

UCD Console for UCD-422



User Manual

Copyright

This manual, Copyright © 2020 Unigraf Oy. All rights reserved

Reproduction of this manual in whole or in part without a written permission of Unigraf Oy is prohibited.

Notice

The information given in this manual is verified in the correctness on the date of issue. The authors reserve the rights to make any changes to this product and to revise the information about the products contained in this manual without an obligation to notify any persons about such revisions or changes.

Edition

UCD Console for UCD-422 User Manual, Version 3

Date: 25 May 2020

Company Information

Unigraf Oy

Piispantilankuja 4
FI-02240 ESPOO
Finland

Tel. +358 9 859 550

<mailto:info@unigraf.fi>

<https://www.unigraf.fi>

<http://www.unigraf-china.cn>

Trademarks

Unigraf, UCD, UCD-422 and TSI are trademarks of Unigraf Oy.

HDMI is a trademark of HDMI Licensing, LLC.

HDCP is a trademark of Digital Content Protection LLC.

Altera and Intel FPGA are trademarks of Intel Corporation or its subsidiaries in the U.S. and/or other countries

Windows® 10, Windows® 8, Windows® 7 and Windows® XP are trademarks of Microsoft Corporation.

DisplayPort™ and the DisplayPort™ logo are trademarks owned by the Video Electronics Standards Association (VESA®) in the United States and other countries.

All other trademarks are properties of their respective owners.

Limited Warranty

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

If the product proves defective within the warranty period, Unigraf will provide repair or replacement of the product. Unigraf shall have the whole discretion whether to repair or replace, and replacement product may be new or reconditioned. Replacement product shall be of equivalent or better specifications, relative to the defective product, but need not to be identical. Any product or part repaired by Unigraf pursuant to this warranty shall have a warranty period of not less than 90 days, from the date of such repair, irrespective of any earlier expiration of original warranty period. When Unigraf provides replacement, then the defective product becomes the property of Unigraf.

Warranty service may be obtained by contacting Unigraf within the warranty period. Unigraf will provide instructions for returning the defective product.

CE Mark

UCD-422 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 | 5 |
| | Purpose..... | 5 |
| | Product and Driver Version | 5 |
| | Notes..... | 5 |
| 2. | Introduction | 6 |
| | Unpacking | 8 |
| | Installation Package | 8 |
| | Software Installation..... | 8 |
| 3. | License Manager | 9 |
| 4. | Firmware Update Procedure..... | 11 |
| | FW Update Tool | 11 |
| | Connect to the UCD-422 Unit | 12 |
| | Programming the FW | 13 |
| 5. | UCD Console..... | 15 |
| | Options..... | 16 |
| 6. | HDMI Reference Sink | 18 |
| | Video Tab..... | 18 |
| | Audio Tab..... | 21 |
| | Link Tab | 23 |
| | EDID Tab | 25 |
| | HDCP Tab..... | 27 |
| | InfoFrame Tab | 28 |
| | Source DUT Testing Tab | 29 |
| 7. | HDMI Reference Source..... | 30 |
| | Pattern Generator Tab | 30 |
| | Audio Generator Tab..... | 33 |
| | Link Tab | 34 |
| | EDID Tab | 36 |
| | HDCP Tab..... | 38 |
| 8. | Event Log..... | 39 |
| 9. | EDID Editor..... | 40 |
| | Appendix A. Product Specification..... | 42 |
| | UCD-422 | 42 |
| | Appendix B. Licensing | 43 |
| | Appendix C: Predefined Timings | 45 |
| | Appendix D: Predefined Patterns | 47 |

1. ABOUT THIS MANUAL

Purpose

This guide is User Manual of UCD-422, USB-connected video interface test unit for use with a PC with Windows® 10 Windows® 8 or Windows® 7 operating system.

The purpose of this guide is to

- Provide an overview of the product and its features.
- Provide instructions for the user on how to install the software and the drivers.
- Provide instructions for the user on how to update the FW of the unit.
- Introduce the HW features of the UCD-422 units.
- Provide instructions for the user on how to use UCD Console software.

Product and Driver Version

This manual explains features found in UCD Console Software Package **1.8**. Please consult Unigraf for differences or upgrades of previous versions.

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

Notes

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

| | |
|------|--------------------------------|
| Note | This text is an important note |
|------|--------------------------------|

2. INTRODUCTION

Product Description

UCD-422 is a USB 3.0 connected video interface test unit with HDMI 2.1 Pattern Generator and Analyzer capability. *UCD Console* is the common graphical user interface (GUI) for Unigraf's UCD-400 and UCD-300 family units. The outlook and details of UCD Console will be different depending on the capabilities of the connected UCD unit reflecting the features enabled.

UCD-400 family feature a high-level Software Development Kit (SDK) for use in automated testing. It is called Test Software Interface (TSI). TSI allows for an easy integration of Production and R&D testing routines into an automated test system environment. Please refer to TSI documentation found in additional Unigraf manuals for more details.

Product Features

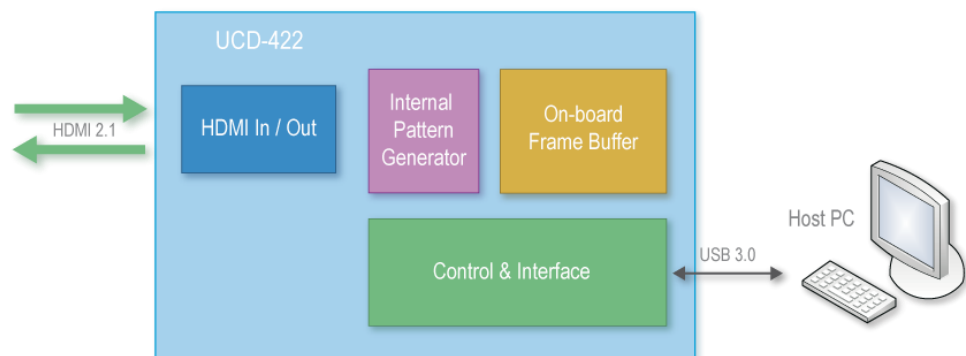
- High resolution video and audio capture up to 10k30Hz, 8k60Hz, 4K/UHD 120 Hz
- Supports FRL
- Supports Auto Low Latency Mode (ALLM) and Variable Refresh rate (VRR)
- Compatible with HDCP versions 1.4 and 2.3
- 2 GB on-board high-speed video buffer
- High speed USB 3.0 host PC interface

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

Functional Description

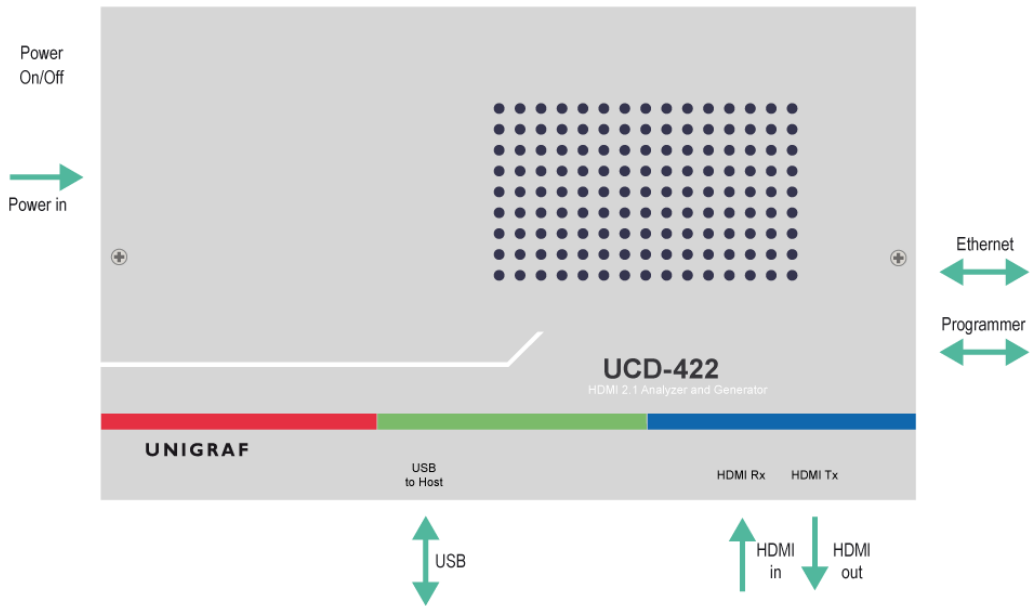
UCD-422 units consist of a multimedia signal input stage, an internal pattern generator, a control stage with on-board frame buffer and a PC interface stage. In the Input Stage the signal is conditioned and converted to desired format. The Interface and Control stages are either passing the captured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

Please find below logical diagram of UCD-422 unit



UCD-422

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 and 8K 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.

Unpacking

The UCD-422 product shipment contains:

- The UCD-422 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

Installation Package

The UCD-422 software installation package can be obtained from Unigraf download page at <https://www.unigraf.fi/support/download-links>. Please log in with the following credentials before attempting to access the download page:

Username: *unigraf*

Password: *ruukintie*

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

- Windows drivers (installed during set up)
- UCD Console software GUI (installed during set up)
- License Manager (installed during set up)
- TSI SDK
- UCD-422 firmware (FW) matching UCD Console version (copied during set up)
- User Manuals including this document.

When launched, UCD Console verifies that the firmware (FW) version programmed to UCD-422 matches the launched version. If conflict, UCD Console informs the user. If FW update is needed please refer to *Firmware Update Procedure* later in this manual for instructions.

Note: The software should be installed before connecting the UCD-422 unit in the PC.

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

Software Installation

- ▶ Start the installation by running **Unigraf Software Bundle Setup.exe**
Once the installer has started, a welcome page is displayed. The welcome page shows the software package release version.
- ▶ Click **Next** to continue. The next two dialogs are used to define the installation folder in your PC and the Start Menu folder used.
- ▶ When the selections are ready, click **Install** to start the installation.
- ▶ Click **Finish** to exit the installation dialog.

3. LICENSE MANAGER

Licensing

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

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

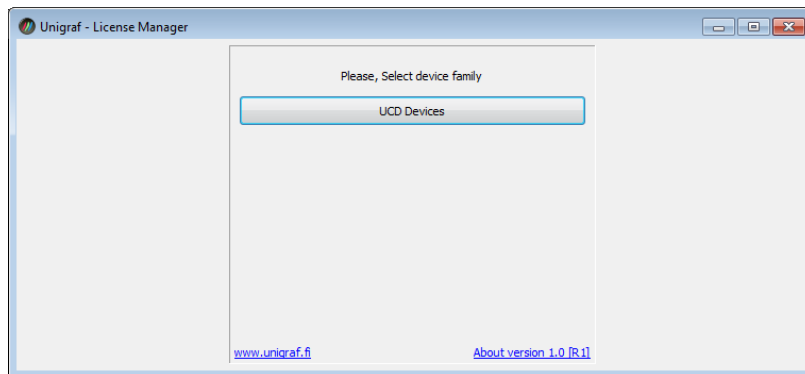
License keys are managed with Unigraf **License Manager**. By default, shortcut to Unigraf License Manager can be found in Start Menu under: **All programs/Unigraf/UCD-400**.

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

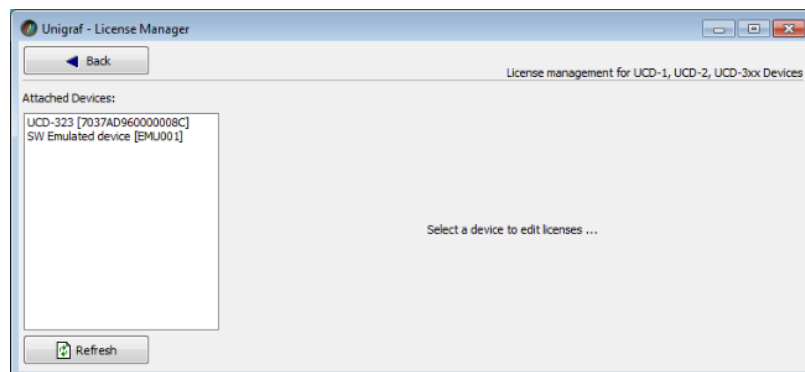
Note: System administrator's privileges are required for accessing the licenses.

License Manager GUI

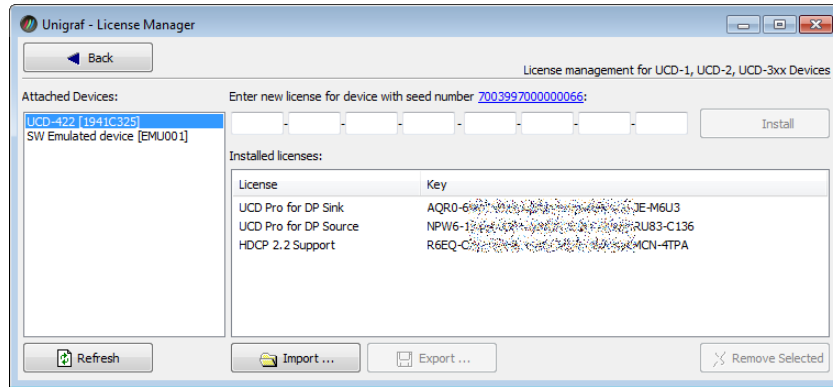
When run, License Manager will list the licensing enabled Unigraf devices. If no suitable device families are detected, License Manager will exit. Please first select one of the available device families by clicking one of the device family selector buttons.



