## SPECIFICATIONS

### DisplayPort 1.4 / USB-C / eDP Capabilities

<table>
<thead>
<tr>
<th>Version</th>
<th>DisplayPort 1.4a</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Standard Formats</strong></td>
<td>VESA, CTA</td>
</tr>
<tr>
<td><strong>Video Data Rates</strong></td>
<td>1.62, 2.7, 5.4, 8.1 Gb/s Link rates</td>
</tr>
<tr>
<td><strong>Color Depths</strong></td>
<td>8, 10, 12, 16 bits</td>
</tr>
<tr>
<td><strong>Video Encoding</strong></td>
<td>RGB, YCbCr</td>
</tr>
<tr>
<td><strong>Video Sampling Modes</strong></td>
<td>4:4:4, 4:2:2, 4:2:0</td>
</tr>
<tr>
<td><strong>HDCP Versions</strong></td>
<td>2.2 &amp; 1.3 (on 1 &amp; 2 lanes only)</td>
</tr>
<tr>
<td><strong>Audio</strong></td>
<td>8 Channel LPCM programmable sine wave</td>
</tr>
<tr>
<td><strong>Capture memory</strong></td>
<td>8 GBytes</td>
</tr>
</tbody>
</table>

### Connectors - Front

- **DP Full-Size**: Tx (1) DP Full-size; Rx (1) DP Full-size
- **USB-C**: Tx (1) USB-C with DP Alt Mode; Rx (1) USB-C with DP Alt Mode
- **eDP Header**: Pins to access eDP Tx backlight controls
- **USB (2)**: For connecting keyboard and mouse for ATP Manager control

### Connectors - Back

- **HDMI - Admin Connector**: HDMI Port for ATP Manager
- **USB (2)**: USB-C (2)
- **41x E1**: For admin control over LAN from computer running ATP Manager
- **All other connectors**: Not used

### Physical / Electrical / Admin

- **Power**: 100-240 VAC, 50-60 Hz, 200 Watts
- **Weight**: 11.15 LBS; 5.057 Kg
- **Size**: Height: 3.44 in. (8.74 cm) Width: 9.57 in. (24.30 cm) Depth: 10.94 in. (27.9 cm)
- ** Rack mountable**: 2 RU mounts in 19 inch rack with rack mounting brackets (provided)
- **Internal Speaker**: Speaker with volume control for monitoring incoming audio
- **Command Line Control**: Ethernet (RJ-45) for external GUI and telnet
- **GUI Control**: Either through External PC connected over LAN to Ethernet RJ45 or: Keyboard / mouse connected to USB ports; External 4K UHDtv at Admin HDMI port
- **Environmental**: Operating Temp: 32 to 104 (F); 0 to 40 (C)

### Ordering - Product Code

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00-00260</td>
<td>M41d hardware and base functional unit – Entry Level with full sized DP connectors activated</td>
</tr>
<tr>
<td>95-00209</td>
<td>M41x rack-mount kit</td>
</tr>
<tr>
<td>95-00211</td>
<td>USB-C Port activation for DP Alt Mode function</td>
</tr>
<tr>
<td>95-00219</td>
<td>Source Link Layer compliance (requires 95-00219)</td>
</tr>
<tr>
<td>95-00220</td>
<td>Sink enhanced functional test - Includes Capture Analysis, Aux Channel Analyzer, Passive Monitoring</td>
</tr>
<tr>
<td>95-00225</td>
<td>Sink Layer Link compliance (requires 95-00220)</td>
</tr>
<tr>
<td>95-00227</td>
<td><strong>NEW</strong> Sink EDID compliance (requires 95-00220)</td>
</tr>
<tr>
<td>95-00215</td>
<td>DSC-FEC Source functional test (requires 95-00219)</td>
</tr>
<tr>
<td>95-00218</td>
<td>DSC-FEC Sink functional test (requires 95-00220)</td>
</tr>
<tr>
<td>95-00214</td>
<td>HDCP 2.2 Source compliance (requires 95-00213)</td>
</tr>
<tr>
<td>95-00217</td>
<td>HDCP 2.2 Sink compliance (requires 95-00218)</td>
</tr>
<tr>
<td>95-00212</td>
<td>Embedded DisplayPort (eDP)</td>
</tr>
</tbody>
</table>

