Introduction

Keysight solutions for PCIe Gen1 to Gen3 analysis and emulation.

- PCI Express generation 1, 2, & 3 protocol architecture
- Lane speeds 2.5 GT/s, 5.0 GT/s, and 8.0 GT/s
  - Lane widths x1, x4, x8, and x16
- Stimulus response testing with the addition of the U4305A protocol exerciser
- NVMe device analysis and emulation
  - Compact AXIe modular system configuration
Overview

Product description

Keysight Technologies’ high speed U4301A PCI Express® 3.0 analyzer module is a protocol analyzer supporting all PCI Express® applications from Gen1 through Gen3 and speeds, including 2.5 GT/s (Gen1) and 5.0 GT/s (Gen2) through PCIe 8 GT/s (Gen3) and with link widths from x1 to x16. The U4301A analyzer captures and decodes PCI Express data and displays it in a packet viewer window.

The U4301A analyzer is a blade that is installed in an AXiLe two slot M9502A or five slot M9505A.

Probing is provided by the U4321A solid slot interposer probe, U4324A flying lead solder down probe, or the U4322A mid bus probe based on Keysight’s equalization snoop probe (ESP) technology.

Stimulus and response testing of the PCIe system is accomplished with the addition of the U4305A PCIe Gen3 exerciser.

A link training status state machine (LTSSM) exerciser provides stimulus for testing PCIe links up to the full speed of Gen3 systems. The analyzer LTSSM overview can pinpoint specific training sequence issues through easy to interpret analysis results.

The Performance analysis package includes the real data throughput calculations, with response-time measurement of the PCIe data flow. It allows designers to measure and understand throughput performance, PCIe response times, and other operational measurements that provide the insight needed to optimize device performance.

Analysis and debug

- Support for Gen1 through Gen3, x1 through x16 link width
- 4 GB of capture buffer per module
- Non-intrusive probing that leverages ESP technology

Industry leading probes

- The mid-bus probe supports x1 to x16 unidirectional or x1 to x8 bidirectional
- The solid slot interposer will support x1 to x16 unidirectional or bidirectional
- The flying lead solder down probe offers support for x1 & x2 bidirectional capability on a single probe. Other standard lane width configuration support is x4, x8, & x16

Stimulus and test

- Support for Gen1 through Gen3 and link widths of x1 through x16
- Link testing from x1 through x16, using automated LTSSM exerciser
- PCIe, MR-IOV, and SR-IOV stimulus response testing
- NVMe Root Complex emulation for test and verification of NVMe devices
- Protocol test card (PTC) to measure PCIe Gen3 DUT port and system BIOS specification compliance as defined by the PCI SIG standards
System Architecture Overview

**Configuration**

**Step 1**
Order the U4301A analyzer module
Select the option for the number of lanes to be tested and software license for 5 Gbps or 8 Gbps applications. Refer to ordering information for details.

**Step 2**
Order a modular chassis
Recommended chassis is the Keysight M9502A 2-slot AXIe chassis or optionally the Keysight M9505A 5-slot AXIe chassis.

**Step 3**
Select a PC controller—Keysight recommends the M9536A embedded controller—or select an external PC that meets the performance requirements as specified in the **PXI and AXIe Modular Instrumentation**, Tested Computer List Technical Note (http://literature.cdn.keysight.com/litweb/pdf/5990-7632EN.pdf).

**Step 4**
Order the probe for your measurement application
- U4321A solid slot interposer 3.0: Order the option for the number of lanes to be tested
- U4322A mid bus probe based on Keysight soft touch technology
- U4324A flying lead solder down probe: Order the option for the number of lanes to be tested

**Step 5**
Add the exerciser for stimulus/response testing
- U4305 exerciser: Order the option for the number of lanes to be tested and software licenses for number of lanes to be tested as well as applications such as end node or root complex emulation, LTSSM, MR-IOV, or SR-IOV emulation

1. **Note**: The slot interposer and exerciser lane width is fixed and is not upgradable due to the connector size being a function of lane width. A smaller lane width probe can be used in a wider lane application, but only those lower lanes will be tested. Keysight does not recommend or support the use of lane converters.
Product Features and Benefits Overview

U4301A analyzer module

Effective presentation of protocol interactions from physical layer to transaction layer
- LTSSM Overview with full state transaction traffic capture at the PHY layer logic sub block
- Industry standard spreadsheet format protocol viewer with:
  - Highlighting by packet type or direction
  - Easy flow columns to better understand the stimulus and response nature of the protocols
  - Context sensitive columns to show only the relevant information, minimizing the need to scroll horizontally
  - Flexible GUI configuration to meet debug needs, with pre-defined GUI layouts for link training debug, config accesses and general I/O

Transaction decode
The Transaction Decode tab in the Protocol Viewer window allows you to compute and view transactions decoded from the captured PCIe traffic. The decoding and display of transactions is done as per the relevant storage protocol specifications such as NVMe to help you easily correlate the decoded data to the protocol specifications and evaluate DUT's compliance to these specifications.