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



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



4. FIRMWARE UPDATE PROCEDURE

FW Update Tool

The firmware (FW) of UCD-422 is programmed with a separate tool called **Quartus Prime (includes Nios II EDS)**. The tool can be downloaded from **Intel® FPGA** website:

<https://fpgasoftware.intel.com/?edition=lite>

On the download page, please **Select release 16.1**. Please download **Quartus Prime (includes Nios II EDS)**.

Quartus Prime Lite Edition

Release date: November, 2016
Latest Release: v19.1

Intel® Quartus® Prime
Design Software

Select release: 16.1

Please select release 16.1



Operating System  Windows  Linux


- ✓ A newer version of the Quartus Prime Design Software is available. Users should upgrade to the latest version of the [Quartus Prime Design Software](#). This version does not include the latest open source components that have functional and security updates. For critical support requests, please contact our [support team](#).
- ✓ You may be exposed to a vulnerability issue if you have installed or plan to install Quartus Prime/Quartus II software from v11.0 to v18.0 to a location with space(s) in the path. See this [KDB solution](#) for more details.
- ✓ The Quartus Prime Lite software version 16.1 supports the following device families: Arria II, Cyclone IV, Cyclone V, MAX II, MAX V, and MAX 10 FPGA. [More](#)

Combined Files Individual Files Additional Software Updates

Download and install instructions: [More](#)
[Read Intel FPGA Software v16.1 Installation FAQ](#)
[Quick Start Guide](#)

Updates Available

Quartus Prime Lite Edition (Free)
Quartus Prime (includes Nios II EDS)
Size: 2.0 GB MD5: 0FFD781FCC23C6FABC6A68019B3CAB62 
ModelSim-Intel FPGA Edition (includes Starter Edition)
Size: 1.1 GB MD5: F665D7016FF793E64F57B08B37487D0E 
** Require 32-bit libraries, see [installation manual](#).

Devices
You must install device support for at least one device family to use the Quartus Prime software.
Arria II device support 
Size: 400.6 MB MD5: 77F1518FE387656110A804E7C6A680A7

Note: Registering is needed for the download.

Please download and install the tool in the PC.

Connect to the UCD-422 Unit

- ▶ Power on the UCD-422.
- ▶ Connect UCD-422 with a USB cable to the PC through **Programmer** connector.
(Pls refer to page 7)

The programming interface is the Ethernet connector in the UCD-422 unit. The PC can be connected to the UCD-422 unit either through a network HUB or directly.

Please follow either of the two procedures below.

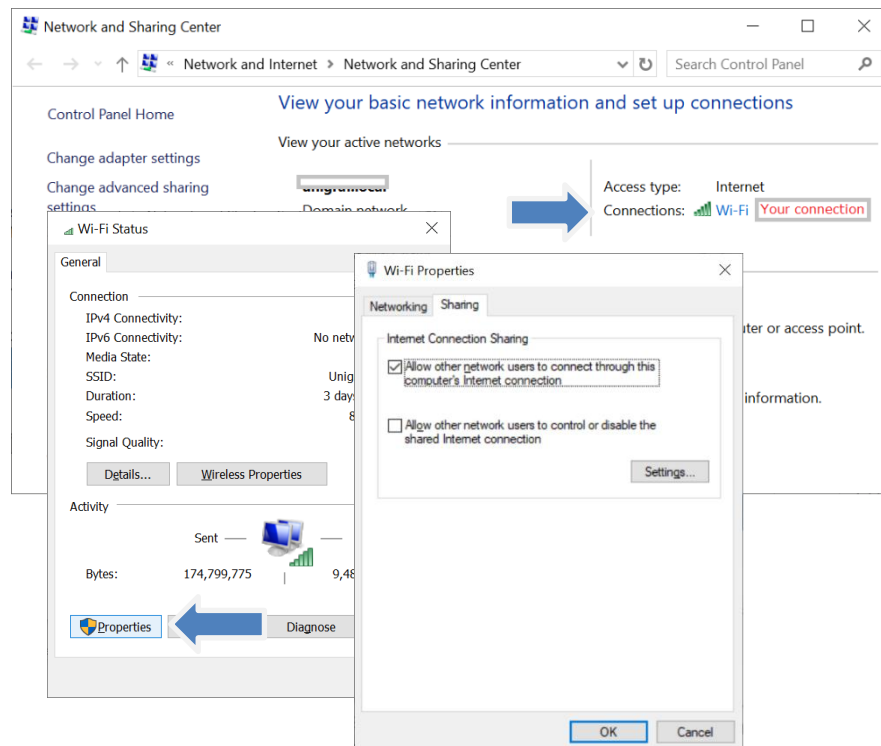
Connecting Through Ethernet Network (Alternative 1)

- ▶ Connect UCD-422 through **Ethernet** connector to the same network HUB where the programming PC is connected.

Connecting with Direct Ethernet Cable (Alternative 2)

In case of direct connection, the PC needs to be configured to be an Ethernet network host by enabling WIFI network share (The WIFI network will not be used for programming).

- ▶ Connect UCD-422 directly to the PC through **Ethernet** connector;
- ▶ Enable **WIFI** Internet access of the PC.
- ▶ From Network and Sharing Center click on the WiFi connection
- ▶ In Wi-Fi Status dialog click **Properties** and select **Sharing** tab
- ▶ Select *Allow other network users to connect through this computer's Internet connection*
- ▶ Click **OK** and **Close**.



Note The network sharing is shown above for Windows 10. Similar controls can be found for other Windows versions and other operating systems.

Programming the FW

- ▶ Run Nios II 16.1 Command Shell application as Administrator

Note *Nios II 16.1 Command Shell* application needs to be run as Administrator
(Right click with mouse and select **Run as Administrator**)

- ▶ Select FW update folder location. For example:
`cd /cygdrive/c/Program Files (x86)/Unigraf/TSI/UCD-400/Firmware/`

- ▶ Run the boot loader that initiates the HTML programming interface.

source run.sh

Upon command completion, the **assigned IP address for UCD-422 device** is highlighted in the picture below.

```

/cygdrive/c/Program Files (x86)/Unigraf/TSI/UCD-400/Firmware
jsa@t440s: /cygdrive/c/Program Files (x86)/Unigraf/TSI/UCD-400/Firmware
$ source run.sh
Searching for SOF file:
in .
a10_fpga_bup.sof

Warning (210120): Arria 10 information is incomplete. The ISP clamp functionality will be disabled.
Info: *****
Info: Running Quartus Prime Programmer
Info: Command: quartus_pgm --no_banner --mode=jtag -o p;a10_fpga_bup.sof
Info (213045): Using programming cable "USB-BlasterII [USB-1]"
Info (213011): Using programming file a10_fpga_bup.sof with checksum 0x30E7799E for device 10ax115s3f45e2sge3@1
Info (209060): Started Programmer operation at Wed May 20 15:31:39 2020
Info (209016): Configuring device index 1
Info (209017): Device 1 contains JTAG ID code 0x02E660D0
Info (209007): Configuration succeeded -- 1 device(s) configured
Info (209011): Successfully performed operation(s)
Info (209061): Ended Programmer operation at Wed May 20 15:31:54 2020
Info: Quartus Prime Programmer was successful. 0 errors, 1 warning
Info: Peak virtual memory: 5621 megabytes
Info: Processing ended: Wed May 20 15:31:54 2020
Info: Elapsed time: 00:00:27
Info: Total CPU time (on all processors): 00:00:17
Using cable "USB-BlasterII [USB-1]", device 1, instance 0x00
Pausing target processor: OK
Initializing CPU cache (if present)
OK
Downloaded 411KB in 0.4s (1027.5KB/s)
Verified OK
Waiting to allow other programs to start: done
Starting processor at address 0x102002BC
nios2-terminal: connected to hardware target using JTAG UART on cable
nios2-terminal: "USB-BlasterII [USB-1]", device 1, instance 0
nios2-terminal: (Use the IDE stop button or Ctrl-C to terminate)

PHY INFO: [phyid] 0x0 0x141 0xcc2

PHY INFO: [phyid] 0x0 0x141 0xcc2
InterNiche Portable TCP/IP, v3.1

Copyright 1996-2008 by InterNiche Technologies. All rights reserved.
prep_tse_mac 0

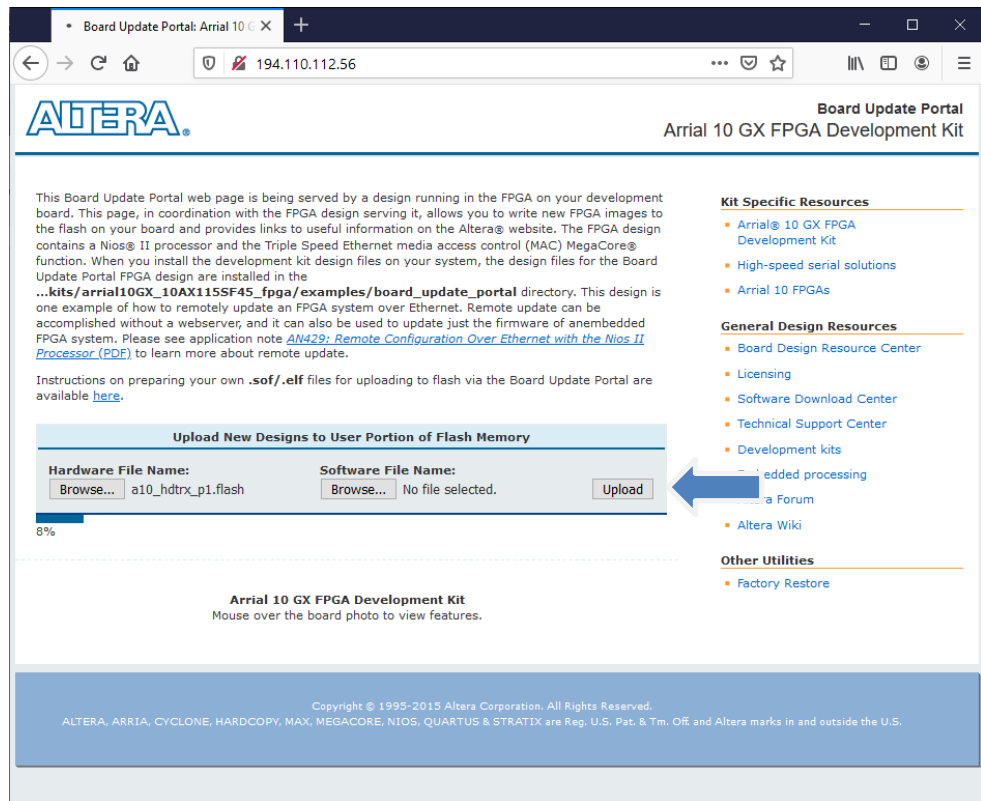
Your Ethernet MAC address is 00:07:ed:2a:0e:e8
prepped 1 interface, initializing...
[tse_mac_init]
INFO : TSE MAC 0 found at address 0x10003000
INFO : PHY Marvell 88E1111 found at PHY address 0x00 of MAC Group[0]
INFO : PHY[0.0] - Automatically mapped to tse_mac_device[0]
INFO : PHY[0.0] - Restart Auto-Negotiation, checking PHY link...
INFO : PHY[0.0] - Auto-Negotiation PASSED
INFO : PCS[0.0] - Configuring PCS operating mode
INFO : PCS[0.0] - PCS SGMIIE mode enabled
INFO : PHY[0.0] - Checking link...
INFO : PHY[0.0] - Link established
INFO : PHY[0.0] - Speed = 1000, Duplex = Full
OK, x=0, CMD_CONFIG=0x00000000

MAC post-initialization: CMD_CONFIG=0x0400020b
[tse_sgdma_read_init] RX descriptor chain desc (1 depth) created
mctest init called
IP address of et1 : 0.0.0.0
Created "inet main" task (Prio: 2)
Created "clock tick" task (Prio: 3)
Acquired IP address via DHCP client for interface: et1
IP address : 194.110.112.56
Subnet Mask: 255.255.255.0
Gateway : 194.110.112.1

nios2-terminal: exiting due to ^D on remote

jsa@t440s: /cygdrive/c/Program Files (x86)/Unigraf/TSI/UCD-400/Firmware
$
  
```

- ▶ Launch web browser on the PC. If Ethernet connection is used, please make sure that the PC is connected to the same network as the UCD-422 unit.
- ▶ Access the HTML programming interface by entering the IP address assigned for the UCD-422 unit.
- ▶ Browse **Hardware File Name** for UCD-422 update (e.g. **a10_hdtrx_p1.flash**) and then press “Upload” button



