Get in Touch
Agilent Bit Error Ratio Testers
Answers for Your Multi-Gigabit Test Challenges
A question of innovation

Enabling the Next Generation Multi-Gigabit Links with Agilent Bit Error Ratio Testers (BERTs)

As speeds increase, the signal degradation and jitter in digital designs keep growing. The devices are also getting more complex, while project schedules and budget are getting tighter and tighter. Engineers in R&D, validation and manufacturing test need a new generation of physical layer test tools, to help reach the market in time, with high quality devices which are prerequisites for market success.

Multi-gigabit technologies are emerging in almost all industry segments, from computer and memory buses, to storage and networking interfaces, from backplanes to access, metropolitan and long-haul networks.

Agilent’s BERT solutions enable the success of your next generation multi-gigabit project, through:

- Continual innovation in physical layer testing to address emerging test challenges, for example by:
  - Simplifying the handling of complex patterns
  - Integrating calibrated jitter injection
  - Recovering clock from data
  - Generating all kinds of jitter
  - Analyzing BER, jitter and eyes

- Test time reduction with:
  - Automated jitter tolerance tests
  - Fast total jitter algorithm
  - Test automation platform which controls all physical layer test equipment such as BERTs, oscilloscopes, pattern generators
  - Web servers for remote control

- Securing your investment in ParBERT 81250 and J-BERT N4903A platforms, with upgrade paths for more functionality.

Key Multi-Gigabit Technologies

Digital Home
Digital Video
Computing
Front Side Bus
Memory Bus
I/O
Enterprise
Storage
LAN
Communications
Wireline/Digital
Wireless
Aerospace/
Defense
Satellite Comm.

HDMI
AMB
Fibre Channel
10G Ethernet
OC-768
PON
PCI Express
SATA
CEI
Sat.Comm

Agilent BERTs provide efficient and accurate physical layer testing of multi-gigabit interfaces, such as PCI Express®, SATA, Fibre Channel, AMB, XAUI, 10 Gb Ethernet, CEI, XFP/XFI, SONET/SDH and PON.
Why do I need a BERT?
Russ McHugh,
Application Engineer, America:
“The bit error ratio is THE quality metric of each transmission link. The BERT measures the number of failed bits at the receiver compared to the total number of transmitted bits. The most common BER level is $10^{-12}$.”

Shigeki Takeshima,
Application Engineer, Japan:
“The BERT is the only instrument that measures the total jitter, because it samples every transmitted bit.”

Sandy Frew,
Application Engineer, UK:
“The only instrument that can measure the jitter tolerance of a receiver is a BERT. It can stress the receiver while monitoring the required BER level.”

On the next pages you can see how BERTs can help in the following applications:

- Manufacturing Test of SFP and XFP Modules [Page 6]
- Characterization of 10 Gb/s optical transceivers [Page 7]
- Passive Optical Network (PON) Test [Page 8]
- High-Definition Multimedia Interface (HDMI) 1.2a and 1.3 Sink Device Test [Page 9]
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A question of receiver robustness

Testing Receiver Jitter Tolerance

Today’s high-speed bus technologies can be viewed as communications systems, even though distances between transmitter and receiver are short. The protocols are becoming faster and more complex. The typical transmission channel – e.g. made of FR4 material – has not kept up with high-speed applications. At gigabit speeds this material becomes lossy and dispersive, which causes jitter that can close the eye opening. Increasing the speed can cause significant eye closure and subsequently result in an entirely closed eye.

How can Agilent help?
Agilent BERTs let you control the composition of the jitter (RJ, PJ, BUJ, ISI, SI) to create both realistic and worse case stress conditions. Typically you can characterize receiver tolerance by sweeping SJ and PJ in frequency and amplitude, and search for the maximum jitter value the receiver tolerates. By building complete jitter tolerance test capabilities into the BERT, Agilent helps take the complexity out of the test setup. This reduces the time to start testing.

Using a real-time or sampling oscilloscope helps to verify the stress level and to analyze precisely the waveform for any bit pattern.

For receiver tolerance testing however, a BERT is needed. The pattern generator of the BERT injects the pattern with the stressed signal, while the BERT error detector monitors the BER level of the received pattern.

