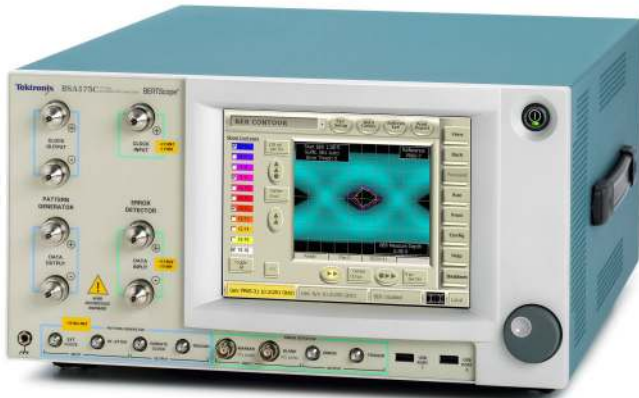


# Bit Error Rate Tester

## BERTScope® BSA Series Data Sheet



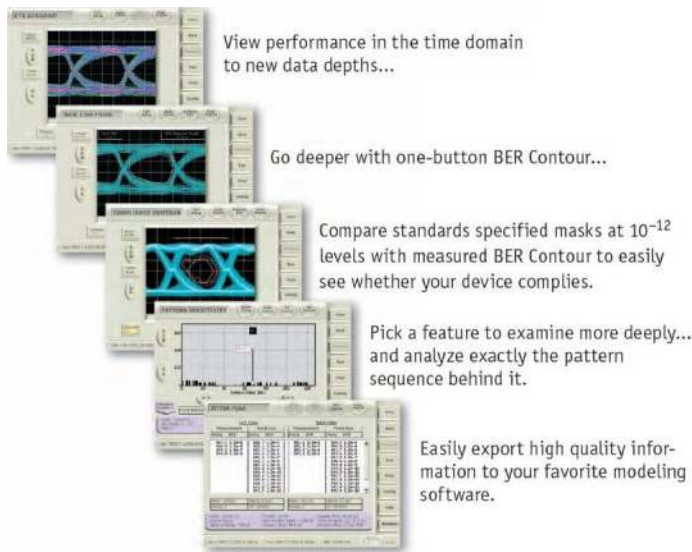
### Features & Benefits

- Pattern Generation and Error Analysis, High-speed BER Measurements up to 26 Gb/s
- Integrated, Calibrated Stress Generation to Address the Stressed Receiver Sensitivity and Clock Recovery Jitter Tolerance Test Requirements for a Wide Range of Standards
  - Sinusoidal Jitter to 100 MHz
  - Random Jitter
  - Bounded, Uncorrelated Jitter
  - Sinusoidal Interference
  - Spread Spectrum Clocking
  - PCIe 2.0 Receiver Testing
  - F/2 Jitter Generation for 8xFC and 10GBASE-KR Testing
- Electrical Stressed Eye Testing for:
  - PCI Express
  - 10/40/100 Gb Ethernet
  - SFP+/SFI
  - XFP/XFI
  - OIF/CEI
  - Fibre Channel
  - SATA
  - USB 3.0

- Jitter Tolerance Compliance Template Testing with Margin Testing
- Physical Layer Test Suite with Mask Testing, Jitter Peak, BER Contour, and Q-factor Analysis for Comprehensive Testing with Standard or User-defined Libraries of Jitter Tolerance Templates
- Integrated Eye Diagram Analysis with BER Correlation
- Optional Jitter Map Comprehensive Jitter Decomposition – with Long Pattern (i.e. PRBS-31) Jitter Triangulation to Extend BER-based Jitter Decomposition Beyond the Limitations of Dual Dirac TJ, DJ, and RJ for a Comprehensive Breakdown of Jitter Subcomponents
- Patented Error Location Analysis™ enables Rapid Understanding of your BER Performance Limitations and Assess Deterministic versus Random Errors, Perform Detailed Pattern-dependent Error Analysis, Perform Error Burst Analysis, or Error-free Interval Analysis

### Applications

- Design Verification including Signal Integrity, Jitter, and Timing Analysis
- Design Characterization for High-speed, Sophisticated Designs
- Certification Testing of Serial Data Streams for Industry Standards
- Design/Verification of High-speed I/O Components and Systems
- Signal Integrity Analysis – Mask Testing, Jitter Peak, BER Contour, Jitter Map, and Q-factor Analysis
- Design/Verification of Optical Transceivers



Testing optical transmitters with BERTScope mask testing and a BERTScope CR.