- ▶ Once uploading process done – cycle power on the UCD-422.

| | |
|------|---|
| Note | Please cycle the power on the UCD-422 unit to enable the FW update. |
|------|---|

5. UCD CONSOLE

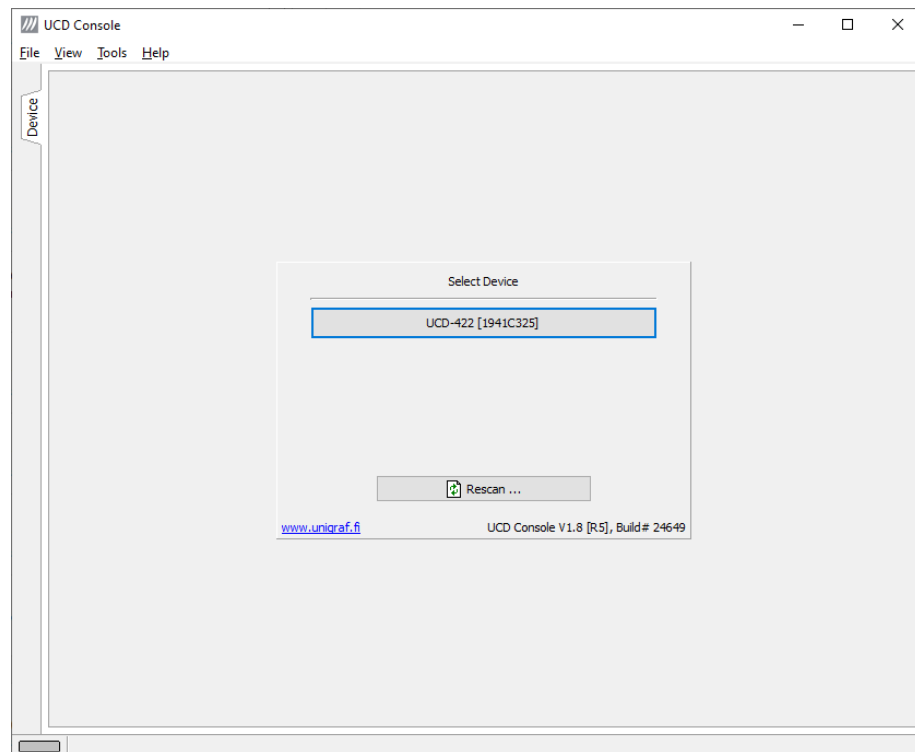
UCD Console is the graphical user interface (GUI) of UCD-422 unit for desktop use. It provides the user access to all features of the unit. UCD Console includes powerful debugging and analysis tools enabling the user to monitor the status of the display interfaces and assist in the problem detection.

The various features of the UCD-422 are divided into tabs. Each tab contains data and controls for analyzing a specific feature.

Device Selection

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

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

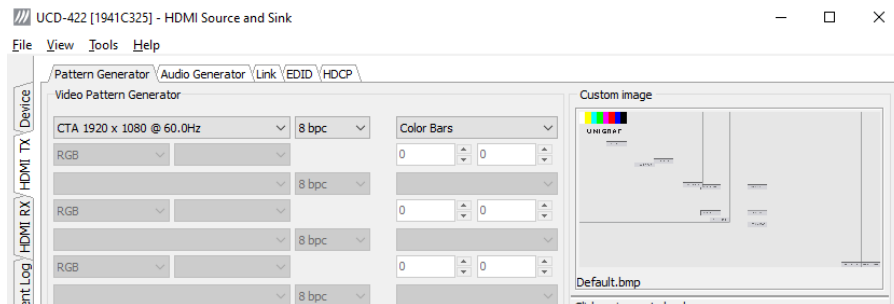


Select Role

The use of UCD-422 devices with UCD Console is divided in display interface specific roles. The structure of UCD Console varies between roles by having a varying set of tabs dedicated to functionalities available in the enabled role. Please find a detailed description of each role in the later chapters of this manual.

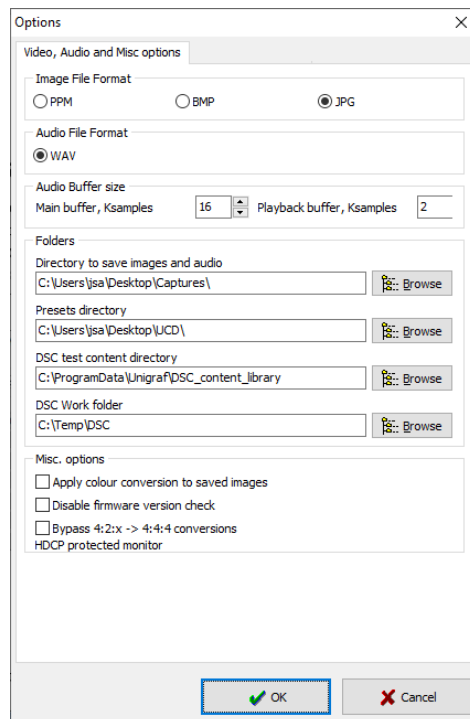
Applying Changes

In various UCD Console dialogues the user needs to update several parameter or fields to make the changes needed. In order to avoid false combinations of parameters the new parameters are applied to UCD-422 test equipment hardware only after **Apply** is clicked. In UCD Console the situation that parameters have been changed but not applied is indicated by **bold values** of the parameter.



Options

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



Video Audio and Misc. Options

Image File Format

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

Audio File Format

Audio files are stored in WAV format

Audio Buffer size

You can define how much memory is allocated in the PC for captured audio. Increased buffer size will ensure a smooth audio output but will also increase the delay between the capture of the audio stream and its playback.

Folders

Please select the directories in the PC for saving the captured images and audio, the saved Presets and DSC test content and DSC Work directories.

Misc. options

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

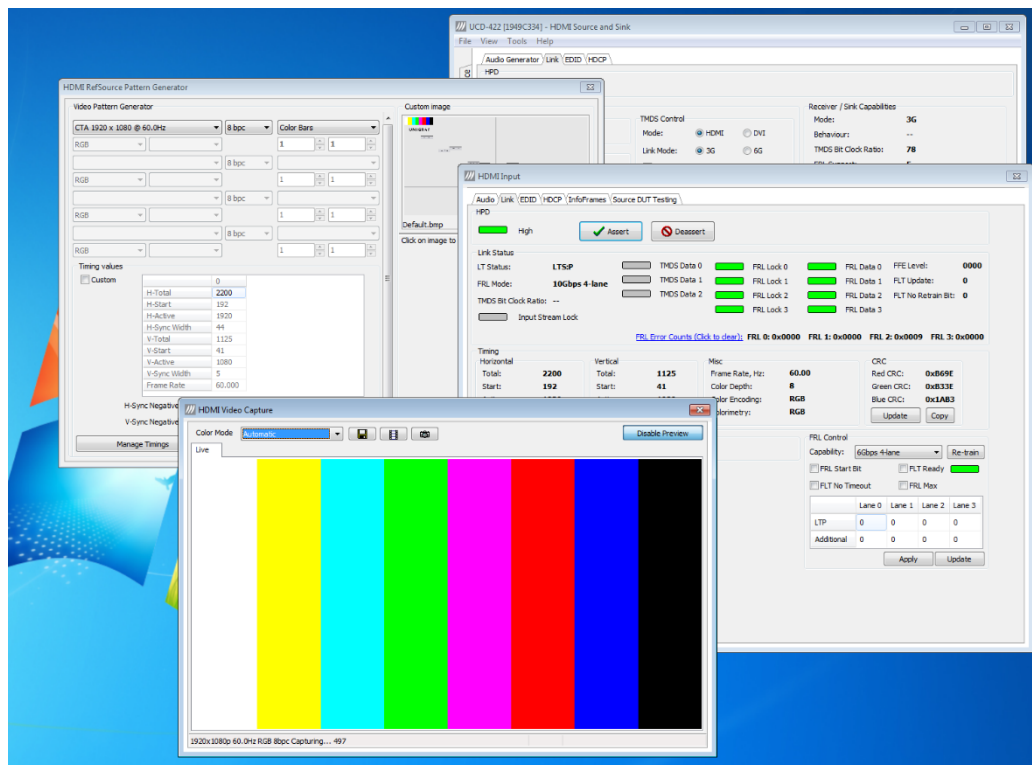
Bypass 4:2:x → 4:4:4 conversions: 4:2:2 and 4:2:0 images are previewed and stored as received, without pixel doubling.

Disable firmware version check: UCD Console lets the user operate a non-matching Software / Firmware combination. NOT RECOMMENDED.

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

Detaching Tabs

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



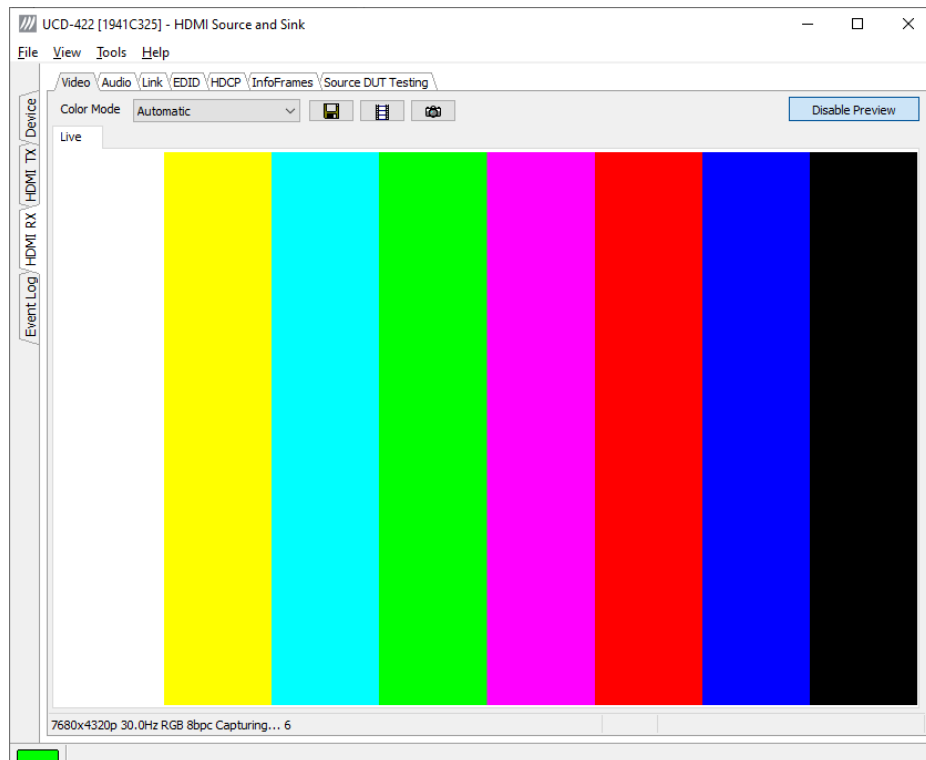
6. HDMI REFERENCE SINK

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

- Video preview and saving (Video).
- Audio monitoring and saving (Audio).
- Status information and control of the upstream link (Link).
- EDID editor (EDID).
- HDCP status monitor and control (HDCP).
- InfoFrames monitoring panel (InfoFrames)
- Source DUT Testing

Video Tab

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



Input video mode

7680x4320p 30.0Hz RGB 8bpc Capturing... 19

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

Disable / Enable Preview

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

The top ribbon of the tab has the following controls:

Color Mode for preview

YCbCr (ITU-709) -> RGB

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

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

Save one frame



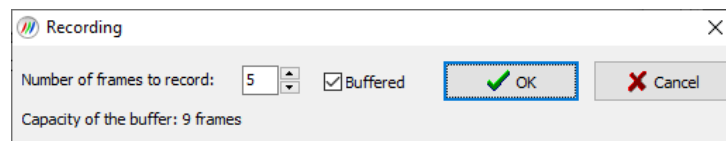
Capture and save one video frame as a bitmap file in the PC. The format and storage location can be selected in Tools > Options pull-down menu. The available bitmap formats are PPM, BMP and JPG.

