Keysight Technologies
15431A Filter Set for 81150A
Generates Random Jitter Profile for Testing
PCI Express® 2.0 Receivers
PCI Express® 2.0 Physical Layer Testing

Increasing speed rate for PCI Express Generation 2 is driving design to new dimensions. Validating and testing of PCI Express devices at the physical layer is getting more and more challenging for today’s engineers. PCIe® 2.0 doubles the data rate from 2.5 Gbit/s to 5 GBit/s, improves point-to-point data transfer protocol and becomes more tolerant of jitter. Therefore the jitter tolerance and transfer measurement become more important.

Keysight’s Offering

Keysight Technologies, Inc. offers serial and multi-lane RX testing.

J-BERT N4903A High-Performance Serial BERT

allows single-lane characterization of jitter tolerance from the device’s input, checks compliance by emulating jitter conditions and has built-in mask tests and eye analysis tools to evaluate the PCIe 2.0 design.

ParBERT 81250A High-Performance Parallel Bit Error Ratio Tester

is a modular BERT platform for clock, data generation and data analysis that allows configuring of a solution with up to 64 output and input channels. Its jitter modulation capability via the delay control input, together with the PCIe multi-lane receiver compliance test suite make it an automated and highly accurate tool for multi-lane PCI Express receiver tolerance compliance and characterization testing. The PCIe 2.0 specification defines a dedicated random jitter profile. The required control voltage for ParBERT’s delay control input can be generated by the Keysight 81150A, a pulse function arbitrary noise generator.

The 81150A Pulse Function Arbitrary Noise Generator

provides white Gaussian noise with a selectable crest factor up to 7 (V_{peak} / V_{RMS}) or 14 (V_{peak-peak} / V_{RMS}). The long repetition rate of 26 days ensures real random noise. After 26 days the noise pattern starts from the beginning. The Keysight 15431A noise filter is an instrument accessory that is intended to be used for jitter measurements on PCIe 2.0 with the 81150A as noise source and the N4903A or the 81250A as jitter tolerance tester. The proper jitter spectrum is achieved by filtering the white noise with a PCIe 2.0-specific filter. The filter can serve two topologies: data driven and common clock.

Table 1. Two different clocking architectures

<table>
<thead>
<tr>
<th>Common reference clock</th>
<th>Data clocked (embedded clock)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RX sampling on (multiplied) ref clk</td>
<td>Receiver with PLL-CDR (using ref clock only until locked)</td>
</tr>
<tr>
<td>RX w / DLL only (no CDR/PLL)</td>
<td>SSC on or off:</td>
</tr>
<tr>
<td>SSC off: no phase error induced</td>
<td>– Common for TX and RX, both TX’s use same ref clk</td>
</tr>
<tr>
<td>SSC on:</td>
<td>– Small error (femtoseconds) due to path delay difference (!) but</td>
</tr>
<tr>
<td></td>
<td>– Significant residual phase error due to potentially different transfer functions (BW and peaking) of TX and RX clock multiplying PLLs (CMU)</td>
</tr>
</tbody>
</table>
Test Setup of a J-BERT

Test setup of a J-BERT with the 81150A for LF noise; the filtered signal from the 81150A is used as delay control input for the J-BERT.

An equivalent setup is valid for the ParBERT 81250A.

The N5990A test automation software supports PCIe 2.0 compliance testing and characterization with J-BERT and ParBERT configurations.

Figure 1. Test setup of a J-BERT with the 81150A for LF noise; the filtered signal from the 81150A is used as delay control input for the J-BERT. ISI and channel effects are merged into the signal path of the J-BERT by using the built-in trace 2.
The PCIe 2.0 Jitter Specification for Receiver Tests

Table 2. The PCIe 2.0 jitter specification for receiver tests

<table>
<thead>
<tr>
<th>Specifications and characteristics</th>
<th>Common reference clock architecture</th>
<th>Data clocked architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impedance</td>
<td>50 Ω</td>
<td></td>
</tr>
<tr>
<td>Low frequency pass band</td>
<td>0.01 – 1.5 MHz</td>
<td></td>
</tr>
<tr>
<td>High frequency pass band</td>
<td>1.5 – 100 MHz</td>
<td></td>
</tr>
<tr>
<td>(|\text{LF}|_2 / |\text{HF}|_2)^{1/2}</td>
<td>4.2 / 3.8 ± 10%</td>
<td>8.0 / 4.2 ± 10%</td>
</tr>
<tr>
<td>Total insertion loss (^{2,3})</td>
<td>21.4 ± 1 dB</td>
<td>21.9 ± 1 dB</td>
</tr>
<tr>
<td>Max. input voltage</td>
<td>10 V (_{pp})</td>
<td></td>
</tr>
<tr>
<td>Input connector</td>
<td>BNC (female)</td>
<td></td>
</tr>
<tr>
<td>Output connector</td>
<td>SMA (female)</td>
<td></td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>0 – 55 °C</td>
<td></td>
</tr>
<tr>
<td>Mech. dimensions (L x W x H)</td>
<td>109 x 20 x 20 mm</td>
<td></td>
</tr>
<tr>
<td>Weight</td>
<td>71 g</td>
<td></td>
</tr>
</tbody>
</table>