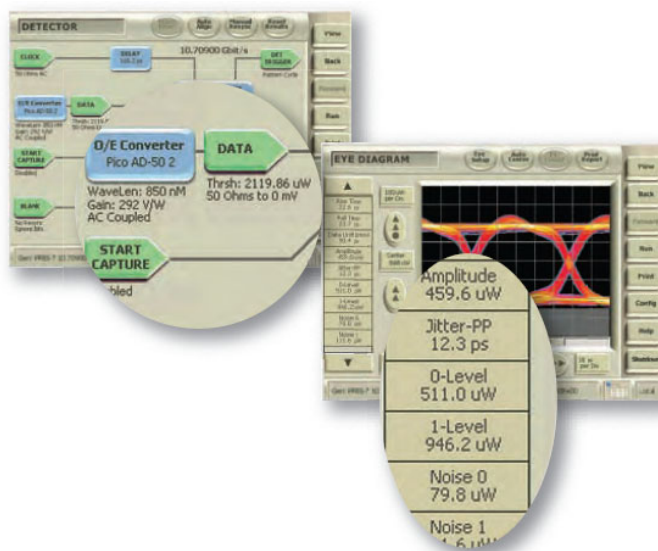
## Linking Domains

Eye diagrams have always provided an easy and intuitive view of digital performance. It has been harder to tie this directly with BER performance, as the instruments that provide views of each have been architected in fundamentally different ways. Eye diagrams have been composed of shallow amounts of data that have not easily uncovered rarer events. BERTs have counted every bit and so have provided measurements based on vastly deeper data sets, but have lacked the intuitive presentation of information to aid troubleshooting.

The BERTScope removes this gap allowing you to quickly and easily view an eye diagram based on at least two orders of magnitude more data than conventional eyes. Seeing a feature that looks out of the ordinary, you are able to place cursors on the item of interest and by simply moving the sampling point of the BERT, use the powerful error analysis capabilities to gain more insight into the feature of interest. For example, check for pattern sensitivity of the latest rising edges. Alternatively, use one-button measurement of BER Contour to see whether performance issues are bounded or likely to cause critical failures in the field. In each case, information is readily available to enhance modeling or aid troubleshooting, and is available for patterns up to  $2^{31} - 1$  PRBS.

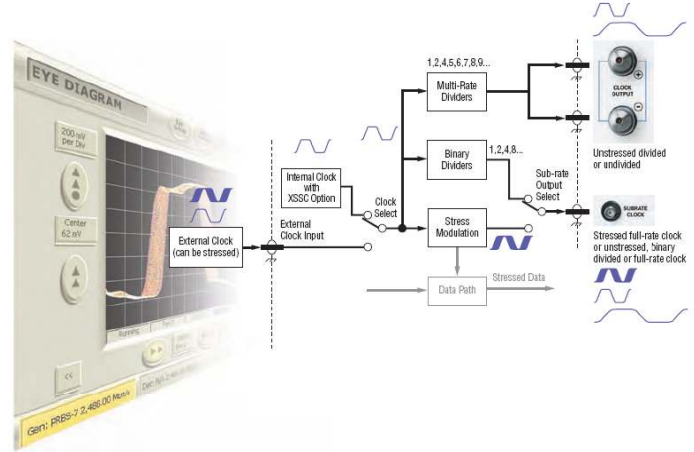
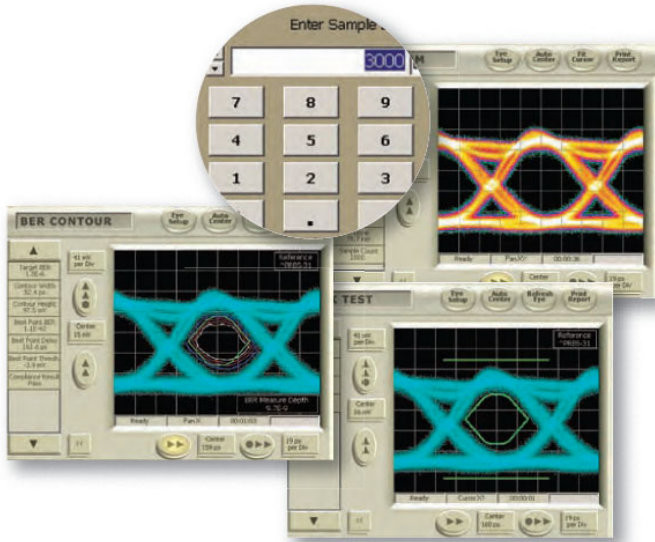
## Data-rich Eye Diagrams

As shown previously, there is an impressive difference in data depth between conventional eye diagrams and those taken with a BERTScope. So what does that mean? It means that you see more of what is really going on – more of the world of low-probability events that is present every time you run a long pattern through a dispersive system of any kind, have



The BERTScope shown with optical units enabled. In this example measurements are converted to the optical domain automatically.

random noise or random jitter from a VCO – a world that is waiting to catch you out when your design is deployed. Adding to this the deeper knowledge that comes from the one-button measurements of BER Contour, Jitter Peak, and Q-factor, and you can be confident that you are seeing the complete picture.



