Video Electronics Production Testing

White Paper

December 2014

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Unigraf is an innovative Finland based company specializing in Test & Measurement, Video signal capturing and Industrial monitoring applications. Unigraf is one of the worldwide leading suppliers of test equipment for testing video and audio enabled devices. Leading chip and device manufacturers are using Unigraf devices both in the design phase and in the production line. Unigraf provides test equipment and software for testing both sinks (TVs and monitors) and sources (PCs, Players, Set top boxes, etc). Unigraf test equipment cover most interface types from DisplayPort and HDMI through analog to dedicated TFT LCD panel interfaces. Unigraf’s Test System Interface (TSI) is the Software Application Program Interface (API) that is used to implement test automation with Unigraf Test Equipment. It provides the user Test Equipment (TE) hardware independent access point for testing a specific display interface(s). This greatly reduces the need for application specific design work and detailed knowledge about the specifics of the display interface in question. (www.unigraf.fi)

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Preface

Video content is created and shared at ever increasing pace. More and more applications from transportation to digital signage are utilizing video content. Migration of mobility and video consumption increases with second screen applications. New display interfaces – such as HDMI2.0 and DP1.3 – are becoming available for consumers and business users.

Display industry is facing increasing challenge where short product development cycles, fast eroding prices and multivendor environment are putting pressure to the whole industry. Consumers and business users alike expect products with latest features, out of box experience and acceptable price levels. Big part of the job will be done in the design labs but eventually it is the manufacturer of the device, who needs to verify the functionality of the manufactured product. Every returned product or field repair will ruin the profitability and damage the brand.

The increasing complexity and e.g. introduction of super high resolution displays will inhibit the tests based on human observation. Human vision is not capable any more for the task and quality fluctuations caused by fatigue cannot be accepted.

Hence, the only practical way for combining efficient production and sufficient testing is increasing the level of test automation.
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Introduction

Functional testing is needed to secure that manufactured device or component meets quality criteria. Traditional human based test systems are being replaced by semi- or fully automated tests systems for both cost saving and quality reasons. The advantage of automated testing is that it is not prone to human fatigue. It is equally precise with small screen sizes and the huge pixel count of modern 4K displays.

Production line testing assumes that all the HW components are already certified and comply with respective specifications. Therefore complex compliance tests are typically not involved at production testing. Tests should be simple with short test time but capable to catch product issues that might be caused at manufacturing stage.

Unigraf is a provider of test equipment hardware and test software that can be used for automating production line functional testing of display interfaces. This document explains the test automation and introduces Unigraf’s solution.
Key Aspects of Test Automation

Production testing is primarily concerned about detecting devices, which fail functionality and/or set quality criteria after the manufacturing. The following requirements apply:

- Short test time
- Primary test purpose is to identify failed devices
- Test must report what functional block of the interface failed and provide enough information about test progress and reasons of failure
- Easy and fast re-configuration of the test process
- The root cause analysis of the failure is not part of production testing discipline, but rather subject to debugging with more sophisticated tools such as R&D test tools

Optimal implementation assumes one test per video interface, which covers all functional blocks that need to be tested. Tests need to be regulated by configuration parameters, which allow the user to select which functional blocks are supported by DUT and require testing. Separate set of test cases per each functional test block is needed.

Often the display interface itself is only one part of the functionality of the device under testing (DUT). It is important that the display test technology is easy to integrate with operator’s existing test system environment.

Production line test need to cover all features of the DUT to make sure that all intended components are operational and properly mounted. At the same time the production line operation time is precious, only tests that are absolutely needed will be performed.

Advantages of automated functional testing:

- Savings in operational costs and savings in space
- Increase the number of DUT’s one operator can handle
- Shorter test cycle times products (traditional human vision based testing is slow in testing multitude of features)
- Improved and consistent test results and quality (not affected by human errors)

To test the functionality of display related electronics or devices, Unigraf’s test equipment replaces the actual display and captures the video frames for evaluation. Our deep experience in video interface protocol testing in development are utilized for more advanced functional testing in production too.
Unigraf Test System

Unigraf Test System (UTS) is a combination of hardware and software, with which the test system operator can easily automate testing of all video electronics devices and products. It can be integrated with existing test scheduler software, which may be already in operation e.g. for PCB functional testing (Mother boards, TV electronics, TCONs, etc), RF testing, keyboard testing, USB testing, etc., or it can be a new test station/system purposely built for testing video electronics devices.