Transaction decoding of NVMe data includes analysis of the trace to identify all of the relevant transactions types to present a transaction overview table that enable quick and easy navigation of key packet types.

Performance analysis
The PCIe Performance Overview tab in the Protocol Viewer window allows you to perform post processing on the captured PCIe traffic to generate an offline performance summary of a wide variety of bus traffic including bus utilization and data throughput as well as transaction measures like response times and latency. These performance measures are displayed in tabular as well as charts form.
Simple and powerful state-based triggering
- New simple trigger mode makes it easy to setup single event triggers
- Powerful state-based triggering including
  - Four states supported in trigger sequencer
  - Triggering on patterns (ordered set patterns or packet types)
  - Internal counters and timers
  - External trigger in/out

Powerful hardware features ensure capture of important transition events
- Large capture buffer, for long recording sessions with 4 GB per module (x1-x8 bidirectional) and 8 GB for x16 bidirectional
- PCIe Gen1 x4 link to the host PC, provides up to 10 Gb/s of data download saving valuable test time
- LEDs to show lane status and speed for fast understanding of current link status
Product Features and Benefits Overview (continued)

U4301A analyzer module characteristics and specifications

- Environmental specifications as per the main frame except maximum operating temperature = 40 °C
- Trigger input: Input Z = 50 ohms, Vmax = 3.3 V
- Trigger output: 2.0 V
- Minimum trigger duration: 20 ns

Host PC requirements

Select a PC controller--Keysight is proud to recommend the M9536A embedded controller--or select an external PC that meets the following performance requirements. Keysight has pre-tested a number of external PCs as listed in the PXI and AXIe Modular Instrumentation, Tested Computer List Technical Note (http://literature.cdn.keysight.com/litweb/pdf/5990-7632EN.pdf).

- Processor speed: 1 GHz 32-bit (x86) or 1 GHz 64-bit (x64) 2 GB minimum available memory running Windows XP Professional (32-bit) or Windows 7 (32-bit or 64-bit);
- Available hard disc space: 1.5 GB
- Support for DirectX 9 graphics with 128 MB graphics memory recommended, (Super VGA graphics is supported)
- Microsoft Internet Explorer 7 or greater
- Compatible with a PCIe Gen1 x4 interface module

Probing

Accurate data recovery with consistent representation of the signal

U4321A slot interposer

- ESP (equalizing snoop probe) technology ensures accurate data recovery in all Gen3 platforms and all link width x1 through x16
- High fidelity signal capture ensures design problems can be reproduced
- Mechanical stabilization for the device under test’s (DUT’s) end point and to ensure firm PCIe slot connections

Characteristics

- Power: 12 VDC, 1.25A max
- Power supply; Keysight part number 0950-5160
- Input: 100 to 250 VAC, 50 to 60 Hz
Accurate data recovery with flexible use model

U4322A mid bus probe
- Provides signal capture in situations where no PCIe connector is available
- Micro spring-pin probe based on Keysight’s soft touch technology provides reliable contact to signal pads
- Independent reference clock per four lanes for maximum layout flexibility

Characteristics
- Input: 25V max or 3 Vrms into 250 ohms
- Temperature: Operating 0 to 40 °C
- Storage -40 to 70 °C
- Humidity: 15 to 95% non-condensing
- Altitude: 3,000 m (10,000 ft)

Accurate data recovery with full channel mapping support & flexible probe points

U4324A flying lead solder down probe
- Provides signal capture in situations where no PCIe slot connector or PCIe standard mid bus footprint is available.
- Low channel count per probe to reduce unnecessary expense for unused channel leads
- Independent reference clock tap for maximum layout flexibility
- Low cost, easily replaceable N5426A zero insertion force (ZIF) tips to maximize probe use life

Characteristics
- Input: 10 V max common mode
- Capacitive loading: 0.250 fF
- Temperature: Operating +5 to +40 °C
- Storage: –40 to 70 °C
- Humidity: Operating 80% RH @ 40 °C
- Storage: 90% RH @ 65 °C
- Vibration: 2.09 Grms (5 to 500 Hz random)
- Shock: 1.6 m/s (63 in/s) (2 mS half sine)
N5426A ZIF tip kit