Clock path in BERTScope Option STR models.

### Mask Compliance Contour Testing

Many standards such as XFP/XFI and OIF CEI now specify mask tests intended to assure a specified  $1 \times 10^{-12}$  eye opening. Compliance Contour view makes this easy by taking a mask, and overlaying it on your measured BER contours – so you can immediately see whether you have passed the mask at whatever BER level you decide.

#### Quick Selection Guide

Model	Max Bit Rate	Stressed Eye – SJ, RJ, BUJ, SI
BSA260C/CPG	26 Gb/s	Opt. STR
BSA175C/CPG	17.5 Gb/s	Opt. STR
BSA125C/CPG	12.5 Gb/s	Opt. STR
BSA85C/CPG	8.5 Gb/s	Opt. STR

### Flexible Clocking

The generator clock path features in the BERTScope provides the test flexibility needed for emerging real-world devices. Whether computer cards or disk drives, it is often necessary to be able to provide a sub-rate system clock, such as 100 MHz for PCI Express® (PCIe). To get the target card running may require a differential clock signal with a particular amplitude and offset; this is easily accomplished with the BERTScope architecture, with many flexible divide ratios available.

Spread Spectrum Clocking (SSC) is commonly used in electrical serial data systems to reduce EMI energy by dispersing the power spectrum. Adjustable modulation amplitude, frequency, and a choice of triangle or sine modulation wave shape allow testing receivers to any compliance standard which utilize SSC. An additional modulator and source allows users to stress the clock with high-amplitude, low-frequency Sinusoidal Jitter (SJ).

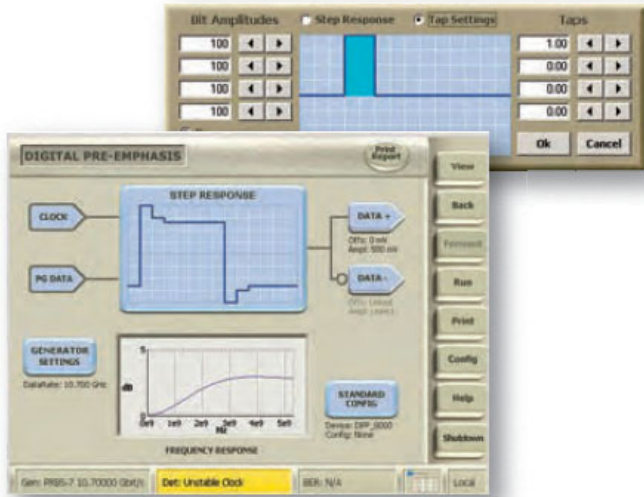
With the ability to vary sample depth, it is very easy to move between deep measurements which give a more accurate view of the real system performance, and shallow measurements that match those of a sampling scope. The measurements shown here are from the eye diagram of an optical transmitter. With the BERTScope sample depth set to only 3000 waveforms, the BERTScope generates the diagram shown in the middle in only 1 second. The measured mask margin of 20% exactly correlates to the same measurement made on a sampling oscilloscope. The lower diagram shows the eye produced by the same device, using Compliance Contour measured at a BER of  $1 \times 10^{-6}$ . Here the mask margin is reduced to 17%.

### Deep Mask Testing

The depth advantage gained for eye diagrams is at least 10 times greater for mask testing. Unlike pseudo-mask testing offered by some BERTs, a BERTScope mask test samples every point on the perimeter of an industry-standard mask, including the regions above and below the eye. Not only that, but each point is tested to a depth unseen before. This means that even for a test lasting a few seconds using a mask from the library of standard masks or from a mask you have created yourself, you can be sure that your device has no lurking problems.

### Accurate Jitter Testing to Industry Standards

Testing with long or short patterns, the most accurate jitter measurement is likely to come from the methodology that uses little or no extrapolation to get its result. With the BERTScope, you can quickly measure to levels of  $1 \times 10^{-9}$  ( $1 \times 10^{-10}$  at high data rates), or wait for the instrument to measure  $1 \times 10^{-12}$  directly. Either way, the BERTScope's one-button measurements are compliant to the MJSQ jitter methodology, and because the underlying delay control is the best available on any BERT you can be sure that the measurements are accurate. Use the built-in calculations for Total Jitter (TJ), Random Jitter (RJ), and Deterministic Jitter (DJ), or easily export the data and use your own favorite jitter model.