### Key Features

- **Run DisplayPort functional tests upgradeable to full protocol compliance tests up to DP 1.4 specification**
- **Equipped with both DP standard and USB-C ports for Tx and Rx functionality—all test features supported through either type of connector**
- **View Power Delivery (PD) negotiations for USB-C DP Alt Mode**
- **Run functional tests on displays and monitors up to 8.1 Gb/s link rates with large format and test pattern library**
- **Generate Display Stream Compression (DSC) select patterns and configure slices and video parameters**
- **Confi gure link training parameters to test display’s handling**
- **View EDID and DPCD registers**
- **Access DSC Test CRC registers for automated verification of DSC compression**
- **Test DP sources up to 8.1 Gb/s link rates—view incoming video and meta-data—including DSC compressed—from a source device in real-time**
- **Capture and decode incoming video, protocol and control packets—including Display Stream Compression (DSC)**
- **Monitor Aux Channel transactions as a DP source or sink**
- **Passively monitor Aux Channel between a source & display even at 8.1Gb/s link rates**
- **Run DP 1.4 Link Layer compliance tests on sources and sinks up to 8.1 Gb/s link rates**
- **NEW! Run DP 1.4 EDID compliance tests on devices**
- **Run DP 1.4 Forward Error Correction (FEC) compliance tests**
- **Run DP 1.4 Display Stream Compression (DSC) compliance tests for sources & sinks**
- **Run HDCP 2.2 compliance tests on DisplayPort sources, sinks and repeaters**
- **Run audio tests using programmable LPCM sine wave audio tones and compressed formats**
- **Run tests on embedded DisplayPort (eDP) 1.4b sources and panels using fast link training and ALPM**
- **Test eDP backlight control functions on panel using either backlight control pins or Aux Channel control commands**

### Operation

The Teledyne LeCroy M41d DisplayPort HBR3 Video Analyzer/Generator provides an unprecedented combination of functional and compliance testing for video, audio and protocol of DisplayPort devices. The M41d supports HBR1 1.62, 2.7, 5.4 & 8.1 Gb/s data rates on 1, 2 & 4 lanes on its Tx video generator port and its Rx analyzer port for both the standard DP ports and the new USB-C ports with DP Alt Mode. The protocol analyzer provides real time analysis and deep analysis using captures of incoming DisplayPort streams from source devices including DSC/FEC compressed streams. The M41d’s video generator can be used for testing displays, USB-C adapters, extenders, etc. The M41d is equipped with all the standard video timings and test patterns necessary for testing modern displays. The M41d supports a full suite of link layer compliance tests for both sources and sinks including compliance tests for forward error correction (FEC), **NEW!** EDID compliance tests are also supported.

The Tx and Rx ports support Auxiliary Channel analysis of the DP aux channel, and the USB-C ports support aux channel analysis of the USB-C Configuration Channel. The adjunct Aux Channel monitoring board supports passive monitoring of the DisplayPort aux channel via full-size DisplayPort connectors, between a source and a display. This enables analysis of link training and HDCP interoperability between devices.

For developers of Embedded DisplayPort (eDP), the M41d offers the hardware necessary to support a variety of optional eDP features. Initial support includes fast link training, alternate scrambler seed, Advanced Link Power Management (ALPM) and Tx backlight control. A pin header is available to provide access to the backlight Tx control test feature.

### M41d DP Video Analyzer/Generator

For admin control over LAN from computer running ATP Manager which presents the data in an easy to understand way. The ATP Manager can be controlled either via a laptop connected to the M41d’s RJ45 LAN port or through a USB keyboard and mouse and a connected UHD HDMI admin display.
### Video Generation
The quantumdata M41d supports video and audio functional testing at link rates up to 8.1 Gb/s on 1, 2 and 4 lanes to support high resolution formats. The M41d has an extensive set of video formats and library of test patterns. You can set any pattern in motion to test motion artifacts with the Image Shift feature.

### Audio Testing
The M41d offers a programmable LPCM audio sine wave generator enabling you to set the number of channels (up to 8), the amplitude, frequency, sampling rate and bit depth for uncompressed formats.

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### Protocol Testing
The quantumdata M41d offers a variety of features for testing DisplayPort protocols. You can verify HDCP 2.2 authentication transactions between the module’s Tx port and a DP display. The M41d’s EDID Decode feature enables you to examine the EDID of the connected display in text. The DPCD Decode feature enables you to examine the DPCD registers of the connected display. You can read the EDID and/or the DPCD of downstream MST nodes.

### EDID Decode View
The M41d’s Auxiliary Channel Analyzer (ACA) feature enables you to monitor the DP Aux Channel for link training and MST negotiations, HDCP transactions and EDID exchanges between the M41d and a connected display. The ACA logs these events and assigns precise timestamps to them. You can view the details of each transaction. These ACA logs can be saved and disseminated for further analysis by colleagues and other subject matter experts.

