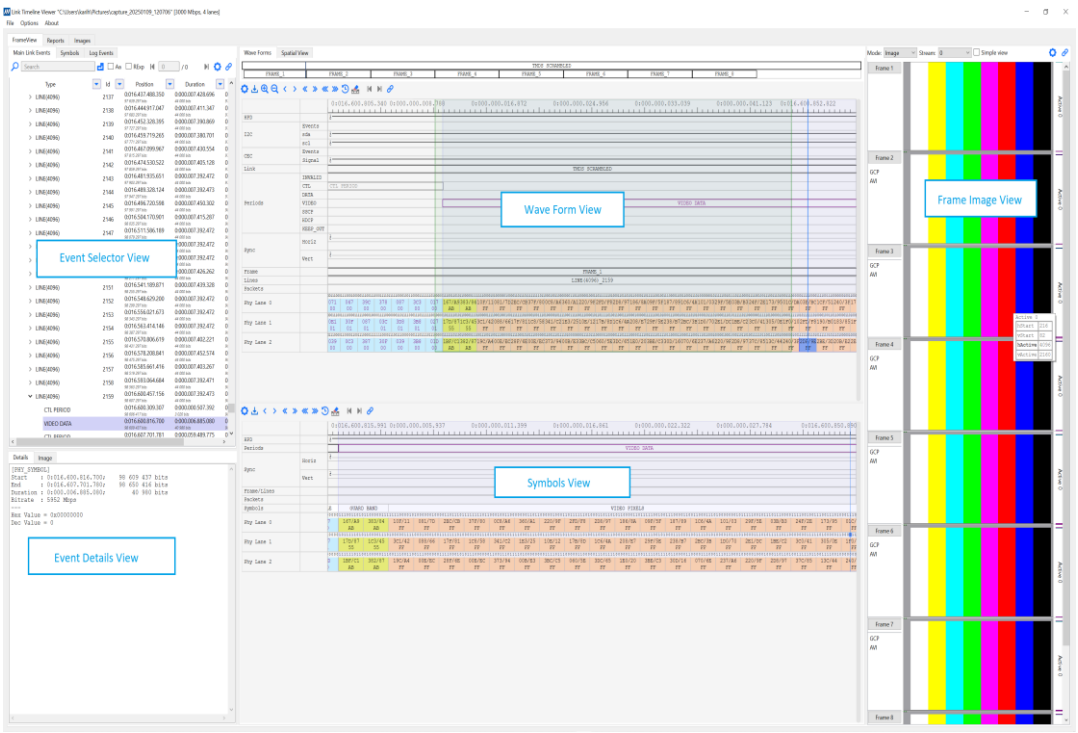
*HDMI Link Timeline Viewer* has three tabs (for three modes):

*FrameView* tab is the **primary** tab for analyzing captured events on the timeline.

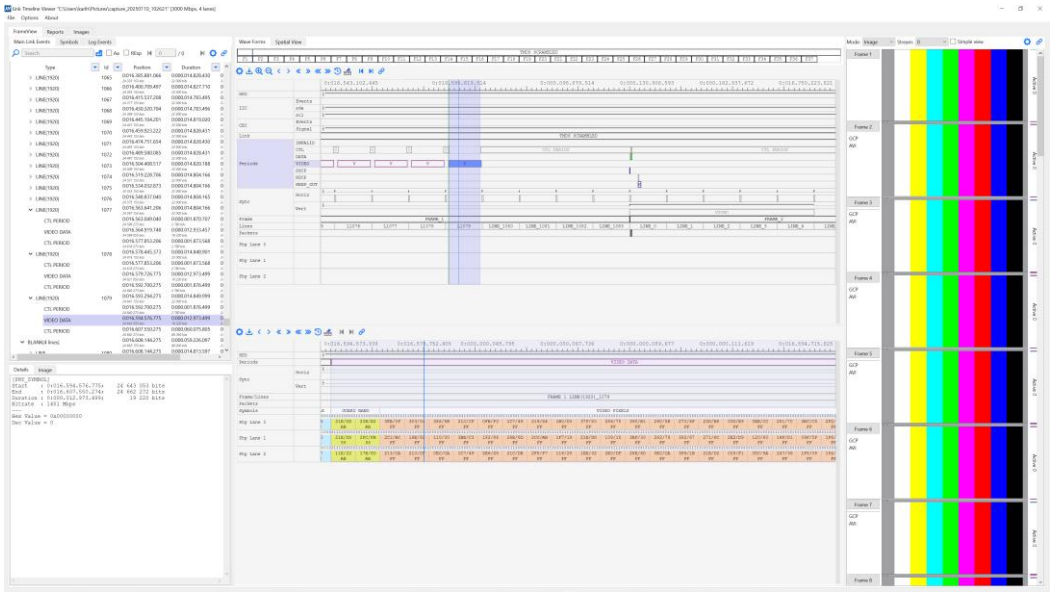
*Reports* tab can be used to summarize events (AUX at present).

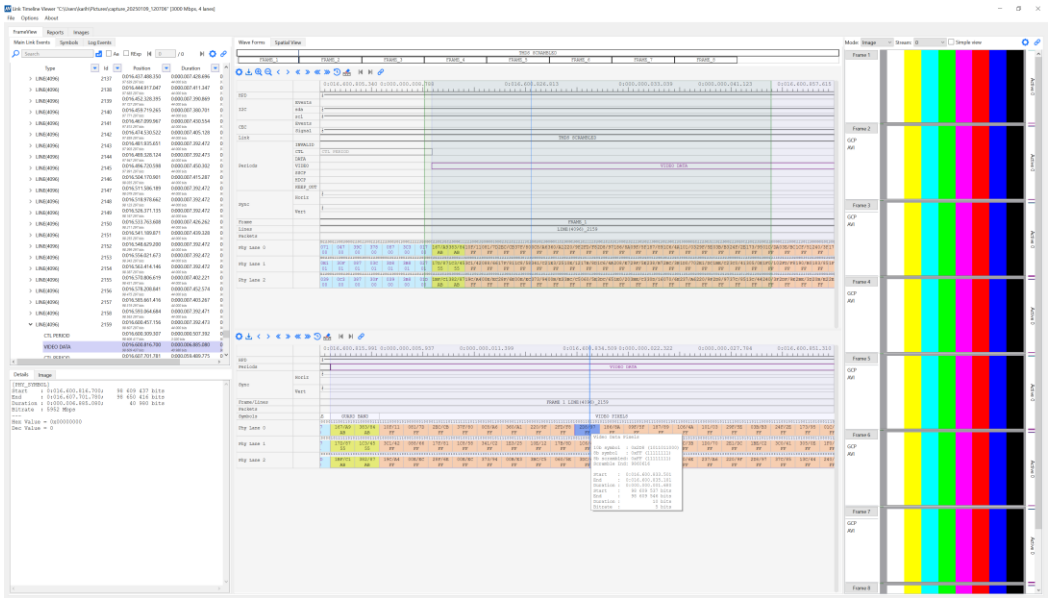
*Images* tab lets the user view captured video frame images.

The *FrameView* tab and its views are shown below.



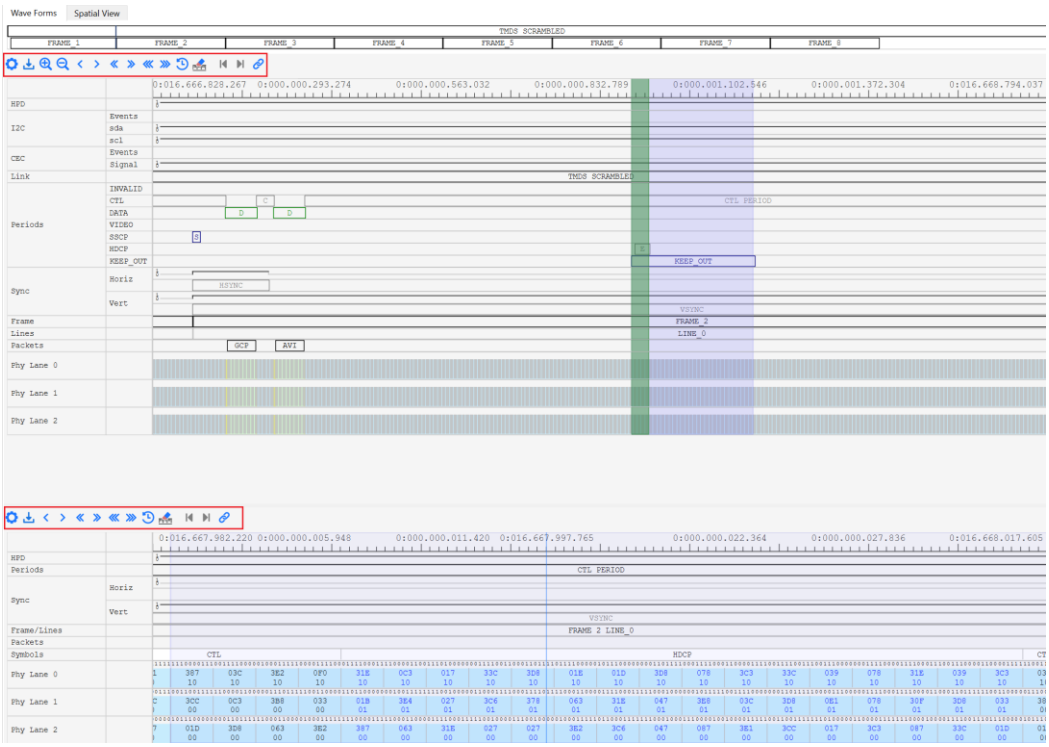
*Wave Form View* zoomed out and zoomed in views are shown below. Event periods are shown under the timeline (at the top) in their proper row as *period rectangles* with text descriptions (or abbreviations or no text, space permitting). Double-clicking a *period rectangle* will highlight the timeline portion of the rectangle and the row header(s) as shown below. To zoom the *Wave Form View*, position the cursor and use the mouse wheel to zoom in or out with respect to the cursor location. Drag to scroll the *Wave Form View* and the *Symbols View* horizontally.





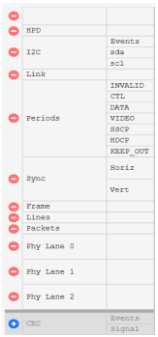
# Wave Form and Symbols View Settings

Shown below are the *WaveForms View* and *Symbols Views* settings widgets.



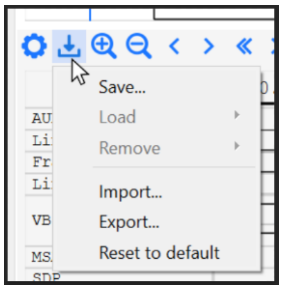
## Gear Icon

Select the *Gear* icon to select events to be displayed (+) or hidden (-). When *Gear* icon is selected, you can drag a row to reorder rows.



## Save Icon

Select the *Save* icon to *Save, Load* or *Remove* named internal settings sets. You can also *Import* or *Export* named *.json files containing settings or *Reset to default*.




## Zooming

Select *Zoom* + or – icons to zoom in and out or use the mouse wheel. The zooming in/out option applies to *Wave Form View* only.

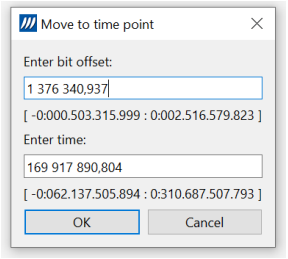
## Scrolling

Use the arrow keys to navigate the timeline. One arrow moves the timeline one page, two arrows 10 pages and three 100 pages.

You can also scroll by dragging ( click and hold while dragging).

## Clock icon

Move to a time point. Enter values and press OK.




## Eraser

Removes all measurements on the timeline.

## Move to Previous or Next Frame

Move back or forward to the same relative location in the previous or next frame.

## Sync Data

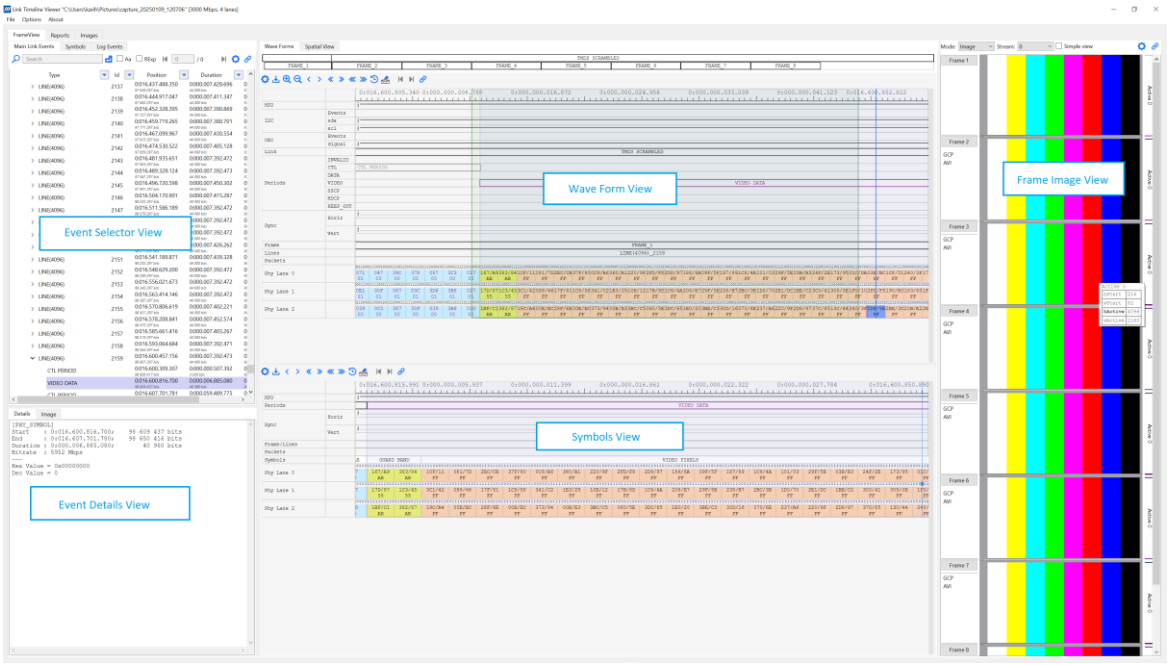
 Not synchronized.  Synchronized.

# FrameView Tab

Frame View tab has three tabs: *Main Link Events, Symbols,* and *Log Events.*
The *Main Link Events* tab is the **primary** tab for analysis and is presented first.

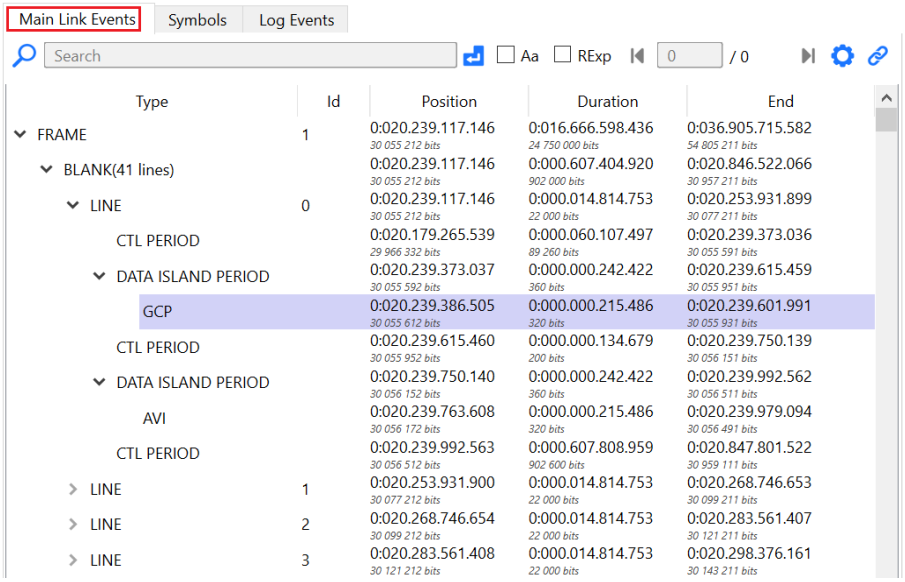
## Main Link Events Tab

*Main Link Events* tab consists of five panels: Event Selector View, Event Details View, Wave Form View, Symbols View and Frame Image View.
Each of these views are synchronized and actions in one will be reflected in others.



## Event Selector View

*Event Selector View* events are presented as a folding list of *FRAME*s. Each *FRAME* contains a set of *BLANK LINE*s followed by a set of *ACTIVE* LINEs and finally by another short set of *BLANK LINE*s. *BLANK* LINEs contain items such as *CTR* periods and *DATA ISLAND* periods. *DATA ISLAND*s contain *HDMI data packets* such as *GCP* and *AVI* packets. *ACTIVE* LINESs contain *CTRL* and *VIDEO DATA* items.



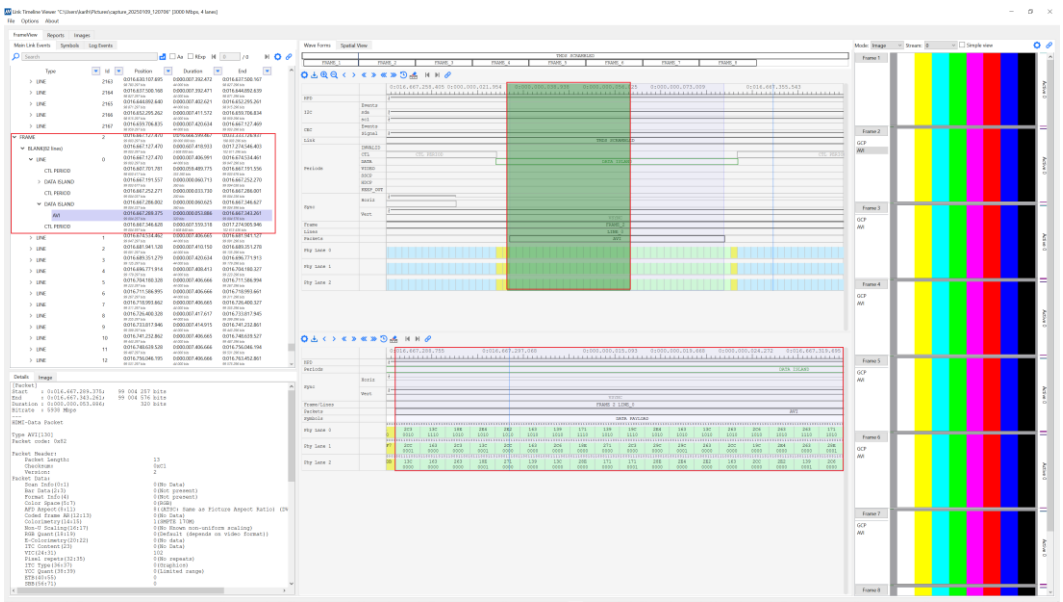

The timing format used in Link Timeline Viewer consists of two timings based on *time* and *bits*.

The time format is as follows:

*seconds:milliseconds.microseconds.nanoseconds.picoseconds*

In the image above you can see the time format on top and the bit format underneath (smaller grey font).

When clicking on a *Main Link Event*, both *Wave Form View* and *Symbol View* are focused, and the time stamp block of the item is highlighted as shown below.

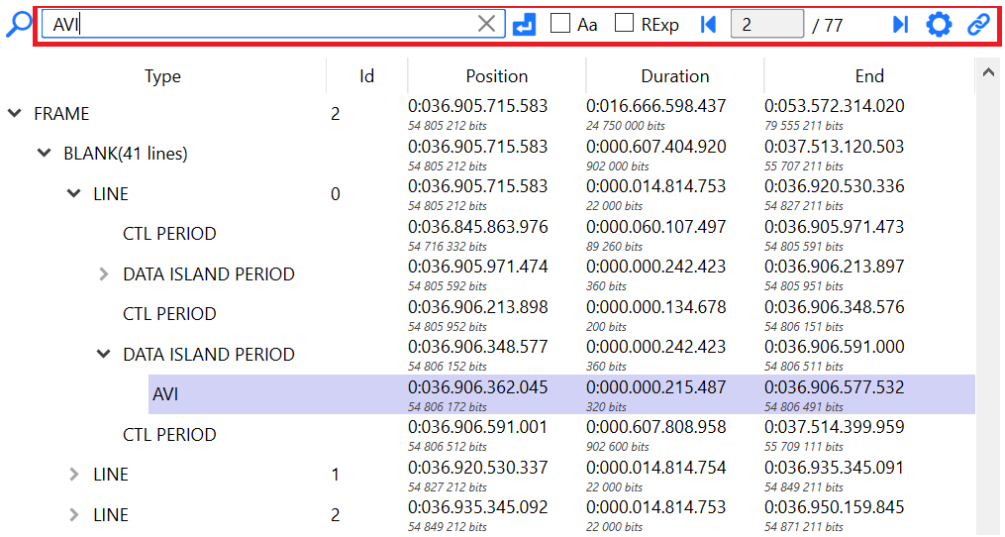


Event timing details are shown in the columns are the following:

| | |
|---|---|
| *Type:* | Type of item. |
| *Id:* | Items occurrence number. |
| *Position:* | Start of the event from start of the captured data |
| *Duration:* | Duration of the event |
| *End:* | End of the event from start of the captured data |

## Search

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

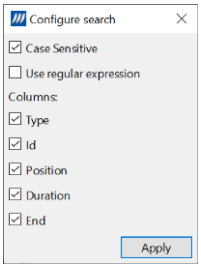



| | |
|---|---|
| *Aa:* | Makes search function case sensitive. |
| *RExp:* | Use regular expressions. |

Click the enter icon to apply filters.


Click *Find Prev* and *Find Next* icons to navigate. Also shown is the instance (here instance 2 out of 77).