In keeping with the BERTScope philosophy, the graphical user interface presents the control functionality in a logical, easy-to-follow format. A time domain representation of the response shows the effects of tap weight settings. The frequency domain Bode plot shows how the filter will compensate for the channel losses.

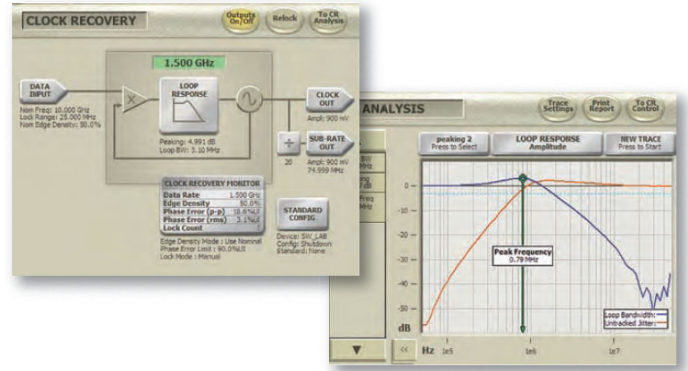


PatternVu

## Working with Closed Eyes

With the need to push ever-increasing data rates through electrical channels, the frequency-dependent losses often result in eye closure at the receiver end. Engineers use equalization to compensate for these losses and “open the eyes” in the real system. Tektronix offers powerful tools that allow designers to characterize and test compliance of receiver and transmitter components used in these systems.

For receiver testing, the DPP125 Digital Pre-emphasis Processor adds calibrated pre-emphasis to the BERTScope pattern generator outputs,



The intuitive user interface provides easy control of all operating parameters. A unique Loop Response view shows the loop characteristics – actually measured, not just the settings value.

emulating pre-emphasis applied at the transmitter. Pre-emphasis is currently used in 10GBASE-KR, PCIe, SAS, DisplayPort®, USB 3.0, and other standards.

Features:

- 1-12.5 Gb/s clock rates
- 3- or 4-tap versions
- Flexible cursor placement allowing pre-cursor or post-cursor

## PatternVu

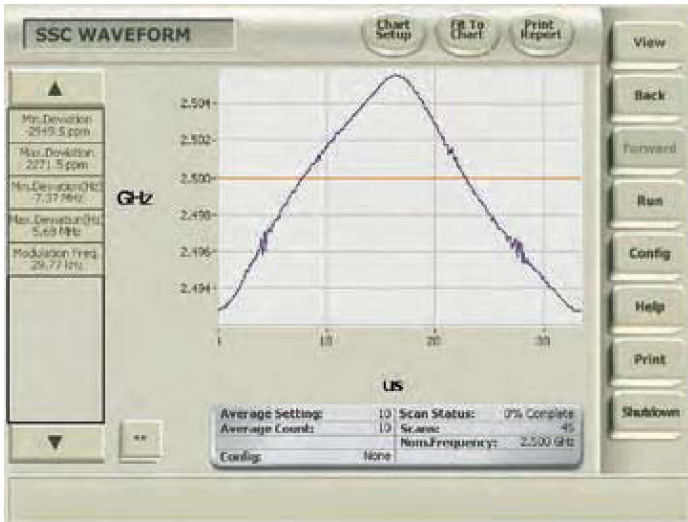
The PatternVu option includes a software-implemented FIR filter which can be inserted before the eye pattern display. In systems employing receiver equalization, this allows you to view the eye diagram and perform physical measurements on the eye as the receiver’s detector would see it, after the effect of the equalizer. Equalizers with up to 32 taps can be implemented, and the user can select the tap resolution per UI.

PatternVu also includes CleanEye, a pattern-locked averaging system which removes the nondeterministic jitter components from the eye. This allows you to clearly see pattern-dependent effects such as ISI (Inter-Symbol Interference) which are normally obscured by the presence of high amounts of random jitter.

Single Value Waveform export is a component in the PatternVu option. This allows you to capture a pattern-locked waveform showing single bits, similar to a single-shot capture in a real-time oscilloscope. Once captured, the waveform can be exported in a variety of formats for further analysis in an external program.

## Add Clock Recovery

The Tektronix CR125A, CR175A, and CR286A add new levels of flexibility in compliant clock recovery. Most standards requiring jitter measurement specify the use of clock recovery, and exactly which loop bandwidth must be used. Using a different or unknown loop bandwidth will almost certainly give you the wrong jitter measurement. The new clock recovery instrument enables easy and accurate measurements to be made to all of the common standards.