### DPCD Register View
The M41d emulates an MST source for testing an MST branch device or MST-capable monitor. Up to four (4) streams are supported with a depth of one. The Auxiliary Channel Analyzer (ACA) utility depicts the MST negotiations with the connected MST Rx device.

### Alt Mode Negotiation
The USB Type C Transmit connector participates in discovery, power contract negotiation, and DP Alt Mode negotiation. The protocol messages can be monitored on the Auxiliary Channel Analyzer (right).
DISPLAY TESTS – VIDEO/AUDIO TESTING

**Video Generation**
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**Format Selection**

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**Link Training Control and Configuration**
The M41d’s link training control feature enables you to configure the link training parameters. You can set limits on the lane count and link rate and allow the link training engine to establish link training based on those limitations or you can force link training parameters—lane count, link rate, voltage swing, pre-emphasis.

**Link Training Control and Configuration**

**Alt Mode Negotiation**
The USB Type C Transmit connector participates in discovery, power contract negotiation, and DP Alt Mode negotiation. The protocol messages can be monitored on the Auxiliary Channel Analyzer (right).

**LPCM Audio Testing**
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**Aux Channel Analyzer – DP Alt Mode Negotiation**

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SOURCE TESTS – CAPTURE & DECODE FOR DEEP

Capture and Decode
The M41d captures and decodes the main link attributes in order to diagnose interoperability issues related to them. The Protocol Analyzer captures & stores main link data and provides visibility into main stream attributes, second-ary data elements, K-Characters and protocol errors. The Protocol Analyzer presents these elements on a graphical timeline and in a table. You can search for data and select any transaction in the table to view its details. The capture utility also enables you to capture specific MST streams from the source.

Capture and Decode (Filter View showing only Audio Packets)

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Real Time Analysis (Basic Analyzer)
The M41d’s Real Time analysis feature enables you to view the incoming video, lanes and link rate, timing, colorimetry and various other metadata in real time at a glance. The Real Time mode provides a basic confidence test to verify that the incoming video is essentially correct. The Rx port emulates any EDID on to test a source devices handling of various EDIDs. You can also configure DPCD registers for emulating on the DP Rx port using the DPCD Editor (below).

Source Test Setup

M41d

DP HBR3-Capable Source device under test

Admin Display for ATP Manager

Source Test Setup

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Passive Monitoring Test Setup

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Capture and Decode (Filter View showing only Audio Packets)

The M41d’s USB-C Rx connector participates in discovery, power contract negotiation, and DP Alt Mode negotiation. The protocol messages can be monitored on the Auxiliary Channel Analyzer.

DP Alt Mode Negotiation

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Real Time Analysis

Auxiliary Channel Analyzer Showing Link Training

(Passive) Auxiliary Channel Analyzer
The M41d’s Adjunct Auxiliary Channel Analyzer board enables you to monitor the DP Aux Channel for link training and MST negotiations, HDCP transactions and EDID exchanges between a DisplayPort source and display device. This enables developers to investigate interoperability problems between DP devices involving link training, HDCP and EDID. Solution is provided using a custom cable (provided). The ACA logs these events and assigns precise timestamps to them. You can view the details of each transaction.

(Passive) Auxiliary Channel Analyzer

Link Training Status

DPCD Editor

Source Test Setup
DISPLAY STREAM COMPRESSION (DSC) SOURCE

DSC Analysis
The M41d’s DSC analysis feature enables developers to view the DisplayPort DSC related protocol elements such as the picture parameter set, end of chunk packets and compression flag settings in the VBID to ensure that these elements are occurring in the video stream and that they are occurring in the proper sequence. The DSC analysis feature also captures and decompresses the video frames enabling developers to examine them for compression artifacts. The Forward Error Correction (FEC) transport mechanism, which ensures reliable, error free video transport, can also be verified.

DSC Analysis showing Picture Parameter Set (PPS)

DSC Source Compliance
The DSC source compliance tests are ideal for pre-testing your DisplayPort source product prior to submission to an Authorized Test Center for approval. Pre-testing provides assurance that your product will pass at the ATC when submitted. The compliance tests enable you to view the auxiliary channel analyzer traces logged during the test to help diagnose the cause of compliance test failures.

DSC Source Compliance Tests

DSC Source Tests - Test Results

DISPLAY STREAM COMPRESSION (DSC) SINK TESTING

Video Generation (DSC/FEC)
The M41d’s DSC/FEC video generator enables display developers to transmit DSC/FEC streams. Users can select from several test patterns and configure the colorimetry, bits per component, bits per pixel, line buffer bit depth and DSC slice configurations.