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

Sequence recording



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



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

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

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

Snap preview



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



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

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

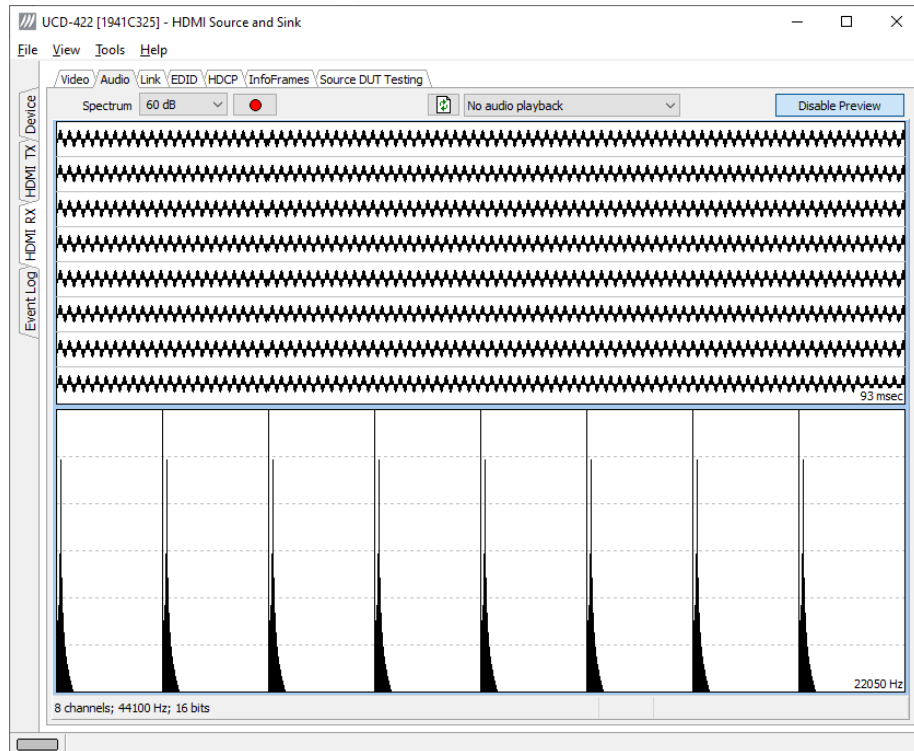
Zoom of the Preview Image can be altered by right clicking on top of the preview image and selecting between

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

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

Audio Tab

Audio tab has a preview of the audio signal format and the controls for audio playback and recording.



The audio signal format is shown in three ways

- The 'oscilloscope' panel displays the waveforms of the received audio channels.
- The frequency spectrum of the audio is shown in the lower panel. The range of the spectrum display is from 0 to 1/2 of the input sampling rate. The amplitude scale of the spectrum display can be selected between 'Linear' to 80 dB.
- The horizontal sound level indicator is in the bottom of the dialog.

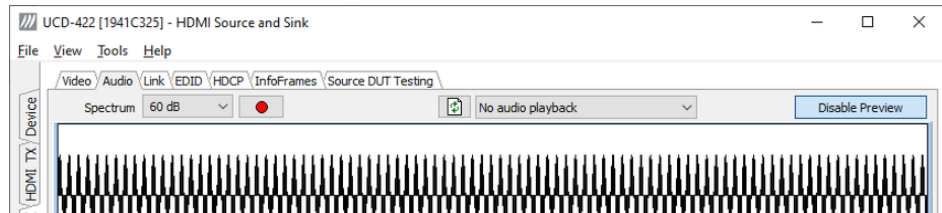
The span of the preview window is defined with **Audio preview size** found in Tools > Options dialog. The value is given in ksamples (1024 samples). The relation between the preview window span in milliseconds (msec) and the value given in *Audio preview size* depends on the sampling frequency. Please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

Disable / Enable Preview

This button controls capturing the audio data.

Playback device selection

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



Note Please note that the audio capabilities of the audio playback device of the PC are not automatically reflected in the audio capabilities description in UCD-422 EDID. Since UCD-422 is not performing any audio format conversion, it might occur that the source provides an audio format that the selected playback device is not supporting. In case a conflict occurs, please change manually the EDID content or disable audio playback to monitor the waveforms in UCD Console.

Refresh audio device list



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

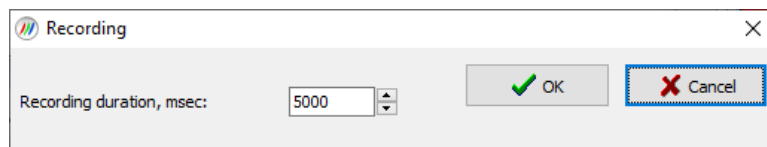
Audio Buffer Size

The amount of buffering used in the data transfer between the UCD-422 unit and the PC in **Audio buffer size** in Tools > Options dialog. Increased buffer size will ensure a smooth audio output but will also increase the delay between the capture of the audio stream and its playback.

Start audio recording



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



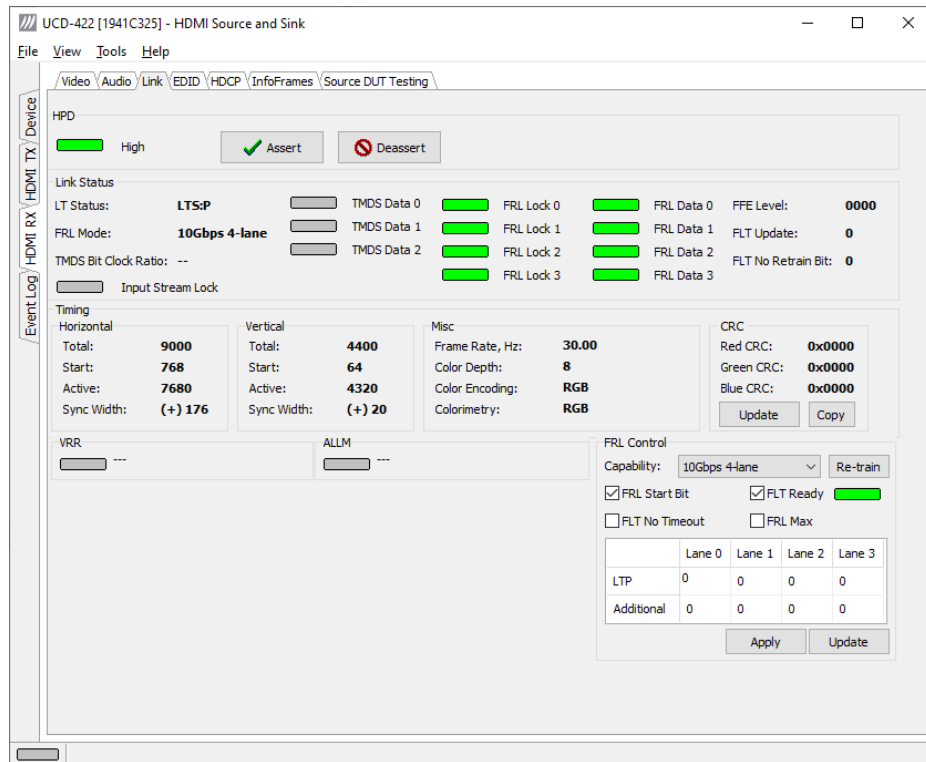
Input audio mode

2 channels; 48000 Hz; 16 bits

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

Link Tab

Link tab contains four panels: HPD, Link Status, FRL Control and Timing.



HPD

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

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

Link Status

Link 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.

LT Status: Status of the FRL Link Training State (only in FRL mode)

FRL Mode: Lane count and link rate configuration used in FRL mode (only in FRL mode)

TMDS Bit Clock Ratio: TMDS Bit Period / TMDS Clock Period ratio (1/10 or 1/40) (only in TMDS mode)

TMDS Data 0/1/2: Indication of data flow in TMDS links 0 to 2 (only in TMDS mode)

FRL Lock 0/1/2/3: Indication of FRL Character Lock in links 0 to 3 (only in FRL mode)

FRL Data 0/1/2/3: Indication of data flow in FRL links 0 to 3 (only in FRL mode)

FFE Level: Status of Feed Forward Equalizer Level that HDMI transmitter is using (only in FRL mode)

FLT Update: Status of the HDMI sink’s FLT_update bit (1/0) (only in FRL mode)

FLT No Retrain Bit: Status of HDMI Sink’s FLT_no_retrain bit (1/0) (only in FRL mode)

FRL Control

Capability: Selection of the maximum link count and link rate capability of UCD-422 sink. Please **Re-train** to apply.

FRL Start Bit: Control of the HDMI sink's FRL_start bit (1/0) (only in FRL mode)

FLT Ready: Status of the HDMI sink's FLT_ready bit (1/0). Indication LED of the status. (only in FRL mode)

FLT No Timeout: Status of the HDMI sink's FLT_no_timeout bit (1/0) (only in FRL mode)

FRL Max: Status of the HDMI sink's FRL_Max bit (1/0) (only in FRL mode)

LTP: Current FRL link training pattern. Click **Update** to re-read. (only in FRL mode)

Additional: Input for user requested training pattern (1 – 8). Click **Apply** to enable request. (only in FRL mode)

Timing

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

CRC

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

VRR

Indication that Variable Refresh Rate is enabled

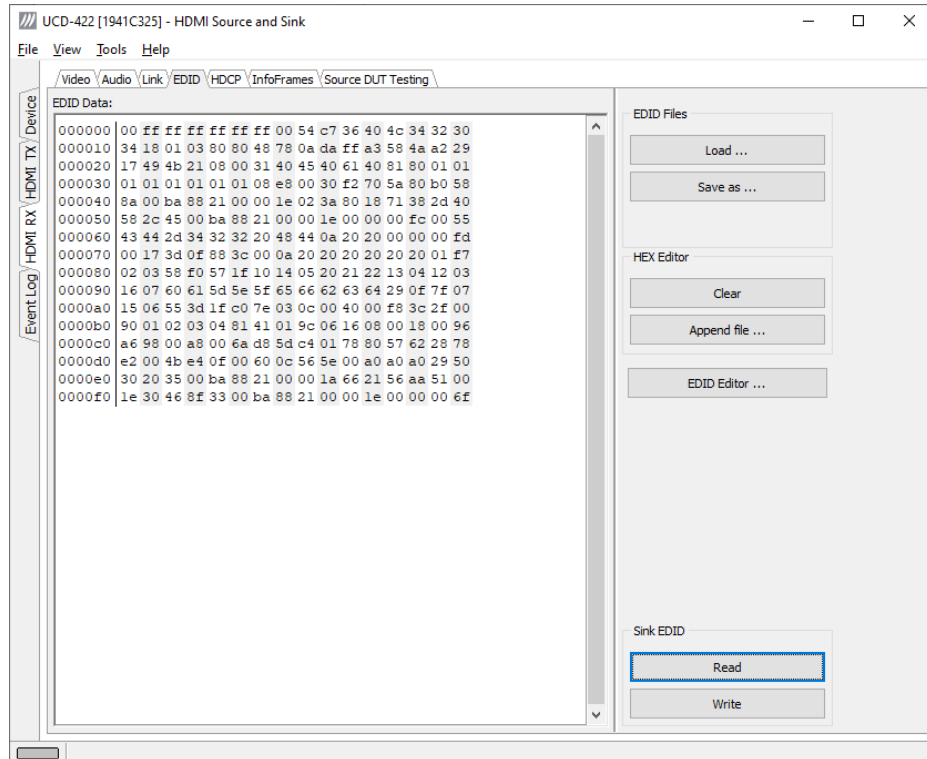
ALLM

Indication that Auto Low-Latency Mode is enabled

EDID Tab

EDID Tab provides tools for accessing the EDID or DisplayID of the UCD-422 Sink presented to the Upstream Source Device. There are three basic functions:

- Load and save EDID data files in the host PC
- Edit the EDID contents
- Program and read the contents of the EDID memory of the local port



EDID Files

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

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

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

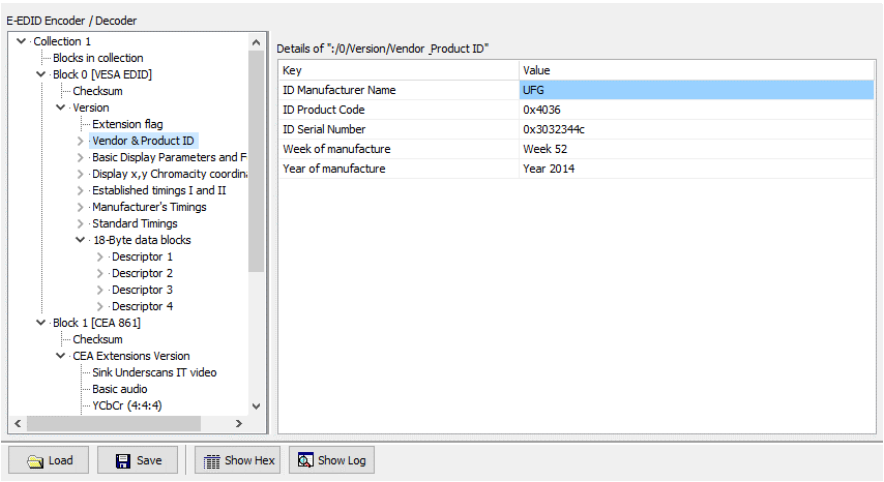
HEX Editor

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

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

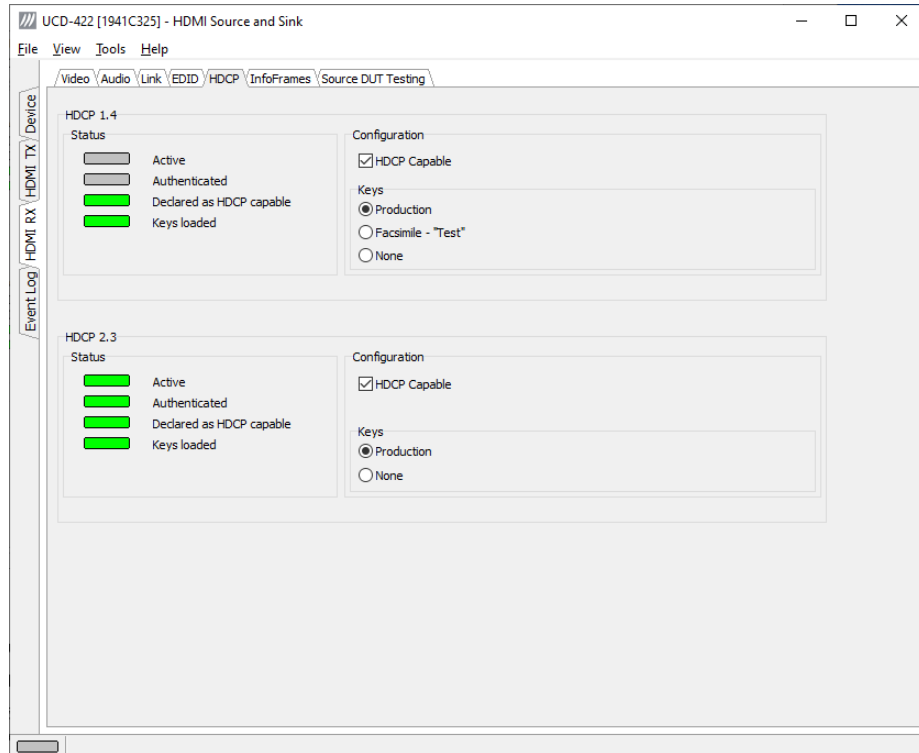
EDID Editor

EDID Editor is launched in a separate pop-up window. Please see the description of the EDID editor in Chapter [EDID Editor](#) later in this document.