SSC Waveform Measurement

## Display and Measure SSC Modulation Waveforms

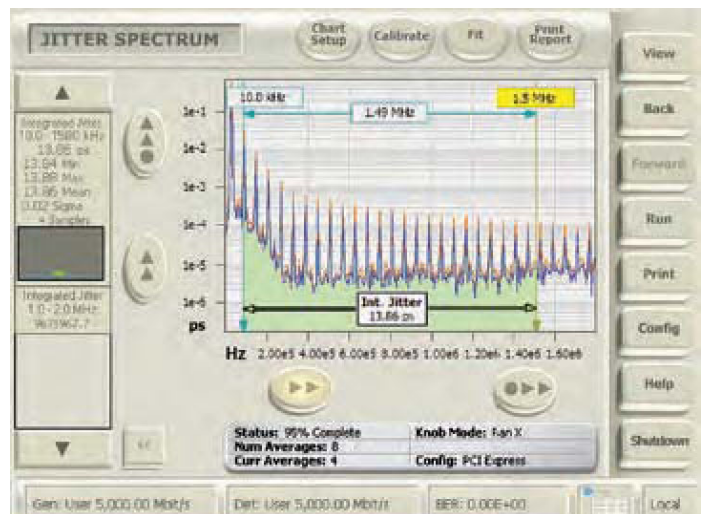
Spread Spectrum Clocking (SSC) is used by many of the latest serial busses including SATA, PCI Express, and next-generation SAS in order to reduce EMI issues in new board and system designs. The Tektronix CR Family provides spread spectrum clock recovery together with the display and measurement of the SSC modulation waveform. Automated measurements include minimum and maximum frequency deviation (in ppm or ps), modulation rate of change (dF/dT), and modulation frequency. Also included are display of the nominal data frequency and easy-to-use vertical and horizontal cursors.

## Add Jitter Analysis

Combine a Tektronix CR125A, CR175A, or CR286A with Option GJ with your sampling scope or BERTScope for variable clock recovery from 1.2 to 11.2 Gb/s, Duty Cycle Distortion (DCD) measurement, and real-time jitter spectral analysis. Display jitter spectral components from 200 Hz to 90 MHz with cursor measurements of jitter and frequency. Measure band-limited integrated jitter with user-settable frequency-gated measurements (preset

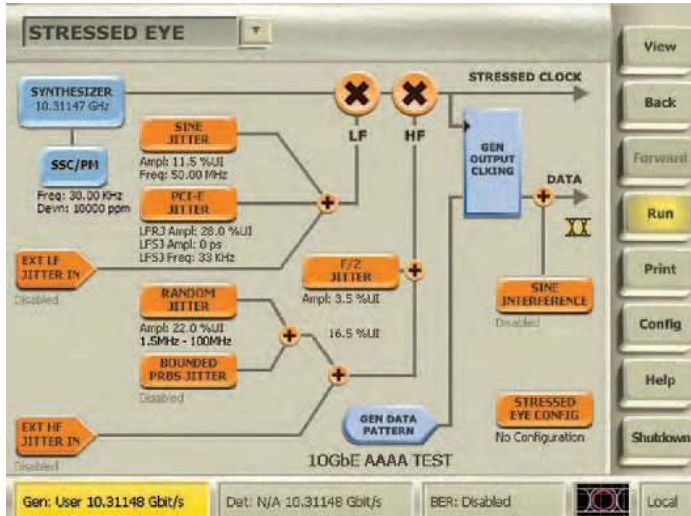


The usefulness of the BERTScope CRs is not just confined to BERTScope measurements. Use them stand-alone in the lab with your sampling oscilloscopes, or with existing BERT equipment. Compliant measurements are available to you by pairing either of these versatile instruments with your existing investments.



Jitter Spectrum Measurement

band limits and integrated jitter measurement for PCI Express 2.0 jitter spectrum in this example).



Creating the stress recipe for receiver testing to a complicated standard such as PCIe 2.0 used to require "racking and stacking" several instruments, then spending hours calibrating the setup. With BERTScope, an easy-to-understand graphical view gives you control of all of the calibrated stress sources you need – inside the same instrument. Eliminating the need for external cabling, mixers, couplers, modulators, etc. simplifies stress calibration.

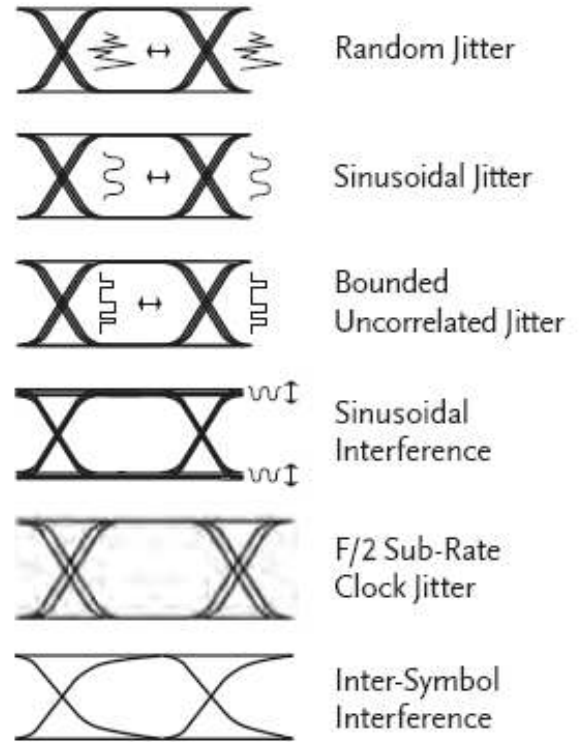
### Taking the Stress out of Receiver Testing