DSC / FEC Video Generation

DSC Sink Compliance
The DSC sink compliance tests are ideal for pre-testing your DisplayPort sink product prior to submission to an Authorized Test Center for approval. Pre-testing provides assurance that your product will pass at the ATC when submitted. The compliance tests enable you to view the auxiliary channel analyzer traces logged during the test to help diagnose the cause of compliance test failures.

DSC Sink Tests

DSC Sink Tests – Test Results

ACD DPCD Reads for DSC Capabilities
The M41d’s ACA utility provides a log of the Aux Channel transactions. The link training can be viewed as well as the DPCD register reads and writes involved in the setup and maintenance of Display Stream Compression (DSC) and Forward Error Correction (FEC).
DSC Analysis
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DSC Source Compliance Tests

DSC Source Tests - Test Results

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DSC / FEC Video Generation

DSC Sink Compliance
The DSC sink compliance tests are ideal for pre-testing your DisplayPort sink product prior to submission to an Authorized Test Center for approval. Pre-testing provides assurance that your product will pass at the ATC when submitted. The compliance tests enable you to view the auxiliary channel analyzer traces logged during the test to help diagnose the cause of compliance test failures.

DSC Sink Tests

DSC Sink Tests – Test Results

DSC Sink Compliances

ACA showing DPCD reads for DSC capabilities

DSC Sink Tests

DP HBR3-Capable
Source device under test

Source Test Setup

M41d

Admin
Display for
ATP Manager

DisplayPort
HBR3-Capable
Display device under test

Display (Sink) Test Setup

Host PC for
ATP Manager

M41d

DisplayPort
HBR3-Capable
Display device under test

ACA showing DPCD reads for DSC capabilities

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DP 1.4 LINK LAYER SOURCE COMPLIANCE

Source Link Layer Compliance
The DP source HBR3 link layer compliance are ideal for self-testing or pre-testing your HBR3-capable DisplayPort 1.4 source product prior to submission to an Authorized Test Center for approval. Pre-testing provides added assurance that your product will pass at the ATC when submitted. The compliance tests (below right) enable you to view the captured data and detailed test results which help pinpoint the cause of compliance test failures. The link layer compliance test suite now includes tests for forward error correction (FEC). You can link to the aux channel traces in the Aux Channel Analyzer (ACA) to view the root cause of failures (below).

DP 1.4 LINK LAYER SINK COMPLIANCE

Sink Link Layer & EDID Compliance
The DP sink (display) and NEW! EDID link layer compliance tests are ideal for pre-testing your DisplayPort 1.4 display product prior to submission to an Authorized Test Center for approval. Pre-testing provides added assurance that your product will pass at the ATC when submitted. The compliance tests (below right) enable you to view the captured data and detailed test results which help pinpoint the cause of compliance test failures. The link layer compliance test suite now includes tests for forward error correction (FEC). You can link to the aux channel traces in the Aux Channel Analyzer (ACA) to view the root cause of failures (below).

DP Aux Channel Traces – From LLC Test

DP 1.4 Source Link Layer Compliance - Test Selection

DP 1.4 Source Link Layer Compliance Test

DP Aux Channel Traces – From LLC Test

DP 1.4 Link Layer Compliance - Test Selection

DP 1.4 Link Layer Compliance - Test Results

Source Test Setup

DisplayPort HBR3-Capable Display device under test

Host PC for ATP Manager

Display (Sink) Test Setup

Admin Display for ATP Manager

M41d

DP HBR3-Capable Source device under test

DP Aux Channel Traces

DP Aux Channel Traces
DP 1.4 LINK LAYER SOURCE COMPLIANCE

Source Link Layer Compliance
The DP source HBR3 link layer compliance are ideal for self-testing or pre-testing your HBR3-capable DisplayPort 1.4 source product prior to submission to an Authorized Test Center for approval. Pre-testing provides added assurance that your product will pass at the ATC when submitted. The compliance tests (below right) enable you to view the captured data and detailed test results which help pinpoint the cause of compliance test failures. The link layer compliance test suite now includes tests for forward error correction (FEC). You can link to the aux channel traces in the Aux Channel Analyzer (ACA) to view the root cause of failures (below).

DP Aux Channel Traces – From LLC Test

DP 1.4 Source Link Layer Compliance - Test Selection

Sink Link Layer & EDID Compliance
The DP sink (display) and new EDID link layer compliance tests are ideal for pre-testing your DisplayPort 1.4 display product prior to submission to an Authorized Test Center for approval. Pre-testing provides added assurance that your product will pass at the ATC when submitted. The compliance tests (below right) enable you to view the captured data and detailed test results which help pinpoint the cause of compliance test failures. The link layer compliance test suite now includes tests for forward error correction (FEC). You can link to the aux channel traces in the Aux Channel Analyzer (ACA) to view the root cause of failures (below).