1. \(L_p\) norm \(\|X\|_p\) yields rms value of \(X\) for \(p = 2\) at \(+25 \pm 5\) °C ambient temperature
2. With 81150A as Gaussian noise source, crest factor = 7
Setting the correct output amplitude on the 81150A

For the reference clock filter the total rms jitter is \((4.2^2 + 3.4^2)^{1/2} = 5.4\) ps. The sensitivity of the J-BERT delay control input is specified with 400ps/V. Thus the filter’s output voltage must be \(5.4/400 = 0.0135 \text{ V}_{\text{RMS}}\) or \(13.5 \text{ mV}_{\text{RMS}}\). With an insertion loss of 21.4 dB for the filter, the appropriate 81150A output voltage is 159 mVrms. The equivalent calculation for the data clocked filter with a total RMS jitter of 9 ps and 21.9 dB insertion loss yields 280 mVrms.

Jitter is separated into two bins:

LF: 0.01 - 1.5 MHz step BPF  
\(\text{LF-RJ}_{\text{RMS}} = 4.2\) ps

HF: 1.5 MHz step HPF and 100 MHz edge filtering  
\(\text{HF-RJ}_{\text{RMS}} = 3.4\) ps

15431 RCA-filter specification:  
\(|\text{LF-RJ}/\text{HF-RJ}|_{\text{RMS}} = 1.23 \pm 10\%\)  
Total insertion loss: 21.4 ±1 dB
## Related Keysight Literature

<table>
<thead>
<tr>
<th>Publication title</th>
<th>Pub number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keysight 81150A Pulse Function Arbitrary Noise Generator Data Sheet</td>
<td>5989-6433EN</td>
</tr>
<tr>
<td>Keysight J-BERT N4903A High-Performance Serial BERT</td>
<td>5989-2899EN</td>
</tr>
<tr>
<td>Test Automation Software Platform N5990A</td>
<td>5989-5483EN</td>
</tr>
<tr>
<td>Keysight ParBERT 81250, Parallel Bit Error Ratio Tester</td>
<td>5968-9188E</td>
</tr>
</tbody>
</table>
Evolving Since 1939
Our unique combination of hardware, software, services, and people can help you reach your next breakthrough. We are unlocking the future of technology.
From Hewlett-Packard to Agilent to Keysight.

myKeysight
www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

http://www.keysight.com/find/emt_product_registration
Register your products to get up-to-date product information and find warranty information.

Keysight Services
www.keysight.com/find/service
Keysight Services can help from acquisition to renewal across your instrument’s lifecycle. Our comprehensive service offerings—one-stop calibration, repair, asset management, technology refresh, consulting, training and more—helps you improve product quality and lower costs.

Keysight Assurance Plans
www.keysight.com/find/AssurancePlans
Up to ten years of protection and no budgetary surprises to ensure your instruments are operating to specification, so you can rely on accurate measurements.

Keysight Channel Partners
www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight’s measurement expertise and product breadth, combined with channel partner convenience.

For more information on Keysight Technologies’ products, applications or services, please contact your local Keysight office. The complete list is available at:
www.keysight.com/find/contactus

America
Canada (877) 894 4414
Brazil 55 11 3351 7010
Mexico 001 800 254 2440
United States (800) 829 4444

Asia Pacific
Australia 1 800 629 485
China 800 810 0189
Hong Kong 800 938 693
India 1 800 11 2626
Japan 0120 (421) 345
Korea 080 769 0800
Malaysia 1 800 888 848
Singapore 1 800 375 8100
Taiwan 0800 047 866
Other AP Countries (65) 6375 8100

Europe Middle East
Austria 0800 001122
Belgium 0800 58580
Finland 0800 523252
France 0805 980333
Germany 0800 6270999
Ireland 1800 832700
Israel 1 809 343051
Italy 800 599100
Luxembourg +32 800 58580
Netherlands 0800 023200
Russia 8800 509226
Spain 800 000154
Sweden 0200 882255
Switzerland 0800 805363
Opt. 1 (DE)
Opt. 2 (FR)
Opt. 3 (IT)
United Kingdom 0800 0260637

For other unlisted countries:
www.keysight.com/find/contactus
(BP-9-7-17)

DEKRA Certified
ISO 9001 Quality Management System

www.keysight.com/go/quality
Keysight Technologies, Inc.
DEKRA Certified ISO 9001:2015
Quality Management System

This information is subject to change without notice.
© Keysight Technologies, 2017
Published in USA, December 2, 2017
5989-9828EN
www.keysight.com