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



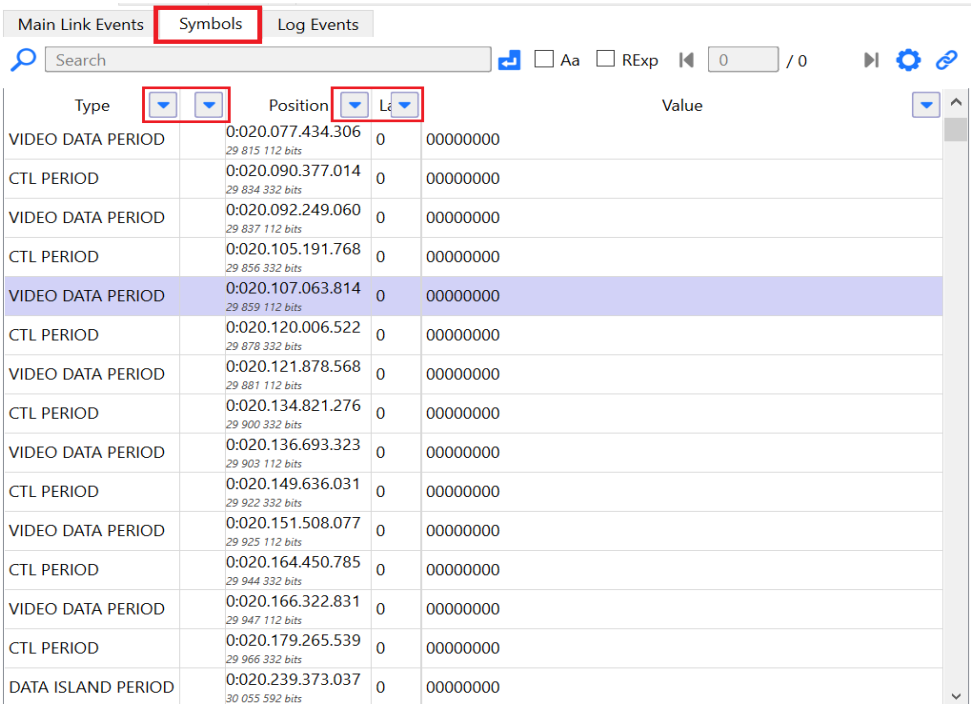

Not synchronized. Synchronized.

Click icons to synchronize data for view.

# Symbols Tab

*Symbols View* lists all *PERIODS*.

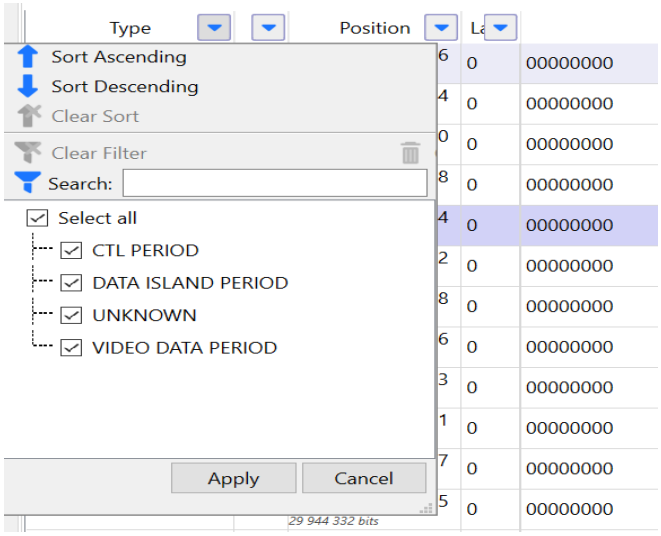
‘




Selection and multiview highlighting behavior is as for *Main Link Events* above.

Search criteria are the same as for *Main Link Events* above.

Each column has a sort and filter icon. Shown below is for the *Type* sort and filter icon.

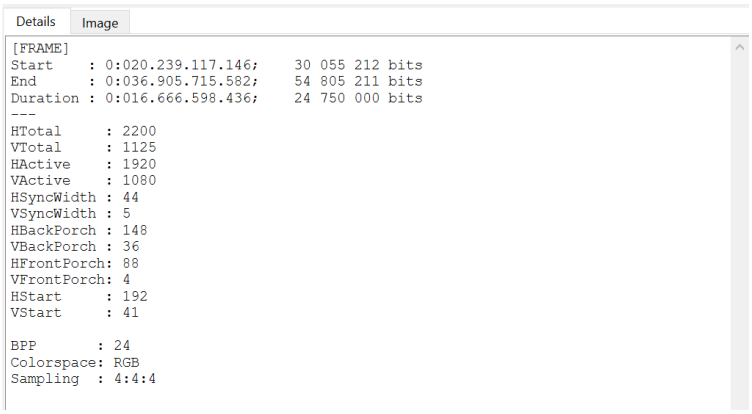


# Event Details View

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

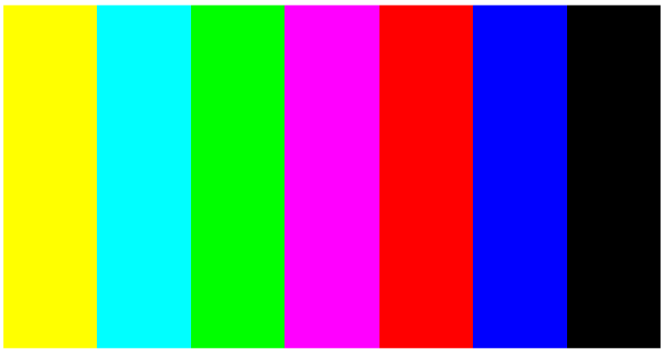
## *Details* Tab

The information shown in the *Details* tab depends on the selected item. A *FRAME* item is shown below.




## Images Tab

Image for currently selected *FRAME* can be viewed (only when *FRAME* is selected).

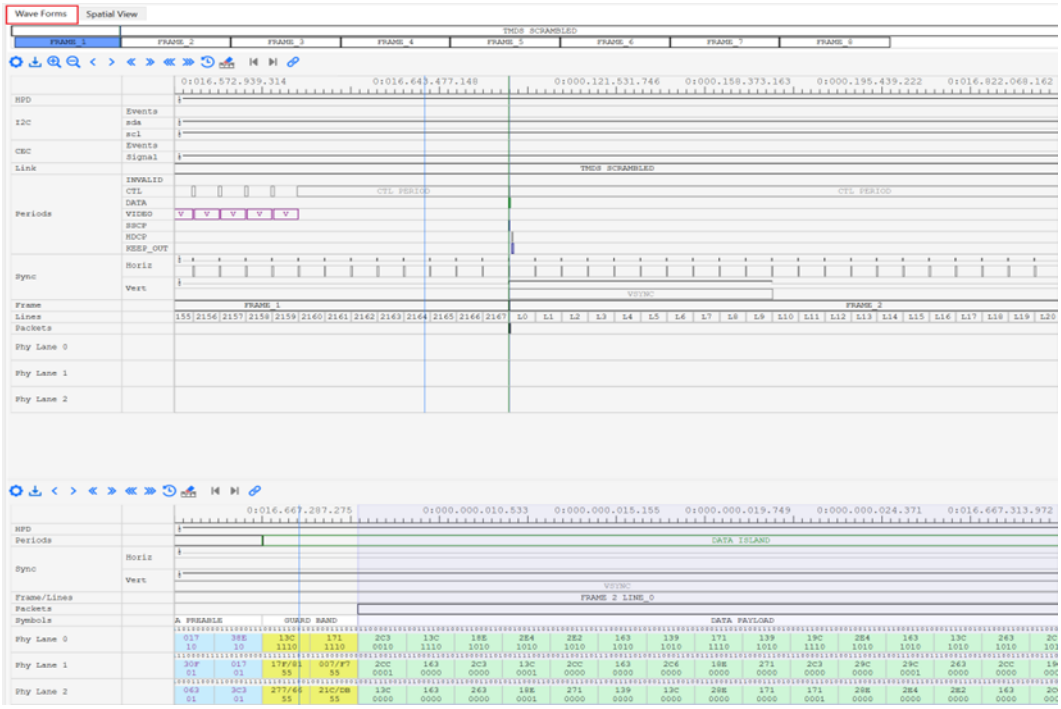
# Wave Forms View

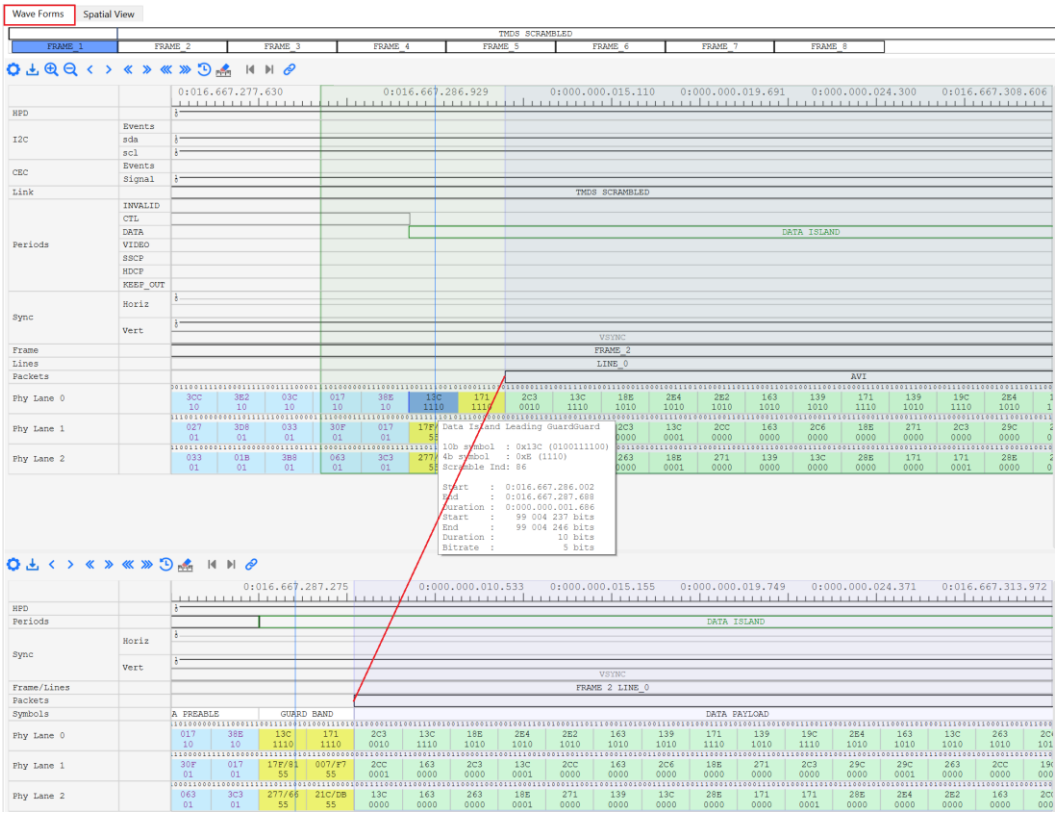
*Wave Form View* consists of two tabs: *Wave Forms* and *Spatial View.*

## Wave Forms Tab

*Wave Form View* looks different depending on zoom level. Images below show the views in zoomed out and zoomed in states.

Event periods are shown under the timeline (at the top) in their proper row as *period rectangles* with text descriptions (or abbreviations or no text, space permitting). Double-clicking a *period rectangle* will highlight the timeline portion of the rectangle and the row header(s). To zoom the *Wave Form View*, position the cursor and use the mouse wheel to zoom in or out with respect to the cursor location. Drag to scroll the *Wave Form View* and the *Symbols View* horizontally.

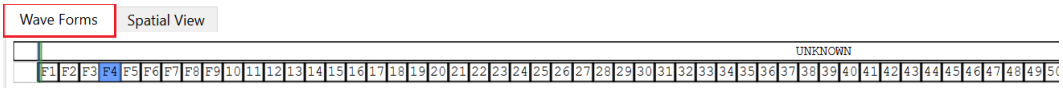





Columns are:

| | |
|---|---|
| *HPD* | Hot Plug Detect signal. |
| *I2C* | *I2C Events* and signals *sda* and *scl* |
| *CEC:* | *CEC Events* and *Signal* |
| *Link* | Link type (TMDS SCRAMBLED for ex.) |
| *Periods* | *INVALID, CTL, DATA, VIDEO, SSCP, HDCP, KEEP_OUT* |
| *Sync* | *HSYNC* and *VSYNC* periods and signals |
| *Frame* | *Frame* number. |
| *Lines* | *ACTIVE and BLANK* lines |
| *Packets* | *GCP and AVI* packets |
| *PHY Lane 0* | *Lane 0 data* |
| *PHY Lane 1* | *Lane 1 data* |
| *PHY Lane 2* | *Lane 2 data* |

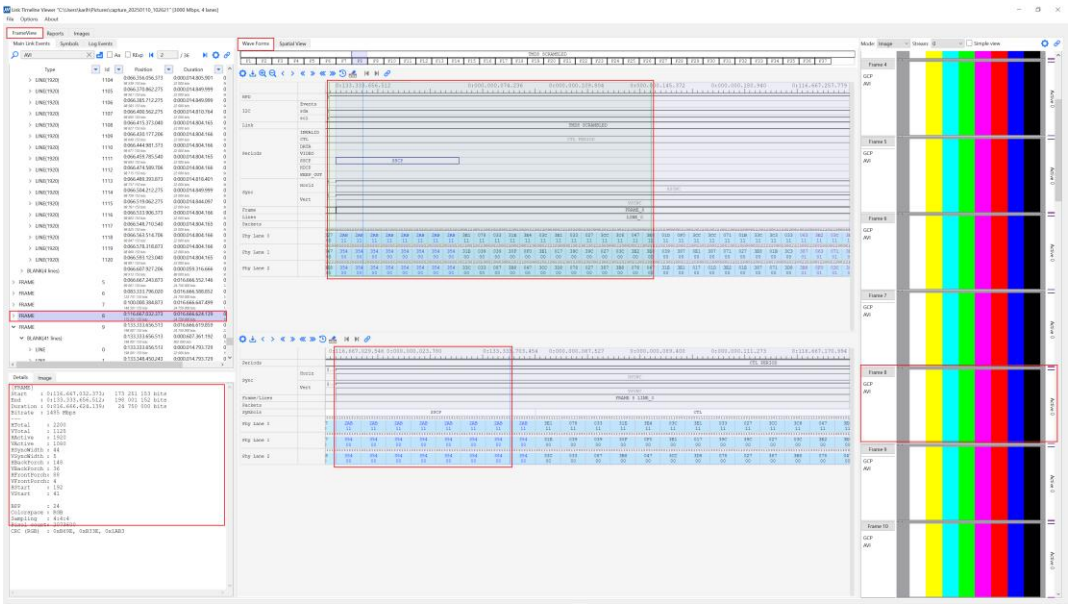
The scroll bar at the top shows all captured frames. Select a frame by double-clicking.




As you hover over the timeline, a timestamp for that position is displayed on the timeline at the cursor horizontal location.

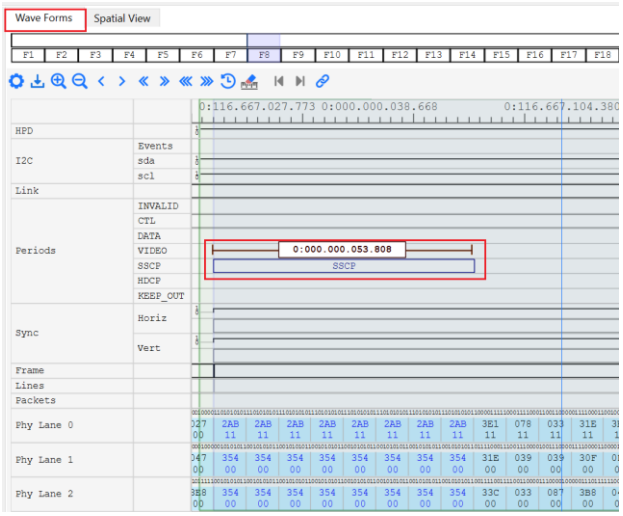
Popups show details of events as you hover over them in *Wave Form View*.

Below illustrates how the different views align when you double click in the *Wave Form View* or the *Symbols View.*



## Measuring

The ruler tool allows users to measure the time between two points on the timeline. When you right click on the timeline, a point willl appear. Right click again on the timeline and the distance between the two points will be shown as illustrated below. Use the eraser tool to remove measures.




## Spatial View Tab

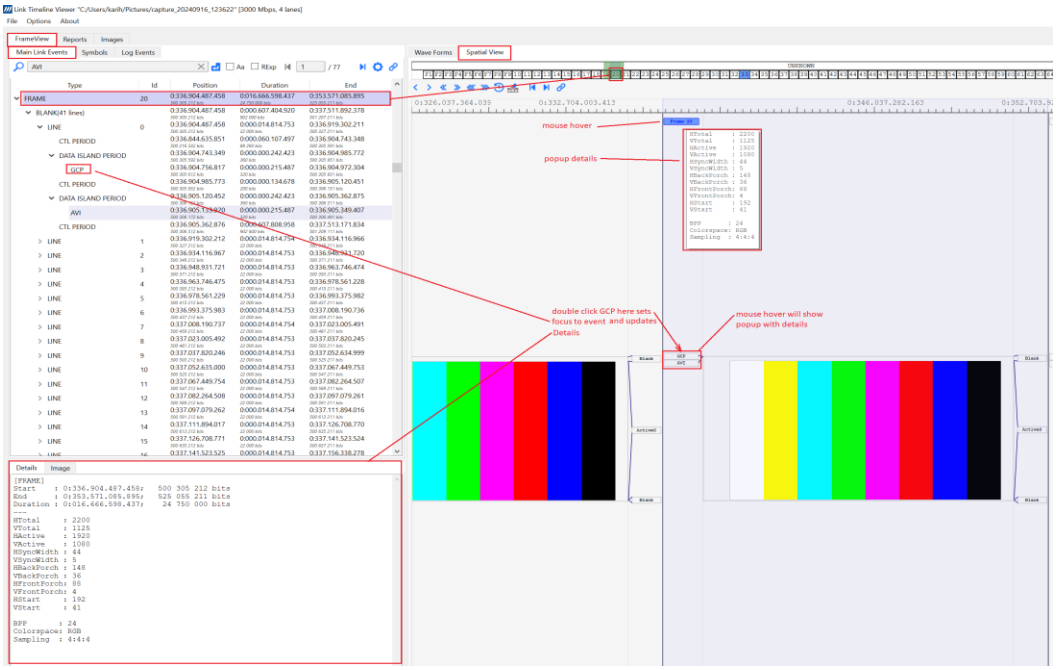
Frame pixel images are shown in *Spatial View*.

Drag to scroll *Frames*.

Double-clicking the timeline when *Spatial View* Tab is active will select the event in *Event Selector View.*

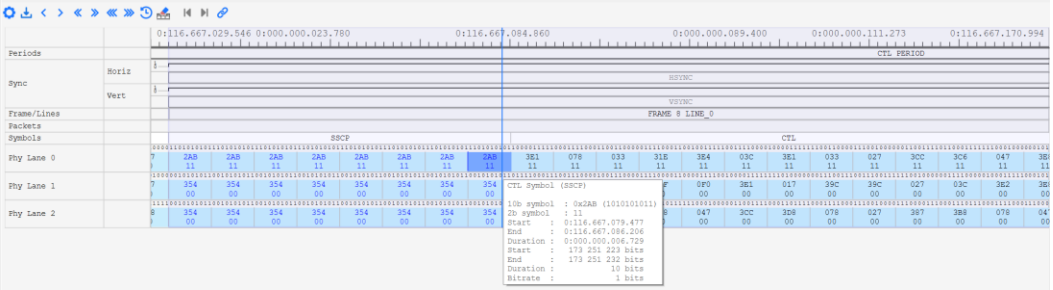
A popup showing details will be shown when hovering over a *Frame* or HDMI data packets such as *GCP* and *AVI*.

Hover over an event to see event details in a popup window. Double-click an event will to select it in and see details in *Event Details View.*


mouse hover
popup details
double click GCP here sets focus to event and updates Details
mouse hover will show popup with details

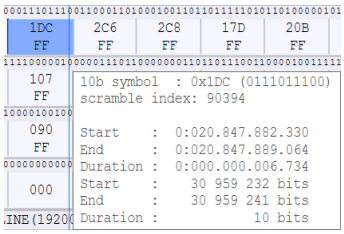
# Symbols View

Like *Wave Form View*, *Symbol View* presents HDMI transmission data and periods. As with *Wave Form View,* drag to scroll horizontally or use the *settings* ribbon arrow keys.

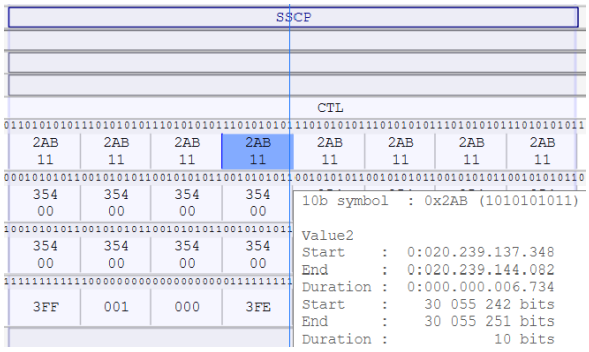



| | |
|---|---|
| *Periods* | *Transmission PERIOD*s |
| *Sync* | *Horiz* and *Vert* periods |
| *Frame/Lines* | *Frame* and *Line* number |
| *Packets* | *HTML GCP* and *AVI* packet identifiers |
| *Symbols* | HDMI transmission symbols. |
| *Phy Lane 0* | *TMDS Channel 0* data. |
| *Phy Lane 1* | *TMDS Channel 1* data. |
| *Phy Lane 2* | *TMDS Channel 2* data. |

Illustrated below are the TMDS channel values for *PIXEL*s for the color white. Note from the tool tip that the value has been scrambled.




Illustrated below are the values for a SSCP period. Note from the tooptip that this is not scrambled.



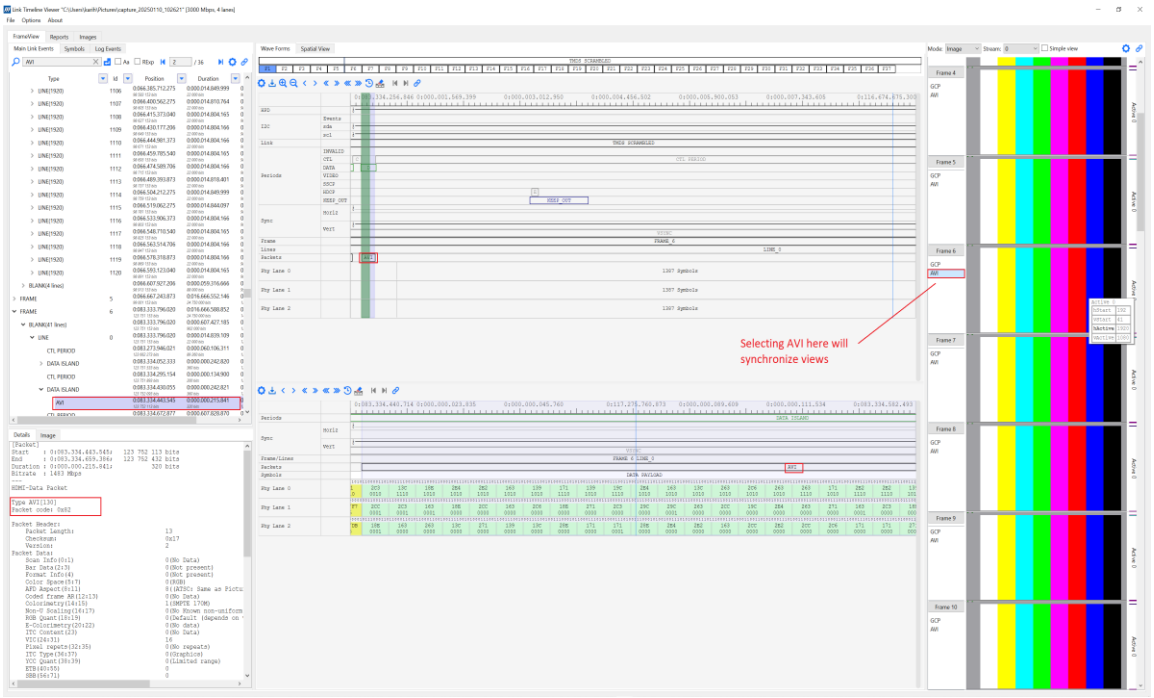

Each individual block contains the following information (tooltiup also shown).

| | |
|---|---|
| *First row* | 10b/8b symbol in HEX format |
| *Second row* | Descrambled value. |

# Frame Image View

Frame Image View can be used to select *Frames* and GCP or AVI periods and synchronizing with other views.