**Unigraf Test System - UTS**

**Test System Interface**
- Control
- Preview / monitoring / snapshots
- Reporting

**Test Cases**
- Interface specific test routines
- Options set by parameters

**Test Equipment Interface**
- Low level, hardware specific functions

- Automated test functions
- Easy to integrate, easy to re-configure
- Hardware independent (future-proof)
Production Testing

Production testing is based on capturing and analyzing video and audio signal quality. Also additional complementing tests - such as e.g. CEC, EDID and electrical testing - are supported. Unigraf offers several hardware options for different production testing needs:

- UFG-06 is PCIe format hardware capable of capturing DisplayPort 1.1 and HDMI1.4 signals
- UCD-1 is USB2.0 connected capture device for testing LVDS and mLVDS video interfaces
- UCD-2 is USB2.0 connected capture device for testing VbyOne video interface
- UCD-300 product family is a selection of test platforms, which come in several different interface combinations. They are all USB3.0 connected capture devices supporting HDMI2.0 and DP1.2 at 4k resolutions (Ethernet connection is made optionally available). First three UCD-300 family products are UCD-301 Digital, UCD-303 Multimedia and UCD-323 HDDP Dual.
Key technical specifications of Unigraf test hardware are presented below:

<table>
<thead>
<tr>
<th>Inputs</th>
<th>UFG-06</th>
<th>UCD-1</th>
<th>UCD-2</th>
<th>UCD-301 Digital</th>
<th>UCD-303 Multimedia</th>
<th>UCD-323 HDDP Dual</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP 1.1 (1920x1200p60 max)</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>HDMI 1.4 (1920x1200p60 max)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DP 1.2 (4096x2160p60 max)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>HDMI 2.0 (4096x2160p60 max)</td>
<td>X</td>
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<tr>
<td>Dual-DVI (2560x1600p60 RB max)</td>
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<tr>
<td>RGB / YPbPr (10-bit, 205 MHz max)</td>
<td></td>
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<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>S-Video / CVBS</td>
<td></td>
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<tr>
<td>S/PDIF audio (192 kHz max)</td>
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<td></td>
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<tr>
<td>Line-in audio (24 bit @ 44.1 kHz)</td>
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<tr>
<td>mLVDS/LVDS</td>
<td></td>
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<tr>
<td>VbyOne (3840x2160p60max)</td>
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</table>

<table>
<thead>
<tr>
<th>Outputs</th>
<th>UFG-06</th>
<th>UCD-1</th>
<th>UCD-2</th>
<th>UCD-301 Digital</th>
<th>UCD-303 Multimedia</th>
<th>UCD-323 HDDP Dual</th>
</tr>
</thead>
<tbody>
<tr>
<td>DP 1.2 (4096x2160p60 max)</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDMI 2.0 (4096x2160p60 max)</td>
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<td></td>
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<tr>
<td>USB 3.0</td>
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<td></td>
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<td>X</td>
<td></td>
<td></td>
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<tr>
<td>PCIe</td>
<td></td>
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<td>Ethernet (optional)</td>
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<td>X</td>
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<td>Operating System</td>
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</tr>
<tr>
<td>Windows 8, 7, XP</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
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<tr>
<td>Linux</td>
<td>X</td>
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<tr>
<td>SW API</td>
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<td>X</td>
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<td>Test Software Interface API</td>
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<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Input</td>
<td>PCIe</td>
<td>+5VDC</td>
<td>+5VDC</td>
<td>+12VDC</td>
<td>+12VDC</td>
<td>+12VDC</td>
</tr>
<tr>
<td>Power over Ethernet (Optional)</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

*) Output capability of UCD-323 HDDP Dual can be operated in two different configurations. In the first release the product supports “monitor out”-function, which means that UCD-323 can relay the incoming video signal as received to the output connector. Second configuration mode allows the operator to use UCD-323 HDDP to act as a pattern generator tool for functional testing of sink and repeater devices.

For more detailed product information, please see test hardware product data sheets.
Hardware Independent Software

Introduction

Despite the fact that a lot of testing requirements remains the same for the new technologies, every new test hardware platform typically involves significant development effort to port already used test software functions to operate with new test hardware. This is not only cumbersome and laborious for the operators, but it also requires a lot of support from the hardware supplier.