DP Aux Channel Traces – From LLC Test

DP 1.4 Source Link Layer Compliance - Test Results
The M41d supports testing of both eDP source and display subsystems. A standard DP connection from the M41d to a test fixture is required to enable connection to the eDP subsystem. For display panel TCON testing, once the connection is made, you can use the Advanced Link Power Management (ALPM) feature to test the display’s ALPM function (right) and run any other video tests using the M41d’s Video Generation function. For eDP source subsystem testing, you can monitor the link training and ALPM state and run captures for analysis, etc. The test setups are depicted below.

HDCP 2.2 Compliance
The HDCP 2.2 compliance tests are ideal for pre-testing or self-testing your DisplayPort source, sink or repeater product prior to submission to an Authorized Test Center for approval. Pre-testing provides assurance that your product will pass at the ATC when submitted. The compliance tests enable you to view the auxiliary channel analyzer traces logged (not shown) during the test to help diagnose the cause of compliance test failures.

HDCP 2.2 Source Tests - Test Selection
Embedded DisplayPort eDP - ALPM
The M41d supports testing of both eDP source and display subsystems. A standard DP connection from the M41d to a test fixture is required to enable connection to the eDP subsystem. For display panel TCON testing, once the connection is made, you can use the Advanced Link Power Management (ALPM) feature to test the display’s ALPM function (right) and run any other video tests using the M41d’s Video Generation function. For eDP source subsystem testing, you can monitor the link training and ALPM state and run captures for analysis, etc. The test setups are depicted below.

HDCP 2.2 Source Tests - Test Results
Embeed DisplayPort eDP - ALPM
The M41d supports testing of both eDP source and display subsystems. A standard DP connection from the M41d to a test fixture is required to enable connection to the eDP subsystem. For display panel TCON testing, once the connection is made, you can use the Advanced Link Power Management (ALPM) feature to test the display’s ALPM function (right) and run any other video tests using the M41d’s Video Generation function. For eDP source subsystem testing, you can monitor the link training and ALPM state and run captures for analysis, etc. The test setups are depicted below.

HDCP 2.2 Sink Tests – Test Results
Embedded DisplayPort eDP - ALPM
The M41d supports testing of both eDP source and display subsystems. A standard DP connection from the M41d to a test fixture is required to enable connection to the eDP subsystem. For display panel TCON testing, once the connection is made, you can use the Advanced Link Power Management (ALPM) feature to test the display’s ALPM function (right) and run any other video tests using the M41d’s Video Generation function. For eDP source subsystem testing, you can monitor the link training and ALPM state and run captures for analysis, etc. The test setups are depicted below.

HBR3 Capable
Display device under test
M41d
DisplayPort
DP Cable
TCO
Display Panel
Host PC for ATP Manager
Test Fixture
Source Test Setup
M41d
Admin Display for ATP Manager
DP HBR3-Capable Source device under test
M41d
Source Test Setup
Advanced Link Power Management (ALPM)
Link Training Control and Configuration
Auxiliary Channel Analyzer – Fast Link Train
eDP Fast Link Training
The M41d supports fast link training acting either as an eDP source subsystem or an eDP display subsystem. The module emulates the necessary Fast Link training DPCD registers when testing a display you can select the Lane Count, Link rate (including “intermediate” eDP lane rates), Voltage Swing, Pre-Emphasis and Training Test Pattern. You can monitor the Aux Channel transactions with the Aux Channel Analyzer utility. (eDP Fast Link Training Source test not shown.)

eDP Tx Backlight Control
The M41d supports testing of the eDP backlight control function on eDP TCON display subsystems. Backlight control is supported through the Aux Channel and the backlight control lead. The connection is made through the module’s EDP header pins on the faceplate. You can select between High and Low backlight enable, set the PWM duty cycle, pre-scaling and PWM generator divider.

HDCP 2.2 Source, Sink & Repeater Compliance
HDCP 2.2 Compliance
The HDCP 2.2 compliance tests are ideal for pre-testing or self-testing your DisplayPort source, sink or repeater product prior to submission to an Authorized Test Center for approval. Pre-testing provides assurance that your product will pass at the ATC when submitted. The compliance tests enable you to view the auxiliary channel analyzer traces logged (not shown) during the test to help diagnose the cause of compliance test failures.