As shown below, selecting the *AVI* event in *Frame Image View* also selects it in *Event Selector View* and synchronizes the other views. Hovering over the Active0 area will show the frame geometry details.




*Mode* can be *Image* or *Rect* (shows just a green rectangle to save processing time).

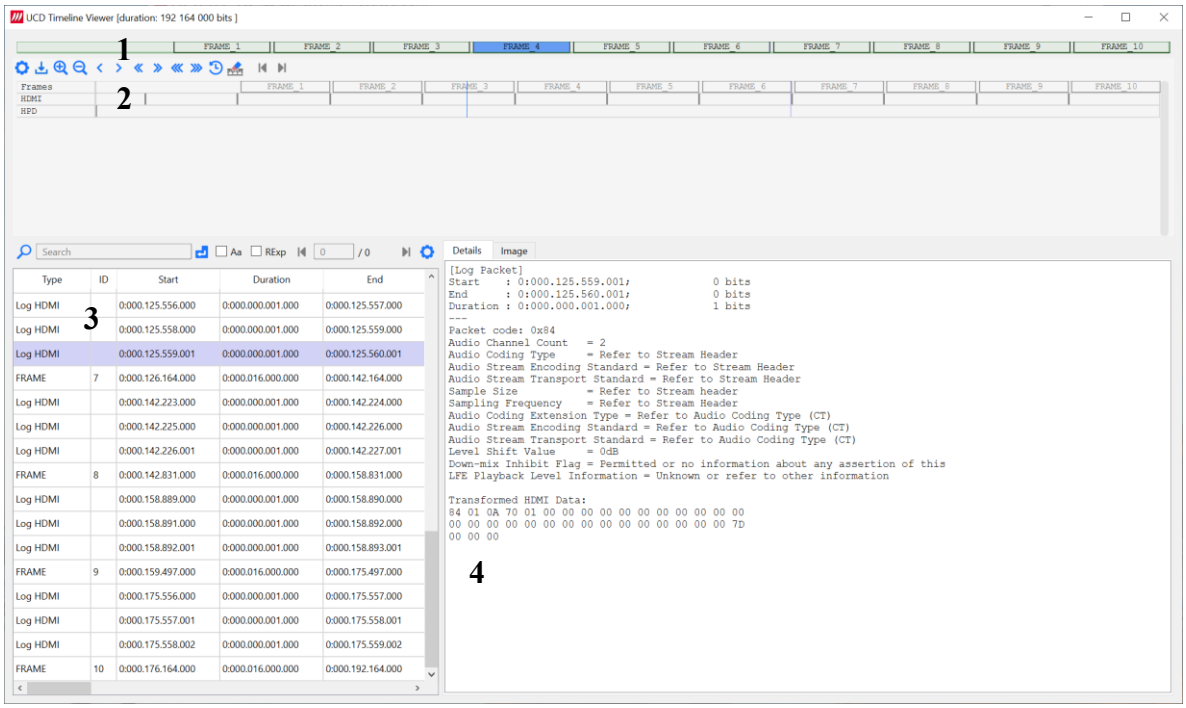
*Stream* combobox and *Simple view* checkbox do not work at present.

# 7. EVENT TIMELINE VIEWER

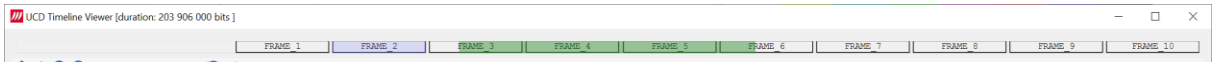
Event Timeline Viewer is an application for inspecting data captured in capture tab.

Event Timeline Viewer consists of four areas.

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

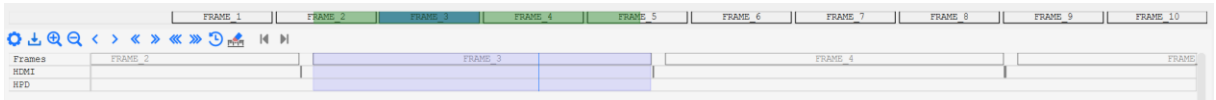



## Frame View




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

## Event View

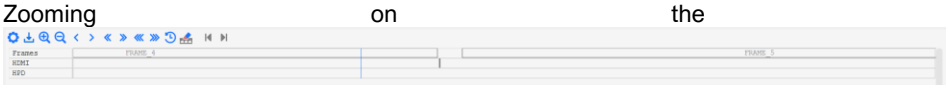



The view below shows all frames and events selected in the capture tab. The are highlighted in green in frame view indicates the are shown in events view.

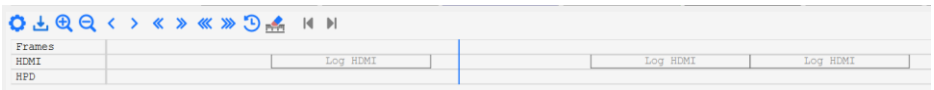
## Tools

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

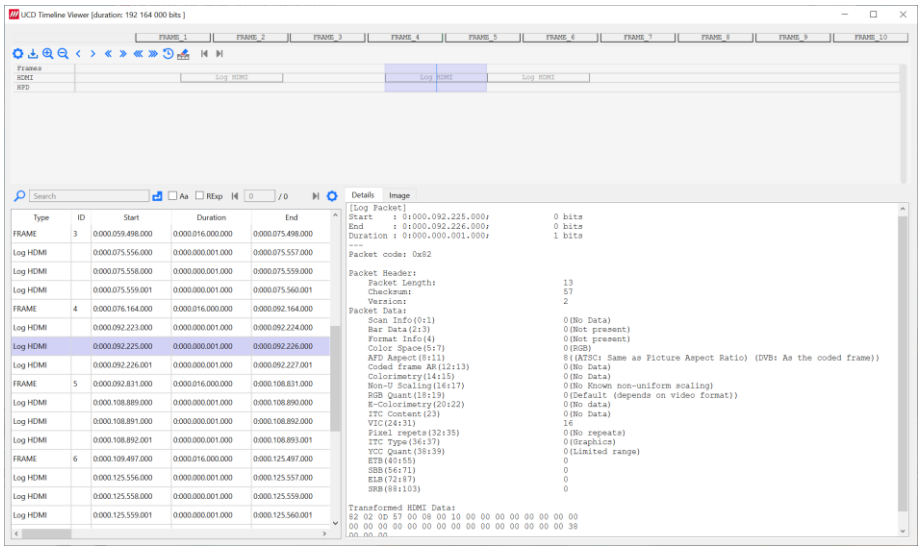
Zooming on the timeline



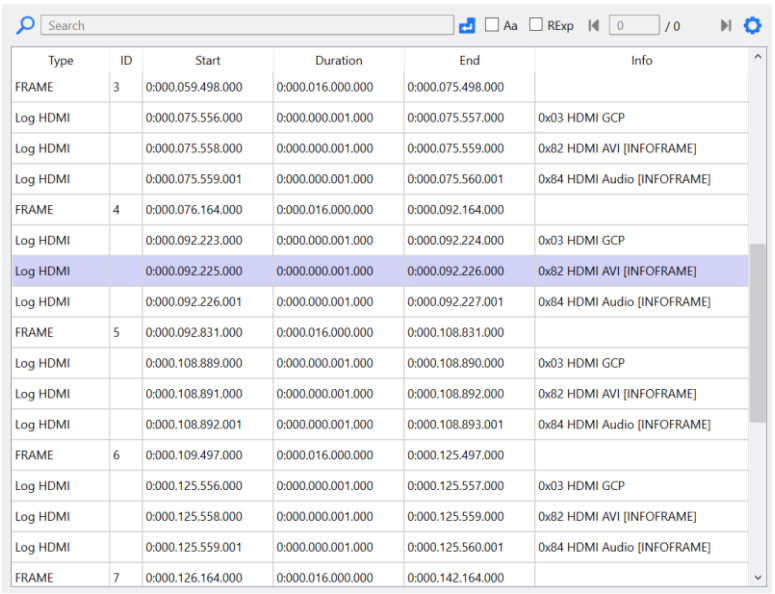
Went the timeline is zoomed out, you can see events as grey lines. When you zoom in you can see the event block. You can zoom in either with the magnifying glass icons or by scrolling with your mouse.




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



## Event Log




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

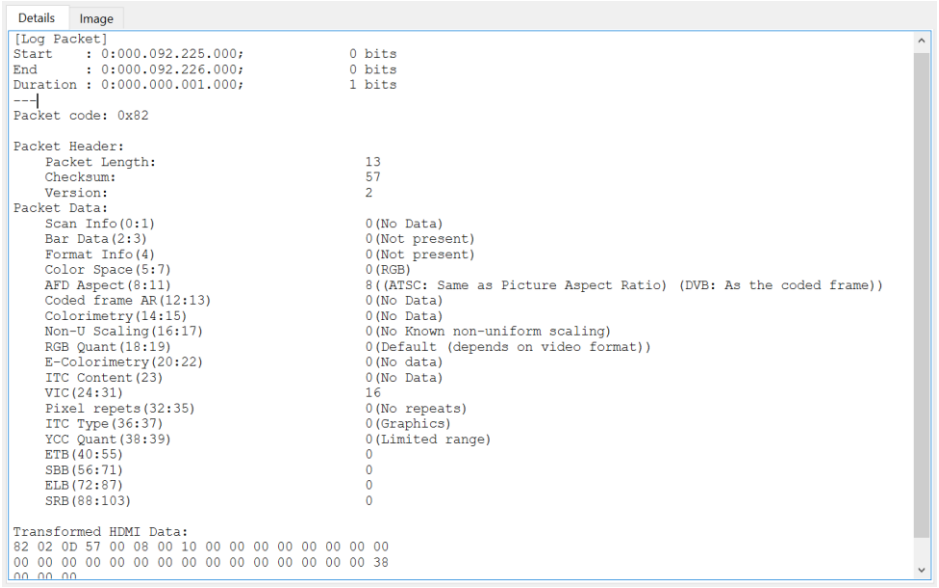
Event log shows all captured events and frames. The following info is presented in the table:

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

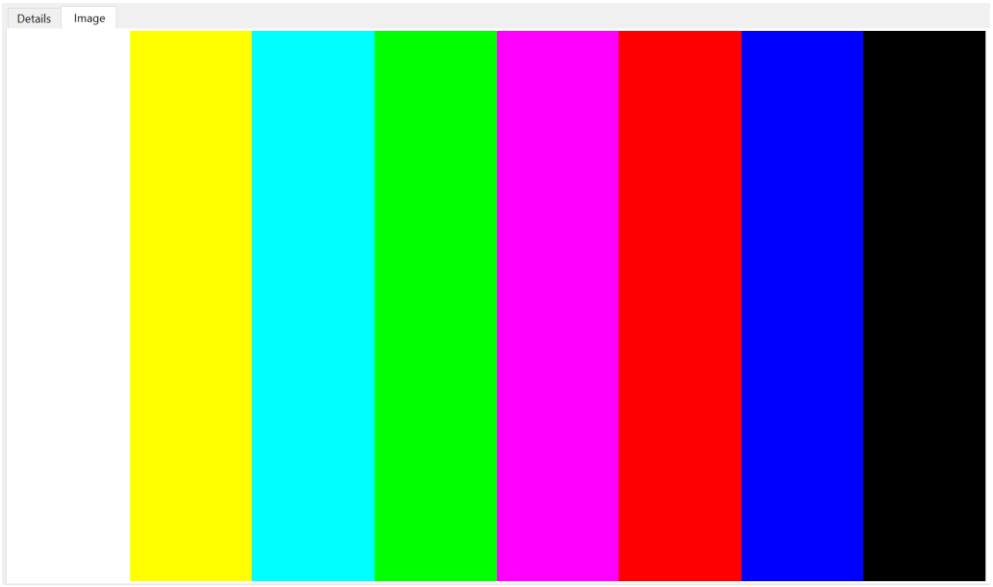
### Event Log Tools

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

## Details / Image

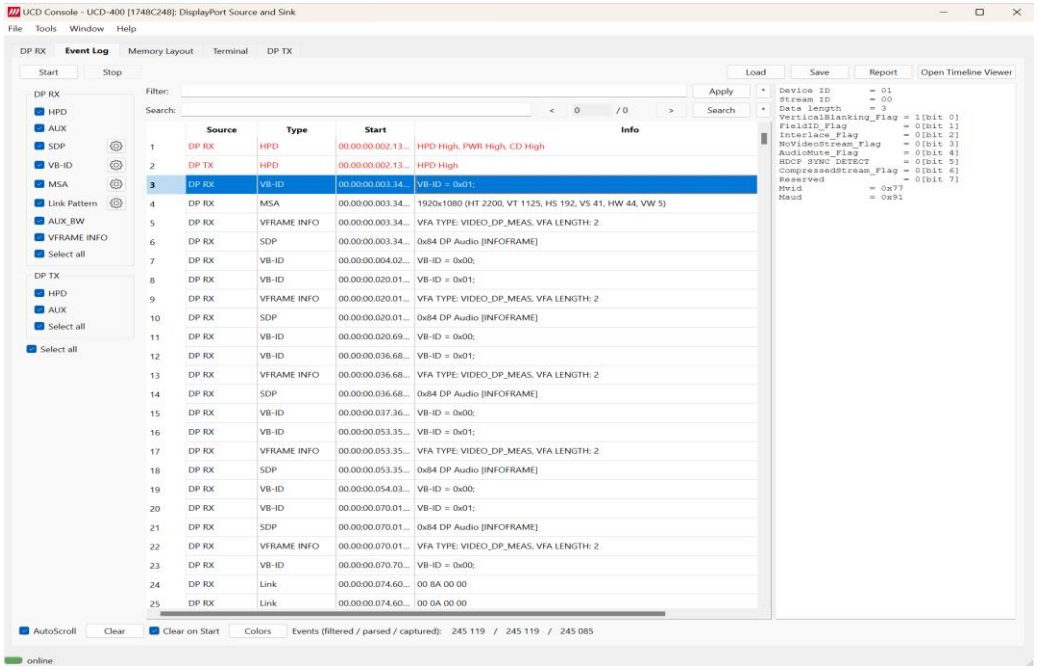


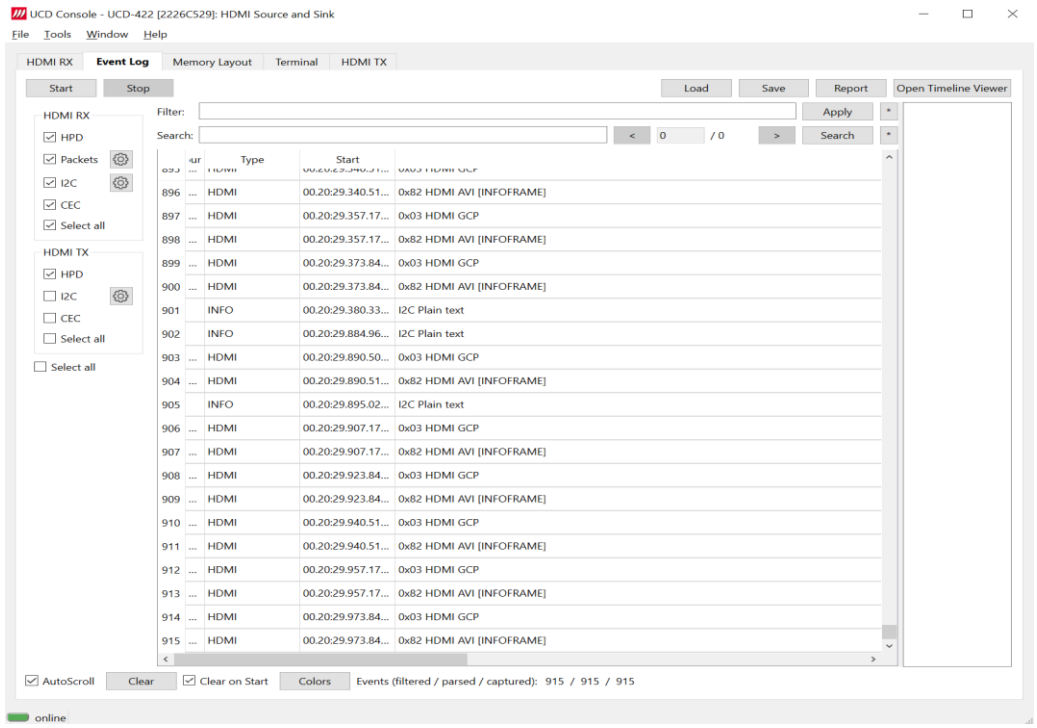

Details tab shows details of the selected event. When the selected event is a frame, the image tab shows the captured frame.



# 8. EVENT LOG

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



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

| | |
|---|---|
| *Start* | Starts event logging and stop it by clicking *Stop*. |
| *Save* | Save transactions as Event Log data. |
| *Loa* | Load Event Log data. |
| *Repor* | Store event logs as reports in HTML format. |
| Open Timeline Viewer | Open Event timeline Viewer to inspect the captured data. For detailed instructions refer to chapters 6 and 7 of this manual. |
| *AutoScroll* | When selected, transaction list is scrolled vertically. The latest transaction is shown as the last item of the list. When not selected, the items shown before clicking *Start* will be shown. |
| *Events* | Number of events detected. |
| *Colors* | Open configure colors dialog. |
| *Clear/Clear on Start* | Click to clear transaction list. When *Clear on Start* is selected, the list is cleared when clicking *Start*. |

# Logged Events

## HPD

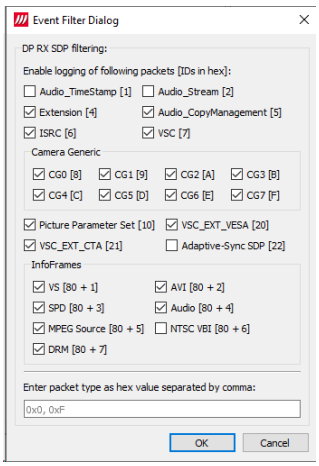
Status and status changes of Hot Plug Detect (HPD) signal, power detection status and cable connection status.

## AUX

DP Log DP AUX Channel transactions and Sideband Messaging.

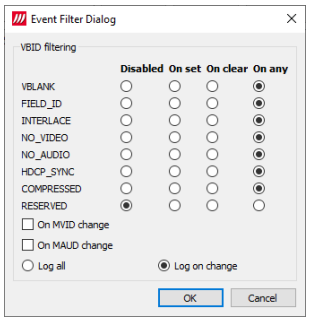
## SDP

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



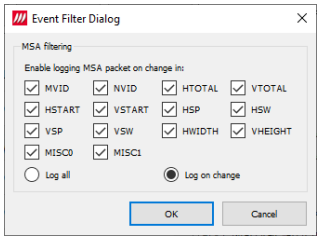

## VB-ID

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




## MSA

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

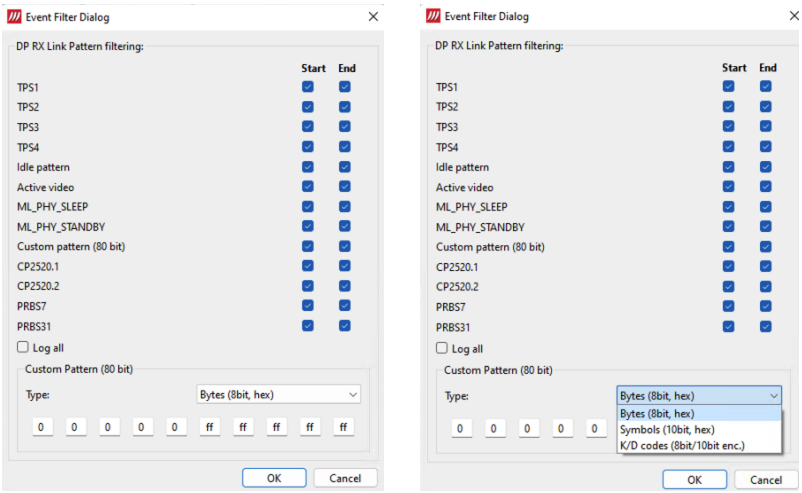


## Link Pattern

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

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

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




## AUX_BW

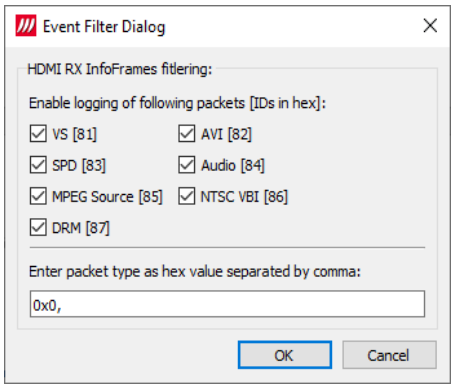
Log AUX_Bitwise transactions as a series of Manchester II codes.

## VFRAME INFO

Dimensions of the catured frame measured by the Sink.