Unigraf Test System (UTS) introduces a high level test software, which allows easy integration of the production testing routines into operator’s (automated) test system environment. It also ensures smooth migration of the already developed test functions to function with the new test hardware platforms.

Unigraf test software consists of Test System Interface (TSI) and number of Test Cases designed for Production line testing of various display interfaces.

Test System Interface

Test System Interface (TSI) is a test equipment hardware independent interface, which offers compact and short cycle time test routines, with which the functionality of most common display interfaces can be verified. Several aspects of the interface is being verified in a single test routine.

Test Case

Test Case implements a display interface specific test procedure. Test procedure is executed in the test equipment hardware. The calling of Test Case is the same regardless of the test hardware in use, hence changing Test Cases and/or test equipment is easy to do and remains the same regardless of test hardware in use. Test engineers can optimize test execution between the thoroughness of the testing and the test cycle time, by the choosing between different optional test routines.

The use of TSI and the Test Cases significantly simplifies integrators’ need to do application specific programming. TSI ensures the compatibility of the application software with any Unigraf test equipment hardware. Both TSI and Test Cases ensure the user flexibility for future upgrades and, what is a major cost factor, re-use of the written code of software.
Available Key Features and Hardware Support

<table>
<thead>
<tr>
<th>Basic Test Software Set</th>
<th>UFG-06</th>
<th>UCD-1</th>
<th>UCD-2</th>
<th>UCD-301</th>
<th>UCD-303</th>
<th>UCD-323</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video capture</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Audio capture</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Live Preview</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Monitor Out</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>EDID Read/Write</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

| Test features           | PASS/FAIL, Basic Test Log | ✓ | ✓ | ✓ | ✓ | ✓ |
|                        | Video test                | ✓ | ✓ | ✓ | ✓ | ✓ |
|                        | Audio test                | ✓ | ✓ | ✓ | ✓ | ✓ |

<table>
<thead>
<tr>
<th>Advanced Test Software Set</th>
<th>UFG-06</th>
<th>UCD-1</th>
<th>UCD-2</th>
<th>UCD-301</th>
<th>UCD-303</th>
<th>UCD-323</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDCP Preview</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>AutoSaving of failed audio and video frames</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

| Test features             | HTML Test Reports | ✓ | ✓ | ✓ | ✓ | ✓ |
|                          | CEC Test          | ✓ | ✓ | ✓ | ✓ | ✓ |
|                          | CEC, HPD & EDID test for HDMI | ✓ | ✓ | ✓ | ✓ | ✓ |

| Optional Testing | Electrical test | ✓ | ✓ | ✓ |

Ready to Use Test Cases

Video and Audio Capture.

Allows operator to capture input video and audio for analyzing purposes. Captured video/audio can be saved into a file.

Live Preview

Incoming video and audio preview on a PC. Video resolution and color format can be altered from original to accomplish best performance of the preview feature with the video data transfer to PC over USB3 (or optional Ethernet) connection.

Monitor Out

Replicate incoming video and audio to the output port to allow real time preview of the video stream on the connected monitor and perform listening audio check.

EDID Read/Write

Allow to load from a file and program custom EDID image to the device as well as read and save to a file currently programmed to a device EDID image.
PASS/FAIL, Basic Test Log

Besides providing “pass” or “fail” information on run tests, the basic software also
give log information. Log example attached below
(note: this is only an example, not a real report).

![Log Example]

Video Test

**Test Objective:** Verify that DUT correctly outputs video.

**Test Method:** Connect DUT to the input port of test hardware and configure DUT to
output video matching configuration for the test reference frame.

**Pass criteria:** DUT will PASS the test if UTS finds input video matching configured
Reference Frame during selected number of consecutive frames (Test Sequence
Length).

**Test Results:** Include available measured parameters of the input video, last failed
frame pixel data, number of failed pixels in frame, failed pixels coordinates, maximum
deviation to the reference pixel color component

Audio Test – Sine Wave Pattern

**Test Objective:** Verify that DUT correctly outputs sine wave pattern.

**Test Method:** Connect DUT to test hardware input port and configure DUT to output
audio matching configuration for test reference audio

**Pass criteria:** DUT will PASS the test if UTS finds input audio parameters matching
expected values.

**Test Results:** Include available measured parameters of the input audio – audio
sample rate, audio signal frequency and audio glitch detection value, audio sample
data

EDID Editor

EDID Editor allows end users to graphically edit EDID information.
HDCP Preview

Monitor HDCP authentication and encryption status. Allow capture and preview of the
HDCP encrypted content. *(Please note that capturing function of this feature can be
made available for only HDCP licensee)*

AutoSaving of Failed Audio and Video Frames

This feature of the Video test enables automatic saving into a file of a frame detected
by the test to be failing

HTML Test Reports

Advanced set of software includes also more tools for reporting. HTML Test Report
tool provides detailed information on test events. Attached example of HTML Test
Report *(note: this is only an example, not a real report)*.