HDCP 2.2 Source Tests - Test Results
Embedded DisplayPort eDP - ALPM
The M41d supports testing of both eDP source and display subsystems. A standard DP connection from the M41d to a test fixture is required to enable connection to the eDP subsystem. For display panel TCON testing, once the connection is made, you can use the Advanced Link Power Management (ALPM) feature to test the display’s ALPM function (right) and run any other video tests using the M41d’s Video Generation function. For eDP source subsystem testing, you can monitor the link training and ALPM state and run captures for analysis, etc. The test setups are depicted below.

HDCP 2.2 Sink Tests – Test Results
Embedded DisplayPort eDP - ALPM
The M41d supports testing of both eDP source and display subsystems. A standard DP connection from the M41d to a test fixture is required to enable connection to the eDP subsystem. For display panel TCON testing, once the connection is made, you can use the Advanced Link Power Management (ALPM) feature to test the display’s ALPM function (right) and run any other video tests using the M41d’s Video Generation function. For eDP source subsystem testing, you can monitor the link training and ALPM state and run captures for analysis, etc. The test setups are depicted below.
**HDCP 2.2 SOURCE, SINK & REPEATER COMPLIANCE**

**HDCP 2.2 Compliance**
The HDCP 2.2 compliance tests are ideal for pre-testing or self-testing your DisplayPort source, sink or repeater product prior to submission to an Authorized Test Center for approval. Pre-testing provides assurance that your product will pass at the ATC when submitted. The compliance tests enable you to view the auxiliary channel analyzer traces (not shown) during the test to help diagnose the cause of compliance test failures.

**HDCP 2.2 Source Tests - Test Selection**

**HDCP 2.2 Source Tests - Test Results**

**HDCP 2.2 Sink Tests – Test Results**

**EMBEDDED DISPLAYPORT (EDP) 1.4B TESTING**

**Embedded DisplayPort eDP - ALPM**
The M41d supports testing of both eDP source and display subsystems. A standard DP connection from the M41d to a test fixture is required to enable connection to the eDP subsystem. For display panel TCON testing, once the connection is made, you can use the Advanced Link Power Management (ALPM) feature to test the display’s ALPM function (right) and run any other video tests using the M41d’s Video Generation function. For eDP source subsystem testing, you can monitor the link training and ALPM state and run captures for analysis, etc. The test setups are depicted below.

**Host PC for ATP Manager**

**DP Cable**

**Test Fixture**

**TCO**

**Display Panel**

**notebook PC motherboard or video subsystem**

**Admin Display for ATP Manager**

**Test Setup for testing eDP source Subsystem**

**eDP Fast Link Training**
The M41d supports fast link training acting either as an eDP source subsystem or an eDP display subsystem. The module emulates the necessary Fast Link training DPCD registers. When testing a display you can select the Lane Count, Link rate (including “intermediate” eDP lane rates), Voltage Swing, Pre-Emphasis and Training Test Pattern. You can monitor the Aux Channel transactions with the Aux Channel Analyzer utility. (eDP Fast Link Training Source test not shown.)

**eDP Tx Backlight Control**
The M41d supports testing of the eDP backlight control function on eDP TCON display subsystems. Backlight control is supported through the Aux Channel and the backlight control lead. The connection is made through the module’s eDP header pins on the faceplate. You can select between High and Low backlight enable, set the PWM duty cycle, pre-scaling and PWM generator divider.

**Link Training Control and Configuration**

**Auxiliary Channel Analyzer – Fast Link Train**

**eDP Tx Backlight Control**

**HBR3-Capable Display device under test**

**DisplayPort HBR3-Capable Display device under test**

**Admin Display for ATP Manager**

**M41d**

**Source Test Setup**

**Display (Sink) Test Setup**

**HDCP 2.2 Compliance**

**HDCP 2.2 Source Tests - Test Selection**

**HDCP 2.2 Source Tests - Test Results**

**HDCP 2.2 Sink Tests – Test Results**

**Embedded DisplayPort eDP - ALPM**

**The M41d supports testing of both eDP source and display subsystems. A standard DP connection from the M41d to a test fixture is required to enable connection to the eDP subsystem. For display panel TCON testing, once the connection is made, you can use the Advanced Link Power Management (ALPM) feature to test the display’s ALPM function (right) and run any other video tests using the M41d’s Video Generation function. For eDP source subsystem testing, you can monitor the link training and ALPM state and run captures for analysis, etc. The test setups are depicted below.**