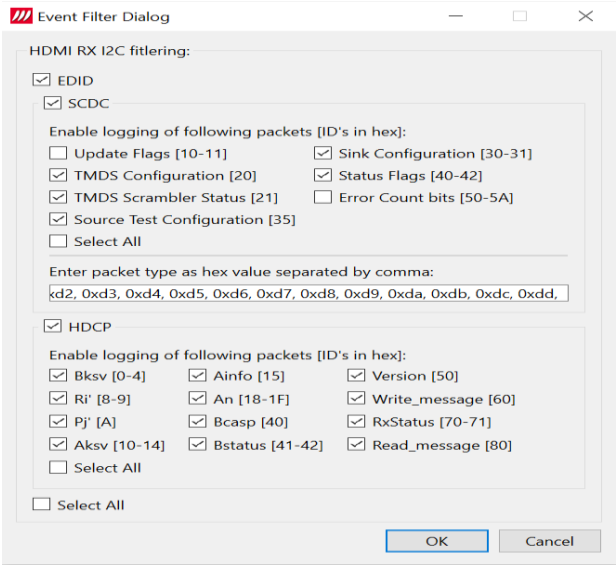
## Packets

Log metadata sent by Source device in HDMI stream.



## I2C

Log data sent over I2C communication lines of HDMI interface. Click the ⚙ button to open the *Event Filter Dialog* (either HDMI RX or HDMI TX dialogs).



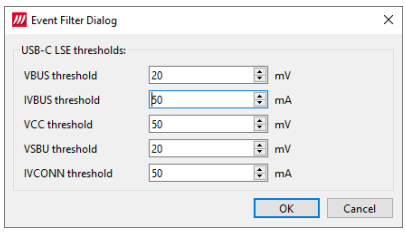

## PD

Log USB-C PD communication messages.

## CEC

Log HDMI CEC communication messages.

## LSE



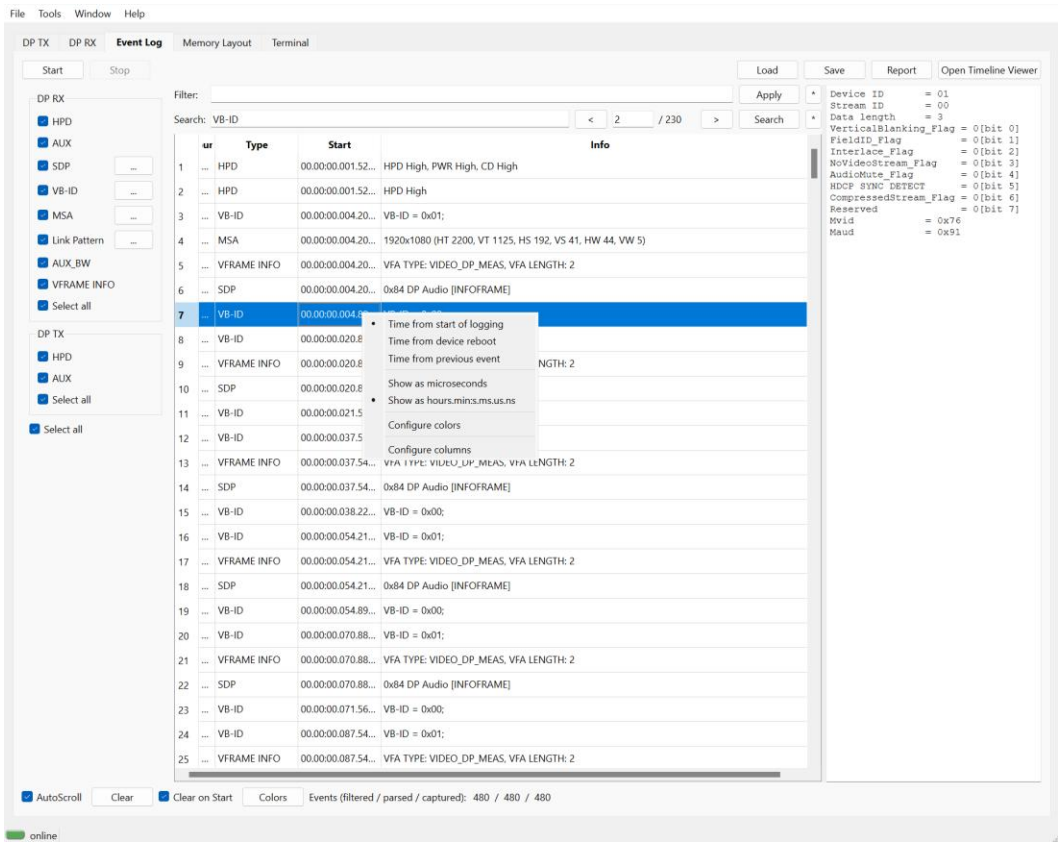

Low Speed Electrical logger captures the Voltage and Current on the low-speed lanes of the USB-C connector including CC, VBUS, VCONN, and SBU.

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

# Event Transaction List

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

You can search events by typing its name in the Search bar and pressing enter or selecting the *Search* button. Pressing F3 (Ctrl+G on macos) takes you to the next found and Shift+F3 (Shift+Ctrl+G on macOS) takes you to the previous found.



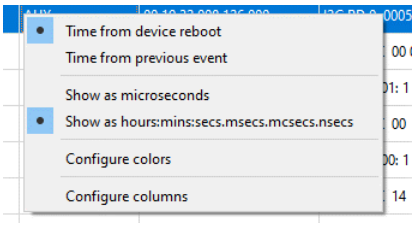

| | |
|---|---|
| *Source:* | The communication port: DP RX, DP TX, HDMI RX, HDMI TX or HDCP 1.X, HDCP 2.3 |
| *Type:* | The logged item:<br>HPD, AUX, SDP, VB-ID, MSA, Link Pattern, AUX_BW, VFRAME INFO (DP or DP Alt Mode)<br>HPD, Packets, I2C, CEC (HDMI) |
| *Start:* | Each line is identified by its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

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

# Customizing Transaction List

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

Right-click on the list to open the menu.




## Configure Start

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

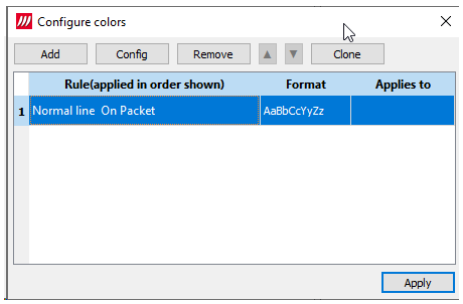
- Time from device reboot
- Time from previous event

The time can be expressed either:

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

## Configure Colors

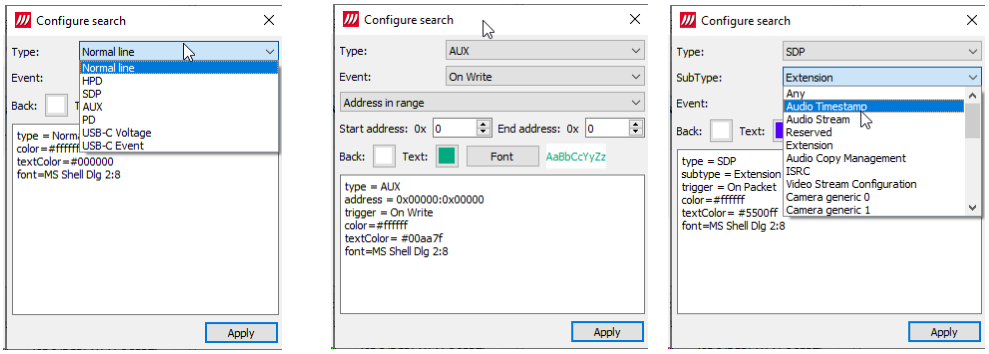
*Configure colors* dialog allows the user to highlight various types of transactions in the list by changing character color and background color of the transaction line.




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

### Adding Rules

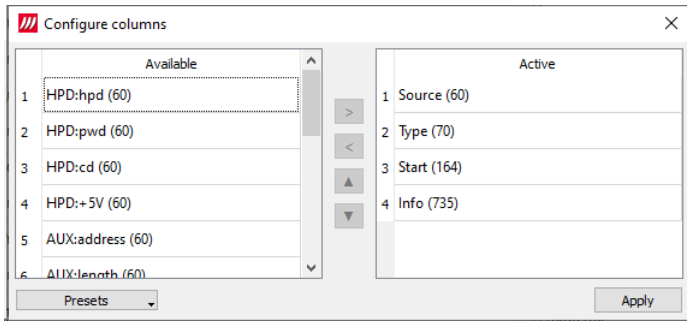
The color highlight rules are set by transaction type. The content of *Add rules* dialog is dependent on the type of item selected.




## Configure Columns

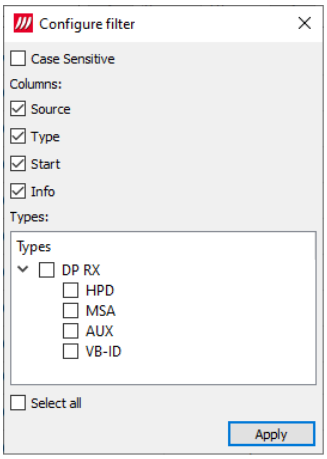
In the dialog there are two columns: *Available* and *Active*. An item from Available list can be included in Active columns by selecting it and clicking on the right arrow [>] in the middle of the two columns.

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




## Type Filter

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




transaction lines are currently shown.

## Quick Filter

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

# Event Details

## HPD

HPD transactions include the following statuses:

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

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

## Packets (UCD-422, UCD-452)

Log metadata sent by Source device in HDMI stream

```
Packet code: 0x82

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

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

## I2C (UCD-422, UCD-452)

Log data sent over I2C communication lines of HDMI interface

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

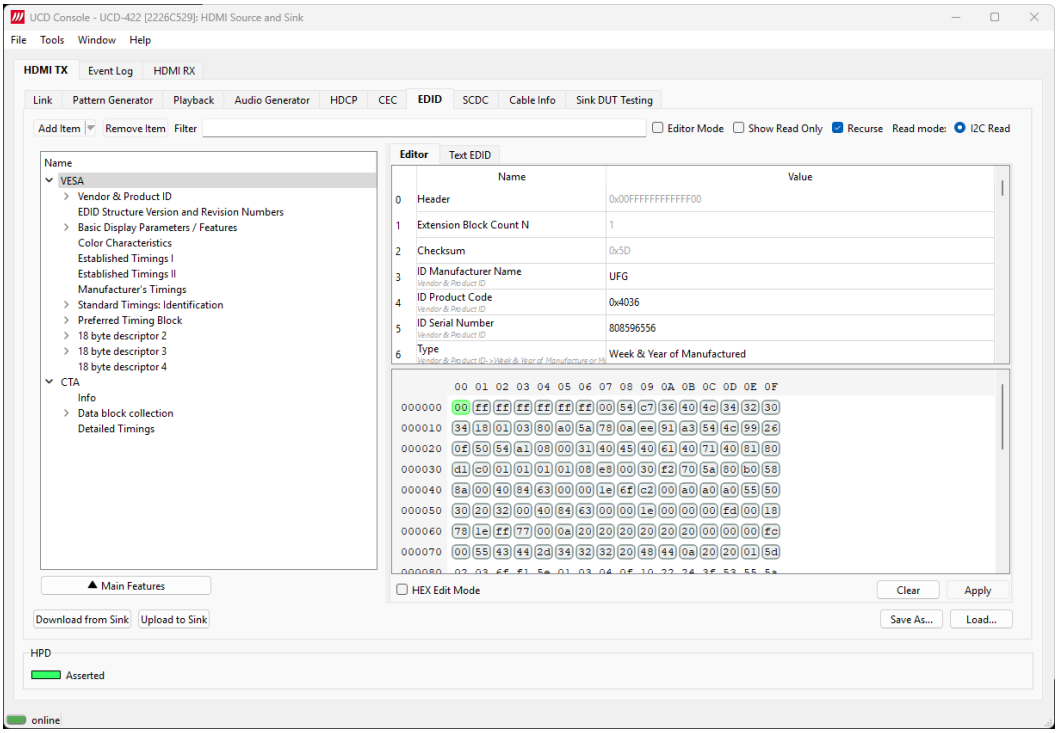
## CEC (UCD-422, UCD-452)

CEC messages

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

# 9. EDID EDITOR

The *EDID Editor* main window is divided into three views. The bottom area additionally has command buttons. The top left tree view selection determines the blocks to be edited. The top right view shows data for the currently selected item in the top left view. These values may be edited when the *Editor Mode* checkbox is checked, The bottom right hex view shows that data as hex values. The hex values of the currently selected item in the top left view are highlighted. Values can be edited when the *HEX Edit Mode* checkbox is checked.



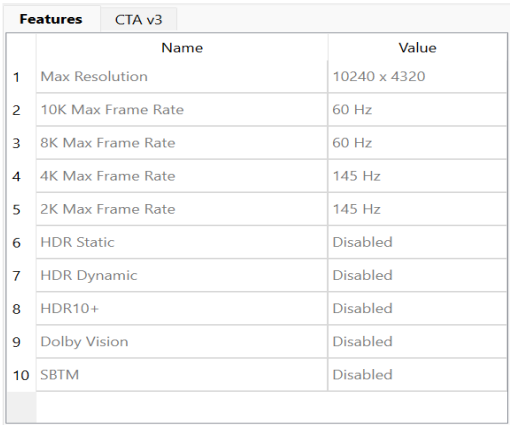

| | |
|---|---|
| *Add Item* | Add a new EDID block. Available when in *Editor Mode* exclusivly and a top node in treeview (CTA or VESA) is selected. |
| *Remove Item* | Delete the selected EDID. Available when in *Editor Mode* exclusivly and a top node in treeview (CTA or VESA) is selected. |
| *Filter* | Show only items having the filter string in the field name. |
| *Editor Mode* | See below. |
| *Show Read Only* | Automatically generated non-editable fields are additionally shown. |
| *Read mode* | Data read mode:<br>I2C (using I2C protocol) or SBM (MST mode only): virtual channels read via SBM protocol. |
| *Recurse* | All subitems of the selected item are presented in *Editor View.* |
| *Virtual Sink #1* (DP) | Dropdown labled with the currently selected virtual sink (MST). |

The buttons at the bottom of the dialog differ based on role: Analyser (*Read fromTE* and *Write to TE*) or Generator (*Download from Sink* and *Upload to Sink*).

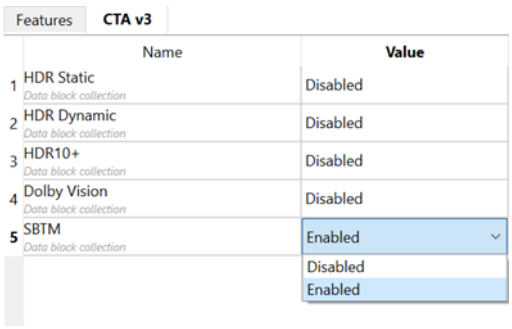

| | |
|---|---|
| *Read from TE (Analyzer)* | Read device local EDID blocks into editor (*HEX Edit Mode* must be unchecked). |
| *Write to TE (Analyzer* | Write editor data to device local EDID blocks. |
| *Download from Sink (Generator)* | Read EDID blocks from connected sink device into editor. |
| *Upload to Sink (Generator)* | Write editor EDID blocks to connected sink device. See note below. |
| *Editor Mode* | Enable editing EDID content in top right view. For example, for testing purposes, it's possible to load invalid EDID/DisplayID data and write it to TE without modifications. Once *Editor Mode* is enabled, the validator corrects errors such as invalid checksums. Top right view name-value paiars can be edited. |
| *HEX Edit Mode* | Enable editing EDID content in bottom right HEX view. When enabled, HEX values may be edited. Click *Apply* to validate changes and update other views. |
| *Save As…* | Save the current editor data to disk in various formats: binary, hex, ecd, txt and xml. |
| *Load …* | Load EDID/DisplayID data from disk. Same formats as above available. |

| | |
|---|---|
| Note: | A source device is always able to read EDID data of the connected Sink device. The connected sink device may or may not allow its EDID content to be modified. |

Select the *Main Features* button to view items of common interest. For example, whether the sink is capable of HDR, or Dolby Vision, etc.




The *Main Features* view *CTA v3* tab (avalable only in EDID tab not DisplayID tab) allows enabling/disabling features. You enable/disable a feature by selecting the *Value* field with *Editor Mode* enabled (AND HEX Edit Mode disabled). When a value is disabled and you want to enable it, the *Editor View* will be blank as focus has been set on the values to be enabled (and are zero when disabled). New highlighted hex values will be added and highlighted in the lower right *Hex View*. New node data will also appear under the CTA node in the top left tree view.




# EDID Editor Features

A practically unlimited number of extension blocks may exist in a single collection. Most EDID blocks contain a structure that is very similar to a tree structure. The Editor decodes each block into a tree view of the block. The tree view then contains all values within the data block. Contents can be browsed. The Editor has a support for automatic variables, such as the block checksum. When a value in a block is modified, the checksum will be updated. Automatic variables are read only. A log print will be made when an automatic variable is updated by the editor.

# Editing Tips

Editing is straightforward:

Select property fields to edit.

Red values in *HEX View* show that values have been modified.

Press *Enter* to apply edit values and combo box selections.

In CTA-861 blocks, you can add and remove 18-byte descriptors and CEA data blocks by setting the values “18-byte Descriptors in this block” and “CEA Data block count”.

Enter hex values with prefixes "**0x**" or "**$**". No prefix represents a decimal value.

Values may be entered as hexadecimal or decimal regardless of presentation.

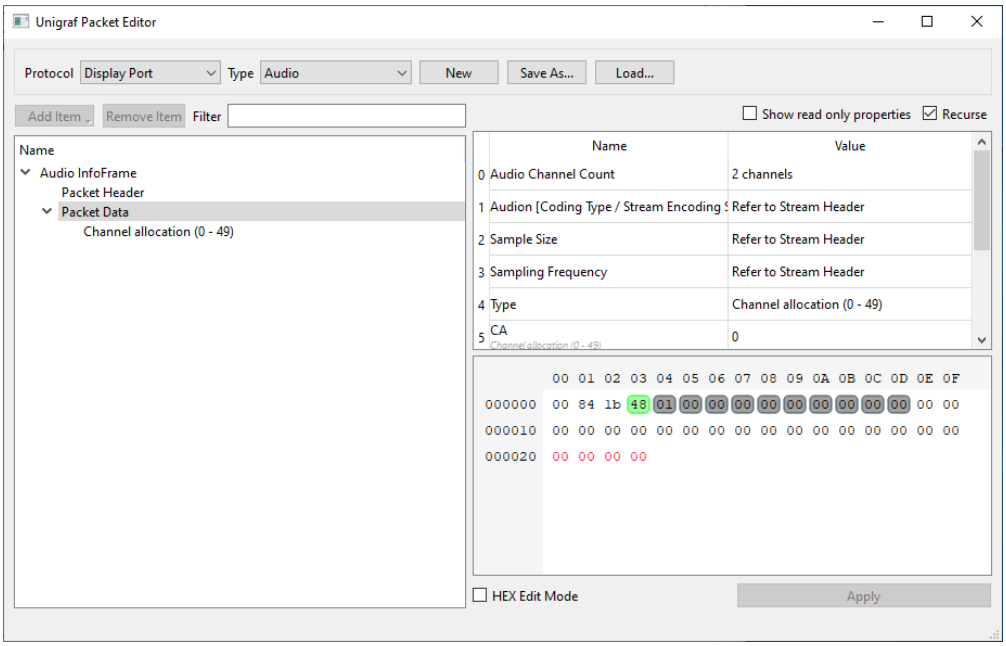
Floating point values must have a period "**.**" decimal separator.

Click *Set* after changing a bit-value presented as a single checkbox if you want the new value applied.

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

# 10. PACKET EDITOR

Packet Editor enables creation and editing metadata packets.




The types of supported packets are:

- Audio InfoFrame (Audio)
- AVI InfoFrame (AVI)
- Custom InfoFrame (Custom) (HDMI)
- Custom Packet (Custom) (DP)
- DR&M InfoFrame (DR&M) (HDMI)
- DR&M Packet (DR&M) (DP)
- EMP-VRR (EMP-VRR)
- GCP InfoFrame (GCP)
- SBTMEM Source-Based Tone Mapping Extended Metadata (HDMI)
- SPD InfoFrame (SPD)
- Vendor-Specific InfoFrame (VS) (HDMI)*
- Vendor-Specific SDP (VS) (DP)*

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

# 11. PATTERN EDITOR

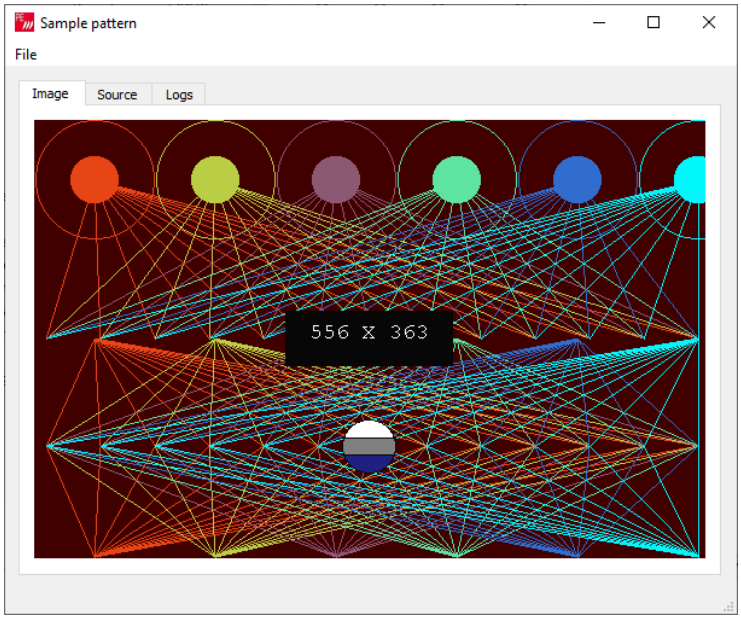
Pattern Editor is a tool for editing and debugging Unigraf Custom VTP Pattern scripts.

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

Pattern Editor consists of three tabs:

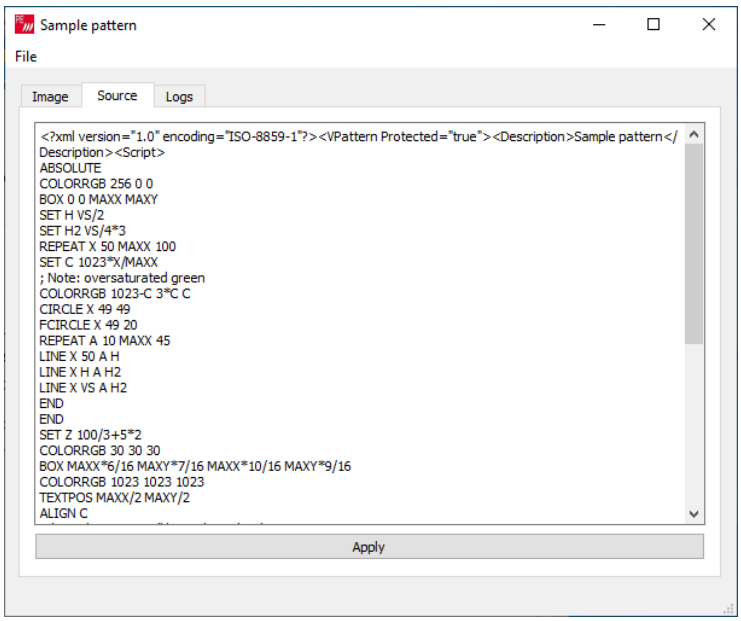
## Image Tab

Monitoring the rendering of the VTP pattern script.



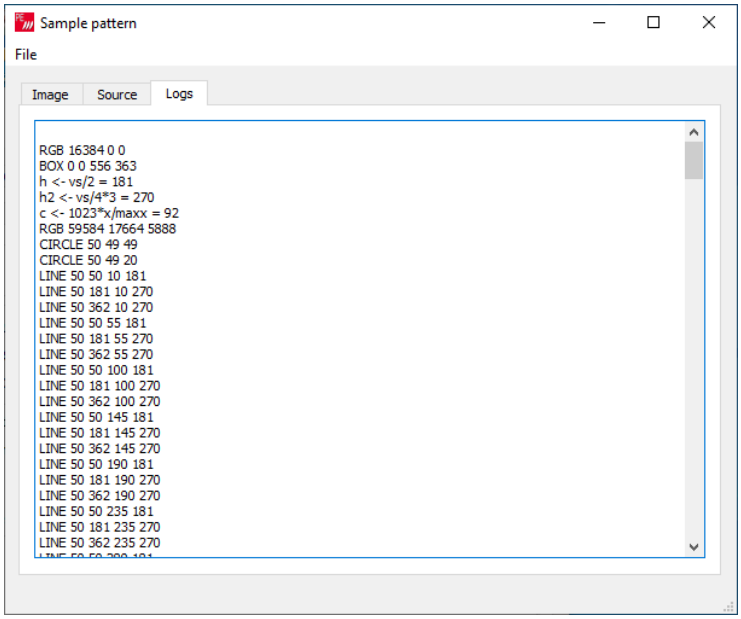

## Source Tab

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



## Logs Tab

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




## Saving and Recalling the Script

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

*Open:* Open a VTP language script from PC

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

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

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

# 12. IMAGE CONVERTER

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

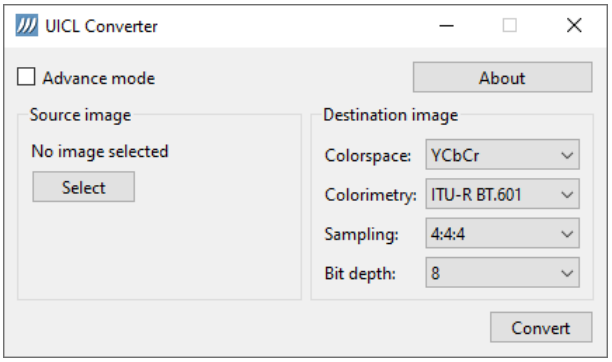
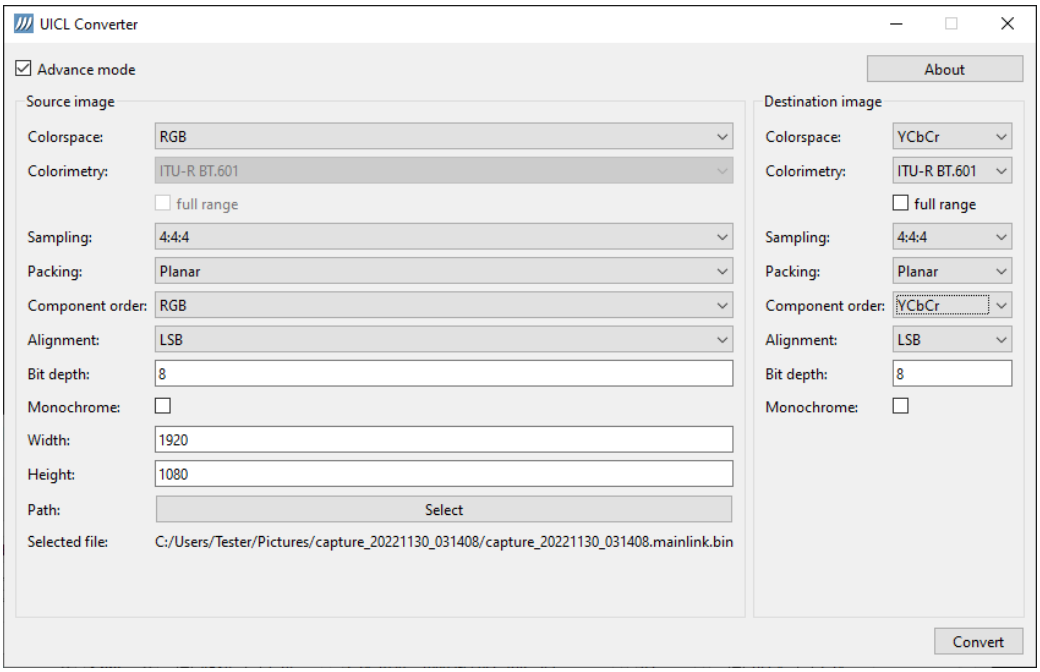



Image Converter has two operating modes: Standard mode and Advanced mode. In Standard mode typical image file formats are used as Source image and the user sets basic color formats for the Destination image. In Advanced mode, the user is able to define the Source and Destination image parameters in detail.

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




the Destination image is of form:

```
Source_image_1920x1080_8bits_yuv444_lsb.bin
```

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

# APPENDIX A: PRODUCT SPECIFICATION

## UCD-422 and UCD-412

| | |
|---|---|
| Input | HDMI 2.1 (10K@30Hz) (HDMI Rx) *(UCD-422 only)* |
| Output | HDMI 2.1 (10K@30Hz) (HDMI Tx) |
| HDMI 2.1 Features | FRL, TMDS, ALLM, VRR, QMS-VRR, SBTM |
| Content Protection | HDCP 2.2, HDCP 2.3 |
| Additional features | eARC, DSC*, FEC* |
| Computer interface | USB 3.0 |
| Operating System | Debian 11.0 or higher.<br>Ubuntu 20.04.4 LTS or higher.<br>MacOS Big Sur 11.7.10 or higher.<br>Windows 10 10.0.19045 or higher. |
| Power supply | AC/DC Power supply<br>(100 to 240 Vac 50/60 Hz input, +12 Vdc output) |
| Environmental | Operating temperature: 15 to 35 deg C<br>Storage temperature: 0 to 50 deg C<br>Humidity 30% to 70% RH, non-condensing |
| Mechanical Size | 272 × 170 × 60 mm |
| Weight | 1.2 kg w/o power supply |

*) Please contact Unigraf for detailed availability

# APPENDIX B: PRODUCT FEATURES

## UCD-422 Gen2, UCD-422 and UCD-412 Features

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

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

# Product Options

## UCD-412, UCD-422, UCD-422 Gen2 Product Options

| Product | P/N |
|---|---|
| HDR10+ DD and SSTM Tests for HDMI Sink DUT | MT6675 |
| HDR10+ DD and SSTM Tests for HDMI Source DUT | MT6677 |
| HDMI 1.4 Link Analyzer | MT6658 |

# APPENDIX C: PREDEFINED TIMINGS

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

*) CVT: Coordinated Video Timings (CVT; VESA-2021-09-27 v2.0)
DMT: VESA and Industry Standards and Guidelines for Computer Display Monitor Timings
CTA: A DTV Profile for Uncompressed High Speed Digital Interfaces (CTA-861-H)

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

*) CVT: Coordinated Video Timings (CVT; VESA-2021-09-27 v2.0)
DMT: VESA and Industry Standards and Guidelines for Computer Display Monitor Timings
CTA: A DTV Profile for Uncompressed High Speed Digital Interfaces (CTA-861-H)

| Description* | HA | VA | HT | VT | HST | VST | HSYN | VSYN | FR | Pixel Clock (MHz) |
|---|---|---|---|---|---|---|---|---|---|---|
| CTA 1920 × 1080 @ 48 Hz (VIC 111) | 1920 | 1080 | 2750 | 1125 | 192 | 41 | 44 | 5 | 48 | 148,50 |
| CTA 1920 × 1080 @ 48 Hz (VIC 112) | 1920 | 1080 | 2750 | 1125 | 192 | 41 | 44 | 5 | 48 | 148,50 |
| DMT 1920 × 1200 @ 60 Hz (ID 45h) | 1920 | 1200 | 2592 | 1245 | 536 | 42 | 200 | 6 | 60 | 193,62 |
| DMT 1920 × 1440 @ 60 Hz (ID 49h) | 1920 | 1440 | 2600 | 1500 | 552 | 59 | 208 | 3 | 60 | 234,00 |
| CVT 2048 × 1536 @ 60 Hz [RB1] | 2048 | 1536 | 2208 | 1580 | 112 | 41 | 32 | 4 | 60 | 209,32 |
| CTA 2560 × 1080 @ 24 Hz (VIC 86) | 2560 | 1080 | 3750 | 1100 | 192 | 16 | 44 | 5 | 24 | 99,00 |
| CTA 2560 × 1080 @ 25 Hz (VIC 87) | 2560 | 1080 | 3200 | 1125 | 192 | 41 | 44 | 5 | 25 | 90,00 |
| CTA 2560 × 1080 @ 30 Hz (VIC 88) | 2560 | 1080 | 3520 | 1125 | 192 | 41 | 44 | 5 | 30 | 118,80 |
| CTA 2560 × 1080 @ 50 Hz (VIC 89) | 2560 | 1080 | 3300 | 1125 | 192 | 41 | 44 | 5 | 50 | 185,63 |
| CTA 2560 × 1080 @ 100 Hz (VIC 91) | 2560 | 1080 | 2970 | 1250 | 192 | 166 | 44 | 5 | 100 | 371,25 |
| CVT 2560 × 1440 @ 60 Hz [RB2] | 2560 | 1440 | 2640 | 1481 | 72 | 14 | 32 | 8 | 60 | 234,59 |
| CVT 2560 × 1440 @ 60 Hz [RB1] | 2560 | 1440 | 2720 | 1481 | 112 | 38 | 32 | 5 | 60 | 241,70 |
| CVT 2560 × 1440 @ 144 Hz [RB3] | 2560 | 1440 | 2720 | 1543 | 152 | 14 | 32 | 8 | 144 | 604,57 |
| CVT 2560 × 1440 @ 200 Hz [RB3] | 2560 | 1440 | 2720 | 1586 | 152 | 14 | 32 | 8 | 200 | 863,09 |
| CTA 2560 × 1080 @ 48 Hz (VIC 113) | 2560 | 1080 | 3750 | 1100 | 192 | 16 | 44 | 5 | 48 | 198,00 |
| CVT 2560 × 1080 @ 60 Hz | 2560 | 1080 | 3424 | 1120 | 704 | 37 | 272 | 10 | 60 | 230,09 |
| CVT 2560 × 1080 @ 60 Hz [RB1] | 2560 | 1080 | 2720 | 1111 | 112 | 28 | 32 | 10 | 60 | 181,32 |
| CVT 2560 × 1080 @ 144 Hz [RB3] | 2560 | 1080 | 2720 | 1157 | 152 | 14 | 32 | 8 | 144 | 453,33 |
| CVT 2560 × 1080 @ 200 Hz [RB3] | 2560 | 1080 | 2720 | 1190 | 152 | 14 | 32 | 8 | 200 | 647,59 |
| CTA 2560 × 1080 @ 60 Hz (VIC 90) | 2560 | 1080 | 3000 | 1100 | 192 | 16 | 44 | 5 | 60 | 198,00 |
| CTA 2560 × 1080 @ 120 Hz (VIC 92) | 2560 | 1080 | 3300 | 1250 | 192 | 16 | 44 | 5 | 120 | 495,00 |
| DMT 2560 × 1600 @ 60 Hz (ID 4Dh) | 2560 | 1600 | 3504 | 1658 | 752 | 55 | 280 | 6 | 60 | 348,58 |
| DMT 2560 × 1600 @ 60 Hz (ID 4Ch) [RB1] | 2560 | 1600 | 2720 | 1646 | 112 | 43 | 32 | 6 | 60 | 268,63 |
| CTA 2880 × 240 @ 60 Hz (VIC 12) | 2880 | 240 | 3432 | 263 | 476 | 18 | 248 | 3 | 60 | 54,00 |
| CTA 2880 × 240 @ 60 Hz (VIC 13) | 2880 | 240 | 3432 | 263 | 476 | 18 | 248 | 3 | 60 | 54,00 |
| CTA 2880 × 288 @ 50 Hz (VIC 27) | 2880 | 288 | 3456 | 314 | 528 | 22 | 252 | 3 | 50 | 54,00 |
| CTA 2880 × 288 @ 50 Hz (VIC 28) | 2880 | 288 | 3456 | 314 | 528 | 22 | 252 | 3 | 50 | 54,00 |
| CTA 2880 × 480 @ 60 Hz (VIC 35) | 2880 | 480 | 3432 | 525 | 488 | 36 | 248 | 6 | 60 | 108,00 |
| CTA 2880 × 480 @ 60 Hz (VIC 36) | 2880 | 480 | 3432 | 525 | 488 | 36 | 248 | 6 | 60 | 108,00 |
| CTA 2880 × 576 @ 50 Hz (VIC 37) | 2880 | 576 | 3456 | 625 | 528 | 44 | 256 | 5 | 50 | 108,00 |
| CTA 2880 × 576 @ 50 Hz (VIC 38) | 2880 | 576 | 3456 | 625 | 528 | 44 | 256 | 5 | 50 | 108,00 |
| 2880 × 1440 @ 60 Hz | 2880 | 1440 | 2976 | 1456 | 48 | 8 | 8 | 1 | 60 | 259,98 |
| CVT 3440 x 1440 @ 60 Hz | 3440 | 1440 | 4688 | 1493 | 992 | 50 | 368 | 10 | 60 | 419.951 |
| CVT 3440 x 1440 @ 60 Hz [RB1] | 3440 | 1440 | 3600 | 1481 | 112 | 38 | 32 | 10 | 60 | 319.896 |
| CVT 3440 x 1440 @ 60 Hz [RB2] | 3440 | 1440 | 3520 | 1481 | 72 | 14 | 32 | 8 | 60 | 312.787 |
| CVT 3440 x 1440 @ 120 Hz | 3440 | 1440 | 4800 | 1545 | 1064 | 102 | 384 | 10 | 120 | 889.92 |
| CVT 3440 x 1440 @ 120 Hz [RB1] | 3440 | 1440 | 3600 | 1525 | 112 | 82 | 32 | 10 | 120 | 658.80 |
| CVT 3440 x 1440 @ 120 Hz [RB2] | 3440 | 1440 | 3520 | 1525 | 72 | 14 | 32 | 8 | 120 | 644.16 |
| CVT 3440 x 1440 @ 165 Hz | 3440 | 1440 | 4832 | 1588 | 1080 | 145 | 384 | 10 | 165 | 1266.081 |
| CVT 3440 x 1440 @ 165 Hz [RB1] | 3440 | 1440 | 3600 | 1559 | 112 | 116 | 32 | 10 | 165 | 926.046 |
| CVT 3440 x 1440 @ 165 Hz [RB2] | 3440 | 1440 | 3520 | 1559 | 72 | 14 | 32 | 8 | 165 | 905.467 |
| CVT 3440 x 1440 @ 200 Hz | 3440 | 1440 | 4848 | 1622 | 1088 | 179 | 384 | 10 | 200 | 1572.691 |
| CVT 3440 x 1440 @ 200 Hz [RB1] | 3440 | 1440 | 3600 | 1586 | 112 | 143 | 32 | 10 | 200 | 1141.92 |
| CVT 3440 x 1440 @ 200 Hz [RB2] | 3440 | 1440 | 3520 | 1586 | 72 | 14 | 32 | 8 | 200 | 1116.544 |
| CVT 3440 x 1440 @ 240 Hz | 3440 | 1440 | 4848 | 1663 | 1088 | 220 | 384 | 10 | 240 | 1934.934 |
| CVT 3440 x 1440 @ 240 Hz [RB1] | 3440 | 1440 | 3600 | 1619 | 112 | 176 | 32 | 10 | 240 | 1398.816 |
| CVT 3440 x 1440 @ 240 Hz [RB2] | 3440 | 1440 | 3520 | 1619 | 72 | 14 | 32 | 8 | 240 | 1367.731 |
| CVT 3840 × 2160 @ 30 Hz [RB1] | 3840 | 2160 | 4000 | 2191 | 112 | 28 | 32 | 5 | 30 | 262,92 |
| CVT 3840 × 2160 @ 30 Hz [RB2] | 3840 | 2160 | 3920 | 2191 | 72 | 14 | 32 | 8 | 30 | 257,66 |
| CVT 3840 × 2160 @ 60 Hz [RB1] | 3840 | 2160 | 4000 | 2222 | 112 | 59 | 32 | 5 | 60 | 533,28 |
| CVT 3840 × 2160 @ 60 Hz [RB2] | 3840 | 2160 | 3920 | 2222 | 72 | 14 | 32 | 8 | 60 | 522,61 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CVT 3840 × 2160 @ 60 Hz [RB3] | 3840 | 2160 | 4000 | 2222 | 152 | 14 | 32 | 8 | 60 | 533,47 |
| CTA 3840 × 2160 @ 60 Hz (VIC 97) | 3840 | 2160 | 4400 | 2250 | 384 | 82 | 88 | 10 | 60 | 594,00 |
| CTA 3840 × 2160 @ 24 Hz (VIC 93) | 3840 | 2160 | 5500 | 2250 | 384 | 82 | 88 | 10 | 24 | 297,00 |
| CTA 3840 × 2160 @ 25 Hz (VIC 94) | 3840 | 2160 | 5280 | 2250 | 384 | 82 | 88 | 10 | 25 | 297,00 |
| CTA 3840 × 2160 @ 30 Hz (VIC 95) | 3840 | 2160 | 4400 | 2250 | 384 | 82 | 88 | 10 | 30 | 297,00 |
| CTA 3840 × 2160 @ 50 Hz (VIC 96) | 3840 | 2160 | 5280 | 2250 | 384 | 82 | 88 | 10 | 50 | 594,00 |
| CTA 3840 × 2160 @ 24 Hz (VIC 103) | 3840 | 2160 | 5500 | 2250 | 384 | 82 | 88 | 10 | 24 | 297,00 |
| CTA 3840 × 2160 @ 25 Hz (VIC 104) | 3840 | 2160 | 5280 | 2250 | 384 | 82 | 88 | 10 | 25 | 297,00 |
| CTA 3840 × 2160 @ 30 Hz (VIC 105) | 3840 | 2160 | 4400 | 2250 | 384 | 82 | 88 | 10 | 30 | 297,00 |

*) CVT: Coordinated Video Timings (CVT; VESA-2021-09-27 v2.0)
DMT: VESA and Industry Standards and Guidelines for Computer Display Monitor Timings
CTA: A DTV Profile for Uncompressed High Speed Digital Interfaces (CTA-861-H)

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

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| CVT 7680 × 4320 @ 30 Hz [RB1] | 7680 | 4320 | 7840 | 4381 | 112 | 58 | 32 | 5 | 30 | 1030,41 |
| CVT 7680 × 4320 @ 60 Hz [RB2] | 7680 | 4320 | 7760 | 4443 | 72 | 14 | 32 | 8 | 60 | 2068,66 |
| CVT 7680 × 4320 @ 100 Hz [RB2] | 7680 | 4320 | 7760 | 4529 | 72 | 14 | 32 | 8 | 100 | 3514,50 |
| CVT 7680 × 4320 @ 60 Hz [RB1] | 7680 | 4320 | 7840 | 4443 | 112 | 120 | 32 | 5 | 60 | 2089,99 |
| CVT 7680 × 4320 @ 100 Hz [RB1] | 7680 | 4320 | 7840 | 4529 | 112 | 206 | 32 | 5 | 100 | 3550,74 |
| CTA 7680 × 4320 @ 120 Hz (VIC 201) | 7680 | 4320 | 8800 | 4500 | 768 | 164 | 176 | 20 | 120 | 4752,00 |
| CTA 7680 × 4320 @ 120 Hz (VIC 209) | 7680 | 4320 | 8800 | 4500 | 768 | 164 | 176 | 20 | 120 | 4752,00 |
| CTA 7680 × 4320 @ 30 Hz (VIC 204) | 7680 | 4320 | 9000 | 4400 | 768 | 64 | 176 | 20 | 30 | 1188,00 |
| CTA 7680 × 4320 @ 30 Hz (VIC 196) | 7680 | 4320 | 9000 | 4400 | 768 | 64 | 176 | 20 | 30 | 1188,00 |
| CTA 7680 × 4320 @ 60 Hz (VIC 207) | 7680 | 4320 | 9000 | 4400 | 768 | 64 | 176 | 20 | 60 | 2376,00 |
| CTA 7680 × 4320 @ 60Hz (VIC 199) | 7680 | 4320 | 9000 | 4400 | 768 | 64 | 176 | 20 | 60 | 2376,00 |

*) CVT: Coordinated Video Timings (CVT; VESA-2021-09-27 v2.0)
DMT: VESA and Industry Standards and Guidelines for Computer Display Monitor Timings
CTA: A DTV Profile for Uncompressed High Speed Digital Interfaces (CTA-861-H)

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

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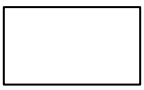
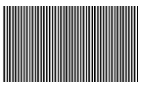
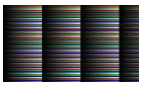
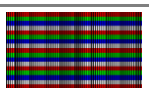
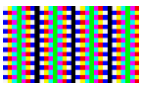
# APPENDIX D: PREDEFINED PATTERNS

## Fixed Patterns

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

## Extended Patterns

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

## Extended Patterns (cont.)

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

## Extended Patterns (cont.)

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

## Extended Patterns (cont.)

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

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

# APPENDIX E: SINK, SOURCE AND REPEATER TESTS

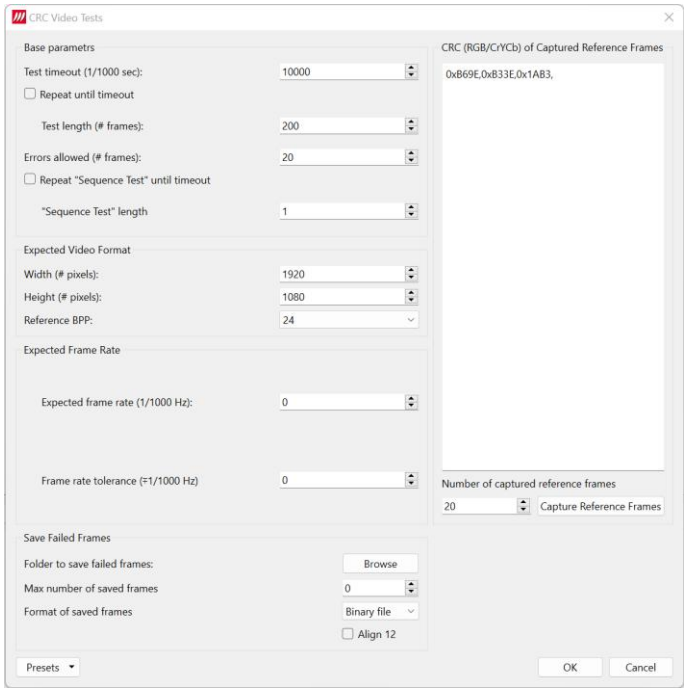
| Source DUT Testing | | Default | HDCP 2.3 CTS* | HDR10+ Distribution Device Tests |
|---|---|---|---|---|
| Audio Test | Validate audio signal frequency and glitch-free audio reproduction | ● | | |
| CEC Functional Test Set | CEC functional test, CEC PHY Addr test,<br>CEC Complete test, CEC Wake up test,<br>CEC Standby test | ● | | |
| CRC Video Tests | CRC based single frame reference video test,<br>CRC based single frame stability test,<br>CRC based sequence of frames reference video test<br>CRC based continuous sequence of frames reference video test | ● | | |
| Pixel Level Video Tests | Compare video frame sequence with a single reference | ● | | |
| VRR Source DUT Tests (HDMI) | VRR static test, QMS Test, VRR Dynamic test | ● | | |
| HDR10+ Distribution Device Tests | Tests from:<br>*HDR10+ TEST SPECIFICATION, HDR10+ Distribution Device* | | | ● |
| HDR10+ SSTM Tests for Source | Tests from:<br>*HDR10+ TEST SPECIFICATION, Source Side Tone Mapping for Source Device* | | | ● |

| Sink DUT Testing | | Default | HDR10+ DD & SSTM CTS |
|---|---|---|---|
| VRR Sink DUT Tests | VRR static test, QMS Test, VRR Dynamic test | ● | |
| HDR10+ CTS Tests | HDR10+ Display Device and SSTM Tests | | ● |
| Cable test | Cable Test Check | ● | |
| Connection test | Connection test | ● | |

# CRC Video Tests – HDMI Rx

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

## Configuration




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

## CRC Based Single Reference Frame Video Test

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

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

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

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

### Parameters in use

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

## CRC Based Single Frame Video Stability Test

The test verifies that the captured video is stable.

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

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

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

### Parameters in use

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

## CRC Based Sequence of Reference Frames Test

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

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

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

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

### Parameters in use

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

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

## CRC Based Continuous Sequence of Reference Frames Test

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

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

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

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

### Parameters in use

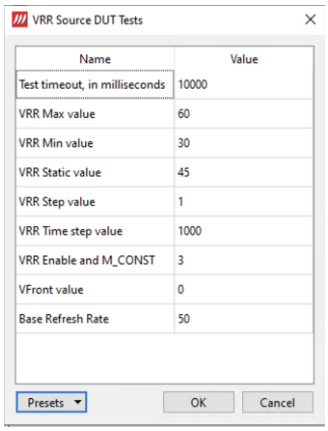
- Test Timeout (default 10 000 ms)
- Number of frames to be tested (default 20)
- Number of iterations
- Reference width (default 1920)
- Reference height (default 1080)
- Reference BPP (default 24)
- Expected frame rate (mHz, 1/1000 Hz)
- Frame rate tolerance (mHz, 1/1000 Hz)
- Expected color format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

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

# VRR Source DUT Tests – HDMI Rx

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

## Configure




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

### VRR Static Test

Test verifies that DUT Source applies expected static VRR value.

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

### Quick Media Switching (QMS) Test

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

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

### VRR Dynamic Test

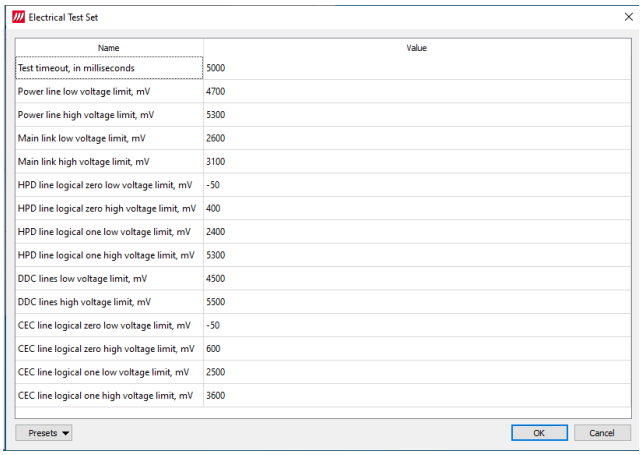
Verify that VRR is set correctly when frame rate is changing with each frame. For example, change VRR from 60 to 120 Hz with step 1 each frame.

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

# Electrical Test Set – HDMI Rx

| Role: | Product: |
|---|---|
| HDMI Reference Sink (HDMI RX) | UCD-301 |

Electrical Tests verify the continuity of the interface signals and the voltage levels applied by the




driving electronics.

## Power Test

*Power Test* verifies the voltage level on the +5 V power line (Pin 18) of the DUT source. The accepted value in HDMI specification is 4.7 V to 5.3 V on the sink side connector. (Called “TP2” in the HDMI specification).

The test will measure the power line voltage using two loads: 0 mA and 55 mA. The latter is the test setup in HDMI CTS specification (HDMI CTS 1.4b: Test ID 7-11: +5V Power). The test will fail if voltage level on the power line is below or above the voltage range set by the parameters.

### Parameters in use

- Test Timeout (default 5 000 ms)
- Power line low voltage limit (default 4 700 mV)
- Power line high voltage limit (default 5 300 mV)

## TMDS Test

*TMDS Test* verifies average voltage levels on TMDS signal lines (8 lines: CLK+/-, D0+/- D1+/- and D2+/-). The positive and negative lines of the TMDS differential pair are measured separately.

TMDS uses DC balanced signaling. Sink pulls the lines up to 3.3 V (AVcc) and source applies the TMDS signal by pulling the line down to ground. On an active TMDS line average voltage level is half of the voltage swing below AVcc (AVcc – Vswing/2). By default, 2.6 V to 3.1 V.

TMDS line voltages outside of the above range might indicate an abnormal situation like short circuit of two TMDS lines, short to ground, open circuit or a broken output driver.

If the measured values fall outside the criteria set by the parameters, test result is FAIL.

| Note: | Fail criteria for each test set-up should be considered separately depending on the source DUT and test cable configuration. |
|---|---|

### Parameters in use

- Test Timeout (default 5 000 ms)
- Main link low voltage limit (default 2 600 mV)
- Main link high voltage limit (default 3 100 mV)

# Audio Test Set – HDMI Rx

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

## Validate audio signal frequency and glitch-free audio reproduction

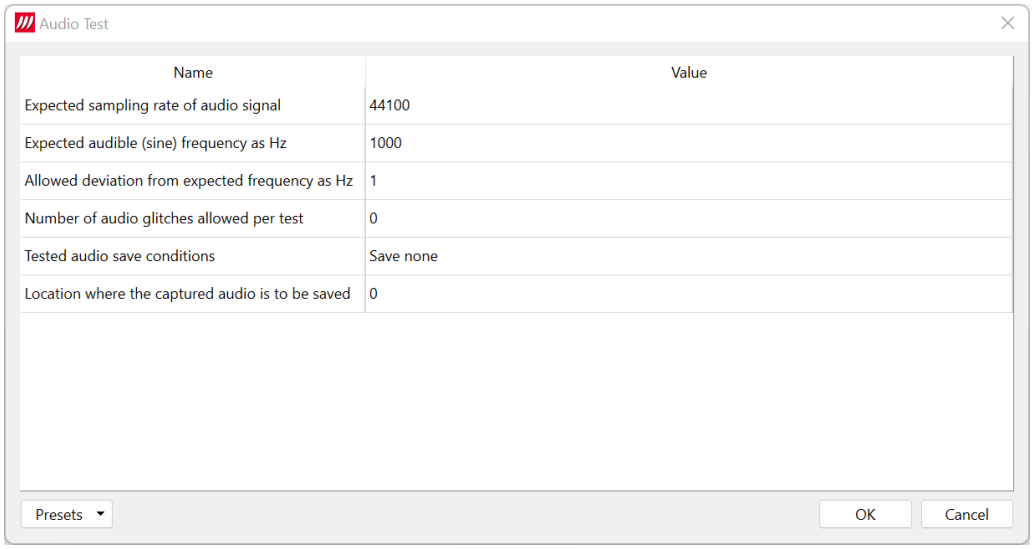
Perform frequency check on the digital audio content and verify the content to be glitch-free. This test assumes that a pure sine-wave audio signal content is being transmitted to the test equipment.

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

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

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

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




### Parameters in use

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

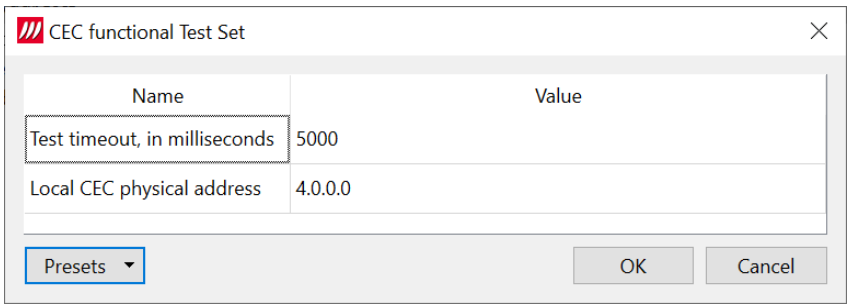
Click **Location where the captured audio is to be saved** to browse for the folder to store tests.

# CEC Functional Tests Set – HDMI Rx

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

## Parameters in use

- Test timeout, in milliseconds
- Local CEC physical address




### CEC Functional Test

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

### CEC Phy Address test.

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

### CEC Wake Up test

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

### CEC Stand By test

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

### CEC Complete test

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

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

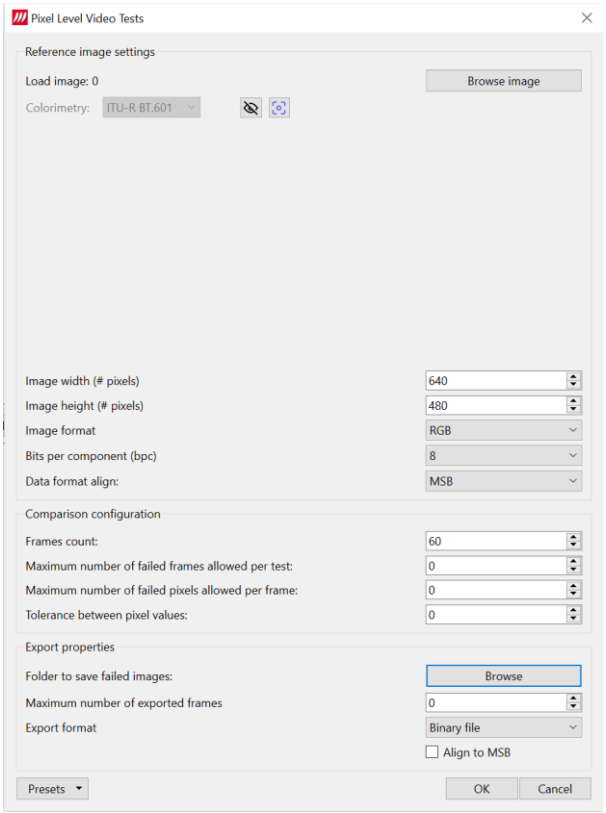
| Note: | As a side effect, the CEC will also verify functionality of HPD and EDID reading if the test passes. |
|---|---|

# Pixel Level Video Tests – HDMI Rx

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

## Compare video frame sequence with a single reference

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




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

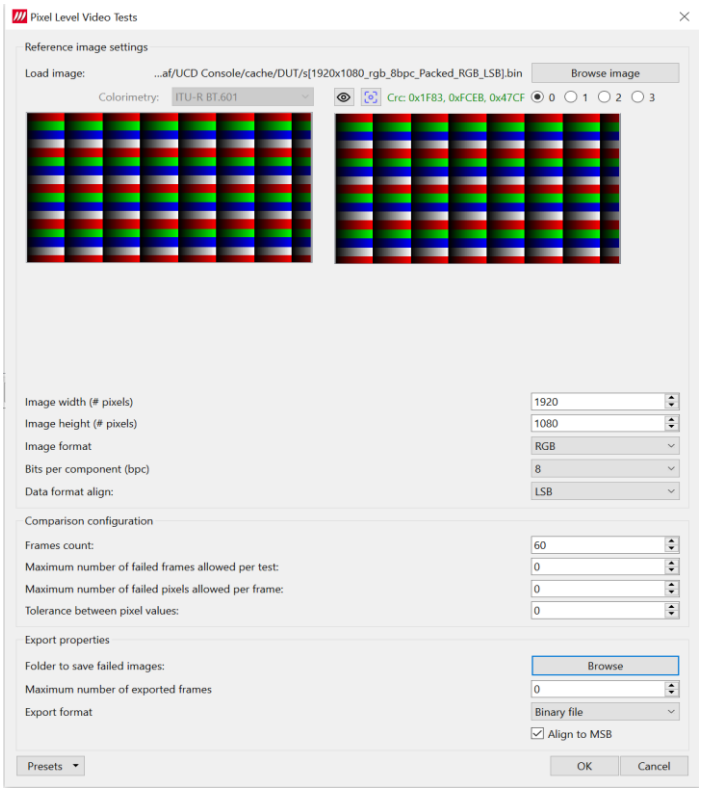
- The color component values of each pixel in the captured frame is compared to the corresponding pixels in the reference image.
- If the difference is larger than the provided tolerance, the pixel is considered failed.
- If the number of failed pixels in a frame is larger than the provided tolerance,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

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

## Capturing Reference Image

User can capture received video as reference:

1. In *Settings* dialog click the enable live preview icon .

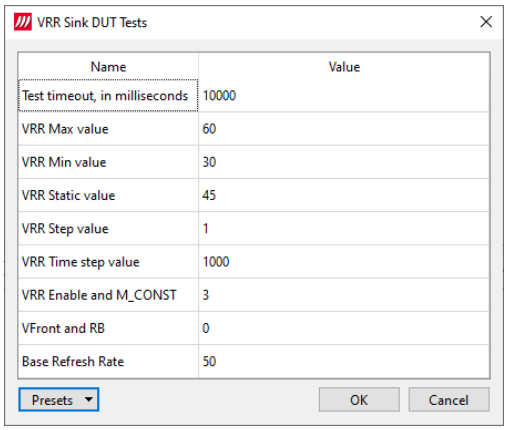


2. When the preview has been enabled click the *Capture reference* icon  to store a frame and use it as reference. Before accepting the frame, stability of the video is verified with a CRC stability check. Captured CRC can also be verified by the user.

# VRR Sink DUT Tests – HDMI Tx

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

## Configure




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

### Static VRR Test

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

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

### Quick Media Switching (QMS) Test

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

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

### Dynamic Test

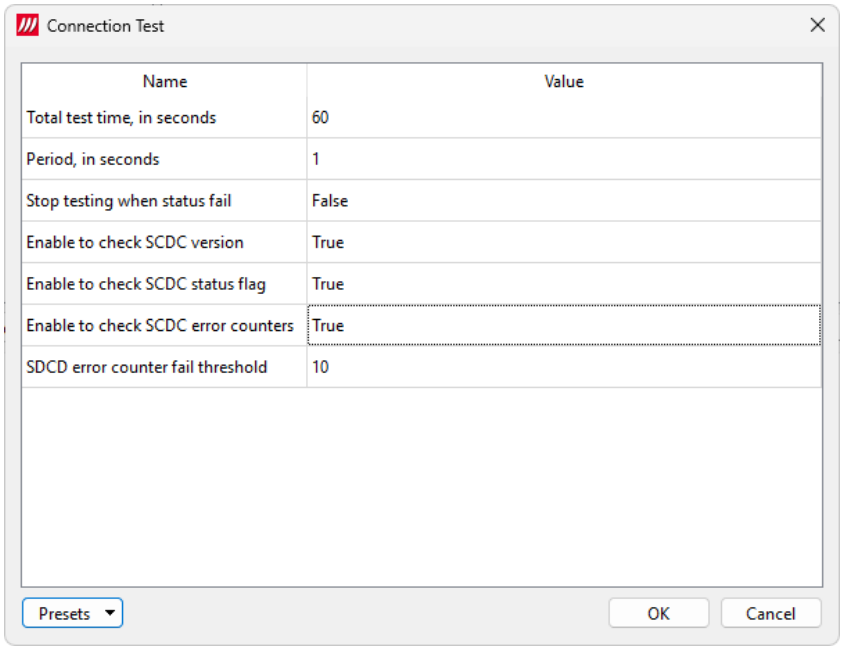
Verify that VRR is set correctly when frame rate is changing with each frame. For example, change VRR from 60 to 120 Hz with step 1 each frame.

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

# Connection Test – HDMI Tx

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

## Configure




| | |
|---|---|
| *Total test time, in seconds:* | Set total test time in seconds |
| *Period, in seconds:* | Set periods in seconds |
| *Stop testing when status fail:* | Set False / True |
| *Enable to check SCDC version:* | Set False / True |
| *Enable to check SCDC status flag:* | Set False / True |
| *Enabl to check SCDC error counters:* | Set False / True |
| *SCDC error counter fail threshold:* | Set threshold for error counter failure |

# Cable Test – HDMI Tx

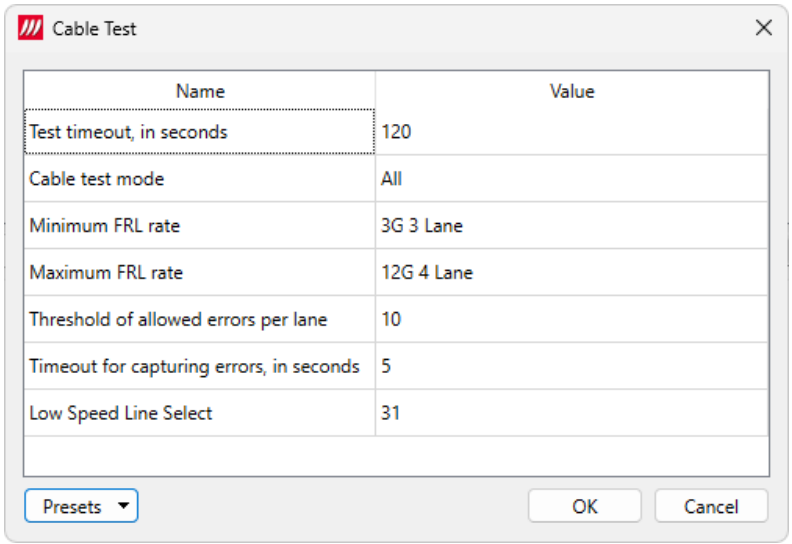
| Role: | Product: |
|---|---|
| HDMI Reference Source (HDMI TX) | UCD-422 |

## Cable Check Test

Test is intended to check that cable can be properly used with UCD-422. Cable should be connected in loopback mode.

Test tries to pass Link training on different rates. If errors are presented on the lanes, then TE applies different FFE level to find configuration where is the best quality (minimum of errors).
If Link training can be done without errors on all link rates then cable quilified as acceptable for usage with UCD-422.

Configure




| | |
|---|---|
| *Test timeout, in seconds:* | Timelimit for the test |
| *Cable test mode:* | High speed can include detection errors on the high speed lanes. Low speed - detect that i2c and ddc lanes are working properly. All modes checks both High speed and low speed. |
| *Minimum FRL rate:* | Determine minimum of range for detection of cable quility |
| *Maxmum FRL rate:* | Determine maximum of range for detection of cable quility |
| *Treshold of allowed errors per lane:* | Determine allowed number of errors |
| *Timeout for capturing errors, in seconds:* | Determine period for screening errors |
| *Low speed line select:* | Configure witch lines of Low speed will be checked. |

# APPENDIX F: VTP PATTERN LANGUAGE

## General

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

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

### Terminology

The following terms are used in this document:

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

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

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

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

### Notation

The following notation is used in this document:

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

### Syntax rules

The following general syntax rules apply to VTP language files:

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

# Commands

## Scaling commands

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

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

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

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

### ABSOLUTE