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-422 device.



Status

The status field indicates the HDCP status of the UCD-422 device.

Active: The link between UCD-422 and the upstream source has been encrypted.

Authenticated: The HDCP handshake between the UCD-422 and the sink unit has been completed successfully.

Declared as HDCP capable: The UCD-422 unit recognizes HDCP handshake messages.

Keys loaded: The HDCP keys are loaded to the UCD-422 unit.

Configuration

HDCP Capable: To disable HDCP uncheck the box.

Keys

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

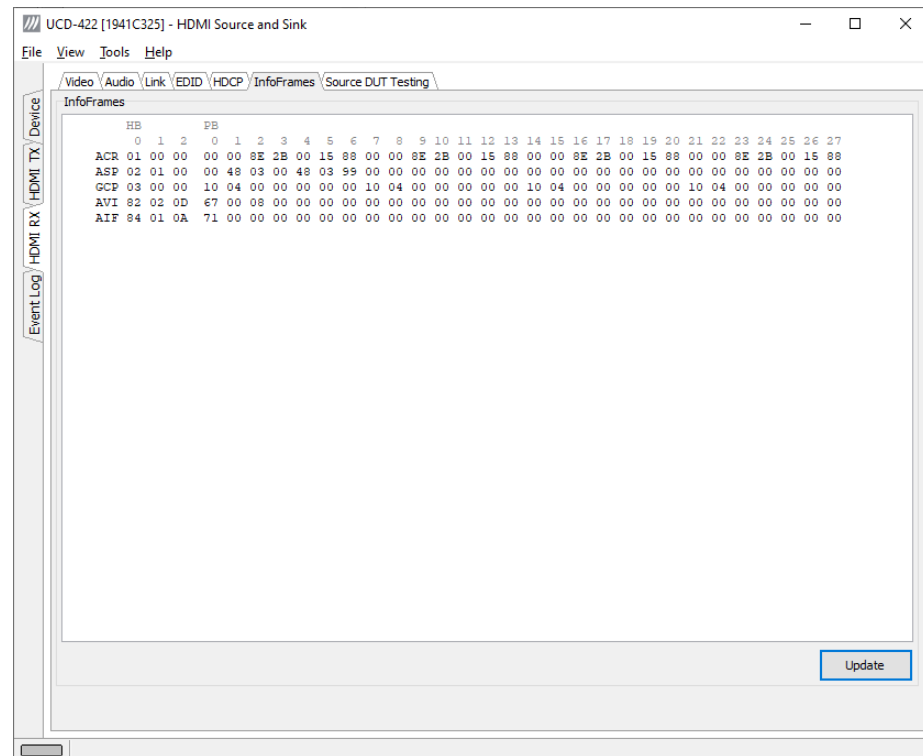
HDCP 1.4 vs. HDCP 2.3

UCD-422 devices support by default both HDCP 1.4 and HDCP 2.3 standard.

| | |
|------|---|
| Note | Please note that when using Fixed Rate Link mode (FRL), only HDCP 2.2 / 2.3 will be used. |
|------|---|

InfoFrame Tab

InfoFrame Tab displays in hexadecimal format the following received infoframes:



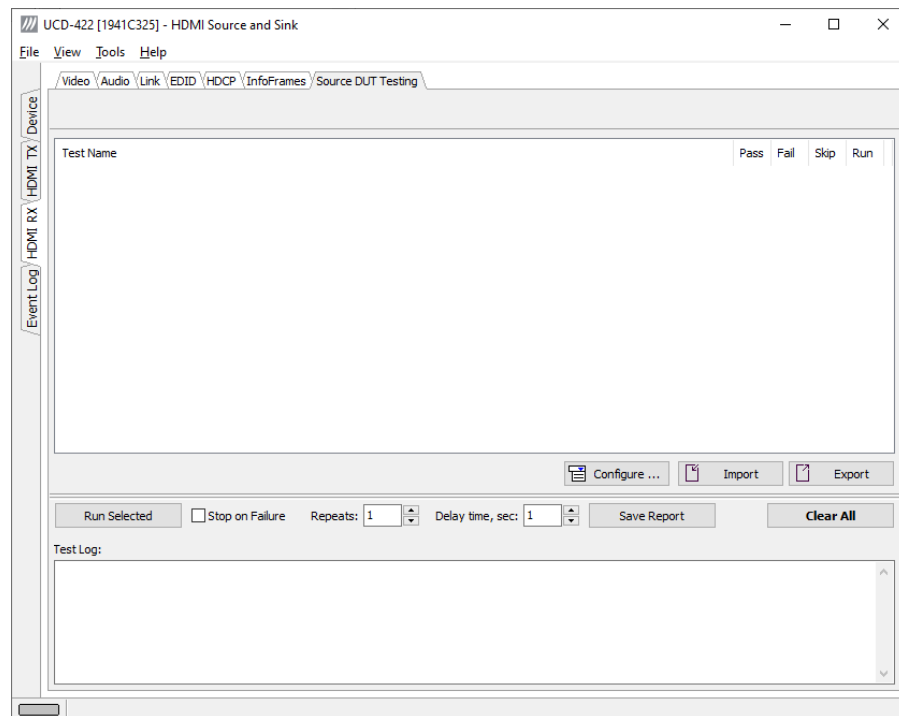
InfoFrames tab displays in hexadecimal format the following received infoframes:

- 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)

Please click **Update** to re-read the InfoFrame data.

Source DUT Testing Tab

Source DUT Testing Tab are not supported in current version of UCD-422.



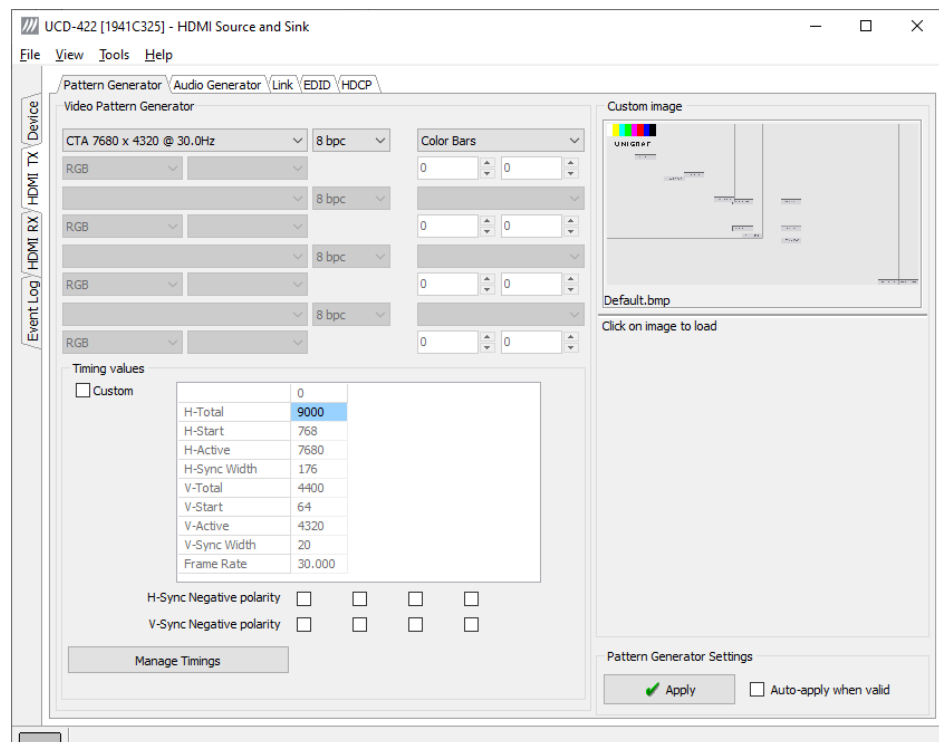
7. HDMI REFERENCE SOURCE

HDMI Reference Source function (HDMI TX) can be selected from vertical tab on the left edge of the GUI.

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

- Video pattern generator (Pattern Generator).
- Audio generator (Audio Generator)
- Status information and control of the downstream link (Link).
- EDID editor (EDID).
- HDCP status monitor and control (HDCP)

Pattern Generator Tab



Predefined Timings

UCD-422 includes a set of common predefined video timings. Please find a list of the timings with their major details in [Appendix C](#) of this document.

Color Mode

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

Color Depth

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

Predefined Video Patterns

UCD-422 has a set of predefined patterns and a possibility to user defined custom pattern. You can select the pattern in the provided combo box. By selecting **Disabled** you can have the links activated but no video data transferred.

Please find a description of the available test patterns in [Appendix D](#) of this document.

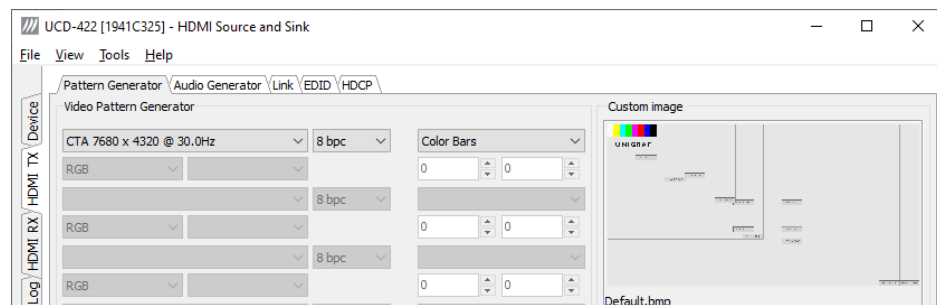
Custom Image Patterns

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

To load a custom image, please click on the image in top right hand corner of the dialog. To enable the custom pattern, select pattern *Custom Image* in the pattern selector combo box.

Pattern Generator Settings

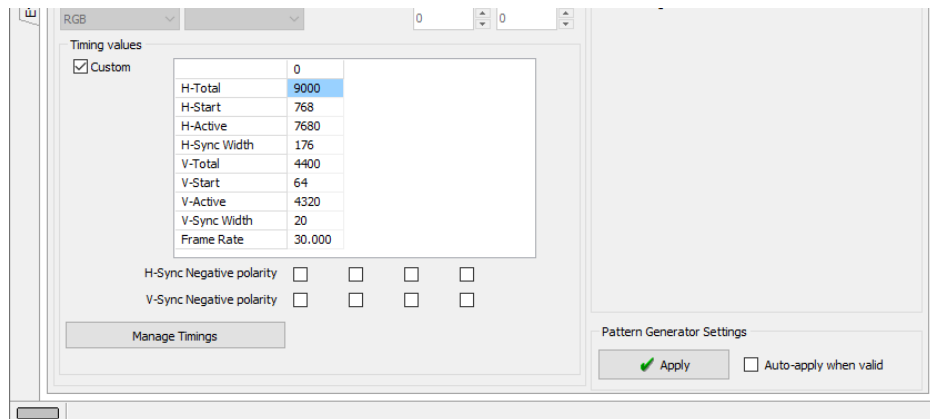
In order to avoid sourcing invalid video mode combinations, the new settings need to be validated by the user by clicking **Apply**. Automatic validation will be applied when **Auto-apply when valid** is checked. The situation that parameters have been changed but not applied is indicated by **bold values** of the parameter.