**Host PC for ATP Manager**

**DP Cable**

**Test Fixture**

**TCO**

**Display Panel**

**Notebook PC motherboard or video subsystem**

**Admin Display for ATP Manager**

**Test Setup for testing eDP source Subsystem**

**eDP Fast Link Training**

**The M41d supports fast link training acting either as an eDP source subsystem or an eDP display subsystem. The module emulates the necessary Fast Link training DPCD registers. When testing a display you can select the Lane Count, Link rate (including “intermediate” eDP lane rates), Voltage Swing, Pre-Emphasis and Training Test Pattern. You can monitor the Aux Channel transactions with the Aux Channel Analyzer utility. (eDP Fast Link Training Source test not shown.)**

**eDP Tx Backlight Control**

**The M41d supports testing of the eDP backlight control function on eDP TCON display subsystems. Backlight control is supported through the Aux Channel and the backlight control lead. The connection is made through the module’s eDP header pins on the faceplate. You can select between High and Low backlight enable, set the PWM duty cycle, pre-scaling and PWM generator divider.**
**Key Features**

- Run DP 1.4 functional tests upgradeable to full protocol compliance tests to up full DP 1.4 specification.
- Equipped with both DP standard and USB-C ports for Tx and Rx function—all test features supported through either type of connector.
- View Power Delivery (PD) negotiations for USB-C DP Alt Mode.
- Run functional tests on displays and monitors up to 8.1 Gb/s link rates with large format and test pattern library.
- Generate Display Stream Compression (DSC) select patterns and configure slices and video parameters.
- Configure link training parameters to test display’s handling.
- View EDID and DPCD registers.
- Access DSC Test CRC registers for automated versioning of DSC compression.
- Test DP sources up to 8.1 Gb/s link rates—view incoming video and meta-data—including DSC compressed—nominal data transfer device in real time.
- Capture and decode incoming video, protocol and control packets—including Display Stream Compression (DSC).
- Monitor Aux Channel transactions as a DP source or sink.
- Passively monitor Aux Channel between a source & display even at 8.1Gb/s link rates.
- Run DP 1.4 Link Layer compliance tests on sources and sinks up to 8.1 Gb/s link rates.
- NEW! Run DP 1.4 EDID compliance tests on USB devices.
- Run DP 1.4 Forward Error Correction (FEC) compliance tests.
- Run DP 1.4 Display Stream Compression (DSC) compliance tests for sources & sinks.
- Run HDCP 2.2 compliance tests on DisplayPort sources, sinks and repeaters.
- Run audio tests using programmable LPCM sine wave audio tones and compressed formats.
- Tests on embedded DisplayPort (eDP) 1.4a sources and panels using fast link training and ALPM.
- Test eDP backlight control functions on panel using either backlight control pins or Aux Channel control commands.

- The LeCroy M41d Video Analyzer/Generator provides an unprecedented combination of functional and compliance testing for video, audio and protocol of DisplayPort devices. The M41d supports HBR3 1.62, 2.7, 5.4 & 8.1 Gb/s data rates on 1, 2 & 4 lanes on its Tx video generator port and its Rx analyzer port for both the standard DP ports and the new USB-C ports with DP Alt Mode. The protocol analyzer provides real time analysis and deep analysis using captures of incoming DisplayPort streams from source devices including DSC/FEC compressed streams. The M41d’s video generator can be used for testing displays, USB-C adapters, extenders, etc. The M41d is equipped with all the standard video timings and test patterns necessary for testing modern displays. The M41d supports a full suite of link layer compliance tests for both sources and sinks including compliance tests for forward error correction (FEC), NEW! EDID compliance tests are also supported.

The Tx and Rx ports support Auxiliary Channel analysis of the DP aux channel, and the USB-C ports support aux channel analysis of the USB-C Configuration Channel. The adjunct Aux Channel monitoring board supports passive monitoring of the DisplayPort aux channel via full-size DisplayPort connectors, between a source and display. This enables analysis of link training and HDCP interoperability between devices.

For developers of Embedded DisplayPort (eDP), the M41d offers the hardware necessary to support a variety of optional eDP features. Initial support includes fast link training, alternate scrambler seed, Advanced Link Power Management (ALPM) and Tx backlight control. A pin header is available to provide access to the backlight Tx control test feature.

**Operation**

The M41d supports video generation and analysis of the FRL/FEC HDMI data streams through the user-friendly ATP Manager which presents the data in an easy to understand way. The ATP Manager can be controlled either via a laptop connected to the M41d’s RJ45 LAN port or through a USB keyboard and mouse and a connected UHD HDMI admin display.