Typical gigabit transmitter and receiver with board traces causing channel effects. For receiver testing, a pattern generator creates the pattern with the stressed signal, and the BERT error detector counts errors against this pattern.
Benefits of Agilent’s BERT solutions

Complete jitter tolerance
J-BERT provides built-in and calibrated jitter sources for SJ/PJ, RJ, BUJ, ISI and sinusoidal interference. Automated jitter tolerance characterization and compliance routines provide immediate test results. By including complete jitter injection capabilities into the BERT, Agilent helps to save weeks of engineering time with the reduced complexity and programming effort of the test setup.

Automated jitter tolerance compliance test
It checks whether the receiver meets the standard and determines non-compliant settings. This result screen from the J-BERT shows the non-compliant and tested points with red crosses, the passed point with green circles. Such automated results make it simple and fast to check whether a receiver meets the compliance criteria.

Multi-lane characterization
For multi-lane standards, the biggest challenge is to ensure the pattern generators for each channel are running synchronously and at the same speed. Agilent leads the market with its modular ParBERT 81250. This cuts out lengthy calibration and tedious checking of the test setup to provide confident test results.

J-BERT combines all these jitter types to create such a compliance eye needed for receiver jitter tolerance testing.

SJ is caused by a deterministic jitter source in real systems.

RJ is caused by thermal and noise effects in real systems.

ISI is typically caused by board traces.

Compliance Eye

J-BERT provides automated jitter tolerance characterization which searches for the maximum jitter value the receiver tolerates by sweeping SJ and PJ in modulation frequency and magnitude. The automated jitter tolerance compliance just measures the compliance curve again.
A question of cost-effective manufacturing test

Manufacturing Test of SFP and XFP Modules

Key parameters to be measured and documented for all optical transceivers are: optical transmitter eye diagram, optical power and the optical receiver sensitivity. With lowering transceiver module prices the real challenge is to test cost-effectively in manufacturing.

How can Agilent help?
Agilent provides a complete set of instruments to test optical transceivers, such as SFP or XFP modules in manufacturing: the N5980A manufacturing serial BERT or the N4906B 12.5 Gb/s serial BERT, the digital communication analyzer 86100 DCA-J and the lightwave multimeter 8163/4B. All you need to add are your DUT-board, your own ‘golden’ module, the cables and a computer.

Benefits of Agilent’s serial BERT solutions
For SFP or other transceivers up to 3 Gb/s, use the N5980A manufacturing serial BERT:
• Cuts test time in half by offering concurrent electrical and optical data signals
• Smallest footprint
• One-screen GUI
• Remote control via USB

For XFP or other transceivers up to 10 Gb/s, use the N4906B 12.5 Gb/s serial BERT:
• Precise measurements with clean output signals with 25 ps transitions, differential I/Os and 50 mV input sensitivity
• Quick pass/fail results with fast eye mask testing with up to 32 points
• Built-in Clock Data Recovery (CDR)
• Remote programming via LAN, USB, GPIB

What are SFP transceivers?
These are intelligent e/o/e converters, with mechanical and electrical standards defined by a multi-source agreement. Electrical speeds range from 125 Mb/s to 4.25 Gb/s; optical wavelengths are 850 nm, 1310 nm or 1550 nm single- or multi-mode. They are available for distances ranging from 10’s of meters to kilometers.
What is XFP/XFI?
XFP is a hot pluggable small footprint serial-to-serial optical transceiver module with a package defined by the XFP Multi Source Agreement (MSA) Group. XFI is the 10 Gb/s serial electrical interface. The modules support nominal data rates from 9.95 Gb/s to 11.1 Gb/s, and the data encodings include OC-192, 10 Gb Ethernet, and 10 G FC. There are other MSA's for 10 Gb/s transceivers such as: XPAK, X2, and XENPAK, which are focusing primarily on 10 Gb Ethernet.

How can Agilent help?
The Agilent J-BERT N4903A offers quick and accurate receiver and transmitter testing of XFP modules. For precise waveform and eye analysis of electrical and optical signals the wide bandwidth oscilloscope 81600C DCA-J can be used. Optical power meters and attenuators complement the test setup on the optical side.

Benefits of Agilent’s J-BERT N4903A
• Fast and efficient jitter tolerance tests through automation with built-in and calibrated RJ, PJ and ISI jitter sources and sinusoidal interference for vertical eye closure
• Automated receiver jitter tolerance mask tests for XFP modules (1000 UI @ 100 Hz – 2.5 UI @ 300 MHz)
• Transmitter eye mask tests with the quick eye analysis with pass/fail testing
• Library of compliance test
• Fast total jitter measurement algorithm reduces the test time to minutes instead of hours

Juswanto Wardojo, Senior Test Engineering Manager, Luxtera:
“Agilent J-BERT provides Luxtera with an accurate and easy to use instrument to characterize our optical transceiver. The J-BERT’s versatility allows our engineers to make BER measurement with very minimal setups required. The internal jitter generation capabilities of the J-BERT greatly reduce the measurement complexities and equipment cost. Its automated jitter tolerance testing capabilities simplified this test and reduced our test time significantly.”
A question of accuracy and flexibility

Passive Optical Network (PON) Test

Because Time Division Multiple Access (TDMA) coordinates the upstream transmission, giving each ONU a time-slot (BPON/GPON), exact timing is critical for testing ONUs or OLTs.