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

Custom Timing

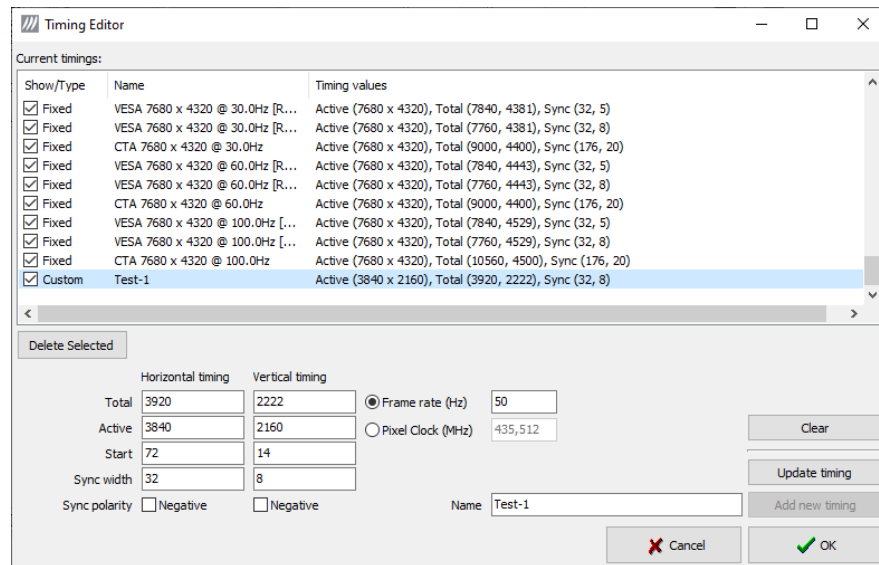
Custom Timing feature is enabled with *UCD Pro for HDMI Source* license.



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

Manage Timings

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



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

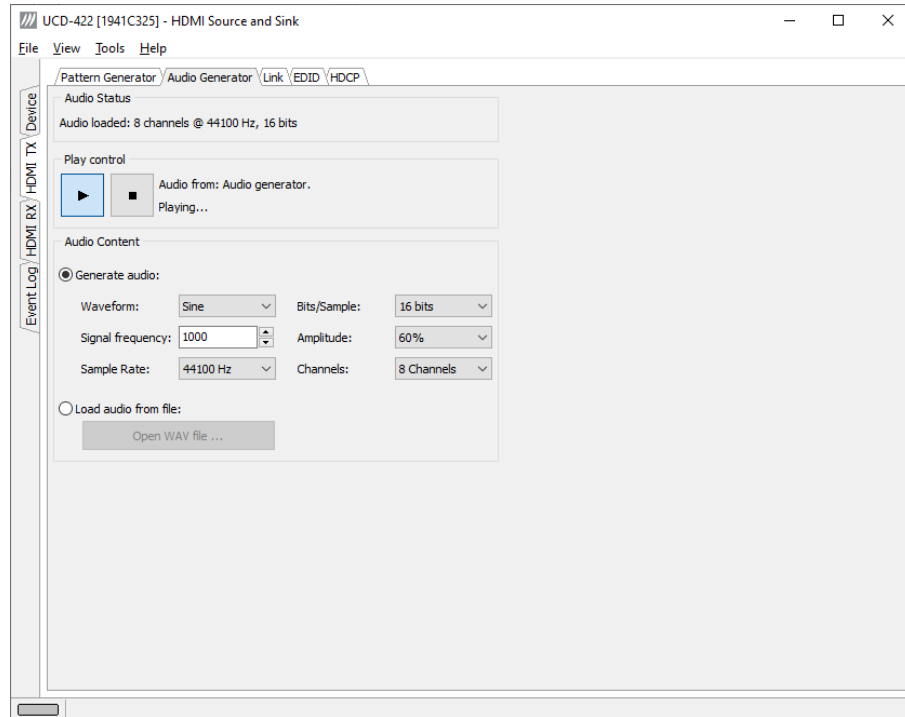
The dialog will make a sanity check for the values entered and will warn the user for any combinations that cannot be used.

Customize Timings List

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

Audio Generator Tab

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



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

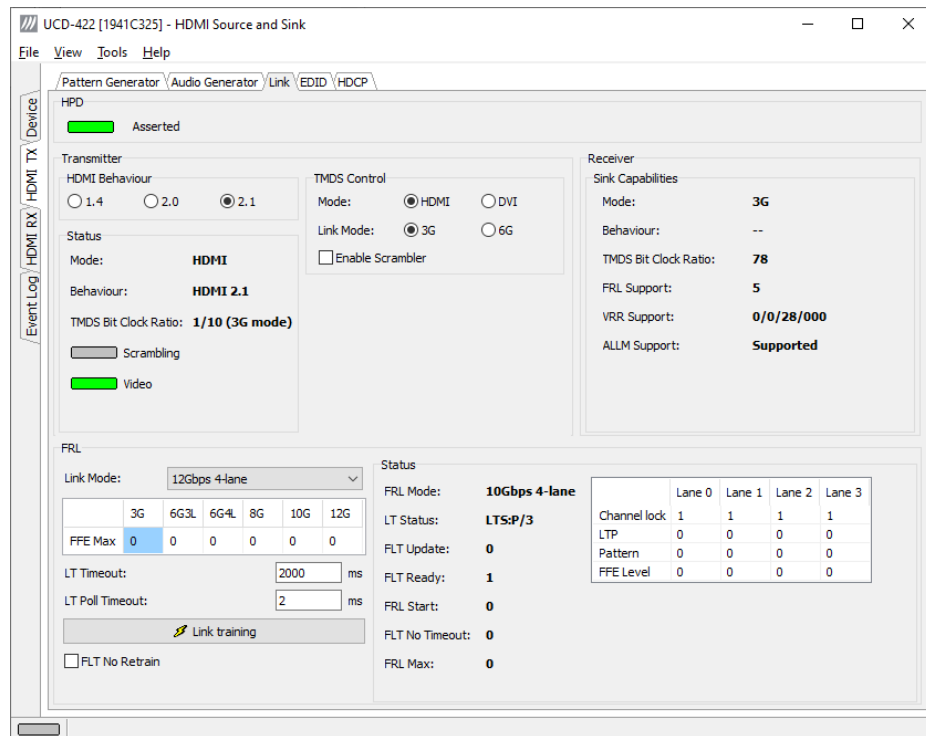
- ▶ To load an audio file from your PC, select **Load audio from file**, click the **Open WAV file...** button, browse and select the file and click **Open**
- ▶ To play the selected audio content, click the **Play** button.

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

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

Link Tab

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



HPD

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

HDMI Behavior

Selection of the HDMI version to be used.

Status

Mode: Indication of the HDMI/TMDs mode (HDMI/DVI) (only in TMDs mode)

Behavior: Status of the HDMI Mode (HDMI 1.4 / HDMI 2.0 / HDMI 2.1).

TMDs Bit Clock Ratio: Status of (TMDs Bit Period) / (TMDs Clock Period) ratio (1/10 or 1/40) (only in TMDs mode)

Scrambling: Status of Scrambling_Enable bit (1=LED on; 0=LED off)

Receiver / Sink Capabilities

Status of connected HDMI Sink device.

Mode: Status of Max_TMDs_Character_Rate byte in the sink's VSDB

Behaviour: Used HDMI mode

TMDs Bit Clock Ratio: Status of the TMDs_Bit_Clock_Ratio (1/10 / 1/40)

FRL Support: Sink's FRL support level as indicated in sink's HF-VSDB

VRR Support: Lowest frame rate and upper limit of the frame rate that sink is able to support using Variable Refresh Rate as indicated in sink's HF-VSDB

ALLM Support: Indication of Auto Low-Latency Mode support in sink's HF-VSDB

FRL

Link Mode: Set the link mode used for FRL link training.

FFE Max: Set the maximum level (0 – 3) supported for each FRL rate

LT Timeout: The time used for FLT Timer (default = 2000 ms)

LT Poll Timeout: Poll interval for FLT_update flag (default = 2 ms)

Link training: Start link training with values set in this dialog.

FLT No Retrain: Set the FLT_no_retrain bit in SCDSC Sink Configuration register of the connected HDMI sink

Status

FRL Mode: FRL Mode used by UCD-422 HDMI source

LT Status: FRL link training status of UCD-422 HDMI source

FLT Update: Status of FLT_update flag in SCDSC Update Flags register of the connected HDMI sink.

FLT Ready: Status of FLT_ready flag in SCDSC Status Flags register of the connected HDMI sink.

FRL Start: Status of FLT_update flag in SCDSC Update Flags register of the connected HDMI sink.

FLT No Timeout: Status of FLT_no_timeout flag in SCDSC Source Test Configuration register of the connected HDMI sink.

FRL Max: Status of FRL_Max flag in SCDSC Source Test Configuration register of the connected HDMI sink.

Lane Status Matrix

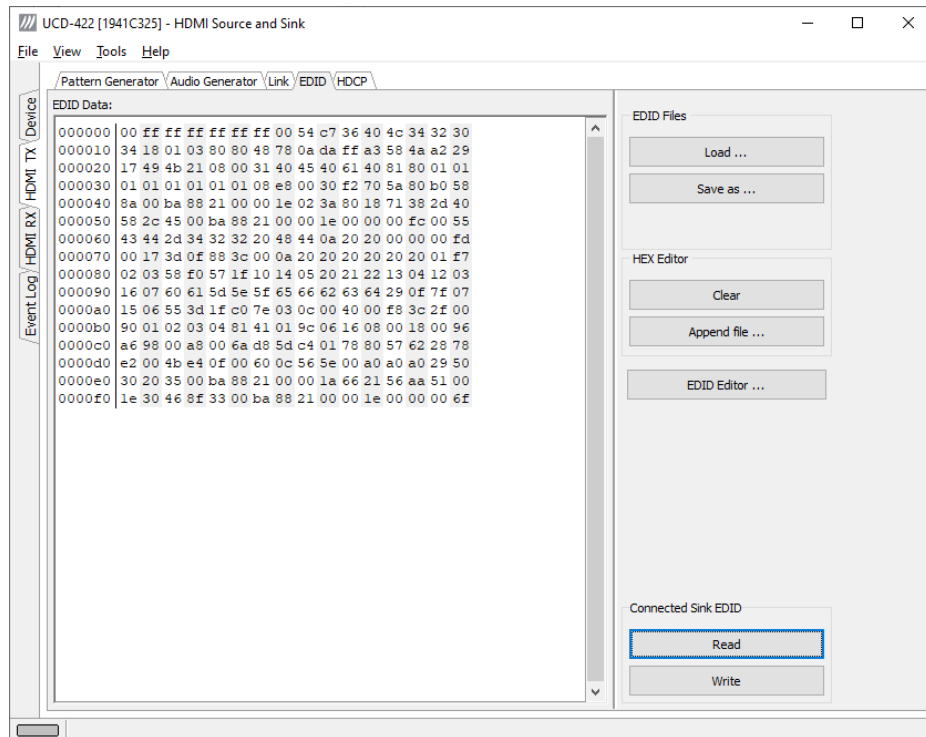
Channel lock: Status of channel lock bits in SCDSC Status Flags register of the connected HDMI sink

LTP: Status of Lnx_LTP_req (x = 0 to 3) fields in SCDSC Status Flags register of the connected HDMI sink

Pattern: Link Training Pattern used (0 to 8)

FFE Level: FFE level used (0 to 4)

EDID Tab



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

There are three basic functions:

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

EDID Files

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

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

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

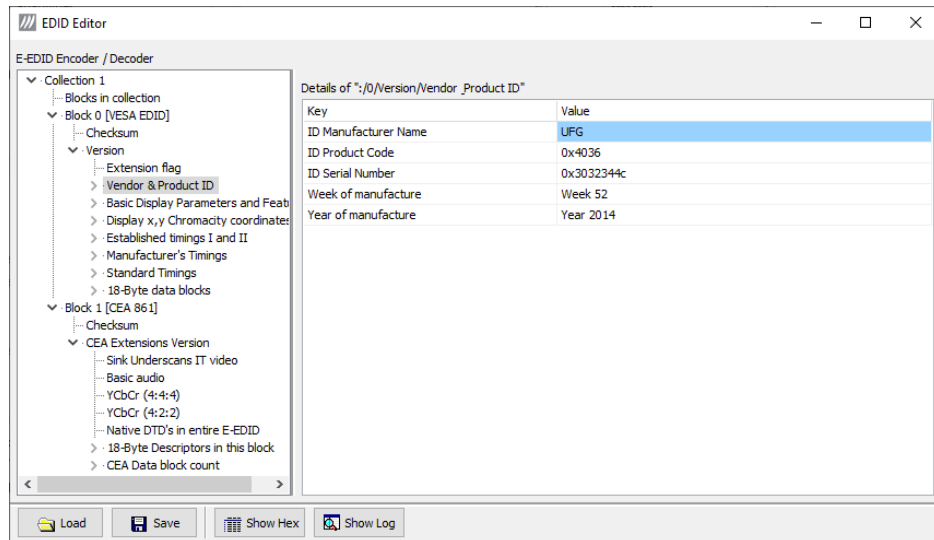
HEX Editor

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

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

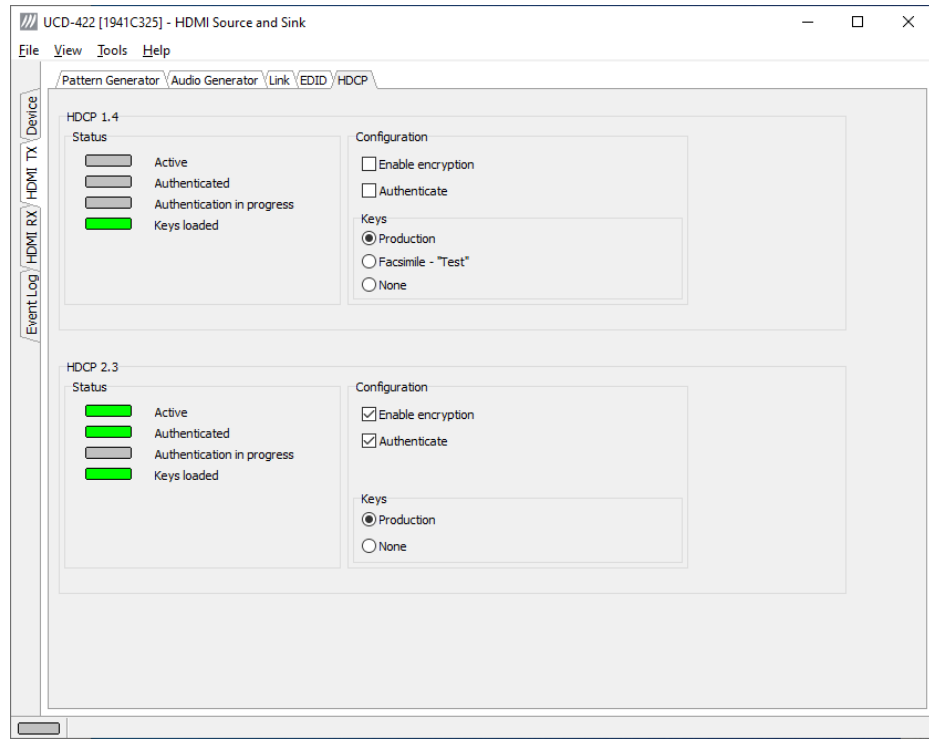
EDID Editor

EDID Editor is launched in a separate pop-up window. Please see the description of the EDID editor in Chapter [EDID Editor](#) later in this document.



HDCP Tab

HDCP tab is the dialog for monitoring the HDCP (for High-Bandwidth Digital Content Protection) Status



The status fields indicate the HDCP status of the connected UCD-422 device.

Active: The stream between UCD-422 and the downstream sink has been encrypted.

Authenticated: The HDCP handshake between the UCD-422 and the sink unit has been completed successfully.

Authentication in process: The HDCP handshake is in process between the UCD-422 and the downstream sink unit.

Keys loaded: The HDCP keys are loaded to the UCD-422 unit.

Configuration

Enable encryption: Check to enable the encryption of the stream between UCD-422 and the downstream sink.

Authenticate: Perform the HDCP initiation handshake between the UCD-422 and the sink unit.

Keys

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

HDCP 1.4 vs. HDCP 2.3

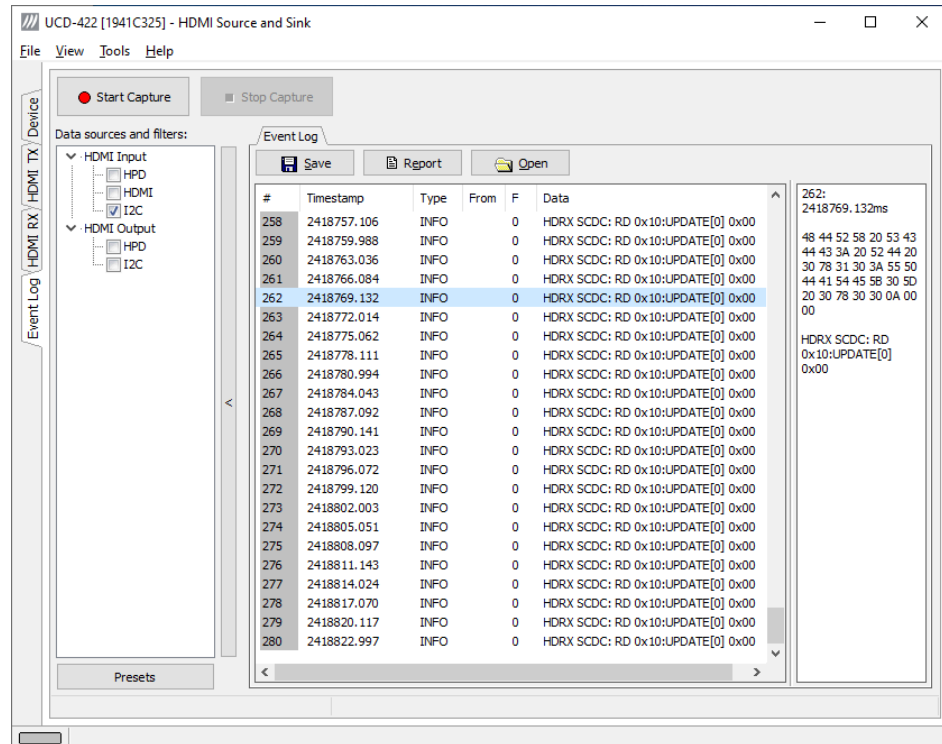
UCD-422 devices support by default HDCP 1.4 and HDCP 2.3.

| | |
|------|---|
| Note | Please note that when using Fixed Rate Link mode (FRL), only HDCP 2.2 / 2.3 will be used. |
|------|---|

8. EVENT LOG

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

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



With the *Event Logger* captures the following items

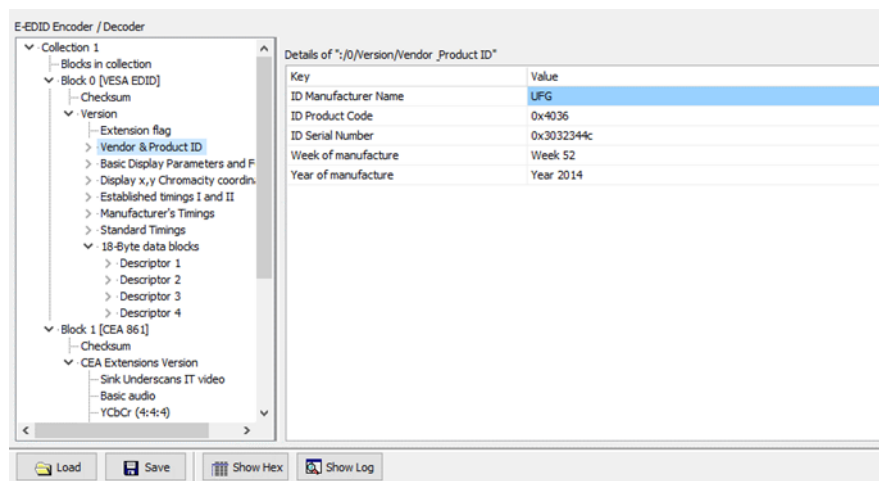
- HPD status (HDMI TX and HDMI RX)
- HDMI Messages
- I2C Messages

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

- ▶ Start event logging by clicking **Start Capture** and stop it by clicking **Stop Capture**.
- ▶ The transactions can be saved in binary *.evt Event Log files by clicking **Save**. Saved Event Log files can be recalled by clicking **Open**.
- ▶ Clicking **Report** stores event logs as html reports to be shared and viewed with any web browser. The save dialog allows inclusion of detailed information about the DUT and the test in free-text *Report information*.

9. EDID EDITOR

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



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

Command Buttons

Load: Load an EDID block collection file from disk.

Save: Save the current block collection to a disk file.

Show Hex: Show or Hide the HEX view.

Show Log: Show or Hide the Log view.

EDID Editor Features

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

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

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

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

Editing Tips

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

- **Enter** key will apply text-edit values and combo-box selection.
- To apply new setting to *binary* values (ones that show a check-box), please click the **Set** button.
- When you see a **Quick Config** button appear below an editor, you can access a configuration menu that allows you to quickly select one of multiple pre-defined setup options.
- In CEA-861 blocks, you can add and remove 18-byte descriptors and CEA data blocks by setting the values “18-byte Descriptors in this block” and “CEA Data block count”. Unfortunately re-arranging the descriptors and CEA data blocks is not supported yet, so you need to be careful when editing these.
- Enter hex values with prefix “0x” or “\$”, no prefix means a decimal value.
- You can always enter HEX or DEC, even if the value is presented as HEX, and/or value range is given in HEX.
- Floating point values must be given with period “.” as decimal separator, even if your localization setting defines decimal separator as comma (or other).
- Remember to click **Set** after changing a bit-value presented as a single check-box if you want the new value applied.

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

Saving EDID Data

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

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

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

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

APPENDIX A. PRODUCT SPECIFICATION

UCD-422

| | |
|---------------------|---|
| Input | HDMI 2.1 (10K@30Hz) (HDMI Rx) |
| Output | HDMI 2.1 (10K@30Hz) (HDMI Tx) |
| HDMI 2.1 Features | FRL, TMDS, ALLM, VRR |
| Content Protection | HDCP 1.4, HDCP 2.2, HDCP 2.3 |
| Additional features | eARC*, DSC* |
| Computer interface | USB 3.0 |
| Operating System | Windows 10, 8 and 7 |
| Software | UCD Console GUI TSI API with interface specific Test Sets |
| Power supply | AC/DC Power supply (100 to 240 Vac 50/60 Hz input, +12 Vdc output) |
| Mechanical Size | 272 × 170 × 60 mm |
| Weight | 1.2 kg w/o power supply |

*) Please contact Unigraf for detailed availability

APPENDIX B. LICENSING

In the following pages, please find detailed explanation of the functions and the licensing.
Please refer to TSI documentation on detailed description of TSI features.

HDMI Reference Sink (HDMI RX)

| Tab | Function | Basic | DSC Decoder |
|--------------------|--|-------|-------------|
| Video | | | |
| | Preview, Capture, Snap preview | ● | |
| | Status | ● | |
| Audio | | ● | |
| | Monitor, Capture and graphical preview | ● | |
| | Status | ● | |
| Link | | ● | |
| | Link Status, Link Configuration | ● | |
| | Stream Status (video, audio) | ● | |
| | HPD Status, HPD Assert / De-assert | ● | |
| | DSC Decoder | | ○ |
| EDID | | | |
| | Read / Write, Save / Load, EDID Editor | ● | |
| HDCP | | | |
| | HDCP 1.4 and HDCP 2.3 Support | ○ | |
| | Authentication status, Encryption status | ○ | |
| Event Log | | | |
| | Event Log | ● | |
| Source DUT Testing | | | |

● Feature available

○ To be introduced later

HDMI Reference Source (HDMI TX)

| Tab | Function | Basic | DSC Encoder |
|-------------------|---|-------|-------------|
| Pattern Generator | | | |
| | Fixed and custom Video Timings | ● | |
| | Fixed and custom Video Patterns | ● | |
| Audio Generator | | | |
| | Play audio files | ● | |
| Link | | | |
| | Link Status | ● | |
| | HPD Status: (Asserted / De-asserted) | ● | |
| | Link Configuration | ● | |
| | DSC Encoder | | ○ |
| EDID | | | |
| | Read / Write, Save / Load, EDID Editor | ● | |
| HDCP | | | |
| | HDCP 1.4 Support | ○ | |
| | Control: (Enable / Disable, authenticate only, Encryption Enable / Disable) | ○ | |
| | Status: (Authentication status, Encryption status) | ○ | |
| | HDCP 2.3 Support | ○ | |
| Event Log | | | |
| | Event Log | ● | |
| Sink DUT Testing | | ○ | |