**M41d DP Video Analyzer/Generator**

- Keyboard & mouse for M41d ATP Manager Control

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**SPECIFICATIONS**

**DisplayPort 1.4 / USB-C / eDP Capabilities**

<table>
<thead>
<tr>
<th>Version</th>
<th>DisplayPort 1.4a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard Formats</td>
<td>VESA, CTA</td>
</tr>
<tr>
<td>Video Data Rates</td>
<td>1.62, 2.7, 5.4, 8.1 Gb/s Link rates</td>
</tr>
<tr>
<td>Color Depths</td>
<td>8, 10, 12, 16 bits</td>
</tr>
<tr>
<td>Video Encoding</td>
<td>RGB, YCbCr</td>
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<tr>
<td>Video Sampling Modes</td>
<td>4:4:4, 4:2:2, 4:2:0</td>
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<tr>
<td>HDPCP Versions</td>
<td>2.2 &amp; 1.3 on 1 &amp; 2 lanes only</td>
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<tr>
<td>Audio</td>
<td>8 Channel LPCM programmable sine wave</td>
</tr>
<tr>
<td>Capture memory</td>
<td>8 GBytes</td>
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</tbody>
</table>

**Connectors - Front**

- **DP Full-Size**: Tx (1) DP Full-size; Rx (1) DP Full-size
- **USB-C**: Tx (1) USB-C with DP Alt Mode; Rx (1) USB-C with DP Alt Mode
- **Aux Chan Adjunct Board**: Tx (1) DP Full-size; Rx (1) DP Full-size
- **eDP Header**: Pins to access eDP Tx backlight controls
- **USB (2)**: For connecting keyboard and mouse for ATP Manager control

**Connectors - Back**

- **HDMI - Admin Connector**: HDMI Port for ATP Manager
- **USB (2); USB-C (2)**: Keyboard / mouse connected to USB ports; External 4K UHD TV at Admin HDMI port
- **ALPS E1**: For admin control over LAN from computer running ATP Manager
- **All other connectors**: Not used

**Physical / Electrical / Admin**

- **Power**: 100-240 VAC, 50-60 Hz, 200 Watts
- **Weight**: 11.15 LBS; 5.057 Kg
- **Size**: Height: 3.44 in. (8.74 cm) Width: 9.57 in. (24.30 cm) Depth: 10.94 in. (27.9 cm)
- **Rack mountable**: 2 RU mounts in 19 inch rack with rack mounting brackets (provided)
- **Internal speaker**: Speaker with volume control for monitoring incoming audio
- **Command Line Control**: Ethernet (RJ-45) for external GUI and telnet
- **GUI Control**: Either through External PC connected over LAN to Ethernet RJ45 or: Keyboard / mouse connected to USB ports; External 4K UHD TV at Admin HDMI port
- **Environmental**: Operating Temp: 32 to 104 (F); 0 to 40 (C)

**Ordering - Product Code**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>00-00260</td>
<td>M41d hardware and base functional unit – Entry Level with full sized DP connectors activated</td>
</tr>
<tr>
<td>95-00209</td>
<td>M41x rack-mount kit</td>
</tr>
<tr>
<td>95-00211</td>
<td>USB-C Port activation for DP Alt Mode function</td>
</tr>
<tr>
<td>95-00219</td>
<td>Source Link Layer compliance (requires 95-00219)</td>
</tr>
<tr>
<td>95-00220</td>
<td>Sink enhanced functional test - Includes Capture Analysis, Aux Chan Analyzer, Passive Monitoring</td>
</tr>
<tr>
<td>95-00225</td>
<td>DSC-FEC Source functional test (requires 95-00225)</td>
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<tr>
<td>95-00227</td>
<td>NEW! Sink EDID compliance (requires 95-00220)</td>
</tr>
<tr>
<td>95-00229</td>
<td>Source Link Layer compliance (requires 95-00220)</td>
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<tr>
<td>95-00235</td>
<td>DSC-FEC Sink functional test (requires 95-00225)</td>
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<tr>
<td>95-00238</td>
<td>DSC-FEC Sink functional test (requires 95-00225)</td>
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<tr>
<td>95-00244</td>
<td>HDCP 2.2 Source compliance (requires 95-00212)</td>
</tr>
<tr>
<td>95-00277</td>
<td>NEW! Sink EDID compliance (requires 95-00220)</td>
</tr>
<tr>
<td>95-00280</td>
<td>Embedded DisplayPort (eDP)</td>
</tr>
</tbody>
</table>

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Teleeye Analyze/Generator

Entry Level Functional Tester Upgradable to Full Compliance

Teledyne LeCroy quantumdata M41d DisplayPort HBR3 Video Analyzer/Generator Testing up to 8.1 Gb/s Link Rates Entry Level Functional Tester Upgradable to Full Compliance

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