As networks have changed, so have the challenges of testing receivers. While tests such as BER and receiver sensitivity are still important, receiver jitter tolerance has evolved to be more real-world for jitter-limited systems such as 10 Gb/s data over back planes and new high-speed buses. Stressed Eye testing is becoming increasingly common as a compliance measurement in many standards. In addition, engineers are using it to explore the limits of their receiver performance to check margins in design and manufacturing.

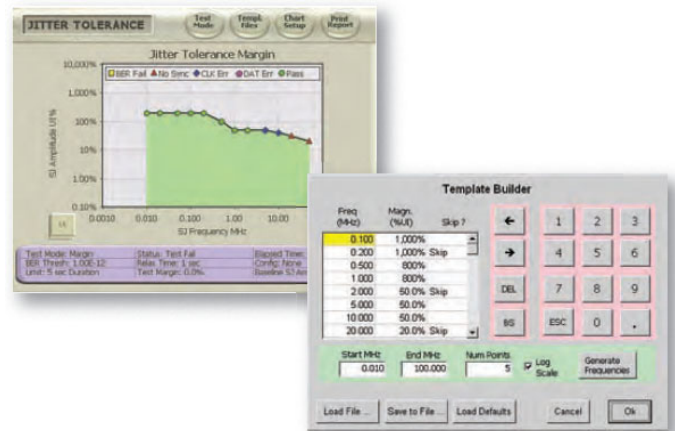
### Flexible Stress Impairments

The BERTScope has high-quality, calibrated sources of stress built-in, including RJ, SJ, BUJ, and SI.

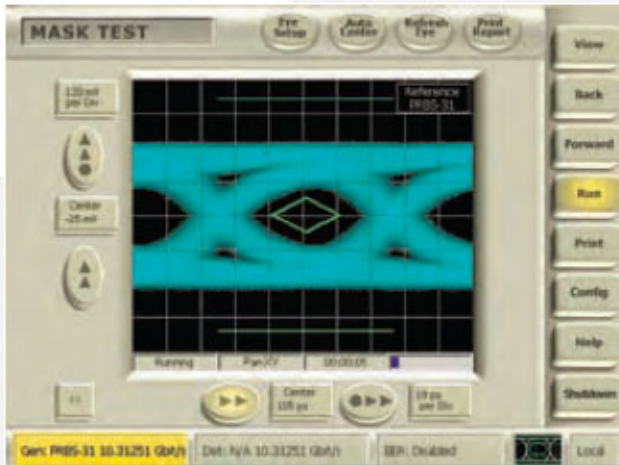
ISI is also a common ingredient in many standards. The BSA12500ISI differential ISI board provides a wide variety of path lengths, free from switching suck-outs and anomalies.



Flexible Stress Impairments



Many standards call for SJ to be stepped through a template with different SJ amplitudes at particular modulation frequencies. This is easy with the built-in Jitter Tolerance function which automatically steps through a template that you designed, or one of the many standard templates in the library.



XFI compliant electrical stressed eye

Stressed Eye Option

**BERTScope Pattern Generator Family**

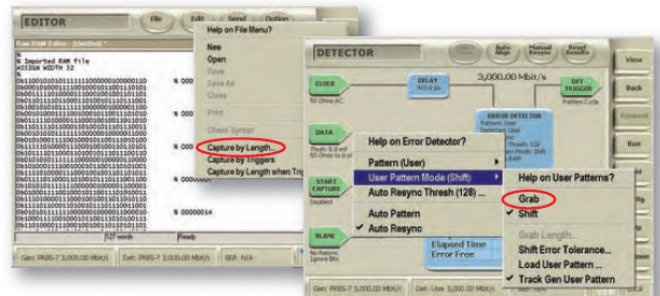
The BSA125CPG, BSA175CPG, and BSA260CPG Family of pattern generators provide a full range of PRBS patterns, common standards-based patterns, and user-defined patterns. Option STR provides full integrated, calibrated stress generation which is an easy-to-use alternative to a rack full of manually calibrated instruments needed to provide a stressed pattern. Uses include receiver testing of devices with internal BER measurement ability such as DisplayPort, or adding stress capability to legacy BERT instruments.