● Feature available

○ To be introduced later

APPENDIX C: PREDEFINED TIMINGS

Supported FRL Lane Combination

| Description | H active | V active | H total | V total | Frame rate | 8 bpc YcbCr 4:2:0 | 10 bpc YcbCr 4:2:0 | 12 bpc YcbCr 4:2:0 | 8 bpc 4:2:2 4:4:4 | 10 bpc 4:2:2 4:4:4 | 12 bpc 4:2:2 4:4:4 |
|--------------------------------|----------|----------|---------|---------|------------|-------------------------|--------------------------|--------------------------|-------------------------|--------------------------|--------------------------|
| VESA 800 x 600 @ 60Hz | 800 | 600 | 1056 | 628 | 60 | | | | 3G | 3G | 3G |
| VESA 848 x 480 @ 60Hz | 848 | 480 | 1088 | 517 | 60 | | | | 3G | 3G | 3G |
| VESA 1024 x 768 @ 60Hz | 1024 | 768 | 1344 | 806 | 60 | | | | 3G | 3G | 3G |
| CTA 1280 x 720 @ 60Hz | 1280 | 720 | 1650 | 750 | 60 | | | | 3G | 3G | 3G |
| VESA 1280 x 768 @ 60Hz | 1280 | 768 | 1664 | 798 | 60 | | | | 3G | 3G | 3G |
| VESA 1280 x 960 @ 60Hz | 1280 | 960 | 1800 | 1000 | 60 | | | | 3G | 3G | 3G |
| VESA 1280 x 800 @ 60Hz [RB] | 1280 | 800 | 1440 | 823 | 60 | | | | 3G | 3G | 3G |
| VESA 1280 x 800 @ 60Hz | 1280 | 800 | 1680 | 831 | 60 | | | | 3G | 3G | 3G |
| VESA 1280 x 768 @ 60Hz | 1280 | 768 | 1440 | 790 | 60 | | | | 3G | 3G | 3G |
| VESA 1280 x 1024 @ 60Hz | 1280 | 1024 | 1688 | 1066 | 60 | | | | 3G | 3G | 3G |
| VESA 1360 x 768 @ 60Hz | 1360 | 768 | 1792 | 795 | 60 | | | | 3G | 3G | 3G |
| VESA 1400 x 1050 @ 60Hz | 1400 | 1050 | 1560 | 1080 | 60 | | | | 3G | 3G | 3G |
| VESA 1600 x 1200 @ 60Hz [RB] | 1600 | 1200 | 1760 | 1235 | 60 | | | | 3G | 3G | 3G |
| VESA 1600 x 1200 @ 60Hz | 1600 | 1200 | 2160 | 1250 | 60 | | | | 3G | 3G | 3G |
| VESA 1680 x 1050 @ 60Hz | 1680 | 1050 | 2240 | 1089 | 60 | | | | 3G | 3G | 3G |
| VESA 1680 x 1050 @ 60Hz [RB] | 1680 | 1050 | 1840 | 1080 | 60 | | | | 3G | 3G | 3G |
| VESA 1792 x 1344 @ 60Hz | 1792 | 1344 | 2448 | 1394 | 60 | | | | 3G | 3G | 3G |
| VESA 1920 x 1080 @ 30Hz [RB1] | 1920 | 1080 | 2080 | 1096 | 30 | | | | 3G | 3G | 3G |
| VESA 1920 x 1080 @ 30Hz [RB2] | 1920 | 1080 | 2000 | 1096 | 30 | | | | 3G | 3G | 3G |
| CTA 1920 x 1080 @ 30Hz | 1920 | 1080 | 2200 | 1125 | 30 | | | | 3G | 3G | 3G |
| VESA 1920 x 1080 @ 60Hz [RB1] | 1920 | 1080 | 2080 | 1111 | 60 | | | | 3G | 3G | 3G |
| VESA 1920 x 1080 @ 60Hz [RB2] | 1920 | 1080 | 2000 | 1111 | 60 | | | | 3G | 3G | 3G |
| CTA 1920 x 1080 @ 60Hz | 1920 | 1080 | 2200 | 1125 | 60 | | | | 3G | 3G | 3G |
| VESA 1920 x 1080 @ 120Hz [RB1] | 1920 | 1080 | 2080 | 1144 | 120 | | | 3G | 3G | 3G | 6G3L |
| VESA 1920 x 1080 @ 120Hz [RB2] | 1920 | 1080 | 2000 | 1144 | 120 | | | 3G | 3G | 3G | 6G3L |
| CTA 1920 x 1080 @ 120Hz | 1920 | 1080 | 2200 | 1125 | 120 | | | 3G | 3G | 6G3L | 6G3L |
| VESA 1920 x 1440 @ 60Hz | 1920 | 1440 | 2600 | 1500 | 60 | | | | 3G | 3G | 3G |
| VESA 2048 x 1536 @ 60Hz | 2048 | 1536 | 2208 | 1580 | 60 | | | | 3G | 3G | 3G |
| VESA 2560 x 1440 @ 60Hz | 2560 | 1440 | 2720 | 1481 | 60 | | | | 3G | 3G | 3G |
| VESA 2560 x 1080 @ 60Hz | 2560 | 1080 | 3424 | 1120 | 60 | | | | 3G | 3G | 3G |
| VESA 2560 x 1080 @ 60Hz [RB] | 2560 | 1080 | 2720 | 1111 | 60 | | | | 3G | 3G | 3G |
| VESA 2560 x 1600 @ 60Hz | 2560 | 1600 | 3504 | 1658 | 60 | | 3G | 3G | 6G3L | 6G3L | 6G3L |
| VESA 2560 x 1600 @ 60Hz [RB] | 2560 | 1600 | 2720 | 1646 | 60 | | | 3G | 3G | 3G | 6G3L |
| Other 2880 x 1440 @ 60Hz | 2880 | 1440 | 2976 | 1456 | 60 | | | | 3G | 3G | 3G |

3G 3 Gbps 3 Lanes


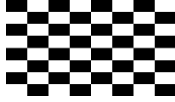




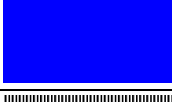


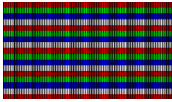
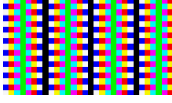


6G3L 6 Gbps 3 Lanes

Supported FRL Lane Combination (contd.)

| Description | H active | V active | H total | V total | Frame rate | 8 bpc YcbCr 4:2:0 | 10 bpc YcbCr 4:2:0 | 12 bpc YcbCr 4:2:0 | 8 bpc 4:2:2 4:4:4 | 10 bpc 4:2:2 4:4:4 | 12 bpc 4:2:2 4:4:4 |
|--------------------------------|----------|----------|---------|---------|------------|-------------------------|--------------------------|--------------------------|-------------------------|--------------------------|--------------------------|
| VESA 4096 x 2160 @ 60Hz | 4096 | 2160 | 4176 | 2222 | 60 | 3G | 6G3L | 6G3L | 6G3L | 6G3L | 6G4L |
| VESA 3840 x 2160 @ 30Hz [RB1] | 3840 | 2160 | 4000 | 2191 | 30 | | | | 3G | 3G | 3G |
| VESA 3840 x 2160 @ 30Hz [RB2] | 3840 | 2160 | 3920 | 2191 | 30 | | | | 3G | 3G | 3G |
| CTA 3840 x 2160 @ 30Hz | 3840 | 2160 | 4400 | 2250 | 30 | | | | 3G | 6G3L | 6G3L |
| CTA 3840 x 2160 @ 50Hz | 3840 | 2160 | 5280 | 2250 | 50 | 3G | 6G3L | 6G3L | 6G3L | 6G4L | 6G4L |
| CTA 4096 x 2160 @ 50Hz | 4096 | 2160 | 5280 | 2250 | 50 | 3G | 6G3L | 6G3L | 6G3L | 6G4L | 6G4L |
| VESA 3840 x 2160 @ 60Hz [RB1] | 3840 | 2160 | 4000 | 2222 | 60 | 3G | 3G | 6G3L | 6G3L | 6G3L | 6G3L |
| VESA 3840 x 2160 @ 60Hz [RB2] | 3840 | 2160 | 3920 | 2222 | 60 | 3G | 3G | 6G3L | 6G3L | 6G3L | 6G3L |
| CTA 3840 x 2160 @ 60Hz | 3840 | 2160 | 4400 | 2250 | 60 | 3G | 6G3L | 6G3L | 6G3L | 6G4L | 6G4L |
| CTA 4096 x 2160 @ 60Hz | 4096 | 2160 | 4400 | 2250 | 60 | 3G | 6G3L | 6G3L | 6G3L | 6G4L | 6G4L |
| VESA 3840 x 2160 @ 120Hz [RB1] | 3840 | 2160 | 4000 | 2287 | 120 | 6G3L | 6G4L | 6G4L | 8G | 8G | 10G |
| VESA 3840 x 2160 @ 120Hz [RB2] | 3840 | 2160 | 3920 | 2287 | 120 | 6G3L | 6G4L | 6G4L | 8G | 8G | 10G |
| CTA 3840 x 2160 @ 120Hz | 3840 | 2160 | 4400 | 2250 | 120 | 6G3L | 6G4L | 6G4L | 8G | 10G | |
| VESA 5120 x 2160 @ 30Hz [RB1] | 5120 | 2160 | 5280 | 2191 | 30 | | | | 6G3L | 6G3L | 6G3L |
| VESA 5120 x 2160 @ 30Hz [RB2] | 5120 | 2160 | 5200 | 2191 | 30 | | | | 6G3L | 6G3L | 6G3L |
| CTA 5120 x 2160 @ 30Hz | 5120 | 2160 | 6000 | 2200 | 30 | | | | 6G3L | 6G3L | 6G3L |
| VESA 5120 x 2160 @ 60Hz [RB1] | 5120 | 2160 | 5280 | 2222 | 60 | 6G3L | 6G3L | 6G3L | 6G4L | 6G4L | 6G4L |
| VESA 5120 x 2160 @ 60Hz [RB2] | 5120 | 2160 | 5200 | 2222 | 60 | 6G3L | 6G3L | 6G3L | 6G4L | 6G4L | 6G4L |
| CTA 5120 x 2160 @ 60Hz | 5120 | 2160 | 5500 | 2250 | 60 | 6G3L | 6G3L | 6G3L | 6G4L | 8G | 8G |
| VESA 5120 x 2160 @ 120Hz [RB1] | 5120 | 2160 | 5280 | 2287 | 120 | 6G4L | 8G | 8G | | | |
| VESA 5120 x 2160 @ 120Hz [RB2] | 5120 | 2160 | 5200 | 2287 | 120 | 6G4L | 8G | 8G | | | |
| CTA 5120 x 2160 @ 120Hz | 5120 | 2160 | 5500 | 2250 | 120 | 6G4L | 8G | 8G | | | |
| Other 5120 x 2880 @ 60Hz | 5120 | 2880 | 5280 | 2962 | 60 | 6G3L | 6G3L | 6G4L | 8G | 8G | 8G |
| VESA 7680 x 4320 @ 30Hz [RB1] | 7680 | 4320 | 7840 | 4381 | 30 | 6G3L | 6G3L | 6G4L | 8G | 8G | 10G |
| VESA 7680 x 4320 @ 30Hz [RB2] | 7680 | 4320 | 7760 | 4381 | 30 | 6G3L | 6G3L | 6G4L | 8G | 8G | 10G |
| CTA 7680 x 4320 @ 30Hz | 7680 | 4320 | 9000 | 4400 | 30 | 6G3L | 6G4L | 6G4L | 8G | 10G | |
| VESA 7680 x 4320 @ 60Hz [RB1] | 7680 | 4320 | 7840 | 4443 | 60 | 8G | 10G | 12G | | | |
| VESA 7680 x 4320 @ 60Hz [RB2] | 7680 | 4320 | 7760 | 4443 | 60 | 8G | 10G | 12G | | | |
| CTA 7680 x 4320 @ 60Hz | 7680 | 4320 | 9000 | 4400 | 60 | 8G | 10G | 12G | | | |
| VESA 7680 x 4320 @ 100Hz [RB1] | 7680 | 4320 | 7840 | 4529 | 100 | 12G | | | | | |
| VESA 7680 x 4320 @ 100Hz [RB2] | 7680 | 4320 | 7760 | 4529 | 100 | 12G | | | | | |
| CTA 7680 x 4320 @ 100Hz | 7680 | 4320 | 10560 | 4500 | 100 | | | | | | |

| | |
|------|-----------------|
| 3G | 3 Gbps 3 Lanes |
| 6G3L | 6 Gbps 3 Lanes |
| 6G4L | 6 Gbps 4 Lanes |
| 8G | 8 Gbps 4 Lanes |
| 10G | 10 Gbps 4 Lanes |
| 12G | 12 Gbps 4 Lanes |

APPENDIX D: PREDEFINED PATTERNS

| Selection | Pattern | Description |
|---------------------------|---|--|
| Disabled | N/A | 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 Black |  | 0% luminance |
| Solid White |  | 100% white |
| Solid Red |  | 100% red |
| Solid Green |  | 100% green |
| Solid Blue |  | 100% blue |
| White Vertical Stripes |  | Vertical stripes of black (0%) and white (100%). Parameters set the widths of the black and white stripes in pixels respectively. Default black / white = 20 / 20 pixels. Parameter range 0 to 5000. |
| Gradient Vertical Stripes |  | 16 pixels high horizontal red green, blue and white stripes. Intensity is increased from 0 to 100% with steps defined by the given parameter (n). (step = $n \cdot \text{color_depth} / 256$). "n" range 0 to 5000 (default 120). |
| 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) |
| Custom Image |  | Bitmap image uploaded by the user. Click on the Custom Images panel to browse. By default, Unigraf test image will be used. |

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