![Unigraf DPR-120 CTS Test Report](image)

### SUMMARY OF INDIVIDUAL TEST RUNS

**Test Result**: PASSED

**Test settings:**
- DUT Capabilities: Max Lanes = 4 Lanes, Max Link Rate = HBR2 (5.4 Gbps)
- Pre-Emphasis level 3 (9.5 Gbps) supported
- HPD Unplug timeout: 700 ms

**Test automation:**
- LLCTS_TEST_LINK_TRAINING
- LLCTS_TEST_PATTERN
- Event indicating DUT ready = Link Training end.

### (400.3.1.2) Successful LT with Request of Higher Differential Voltage Swing During Clock Recovery Sequence: HBR2 Extension

**Test Result**: PASSED

**Test settings:**
- DUT Capabilities: Max Lanes = 4 Lanes, Max Link Rate = HBR2 (5.4 Gbps)

CEC Test

**Test Objective**: Verify that the CEC communications are working as specified.

**Test Method**: UTS executes CEC device discovery function and verifies correct
transmission between the DUT and test hardware.

**Pass criteria**: DUT will pass if UTS verifies CEC communication is executed according
to specifications.

CEC, HPD, & EDID Test

**Test Objective**: Verify that DUT Source correctly handles HPD event, reads EDID and
broadcasts CEC <Report Physical Address> CEC message.
Test Method. Configure UTS to allocate Physical address of 2.0.0.0, connect DUT to test hardware input port, issue HPD unplug, configure UTS to allocate Physical address of 1.0.0.0, issue HPD plug, wait for DUT to read EDID and broadcast CEC message.

Pass criteria. DUT will PASS the test if UTS finds that DUT broadcasts a <Report Physical address> [1.0.0.0] CEC message.

HDMI TMDS Electrical Test

Test Objective: Verify that TMDS connection is valid. Detect shorts and disconnects.

Test Method: Connect DUT to test hardware input port and read measured values for all conductors.

Pass criteria: DUT will pass the test if no shorts and disconnects are detected (all values are within range).

Test Results: Include measured voltage on each TMDS line.

HDMI HPD, HDMI DDC, HDMI CEC, VGA DDC, DP AUX and DP HPD Electrical Test

Test Objective. Verify that measured voltage levels on HPD, DDC and CEC (if supported) lines are within specified range.

Test Method. Connect DUT to test hardware input port and read measured waveform for all conductors.

Pass criteria. DUT will pass the test if waveform voltages and rise times meet specified requirements.

Test Results. Include corresponding measurement results performed during the test.
Test Software Demo Application

Test software release package shall include also a Demo Application - binary and source code, Reference Manual, and Demo Application User Manual

Test Software Demo Application shall cover all the test routines and can be used as a demo application showing how to use Test System Interface (TSI) for building customer test automation software.

Demo Application Graphical User Interface (GUI) include following controls:

- Test hardware selection
- Two test cases (Video and Audio test)
- Test Configuration setting (save and load settings)
- Test Log view
- Video and Audio Preview
- Capture and save reference video frame and audio samples

Conclusions

Automated functional testing in the production of video electronics products will bring several benefits. Manufacturing volumes can be increased without adding more operators in production lines. This reduces cost of testing each DUT. Test automation also shortens test time and hence increases manufacturing volume of the production line. Removing human error from quality assurance process secures higher quality and reduces risk of product returns and brand damage.

Unigraf Test System (UTS) is designed to enable automated functional testing of all video electronics products. If offers tools and interfaces for test system integrator to easily implement UTS as part of the overall test system. With help of UTS, the existing test systems can be extended to include testing of most common display interfaces too. UTS test cases are hardware independent. The future releases of Unigraf test hardware will be backwards compatible and function with developed test cases.