```
Syntax: ABSOLUTE
```

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

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

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

### SCALED

```
Syntax: SCALED
```

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

## Graphics Drawing Commands

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

### LINE

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

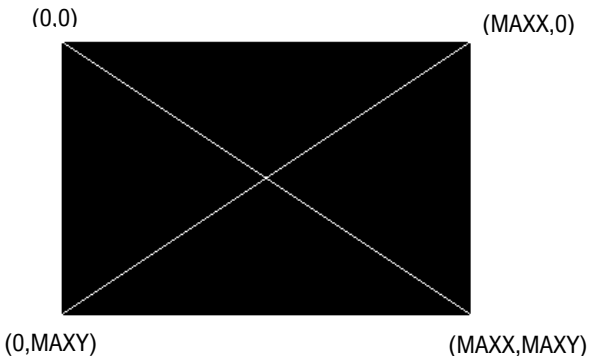
Draws a line from point (x1,y1) to point (x2,y2).

Example:

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

*ABSOLUTE ; Set scaling mode to absolute*
*COLORDEPTH 8 ; 8 bits per color*
*COLORRGB 255 255 255 ; white*
*LINE 0 0 MAXX MAXY ; Draw a line from upper left to lower right corner*
*LINE 0 MAXY MAXX 0 ; Draw a line from lower left to upper right corner*
*Or if you want a fixed size for 640 x 480 resolution*
*LINE 0 0 639 479*
*LINE 0 479 639 0*

The pattern will look like this:




Using SCALED instead of ABSOLUTE.

*SCALED*
*COLORDEPTH 8*
*COLORRGB 255 255 255*
*LINE 0 0 10000 10000*
*LINE 0 10000 10000 0*

### BOX

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

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

Example:

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

*SCALED*
*COLORDEPTH 8*
*COLORRGB 255 255 255*
*BOX 0 0 10000 10000*

## DOT

```
Syntax: DOT x y
```

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

## FILL