How can Agilent help?
The pattern sequencer of the ParBERT 81250 provides an exact burst timing control for multiple channels, ideal for data and control signals. ParBERT combines with the 8163B/8164B lightwave multimeter system and 81600C digital communication analyzer (DCA) to form a full, flexible test system for electrical and optical ONU/OLT testing.

Benefits of Agilent’s ParBERT
Test accurately using:
• Exactly timed signals for data bursts and control signals
• Adjustable signal delays
• Controllable preamble states
• Superior signal quality

Test flexibly using:
• A modular multi-lane generator and analyzer platform
• Several generator/analyzer with speed classes up to 13.5 Gb/s

PON requires exact timed data bursts in an upstream test.

What is PON?
A passive optical network (PON) – specified by the full service access network (FSAN) vendor consortium – is an access technology for FTTx networks using small inexpensive, passive splitters, instead of optical repeaters. In downstream direction, the signal from an optical line terminal (OLT) is split and sent to optical network units (ONUs). The upstream direction is more challenging for the receiver performance testing, with signals sent from the ONUs to the OLT using TDMA and different power levels due to different distances.

* Setup for timing and signal measurements of PON OLT (Optical Line Terminals) and ONU (Optical Network Unit) devices.
Increasing color depth and higher resolution means faster bit rates for HDMI source/sink devices and cables, which challenges sinks particularly over long cable runs. This means testing sinks for tolerance of minimum and maximum differential swings, intrapair skew and jitter. Of these, jitter tolerance is the most critical test. Because HDMI works with an incoherent design, with a Transition Minimized Differential Signaling (TMDS) clock rate at a tenth of the bit rate, jitter behavior is different on the data and clock lines. To comprehensively characterize the jitter tolerance of a sink you need to apply jitter independently to the differential clock and the three differential data signals.

**How can Agilent help?**

Based on the ParBERT 81250, the E4887A HDMI TMDS Signal Generator provides differential clock and data generation for all four TMDS channels with independent clock and data jitter injection. The frame generator software makes it easy to set up the TMDS Generator with all the required video frames. The N5990A test automation platform provides a convenient user interface for characterization and compliance testing.

**Benefits of Agilent’s E4887A HDMI TMDS Signal Generator**

- Tests quickly, because of fast calibration and automated compliance testing
- In depth characterization through accurate and independent clock and data jitter modulation and excellent signal performance

**What is HDMI?**

The HDMI specifications ensure the interoperability of digital audio and video devices, such as set-top boxes, DVD players, or digital televisions (DTV). The HDMI source device includes the transmitter and the channel to a HDMI receptacle. The sink device starts at the HDMI receptacle and ends at the receiver.
A question of quick and accurate characterization and compliance testing

**PCI Express® Test**

Data rates up to 5 Gb/s, for PCI Express 2.0, stress signal integrity on FR4 material. This presents new challenges for validating, testing and characterizing receiver physical parameters. 8b/10b-encoding, spread spectrum clocking (SSC) and up to 16 I/O lanes lead to the complications.

**How can Agilent help?**
The Agilent J-BERT N4903A provides complete built-in jitter tolerance testing. It is the industry-first BERT with the ability to handle the SSC clocks and pattern complexities of PCI Express devices. High-performance real-time oscilloscopes can be used for accurate transmitter eye and waveform analysis.

**Benefits of Agilent’s J-BERT N4903A**
Simplify your test and characterization with a one-box solution for receiver and transmitter testing and characterization that is both accurate and reproducible through:
- Complete jitter tolerance testing with built-in and calibrated jitter sources that go beyond the requirements of the standard
- Sub-rate clocks at 100 MHz
- SSC generation with triangular modulation at 30 kHz
- Pattern sequence editor to bring PCIe devices into loopback mode
- Bit recovery mode to analyze non-deterministic traffic from the DUT
- Built-in CDR
- Quick eye analysis with transmitter mask testing, SSC tolerant

**What is PCI Express?**
A popular serial interconnection used in most computers and servers. The PCI Express link consists of up to 32 lanes with data rates of 2.5 Gb/s and 5.0 Gb/s in its second generation. PCI Express is standardized by the PCI-SIG™.
What is Fully Buffered Dimm (FBD)/Advanced Memory Buffer (AMB)?