**Pattern Capture**

There are several methods for dealing with unknown incoming data. In addition to Live Data Analysis discussed above, a useful standard feature

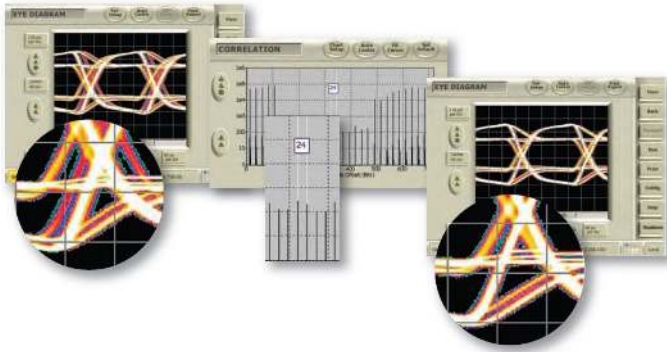


BERTScope Pattern Generator



Pattern Capture

on all BERTScope analyzers is pattern capture. This allows the user to specify the length of a repeating pattern and then allow the analyzer to grab the specified incoming data using the detector's 128 Mb RAM memory. This can then be used as the new detector reference pattern, or edited and saved for later use.



Using the Power of Error Analysis – In this example eye diagram views were linked with BER to identify and solve a design issue in a memory chip controller. The eye diagram (top left) shows a feature in the crossing region that is unexpected and appearing less frequently than the main eye. Moving the BER decision point to explore the infrequent events is revealing. Error Analysis shows that the features are related in some way to the number 24. Further investigation traced the anomaly to clock breakthrough within the IC; the system clock was at 1/24th of the output data rate. Redesigning the chip with greater clock path isolation gave the clean waveform of the top right eye diagram.

### Jitter Measurements

Multi-gigabit serial data channels have eye openings only a couple hundred picoseconds wide – or less. In systems where only a few picoseconds of jitter count, accurate measurement of jitter is essential for managing tight jitter budgets. The BERTScope has two sets of tools which perform these critical measurements.

The Physical Layer Test Suite option includes measurement of Total Jitter (TJ) along with breakdown into Random Jitter (RJ) and Deterministic Jitter (DJ), using the well-accepted Dual Dirac method. The deep, BERT-collected measurements use several orders of magnitude less extrapolation, or in some cases no extrapolation, than oscilloscopes use as a basis for the jitter measurements. This produces inherently more accurate results than measurements made on other instruments which rely on high levels of extrapolation.

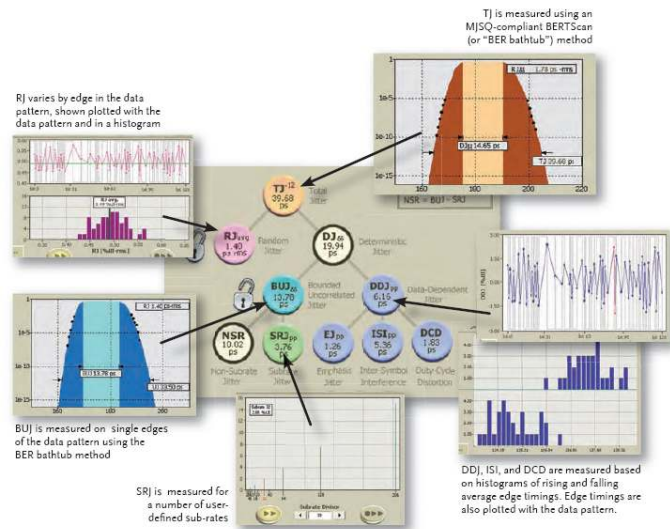
The optional Jitter Map is the latest suite of jitter measurements available for the BERTScope. It provides a comprehensive set of subcomponent analysis beyond RJ and DJ, including many measurements compliant with higher data rate standards. Jitter Map can also measure and decompose jitter on extremely long patterns, such as PRBS-31, as well as live data (requires Live Data Analysis option) providing that it can first run on a shorter synchronized data pattern.