```
Syntax FILL x y
```

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

## CIRCLE

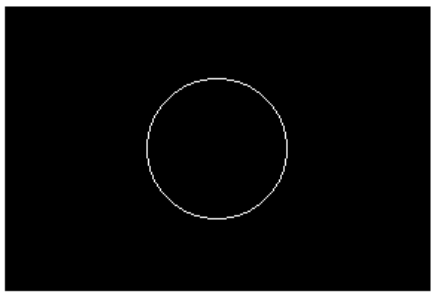
```
Syntax: CIRCLE x y r
```

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

Example:

*SCALED*
*COLORDEPTH 8*
*COLORRGB 255 255 255*
*CIRCLE 5000 5000 2500*

The pattern will look like this:

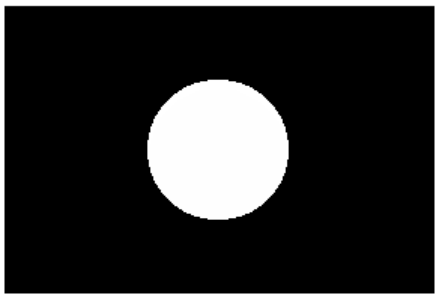


## FCIRCLE

Syntax: FCIRCLE x y r

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

The pattern will look like this:



### ELLIPSE

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

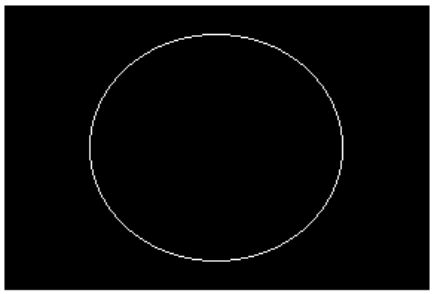
Draws an ellipse with center point at (x,y), horizontal radius hr and vertical radius vr.

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

Example:

*SCALED*
*COLORDEPTH 8*
*COLORRGB 255 255 255*
*ELLIPSE 5000 5000 3000 4000*

The pattern will look like this:



## Text Drawing Commands

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

### TEXTPOS

```
Syntax: TEXTPOS x y
```

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

### TEXT

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

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

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

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

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

Example:

*ABSOLUTE*
*COLORDEPTH 8*
*COLORRGB 255 255 255*
*TEXTPOS 100 100* *; Text starting point 100 pixels from left edge and*
*; 100 display lines down from top*
*TEXT “HRES=” HR “ PIXELS”* *; This will draw the text HRES then the value of variable HR*
*; and PIXELS*
*TEXT “Quote character \” and backslash \\”*

## Program Flow Commands

### REPEAT

```
Syntax: REPEAT <variable> a b s
```

All commands after between REPEAT and END command are repeated the number of times defined by <variable>. <variable> is set to value a before starting the first iteration loop. At the end of each iteration, variable is incremented by s (variable = variable + s). The REPEAT is terminated when variable reaches or exceeds value b, and the execution continues from the command following the END command. For example:

*SCALED*
*COLORDEPTH 8*
*COLORRGB 255 255 255*
*REPEAT W 0 10000 200*
*LINE W 0 W 10000*
*END*

A maximum of 2 REPEAT loops can be nested (placed inside each other).

### END

Syntax: END

This command follows a REPEAT command and defines a group of instructions to be repeated.

## Color Commands

The user can assign the used colors in two basic ways: either by giving the actual Red, Green and Blue (or R, G and B) color component values or using pre-defined color palettes. The first method is referred as True Color Mode and the latter as Palette Mode.

In True Color Mode the numerical values given for R, G and B will be the actual output signal intensity values for the pixel in question. The numerical color value in Palette Mode will act as an address (or index) to a pre-defined color in a 256 color table. The output signal intensity will be the R, G and B value entry in the cell where the address points to.

Palette mode can only be used with True Color Mode is .

### COLORDEPTH

```
Syntax: COLORDEPTH n
```

The command is used in True Color Mode (COLORMODE 2), to define the number of bits used for each color component (R, G and B) of the data to be displayed. Possible values for the parameter n are 6, 8, 10 and 12. If COLORDEPTH command is not used, 10 bits per color is used.

Example: To display a bitmap that uses 8 bits for r, g and b (24-bit colors) you have to use COLORDEPTH 8.

| Command | Nr of color bits | Range of values for R, G and B |
|---|---|---|
| COLORDEPTH 6 | 18 | 0 to 63 |
| COLORDEPTH 8 | 24 | 0 to 255 |
| COLORDEPTH 10 | 30 | 0 to 1023 |
| COLORDEPTH 12 | 36 | 0 to 4095 |

COLORDEPTH can be used only once in a VTP file, and it has to be placed before all drawing instructions it is supposed to affect.

### COLORRGB

```
Syntax: COLORRGB r g b
```

The command defines the foreground color used for the following drawing commands. The command is used in True Color Mode only.

The range of values for r, g and b depends on the bits per color used. If not changed with COLORDEPTH command, 10 bits per color is used. Please refer to COLORDEPTH command for range of values.

## Various Commands

### SET

```
Syntax: SET <variable> n
```

Assigns value n to programming variable called variable. n must be a positive number or zero.

# Variables

## Timing Variables

| Timing Variable | Value name |
|---|---|
| HF | Drawing resolution horizontal size minus one |
| HP | Drawing resolution vertical size minus one |
| HR | Current timing horizontal frequency (MHz?) |
| HA | Current timing horizontal period (pixels) |
| HS | Current timing horizontal resolution (pixels) |
| HBP | Current timing horizontal active time (pixels) |
| HFP | Current timing horizontal sync length (pixels) |
| VF | Current timing horizontal back porch length (pixels) |
| VP | Current timing horizontal front porch length (pixels) |
| VR | Current timing vertical frequency (MHz?) |
| VA | Current timing vertical period (lines) |
| VS | Current timing vertical resolution (lines) |
| VBP | Current timing vertical active time (lines) |
| VFP | Current timing vertical sync length (lines) |
| PF | Current timing vertical back porch length (lines) |
| HLB | Current timing vertical front porch length (lines) |
| HRB | Pixel frequency (Mpps?) |
| VTB | Drawing resolution horizontal size minus one |
| VBB | Drawing resolution vertical size minus one |

## Expressions

Any command numeric parameter can be replaced by an expression, according to the syntax below:

<term> ::= <variable> | <constant> | <number>

<expression> ::= <term> { '+' | '-' | '*' | '/' | '%' }  <term>

<parameter> ::= <term> | <expression>

Some example of legal parameter values:

*B*
*MAXX*
*342*
*B + MAXX*
*B / 2*
*B * C*

Expressions have always positive integers or zero value. When an expression evaluates to a negative value, it is set automatically to zero. Number values are also always positive integers or zero.

## Assignments

A variable can be assigned a numerical value by using the SET command.

The second parameter of the SET command can be replaced by an expression thus allowing commands like those here below:

*SET C B+MAXX*
*SET K K+1*
*SET K A+B*

## Default state at VTP execution startup

| | |
|---|---|
| *Coordinate system:* | ABSOLUTE |
| *Foreground color:* | 1023 1023 1023 |
| *Background color:* | 0 0 0 |
| *Image:* | Output image is cleared (all black) |
| *Variables:* | All variables are initialized to zero |
| *Color depth:* | COLORDEPTH 10 |

# APPENDIX G: FIRMWARE UPDATE WITH QUARTUS

The chapter below describes a procedure for updating UCD-4XX Series Firmware when the normal FW Update procedure fails.

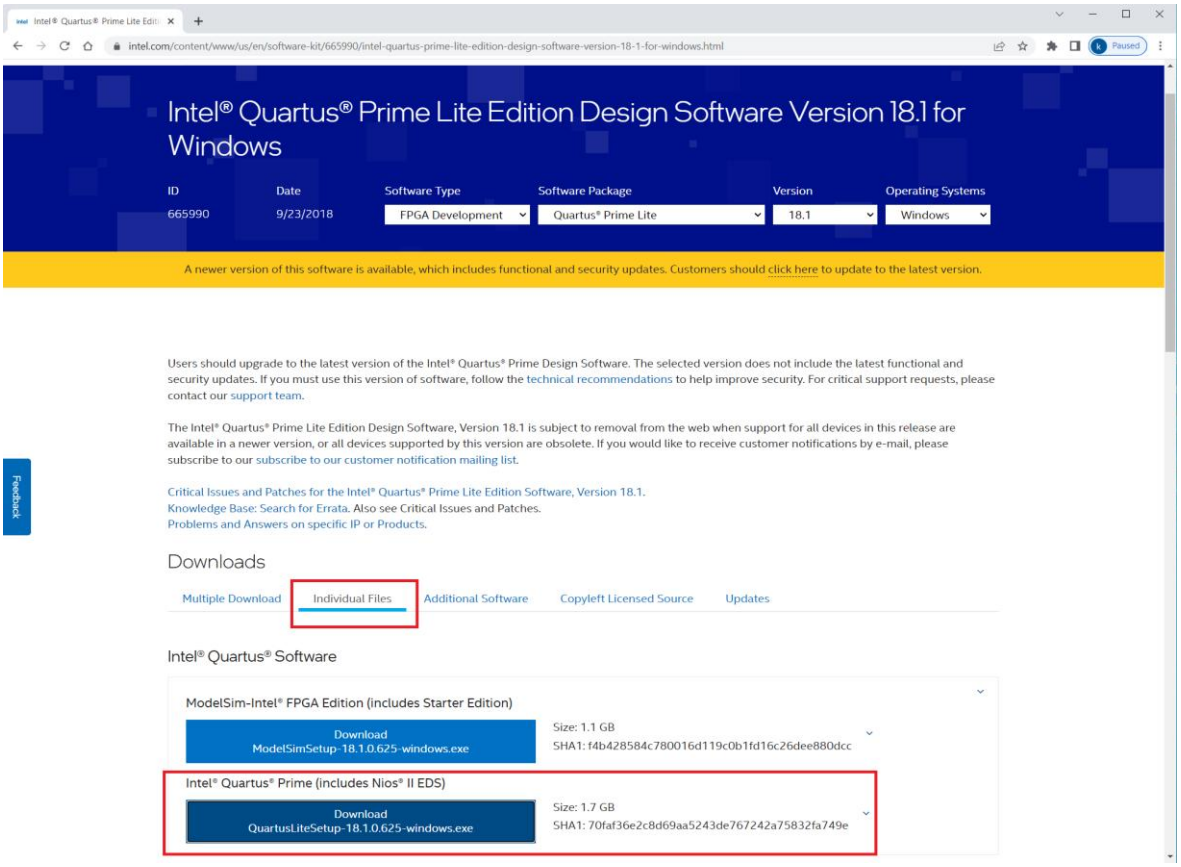
| Note | The firmware recovery procedure is only available for Windows operating system. |
|---|---|

## Downloading Tools

The Recovery patch is programmed to UCD Device with a separate tool called **Intel® Quartus® Prime Lite Edition Design Software Version 18.1 for Windows**. The tool can be downloaded from the **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

1. On the download page, please select section "**Individual Files**". Please download the software under "**Intel® Quartus® Prime (includes Nios® II EDS)**".

2. Please download and install the tool using defaults on the PC.




## Step 1

1. Connect the UCD device to the power supply and switch on power.
2. Connect the UCD device with a USB cable to the PC through USB connector (Please refer to chapter **Product Description** > **Connections** earlier in this document).
3. Please locate the *UCD-4xx_recovery.*zip file. By default the file is at C:\Program Files\Unigraf\Unigraf UCD Tools\recovery.

4. Extract the content of the ZIP file in a folder on your PC (e.g., C:\Temp).
5. Open Windows **Command Prompt** application.
6. Navigate to the directory to where the ZIP file was extracted (e.g. *cd \Temp*).
7. Connect a micro-USB cable to the **JTAG** connector on the UCD device (Please refer to chapter **Product Description** > **Connections** earlier in this document).
8. In the directory where the ZIP file was extrected (e.g. c:\Temp) please edit file **recovery.bat**
9. On line three, the parameter “QUARTUS_DIR” is set to point to the folder where the Qartus Programmer was installed (by default **C:\intelFPGA_lite\18.1**). Edit and save as needed.

recovery4xx.bat

```
@ECHO OFF

SET QUARTUS_DIR=C:\intelFPGA_lite\18.1
SET QUARTUS_BINS=%QUARTUS_DIR%\quartus\bin64
setlocal ENABLEDELAYEDEXPANSION

if EXIST %QUARTUS_DIR%\ (

  ECHO ------------------------------------------------------------
  ECHO Programming a10_isp.sof to FPGA. Wait for ~1-2 minutes
  ECHO ------------------------------------------------------------
  call %QUARTUS_BINS%\jtagconfig.exe --setparam 1 JtagClock 6000000

  if !ERRORLEVEL! EQU 0 (
  ECHO ------------------------------------------------------------
  ECHO Set parameter 1 JtagClock 6000000 - SUCCESS
  ECHO ------------------------------------------------------------
  ) else (
  ECHO ------------------------------------------------------------
  ECHO Set parameter 1 JtagClock 6000000 - FAIL
  ECHO ------------------------------------------------------------
  exit !ERRORLEVEL!
  )

  %QUARTUS_BINS%\quartus_pgm.exe -c 1 --mode=JTAG --operation="p;a10_isp.sof@1"

  if !ERRORLEVEL! EQU 0 (
  ECHO ------------------------------------------------------------------------------------
  ECHO Please check if a10_isp.sof was programmed successfully, i.e. no errors on log above
  ECHO Please run FW update utility to complete recovery procedure
  ECHO ------------------------------------------------------------------------------------
  ) else (
  ECHO ------------------------------------------------------------
  ECHO Programming operation - FAIL
  ECHO ------------------------------------------------------------
  exit !ERRORLEVEL!
  )
) else (
  ECHO "%QUARTUS_DIR% directory does not exist. Find Quartus programming tool location and correct QUARTUS_DIR variable in the script
```

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

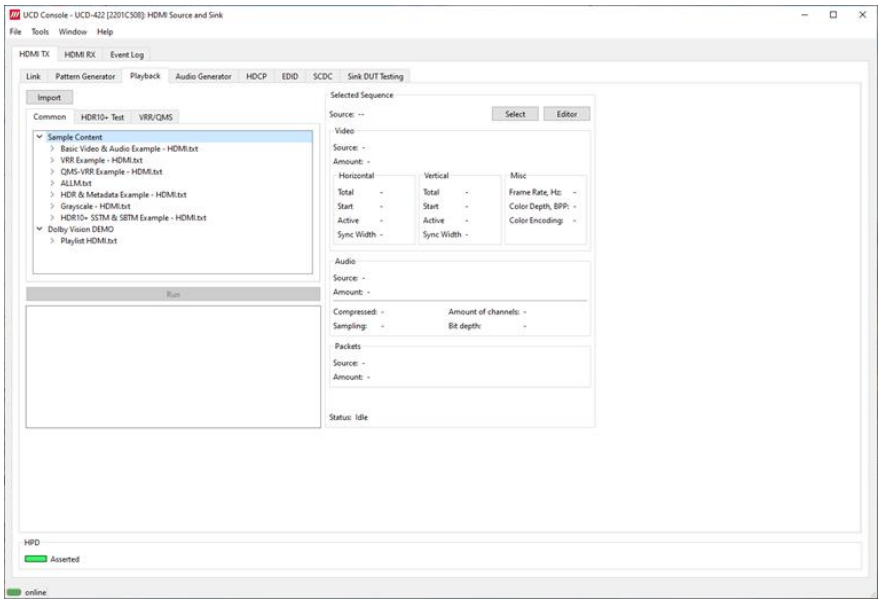
## Step 2

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

After Recovery procedure has completed, you can delete the files (in e.g., C:\Temp).

# APPENDIX H: PLAYLISTS AND SCENARIOS

UCD Console's Playback enables you to run scripts called playlists. Use playlists to stream video, audio and metadata. See the Unigraf UCD Console Playback Tutorial at www.unigraf.fi/resource/tutorial-run-edit-and-create-sdr-and-hdr-scenarios-with-unigrafs-playback-tool/



## Playlist

A *Playlist* is a text script consisting of a *[Device]* block and *[Scenario]* block(s). *A [Device]* block lists the serial number of the device and *connectortype* (such as a displayport transmitter). *[Scenarios]* blocks have a *caption* (which are used to display sample content), a period (*Scenario* duration in milliseconds) and a relative path to a script text file (ex. Scenario_PSR1_Entry_N.txt). Scenarios are played in sequence.

## Scenario

A *scenario* is a script text file to specify a sequence of video frames, metadata packets and audio to be transmitted.

## Frame Memory

Before transmission content is loaded to frame memory buffer of the UCD device. Frame buffer memory limits content (number of frames) that can be played. UCD-5XX devices by default feature 16 gigabytes of memory. This enables loading up to 320 4K or 80 8K video frames. Contact Unigraf for information for larger frame buffer sizes.

## Sample Content

You can us sample content as a basis for creating custom test sequences: see UCD Console *Playback* tab. Sample content is stored by default (on Windows) at *C:\Program Files\Unigraf\Unigraf UCD Tools\Resources\playback\content*. See Sample Content in Playback in this Appendix.

# Playlists

A *playlist* defines the UCD device to be used and the output destination for transmission. It lists *scenarios* the played (video and audio sequences including metadata) to be transmitted and their duration.

Note: *Playlists* and *Scenarios* are technology dependent. Metadata (or packets) differ for HDMI and DisplayPort.

## Device block

Section describes what device and what output connector to use.

| Key | Description | Possible values |
|---|---|---|
| [Device] | Required. Start of the Device block. | |
| serialnumber | Required. Specifies serial number of the UCD device. The '*' wildcard can be used if only one UCD source device is connected to the PC. | '*'<br>'1722C333' |
| connectortype | Required. Specifies output connector type to be used. Playlists shall not contain scenarios for different connector types. | 'HDMI Out'<br>'DisplayPort Out'<br>'USBC Out' |
| reset | Only applies to UCD-323. | |

## Scenario block

Section describes selected scenario and its playback parameters. Playlist runs scenarios in the order they are listed.

| Key | Description | Possible values |
|---|---|---|
| [Scenario] | Required. Start of a *Scenario* block. *Playlists* can have multiple *Scenario* blocks. | |
| caption | Optional. Title. Any character string accepted. | 'Scenario 1' |
| path | Required. Specifies relative path to scenario file. | Any valid path |
| period | Required. Duration of Scenario in msec. The duration is ignored if close-after-upload is set to '1'. | '60000'<br>'5000' |
| close-after-upload | Optional. When set to '1', command line version of the Playback tool will exit after loading scenario content and starting playback. | '0' or '1'<br>Default '0' |
| execute-after-upload | Optional. Executes provided command in cmd.exe or bash and waits for its completion. Calculation of 'period' starts after the command is executed. | 'script.bat && dir'<br>'rmdir /home/user/test/' |
| prompt | Optional. Prompt text. Launches a dialog with prompt *text* and *Ok* and *Abort* buttons: | 'Record video with camera and click *OK* or *Abort*' |

# Scenarios

A Scenario is text file for specifying a specific sequence of video frames, events (packets) and audio to be played in order. *Scenarios* also set up the device state for transmission.

## Parameters

Scenario parameters are defined below. items.

| Scenario item | Description |
|---|---|
| *video* | Path and file name format of video frame files |
| *audio* | Path and file name of the audio file |
| *packets* | Path and file name format of metadata packet files |
| *porder* | Content Playing Order. Please see *Content Playing Order* below. |
| *mappin* | |
| *align1* | Alignment of 12-bit binary pixel data. '1' aligned to LSB; '0' aligned to MSB. |
| *audioswap* | '1' for Little Endian audio samples |
| *audiocompressed* | '1' compressed audio; '0' uncompressed audio |
| *audiosampling* | Audio sampling rate. E.g., 44100 |
| *audiochannels* | Nr. of audio channels |
| *audiobits* | Audio bits per sample (usually 16 or 24) |
| *scrambler* | '1' scrambling enabled; '0' scrambling disabled |
| *audiosync* | Audio sync |
| *colorspace* | Video color space: RGB; YUV444; YUV422; YUV420 |
| *bitspercolor* | Video color depth (bits per color) |
| *timing.hactive* | Timing: Horizontal active |
| *timing.vactive* | Timing: Vertical active |
| *timing.htotal* | Timing: Horizontal total |
| *timing.vtotal* | Timing: Vertical total |
| *timing.hstart* | Timing: Horizontal start |
| *timing.vstart* | Timing: Vertical start |
| *timing.hsync* | Timing: Horizontal sync width |
| *timing.vsync* | Timing: Vertical sync width |
| *timing.frate* | Timing: frame rate |
| *hdcp* | HDCP version used (can be 1.4 2.3 or 'none') |
| *loadingRGB* | The R, G and B color components of solid color pattern shown when content is being uploaded to the device before playback (e.g., 0,0,0) |
| *linkRate* | Default link rate.<br>HDMI: 0 = TMDS; 1 – 5 = FRL with 3, 6, 8, 10 and 12 Gbps link rate.<br>DP: Link rate = Value × 0.27 Gbps. (E.g., 20 = 5.4 Gbps/lane (HBR2)). |
| *linkRateMin* | Minimum link rate desired. *Scenario* will fail if not achieved |
| *DSC timing parameters* | Parameters are different for DP and HDMI. See below. |

### DSC Timing parameters for HDMI

| | |
|---|---|
| dscFrameRate | DSC Timing: Frame rate [fps] × 1000 |
| dscHcactive | DSC Timing: Horizontal active |
| dscHcblank | DSC Timing: Horizontal blank |
| dscVtotal | DSC Timing: Vertical total |
| dscVsync | DSC Timing: Vertical sync |
| dscVstart | DSC Timing: Vertical start |
| dscVactive | DSC Timing: Vertical active |

### DSC Timing parameters for DP

| | |
|---|---|
| dscFrameRate | DSC Timing: Frame rate [fps] × 1000 |
| dscVtotal | DSC Timing: Vertical total |
| dscVsync | DSC Timing: Vertical sync |
| dscVstart | DSC Timing: Vertical start |
| dscVactive | DSC Timing: Vertical active |
| dscHtotal | DSC Timing: Horizontal total |
| dscHsync | DSC Timing: Horizontal sync |
| dscHstart | DSC Timing: Horizontal start |
| dscHactive | DSC Timing: Horizontal active |

## Content Playing Order

Play order is a sequence of steps. Steps are delimited with semicolons (;).

Each step has:

Range (possibly numbered e.g. allm_000.jpg, allm_001.jpg, …) of video frame(s)

How many times the frame(s) are played

Packet(s) (possibly numbered e.g. allm_0.bin, allm_1.bin, …) indices to be sent during the video frame(s) transmission

Color format

Optional frame rate when VRR/Adaptive-Sync is enabled

### Format

Each scenario step is of the form :