The new fully buffered DIMM (FBD) interface uses a gigabit, multiple-serial connection between the memory controller hub/CPU and an advanced memory buffer (AMB), for higher memory bandwidth to supply increasing CPU speeds. The FBD interface is a point-to-point bus with up to 10 south-bound lanes (relaying commands from the CPU to the memory) and 12 to 14 north-bound lanes (transporting data back to the CPU). Each lane runs at up to 4.8 Gb/s in the first generation.

Benefits of Agilent’s ParBERT 81250
- Characterize quickly and accurately by testing receivers and transmitters on several lanes at the same time
- Set different states of the AMB chip easily with the ParBERT data sequence editor
- Enjoy the convenience of a complete test solution provided with fixtures, probes and oscilloscopes

Benefits of Agilent’s J-BERT N4903A
Simplified testing through:
- Integrated and calibrated jitter sources
- Sub-rate clock
- Quick eye analysis

How can Agilent help?
The ParBERT 81250 can stimulate and analyze the multi-lane point-to-point interface. The data sequence editor even lets you control different states of the AMB chip to prepare the AMB for testing. To test receiver jitter tolerance, each pattern generator’s delay control input lets you inject input stress for receiver lanes. Parallel and synchronous transmitter analysis is provided with the output timing measurements and RJ, DJ, TJ measurements. Some AMB devices can be set in test state via a com interface. These devices can be conveniently tested by the J-BERT N4903A.

A question of fast, multi-lane characterization of receiver jitter tolerance and transmitter timing

Advanced Memory Buffer (AMB) Test

With data rates up to 4.8 Gb/s, and in the future up to 9.6 Gb/s, signal integrity is degraded by the bandwidth limitations of the transmission medium. Test engineers are required to measure and characterize jitter (RJ, DJ, and TJ) and parallel output timing on the multi-lane receiver and transmitter lanes, as well as receiver jitter tolerance.

Benefits of Agilent’s ParBERT 81250
- Characterize quickly and accurately by testing receivers and transmitters on several lanes at the same time
- Set different states of the AMB chip easily with the ParBERT data sequence editor
- Enjoy the convenience of a complete test solution provided with fixtures, probes and oscilloscopes

Benefits of Agilent’s J-BERT N4903A
Simplified testing through:
- Integrated and calibrated jitter sources
- Sub-rate clock
- Quick eye analysis
A question of choice

Choose the Best BERT for

Volume transceiver manufacturing test up to 3 Gb/s
The N5980A manufacturing serial BERT enables test of transceivers, such as SFP modules at one-sixth of the test cost and size of comparable BERT solutions.

Economic manufacturing and XFP test up to 12.5 Gb/s
The serial BERT N4906B addresses the needs for economic BER testing in manufacturing environments, and for budget-sensitive telecom device testing.

N5980A Manufacturing Serial BERT:
- Standard discrete data rates from 125 Mb/s to 3.125 Gb/s
- PRBS data and K28.5 pattern
- 3.5 mm differential electrical coax connectors and/or standard optical SFP module
- Single screen graphical user interface running on an external PC (Windows® 2000 or XP) over a USB 2.0 interface
- Fully remote programmable for test automation

N4906B Serial BERT:
- 3 or 12.5 Gb/s max. data rate
- Fast eye mask for pass/fail testing (option 101)
- Excellent precision for accurate measurements
- LCD touch-screen and Windows® XP operating system
- Small form factor
- Remote programming commands compatible for 71612, 86130A and N4900 series

www.agilent.com/find/manufacturing_bert
www.agilent.com/find/N4906B
your Multi-Gigabit Test

**J-BERT N4903A:**
- Today’s and tomorrow’s data rates: 150 Mb/s to 7 or 12.5 Gb/s
- >0.5 UI jitter injection with built-in and calibrated jitter sources for PJ, RJ, BUJ, ISI and sinusoidal interference
- Fits gigabit serial port test requirements: built-in CDR, differential I/Os, subrate clocks, pattern sequencing, SSC
- Quick eye mask and BER contours
- Upgradeable BERT platform

**Multi-lane device characterization up to 13.5 Gb/s**

**Jitter tolerance characterization and compliance testing up to 12.5 Gb/s**
The Agilent J-BERT N4903A high-performance serial BERT is the ideal choice for R&D applications at speeds up to 12.5 Gb/s. It provides complete, built-in, calibrated jitter injection for stressed eye testing of receivers. Automated jitter tolerance testing allows quick and accurate characterization and compliance testing for all popular serial bus standards.