- The ZIF tip is a connection accessory used to connect the U4324A flying lead cable to the channel on the DUT
- One side of the ZIF tip connects to the flying lead and is soldered to the DUT on the other end
- The ZIF tip is calibrated to the U4324A flying lead; no impedance changes should take place to the ZIF tip
- 10 ZIF tips per kit

Characteristics

- Input: 10 V max common mode
- Capacitive loading: 0.250 fF
- Temperature: Operating +5 to +40 °C
- Storage: -40 to 70 °C
- Humidity: Operating 80% RH @ 40 °C
- Storage: 90% RH @ 65 °C
- Vibration: 2.09 Grms (5 to 500 Hz random)
- Shock: 1.6 m/s (63 in/s) (2mS half sine)

Thorough link testing U4305A PCI exerciser

- Addition of the U4305A provides PCIe, MR-IOV and SR-IOV stimulus response testing
- Predefined LTSSM sequences simplify state transition testing
- Predefined protocol test card (PTC) test cases applied to Lane 0 only, provide specification compliance feedback
- Full speed testing of Gen 1 through Gen 3 systems
- All lane widths supported at full speed
- End point emulation and act as a down stream component (DSC)
- Root complex emulation and act as an upstream component (USC)

Specifications

Refer to the U4305A data sheet pub number 5990-8458EN for detailed characteristics and specifications.
Related Keysight Literature

<table>
<thead>
<tr>
<th>Publication title</th>
<th>Pub number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware and Probing for PCI Express Gen3 User’s Guide available at Keysight.com/find/U4301A</td>
<td>U4301-97000</td>
</tr>
<tr>
<td>PCIe 3.0 Analyzer User Guide</td>
<td>U4301-97001</td>
</tr>
<tr>
<td>PCI Express Design and Test – From Electrical to Protocol – Brochure</td>
<td>5989-5594EN</td>
</tr>
<tr>
<td>U4305A Protocol Exerciser for PCI Express® 3.0 – Data Sheet</td>
<td>5990-8458EN</td>
</tr>
</tbody>
</table>

Ordering Information

**U4301A analyzer module**

A specific configuration is required to determine the lane width to be tested.

<table>
<thead>
<tr>
<th>Model number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>U4301A-A01</td>
<td>Link width x1</td>
</tr>
<tr>
<td>U4301A-A04</td>
<td>Link width x4</td>
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<tr>
<td>U4301A-A08</td>
<td>Link width x8</td>
</tr>
<tr>
<td>U4301A-A16</td>
<td>Link width x16</td>
</tr>
</tbody>
</table>

**Note:** Analyzing x16 requires the purchase of two U4301A-A16 modules.

<table>
<thead>
<tr>
<th>Model number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>U4301A-AN2</td>
<td>Software license for PCIe Gen2, 5 Gbps</td>
</tr>
<tr>
<td>U4301A-AN3</td>
<td>Software license for PCIe Gen3, 8 Gbps</td>
</tr>
<tr>
<td>U4301A-1FP</td>
<td>LTSSM software license for fixed node, perpetual</td>
</tr>
<tr>
<td>U4301A-1NP</td>
<td>LTSSM software license for floating, server based</td>
</tr>
<tr>
<td>U4301A-2FP</td>
<td>Performance summary, software license for fixed node, perpetual</td>
</tr>
<tr>
<td>U4301A-2NP</td>
<td>Performance summary, software license for floating, server based</td>
</tr>
<tr>
<td>U4301A-3FP</td>
<td>Transaction Decoder, software license for fixed node, perpetual</td>
</tr>
<tr>
<td>U4301A-3NP</td>
<td>Transaction Decoder, software license for floating, server based</td>
</tr>
</tbody>
</table>

**Modular chassis and computer interface**

The recommended chassis is the 2 slot AXIe configuration.