```
pV:R:E:FvXX;
```

### Parameters

Please see table below for description of used parameters.

| Char | Description | Possible values | Examples |
|---|---|---|---|
| : | Separator between step parameters. | ':' | See below |
| ; | Step delimiter. | ';' | See below |
| p | Optional. Indicates assertion of a HPD pulse on HDMI RX connector of UCD device during current step. Preceding video frame index. Only for HDMI playback. | 'p' | 'p1:60:1:256;'<br>'p0-59:60:1:256;' |
| V | Required. Video frame indices (zero based). Parameters are applied to all frames in the step. Images (possibly numbered) are loaded from the *video* file path. | '1'<br>'1,2,5'<br>'0-59' | '1:60:16:256;'<br>'1,2,5:60:16:256;'<br>'0-59:60:16:256;' |
| R | Required. Repetitions of current step.<br>For example, '1' with 60 FPS frame rate means that current step will be played only for 1/60 of a second. | '30'<br>'1' | '1:30:16:256;'<br>'1:1:16:256;' |
| E | Optional. Metadata packet indices (zero based): A single packet or a comma separated list of packets.<br>The index may be of the form 3l15 (lower case 'l').<br>At which vertical line do we want to put our packet in. 3l15 means insert packet 3 at line 15.<br>Packets are loaded from the *packets* path. | '0'<br>'4,1,29'<br>none<br>3l15 | '1:30:0:256;'<br>'1:30:4,1,29:256;'<br>'1:30::256;'<br>0:10000:3l15:256; |
| F | Required. Color format and color depth.<br>See Color Format below. | '256'<br>'513' | '1:30:0:256;'<br>'1:30:0:513;' |
| vXX | Optional. Control of frame rate when VRR/Adaptive-Sync is enabled. To enable VRR/Adaptive-Sync, the corresponding HDMI VSIF event must be included. The parameter is in the form 'vXX', where 'XX' is the frame rate. | 'v60'<br>'v30' | '1:30:0:256v60;'<br>'1:30:0:256v30;' |

## Color Format

Color format is a two-byte value presented in decimal. The lower byte provides an index to used color space and the higher byte an index to the color depth. Please find the indexes in the table below.

| Index | Color Depth (bits/color) | Color Space |
|---|---|---|
| 0 | 6 | RGB |
| 1 | 8 | YCbCr 4:4:4 |
| 2 | 10 | YCbCr 4:2:2 |
| 3 | 12 | YCbCr 4:2:0 |
| 4 | 16 | – |

The parameter value is encoded as follows:

[Color Depth] × 256 + [Color Space],

where *[Color Depth]* and *[Color Space]* are indexes obtained from the table above.

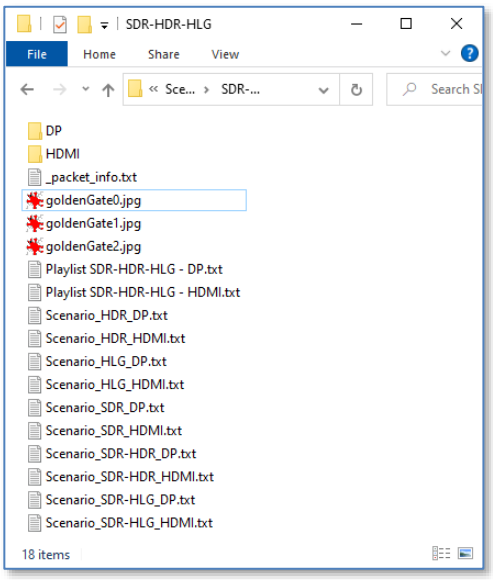
For example, parameter for YCbCr 4:4:4, 10 bits is ( 2 × 256 + 1 ) = 513.

Pre-calculated values for available color formats are shown below:

| | 6 BPC | 8 BPC | 10 BPC | 12 BPC | 16 BPC |
|---|---|---|---|---|---|
| RGB | 0 | 256 | 512 | 768 | 1024 |
| YCbCr 4:4:4 | N/A | 257 | 513 | 769 | 1025 |
| YCbCr 4:2:2 | N/A | 258 | 514 | 770 | 1026 |
| YCbCr 4:2:0 | N/A | 259 | 515 | 771 | 1027 |

# Example

Please find below description of Playlist SDR-HDR-HLG – HDMI.




## Playlist file (Playlist SDR-HDR-HLG - HDMI.txt)

| Playlist item and example content | Description |
|---|---|
| [Device] | Start of device section |
| serialnumber=* | Only one UCD device present. |
| connectortype=HDMI Out | HDMI output |
| [Scenario] | Start of Scenario 1 |
| caption = SDR | Scenario title “SDR” |
| period = 10000 | Duration 10 sec |
| path = Scenario_SDR_HDMI.txt | Scenario file: Scenario_SDR_HDMI.txt in current folder |
| [Scenario] | Start of Scenario 2 |
| caption = HDR | Scenario title “HDR” |
| period = 10000 | Duration 10 sec |
| path = Scenario_HDR_HDMI.txt | Scenario file: Scenario_HDR_HDMI.txt in current folder |
| [Scenario] | Start of Scenario 3 |
| caption = HLG | Scenario title “HLG” |
| period = 10000 | Duration 10 sec |
| path = Scenario_HLG_HDMI.txt | Scenario file: Scenario_HLG_HDMI.txt in current folder |
| [Scenario] | Start of Scenario 4 |
| caption = SDR – HDR | Scenario title “SDR – HDR” |
| period = 10000 | Duration 10 sec |
| path = Scenario_SDR-HDR_HDMI.txt | Scenario file: Scenario_SDR-HDR_HDMI.txt in current folder |
| [Scenario] | Start of Scenario 5 |
| caption = SDR – HLG | Scenario title “SDR – HLG” |
| period = 10000 | Duration 10 sec |
| path = Scenario_HDR_HDMI.txt | Scenario file: Scenario_SDR-HLG_HDMI.txt in current folder |

## Scenario File (Scenario_SDR-HDR-HDMI.txt)

| Scenario item and example content | Description |
|---|---|
| video=goldenGate0.jpg | Video files in current folder, file name format goldenGate0.jpg (0…) |
| audio=<Audio not selected> | Audio not selected |
| packets=HDMI\Infoframes_0000.bin | Packet files in folder HDMI\, file name format Infoframes_0000.bin (0…) |
| porder=0:180:2:256;1:180:2,0:256; | 180 frames of image index 0, Packet index 2, RGB 8 bpc<br>180 frames of image index 1, Packets index 2 and 0, RGB 8 bpc |
| align12=1 | Pixel data is aligned to LSB |
| audioswap=0 | - |
| audiocompressed=0 | - |
| audiosampling=0 | - |
| audiochannels=0 | - |
| audiobits=0 | - |
| scrambler=0 | scrambling disabled |
| colorspace=RGB444 | Video color space: RGB 4:4:4 |
| bitspercolor=8 | Video color depth: 8 (bpc) |
| timing.hactive=1920 | Timing: Horizontal active |
| timing.vactive=1080 | Timing: Vertical active |
| timing.htotal=2200 | Timing: Horizontal total |
| timing.vtotal=1125 | Timing: Vertical total |
| timing.hstart=192 | Timing: Horizontal start |
| timing.vstart=41 | Timing: Vertical start |
| timing.hsync=44 | Timing: Horizontal sync width |
| timing.vsync=5 | Timing: Vertical sync width |
| timing.frate=60000 | Timing: Frame rate 60 fps |
| hdcp=none | HDCP not enabled |
| loadingRGB=52,127,150 | Solid color pattern shown when content is being uploaded to the device before playback is R=52, G=127, B=150. |

# Sample Content in Playback Tab

UCD Console's Playback tab features a set of examples for the user to create custom test content. This content is stored by default in *C:\Program Files\Unigraf\Unigraf UCD Tools \data\playback\content*. It is advisable to create copy of the installed files and edit the copies.

Note: Playlists and Scenarios are interface technology dependent.
The provided examples are different for HDMI and DisplayPort.

Provided examples for each interface are shown below:

## HDMI

The following playlists are available for HDMI interface.

| Playlist Name | Description | Location |
|---|---|---|
| Basic Video & Audio Example | Example playlist for demonstrating the use of video and audio files. | *C:\Program Files\Unigraf\Unigraf UCD Tools \data\playback\content\Basic* |
| VRR Example | Playlist for demonstrating Variable Refresh Rate (VRR) capability of a DUT monitor.<br>Utilizes extensively frame sequencing capability in scenario, and the use of metadata packets. | *C:\Program Files\Unigraf\Unigraf UCD Tools \data\playback\content\VRR* |
| QMS-VRR Example | Playlist for demonstrating Quick Media Switching - Variable Refresh Rate (QMS-VRR) capability of a DUT monitor. Utilizes extensively frame sequencing capability in scenario, and the use of metadata packets. | *C:\Program Files\Unigraf\Unigraf UCD Tools \data\playback\content\VRR* |
| ALLM | Playlist for demonstrating Auto Low-latency Mode (ALLM) capability of a DUT monitor. | *C:\Program Files\Unigraf\Unigraf UCD Tools \data\playback\content\ALLM* |
| Audio-Video Latency | These scenarios can be used to estimate audio-video synchronization using external tools like Sync-One2 or similar. | *C:\Program Files\Unigraf\Unigraf UCD Tools \data\playback\content\AV Latency* |
| HDR & Metadata Example | Example playlist that demonstrates the use of video files and metadata packets in testing a DUT monitor | *C:\Program Files\Unigraf\Unigraf UCD Tools \data\playback\content\HDR GoldenGate* |
| Grayscale | The scenarios show smooth transition though shades of gray from black to white. | *C:\Program Files\Unigraf\Unigraf UCD Tools \data\playback\content\Grayscale* |
| HDR10+ SSTM & SBTM Example | Playlist demonstrates using HDR10+ SSTM VSIF for Source-Side Tone Mapping, and HDMI Forum SBTM VSIF for Source-Based Tone Mapping. | *C:\Program Files\Unigraf\Unigraf UCD Tools \data\playback\content\SBTM-SSTM* |
| Dolby Vision DEMO – Playlist | A set of static images transmitted with matching Dolby Vision metadata. | *C:\Program Files\Unigraf\Unigraf UCD Tools \data\playback\content\Dolby Vision* |

# Playlist: Basic Video & Audio Example

The playlist sequences video files and audio according to the description below.

## Video

Frames used for Scenario 1 and Scenario 2 (Image1.jpg, Image 2.jpg)

Frame used for Scenario 3 and Scenario 4 (Philips.svg)

## Description of Scenarios

| | Name | Duration | Repeated sequence |
|---|---|---|---|
| 1 | Flip-flop with LPCM Audio | 60 s | CTA 1920×1080 60 Hz (VIC 16), RGB 8 BPC,<br>60 frames Image1.jpg, 60 frames Image2.jpg,<br>Audio: Rhythm.wav |
| 2 | Flip-flop with AC3 Audio | 60 s | CTA 1920×1080 60 Hz (VIC 16), RGB 8 BPC,<br>60 frames Image1.jpg, 60 frames Image2.jpg,<br>Audio:<br>44100Hz_16bit_AC3_2channels_60sec_sine.iec61937.bin |
| 3 | Flip-flop Silent | 60 s | CTA 1920×1080 60 Hz (VIC 16), RGB 8 BPC,<br>60 frames Image1.jpg, 60 frames Image2.jpg,<br>No Audio. |
| 4 | Philips 1920x1080p + 1kHz | 60 s | CTA 1920×1080 60 Hz (VIC 16), RGB 8 BPC,<br>60 Frames Philips.svg,<br>Audio: 1 kHz sine wave (1kHz.wav) |
| 5 | Philips 3840x2160p + 1kHz | 60 s | CTA 3840 x 2160 @ 60Hz (VIC 97), RGB 8 BPC<br>60 Frames Philips.svg,<br>Audio: 1 kHz sine wave (1kHz.wav) |

# Playlist: Audio-Video Latency

Note: To measure video latency, ULT-01 test tool is needed.

## Description of Scenarios

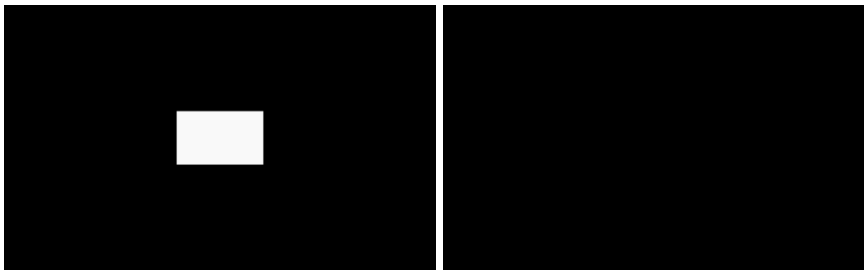
These scenarios can be used to estimate audio-video synchronization using external tools like Sync-One2 or similar. Video latency measuring requires the Unigraf ULT-01 tool.

The pattern with a white patch is shown for 15 frames, and then the black screen is shown for 45 frames. The audio beep is transmitted during the first frame of a white patch pattern.

## Video

| | Name | Duration | Repeated sequence |
|---|---|---|---|
| 1 | vic16 | 60 s | CTA 1920×1080 60 Hz (VIC 16), RGB 8 BPC,<br>15 frames frame1.vpattern, 45 frame0.vpattern,<br>Audio: beep.wav |
| 2 | vic97 | 60 s | CTA 3840×2160 60 Hz (VIC 97), RGB 8 BPC,<br>45 frames frame1.vpattern, 15 frame0.vpattern,<br>Audio: beep.wav |

Frames used for the scenario (frame1.vpattern frame0.vpattern)



# Playlist: HDR & Metadata Example

Example demonstrates the use of metadata packets.

## Video:

The Scenarios use four versions of the same image: GoldenGate0.jpg, GoldenGate1.jpg, GoldenGate2.jpg and GoldenGate3.jpg.

All four images use the same dynamic range in pixel data but contain a text label indicating pixel dynamic range applied in the metadata. If DUT behaves correctly, applying different metadata changes the appearance of the image on DUT screen.


## Scenarios for HDMI Output

Video mode in all steps: CTA 1920×1080 60 Hz (VIC 16), RGB 8 BPC, No audio.

| Name | Duration | Repeated sequence |
|---|---|---|
| SDR | 10 sec | 180 frames GoldenGate0.jpg, Packet: Infoframes_0002; |
| HDR | 10 sec | 180 frames GoldenGate1.jpg, Packets: Infoframes_0002, Infoframes_0000 |
| HLG | 10 sec | 180 frames GoldenGate2.jpg, Packets: Infoframes_0001, Infoframes_0002 |
| HDR10+ | 10 sec | 180 frames GoldenGate3.jpg, Packets: Infoframes_0002, Infoframes_0003, Infoframes_0000 |
| SDR – HDR | 10 sec | 180 frames GoldenGate0.jpg, Packets: Infoframes_0002;<br>180 frames GoldenGate1.jpg, Packets: Infoframes_0002, Infoframes_0000 |
| SDR – HLG | 10 sec | 180 frames GoldenGate0.jpg, Packet: – ;<br>180 frames GoldenGate2.jpg, Packets: Packets: Infoframes_0001, Infoframes_0002 |
| SDR – HDR10+ | 10 sec | 180 frames GoldenGate0.jpg, Packet: Infoframes_0002;<br>180 frames GoldenGate3.jpg, Packets: Infoframes_0002, Infoframes_0003, Infoframes_0000 |

# Playlist: Grayscale

## Description of Scenarios

The scenarios show smooth transition though shades of gray from black to white.

| | Name | Duration | Repeated sequence |
|---|---|---|---|
| 1 | GrayFHD_60 | 60 s | CTA 1920×1080 60 Hz (VIC 16), RGB 12 BPC,<br>120 frames: gray0.vpattern - gray119.vpattern,<br>Audio: No audio |
| 2 | GrayUHD_119 | 60 s | CTA 3840×2160 119,88 Hz, RGB 12 BPC,<br>120 frames: gray0.vpattern - gray119.vpattern,<br>Audio: No audio |

## Video

Below you can see three example frames from the video.

Gray0.vpattern

Gray60.vpattern

Gray119.vpattern

# Playlist: Dolby Vision DEMO

## Description of Scenarios

A set of static images transmitted with matching Dolby Vision metadata.

| | Name | Duration | Repeated sequence |
|---|---|---|---|
| 1 | playFiles_scenario | 30 s | 1920×1080 60Hz, RGB 8 BPC,<br>4 frames: Video_0000.bin – Video_0003.bin,<br>Infoframes: Infoframe0000.bin – InfoFrame0033.bin<br>Audio: No audio |

# Playlist: VRR Example

Playlist demonstrates controlling VRR (Variable Refresh Rate) in Scenarios when using HDMI output.

## Video

The image used for the test contains a combination of color bars, gray scales, and rotating items. The test uses a sequence of images creating a full rotation in 60 frames.

## Scenario with Video Mode 1920.1080 60 Hz

The scenario uses 1920×1080 59.94/60 Hz video timing (VIC 16). No audio.

| | Name | Duration | Repeated sequence |
|---|---|---|---|
| 1 | FHD VRR 48..59 switch | 60 s | VRR enabled. RGB 8 BPC.<br>Packets: infoframe_00, infoframe_01<br>300 frames with 48 Hz frame rate,<br>300 frames with 59 Hz frame rate. |

## Scenario with Video Mode 3840.2160 60 Hz

The scenario uses 3840×2160 59.94/60 video timing (VIC 97). No audio.

| | Name | Duration | Repeated sequence |
|---|---|---|---|
| 1 | UHD VRR48..59 switch | 60 s | VRR enabled. RGB 8 BPC.<br>Packets: infoframe_00, infoframe_02<br>300 frames with 48 Hz frame rate,<br>300 frames with 59 Hz frame rate. |

## Scenario with Video Mode 3840.2160 60 Hz

The scenario uses 3840×2160 59.94/60 video timing (VIC 97). No audio.

| | Name | Duration | Repeated sequence |
|---|---|---|---|
| 1 | UHD VRR48..59 switch | 60 s | VRR enabled. RGB 8 BPC.<br>Packets: infoframe_00, infoframe_02<br>300 frames with 48 Hz frame rate,<br>300 frames with 59 Hz frame rate. |

# Playlist: QMS-VRR Example

Playlist demonstrates Quick Media Switching QMS by sending Video Timing Extended Metadata (VTEM) with TFR changing between 48/1.001 and 60.

## Video

The same as in VRR Example above.

# Playlist: ALLM

Playlist for demonstrating Auto Low-latency Mode (ALLM) capability of a DUT monitor.

## Video:

The Scenarios use a series of images: allm_on_off_000.jpg to allm_on_off_0011.jpg. Text panel on the images indicate if ALLM is enabled or not. The first scenario is presented with ALLM enabled and the second by switching ALLM on and off sequentially.



## Scenarios for HDMI Output

Video mode in all steps: CTA 1920×1080 60 Hz (VIC 16), RGB 8 BPC, No audio.

| Name | Duration | Repeated sequence |
|---|---|---|
| ALLM Static | 60 sec | 10 frames allm_on_off_000.jpg, Packet: allm_0.bin;<br>10 frames allm_on_off_001.jpg, Packet: allm_0.bin;<br>10 frames allm_on_off_002.jpg, Packet: allm_0.bin;<br>10 frames allm_on_off_003.jpg, Packet: allm_0.bin;<br>10 frames allm_on_off_004.jpg, Packet: allm_0.bin;<br>10 frames allm_on_off_005.jpg, Packet: allm_0.bin |
| ALLM Toggle | 60 sec | 10 frames allm_on_off_000.jpg, Packet: allm_0.bin;<br>10 frames allm_on_off_001.jpg, Packet: allm_0.bin;<br>10 frames allm_on_off_002.jpg, Packet: allm_0.bin;<br>10 frames allm_on_off_003.jpg, Packet: allm_0.bin;<br>10 frames allm_on_off_004.jpg, Packet: allm_0.bin;<br>10 frames allm_on_off_005.jpg, Packet: allm_0.bin;<br>10 frames allm_on_off_006.jpg, Packet: allm_1.bin;<br>10 frames allm_on_off_007.jpg, Packet: allm_1.bin;<br>10 frames allm_on_off_008.jpg, Packet: allm_1.bin;<br>10 frames allm_on_off_009.jpg, Packet: allm_1.bin;<br>10 frames allm_on_off_0010.jpg, Packet: allm_1.bin;<br>10 frames allm_on_off_0011.jpg, Packet: allm_1.bin |

# Playlist: HDR10+ SSTM & SBTM Example

## Description of Scenarios

Playlist demonstrates using HDR10+ SSTM VSIF for Source-Side Tone Mapping, and HDMI Forum SBTM VSIF for Source-Based Tone Mapping.

| | Name | Duration | Repeated sequence |
|---|---|---|---|
| 1 | SDR | 10 s | 3840×2160 30 Hz, RGB 10 BPC,<br>Video: Channel1.jpg, repeated 180 times<br>Packets: Infoframes_0005.bin,<br>Audio: No audio |
| 2 | HDR10+ SSTM | 10 s | 3840×2160 30 Hz, RGB 10 BPC,<br>Video: Channel0.jpg, repeated 180 times<br>Packets: Infoframes_0000.bin, _0005.bin, _0006.bin<br>Audio: No audio |
| 3 | SBTM G-RDM | 10 s | 3840×2160 30 Hz, RGB 10 BPC,<br>Video: Channel0.jpg, repeated 180 times, Packets: Infoframes_0000.bin, _0005.bin, _0007.bin<br>Audio: No audio |
| 4 | SDR – SBTM G-RDM | 10 s | 3840×2160 30 Hz, RGB 10 BPC,<br>Video:<br>Step1: Channel1.jpg, repeated 150 times, Packets: Infoframes_0005.bin<br>Step2: Channel0.jpg, repeated 180 times, Packets: 0000.bin, _0005.bin, _0007.bin<br>Audio: No audio |
| 5 | SBTM D-RDM | 10 s | 3840×2160 30 Hz, RGB 10 BPC,<br>Video: Channel0.jpg, repeated 180 times<br>Packets: Infoframes_0000.bin, _0005.bin, _0008.bin<br>Audio: No audio |
| 6 | SDR – SBTM D-RDM | 10 s | 3840×2160 30 Hz, RGB 10 BPC,<br>Video:<br>Step1: Channel1.jpg, repeated 150 times, Packets: Infoframes_0005.bin<br>Step2: Channel0.jpg, repeated 150 times, Packets: 0000.bin, _0005.bin, _0008.bin<br>Audio: No audio |

## Video

Channel0.jpg

Channel1.jpg