**ParBERT 81250:**
- Modular BERT platform
- Various speed classes up to 13.5 Gb/s
- Up to 64 parallel input and output channels
- Powerful pattern sequencer to control complex devices
- Delay control input to apply external jitter sources
- PRWS/PRBS and memory based patterns
- Measurement suite

**Multi-lane device characterization up to 13.5 Gb/s**
The Agilent ParBERT 81250 is a modular BERT platform for data generation and analysis up to 13.5 Gb/s that provides the most flexible and scalable BERT solution on the market. It is ideal for accurate and efficient characterization of multi-port and multi-gigabit devices in the computer, semiconductor and communication industry.
A question of turning instruments into solutions

Automated Characterization and Compliance Tests

This test automation software platform combines the performance of instruments with the convenience of a PC. It provides test integration, high throughput and ease-of-use for a wide range of generator and analyzing instruments, such as the modular multi-channel ParBERT, the J-BERT, pulse pattern generators as well as sampling and real-time oscilloscopes. This level of control turns a collection of instruments into a solution.

**Save engineering time**
- Test engineers and designers can focus on analyzing test results instead of programming their equipment
- Avoid duplicating effort across multiple groups and sites
- Minimize debugging of test setups with fully supported test libraries

**Get correlatable and repeatable results**
- Results are referenced to industry standards
- The common test platform provides consistency across virtual teams, throughout the life cycle
- Test results can be tracked and compared using a test database

**Benefit from a growing range of supported standards**
Test libraries, for example for PCI Express and HDMI, are already available. Others are planned. For a current list of supported standards visit [www.agilent.com/find/automation](http://www.agilent.com/find/automation)

**Customization**
Our partner BitiEye can also adapt the test automation software platform to your special needs, for example, to integrate environmental control instruments. To learn how BitiEye can help to customize your needs visit [www.bitifeye.com](http://www.bitifeye.com)

[Control and result screen for a one-button PCI Express compliance test.](http://www.agilent.com/find/automation)
A question of one-stop-shopping for physical layer test tools

Complete Signal Integrity Made Easy

Agilent offers the only complete portfolio of physical layer test equipment for characterizing multi-gigabit devices, during the whole design and manufacturing life cycle. Leading edge design and test efficiency is achieved by Agilent’s continual innovations in all areas of digital high-speed testing.

**Pulse data generators**
By stimulating high-speed ports of digital devices with precise clock and data signals, pulse data generators are a flexible tool for generating best and worst-case pulses and patterns for testing.

**Real-time oscilloscopes and digital communication analyzers**
Real-time and sampling oscilloscopes allow quick and precise analysis of waveforms, eyes and jitter. They are suitable for all phases of design, validation and manufacturing tests of high-speed chips and boards.

**Bit error ratio testers (BERTs)**
BERTs are ideal for characterizing gigabit receivers. A BERT can inject clock and data signals on one or multiple lanes, injecting jitter for jitter tolerance testing. The error detector is used for total jitter measurements as well as eye and jitter analysis.

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Agilent satisfies all physical layer test needs

**Infiniium oscilloscopes and DCA-J**
High-performance real-time scopes and wide bandwidth oscilloscope with jitter analysis

**ParBERT, Serial BERTs**
Pattern generator and error detector with jitter sources and BER, jitter and eye analysis

**Pulse data generators**
Leading pulse, pattern, data and clock generation for digital design

**Design verification:** boards, general purpose

**Device characterization:** transceiver, MUX, SERDES, backplanes
Remove all doubt

Our repair and calibration services will get your equipment back to you, performing like new, when promised. You will get full value out of your Agilent equipment throughout its lifetime. Your equipment will be serviced by Agilent-trained technicians using the latest factory calibration procedures, automated repair diagnostics and genuine parts. You will always have the utmost confidence in your measurements.

Agilent offers a wide range of additional expert test and measurement services for your equipment, including initial start-up assistance onsite education and training, as well as design, system integration, and project management.

For more information on repair and calibration services, go to

www.agilent.com/find/removealldoubt

Related Literature

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