<table>
<thead>
<tr>
<th>Chassis type</th>
<th>Model number</th>
<th>PC configuration</th>
<th>Interface</th>
<th>Cable</th>
</tr>
</thead>
<tbody>
<tr>
<td>AXIe (recommended)</td>
<td>M9502A 2 slot AXIe</td>
<td>Lap top</td>
<td>M9045A</td>
<td>Y1200A</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Desk top</td>
<td>M9047A</td>
<td>Y1200A</td>
</tr>
</tbody>
</table>

**Probe selection**

<table>
<thead>
<tr>
<th>Probe type</th>
<th>Model number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid slot interposer 8 Gbps</td>
<td>U4321A-A01</td>
<td>Link width x1</td>
</tr>
<tr>
<td>U4321A-A04</td>
<td>Link width x4</td>
<td></td>
</tr>
<tr>
<td>U4321A-A08</td>
<td>Link width x8</td>
<td></td>
</tr>
<tr>
<td>U4321A-A16</td>
<td>Link width x16</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** The U4321A interposer probe lane width is fixed and is not upgradable to accommodate different lane widths due to the fact that the connector size is a function of lane width. Keysight does not recommend or support the use of lane converters.

<table>
<thead>
<tr>
<th>Probe type</th>
<th>Model number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-bus probe</td>
<td>U4322A</td>
<td>Mid-bus probe based on Keysight soft touch technology for applications where no standard PCIe connector is available for testing</td>
</tr>
<tr>
<td>U4322A-R05</td>
<td>Set of 5 retention modules</td>
<td></td>
</tr>
<tr>
<td>U4317A</td>
<td>Gen3 to Gen2 mid bus adaptor</td>
<td></td>
</tr>
</tbody>
</table>

| Flying lead probe              | U4324A       | 4 channel/probe                                                             |
|                                | N5426A       | ZIF tip kit (10 pcs)                                                        |
### Analyzer upgrades

<table>
<thead>
<tr>
<th>Model number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>U4301U-2FP</td>
<td>Performance summary, software license for fixed node, perpetual</td>
</tr>
<tr>
<td>U4301U-2NP</td>
<td>Performance summary, software license for floating, server based</td>
</tr>
<tr>
<td>U4301U-3FP</td>
<td>Transaction Decoder, software license for fixed node, perpetual</td>
</tr>
<tr>
<td>U4301U-3NP</td>
<td>Transaction Decoder, software license for floating, server based</td>
</tr>
<tr>
<td>U4301U-AFP</td>
<td>Analyzer software license upgrade x1 to x4</td>
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<tr>
<td>U4301U-BFP</td>
<td>Analyzer software license upgrade x1 to x8</td>
</tr>
<tr>
<td>U4301U-CFP</td>
<td>Analyzer software license upgrade x1 to x16</td>
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<tr>
<td>U4301U-DFP</td>
<td>Analyzer software license upgrade x4 to x8</td>
</tr>
<tr>
<td>U4301U-EFP</td>
<td>Analyzer software license upgrade x4 to x16</td>
</tr>
<tr>
<td>U4301U-FFP</td>
<td>Analyzer software license upgrade x8 to x16</td>
</tr>
</tbody>
</table>

### Stimulus/response tester

#### Exerciser card
PCIe exerciser and PCIe LTSSM exerciser for PCIe 3.0, PCIe 2.0 and PCIe 1.0

**Note:** The U4305A PCIe exerciser lane width is fixed and is not upgradable to accommodate different lane widths due to the fact that the connector size is a function of lane width. Keysight does not recommend or support the use of lane converters.

<table>
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<td>U4305A-E01</td>
<td>Link width x1</td>
</tr>
<tr>
<td>U4305A-E04</td>
<td>Link width x4</td>
</tr>
<tr>
<td>U4305A-E08</td>
<td>Link width x8</td>
</tr>
<tr>
<td>U4305A-E16</td>
<td>Link width x16</td>
</tr>
<tr>
<td>U4305A-EX3</td>
<td>Software license for the exerciser</td>
</tr>
<tr>
<td>U4305A-LT3</td>
<td>LTSSM software license</td>
</tr>
<tr>
<td>U4305A-MR2</td>
<td>Multi-root visualization software license</td>
</tr>
<tr>
<td>U4305A-1FP</td>
<td>NVMe RC exerciser, software license for fixed node, perpetual</td>
</tr>
<tr>
<td>U4305A-1NP</td>
<td>NVMe RC exerciser, software license for floating, server based</td>
</tr>
<tr>
<td>U4305A-022</td>
<td>ECRC testing</td>
</tr>
<tr>
<td>U4305A-023</td>
<td>SR-IOV emulation</td>
</tr>
<tr>
<td>U4305A-024</td>
<td>Increase to 5 function emulation</td>
</tr>
</tbody>
</table>

#### PTC test suite for PCIe 3.0 and PCIe 2.0

<table>
<thead>
<tr>
<th>Model number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>U4305A-021</td>
<td>PCIe spec compliance test suite</td>
</tr>
</tbody>
</table>
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