Features include:

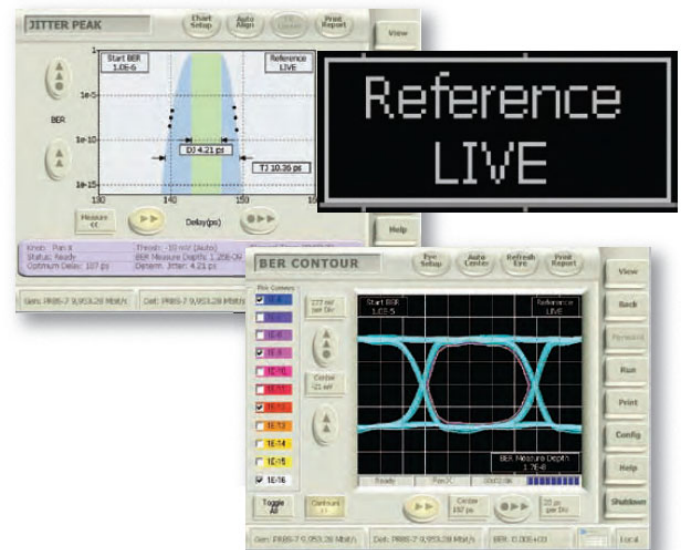
- DJ breakdown into Bounded Uncorrelated Jitter (BUJ), Data Dependent Jitter (DDJ), Inter-Symbol Interference (ISI), Duty Cycle Distortion (DCD), and Sub-Rate Jitter (SRJ) including F/2 (or F/2) Jitter
- BER-based for direct (non-extrapolated) Total Jitter (TJ) measurement to 10<sup>-12</sup> BER and beyond
- Separation of correlated and non-correlated jitter components eliminates mistaking long pattern DDJ for RJ
- Can measure jitter with minimum eye opening
- Additional levels of breakdown not available from other instruments such as: Emphasis Jitter (EJ), Uncorrelated Jitter (UJ), Data Dependent Pulse Width Shrinkage (DDPWS), and Non-ISI
- Intuitive, easy-to-navigate jitter tree



MJSQ-compliant Dual Dirac jitter measurement.



Jitter Map



Jitter Peak and BER Contour measurements made on live data.

### Testing Interface Cards

Finally a solution to the age-old problem of making physical layer measurements on high-speed line cards, motherboards, and live traffic

– the BERTScope Live Data Analysis option. Through novel use of the dual-decision point architecture, the instrument is able to make parametric measurements such as Jitter, BER Contour, and Q-factor in addition to the eye and mask measurements that are usable as standard – all that is required is a clock signal. Add the Jitter Map option to see even more layers

of jitter decomposition on live data. No more frustration because the pattern is not known, is unpredictable, or involves rate-matching word insertions. Troubleshooting is so much easier now that the one-button physical layer tests can be employed to provide unique insight.

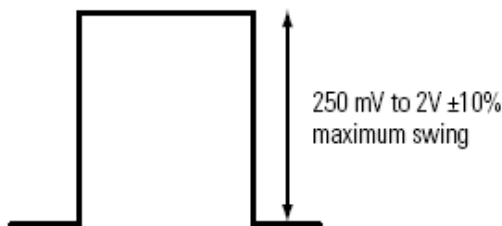


Figure 1. Amplitude range.

## Characteristics

### Pattern Generator\*1

#### Input/Output Specifications

##### Clock Outputs

Characteristic	Description
Frequency Range	
BSA85C, CPG	0.1-8.5 GHz
BSA125C, CPG	0.1-12.5 GHz*2
BSA175C, CPG	0.5-17.5 GHz*2
BSA260C, CPG	1-26 GHz*2
Phase Noise	< -90 dBc/Hz at 10 kHz offset (typical)
Clock Output Divide Ratios	Option STR only

\*1 Rise times are measured 20% to 80% unless otherwise stated. Specifications are following a 20-minute warm-up period. Specifications subject to change.

\*2 Output at data rate +2 above 11.2 Gb/s.

##### Data Outputs

Characteristic	Description
Date Rate Range	
BSA85C	0.1-8.5 Gb/s
BSA125C, CPG	0.1-12.5 Gb/s
BSA175C, CPG	0.5-17.5 Gb/s
BSA260C, CPG	1-26 Gb/s
Format	NRZ
Polarity	Normal or Inverted
Variable Crossover	25 to 75%
Patterns	
Hardware patterns	Industry-standard Pseudo-random (PRBS) of the following types: $2^n - 1$ where $n = 7, 11, 15, 20, 23, 31$
RAM patterns	
BSA85C	128 bits to 128 Mb total, allocated in 32 Mb portions to each of two A/B pages. Single page max is 128 Mb
BSA125C, CPG	
BSA175C, CPG	
BSA260C, CPG	
Library	Wide variety including SONET/SDH, Fibre Channel based such as k28.5, CJTPAT; $2^n$ patterns where $n = 3, 4, 5, 6, 7, 9$ ; Mark Density patterns for $2^n$ where $n = 7, 9, 23$ ; and many more
Error Insertion	
Length	1, 2, 4, 8, 16, 32, 64 bit bursts
Frequency	Single or repetitive

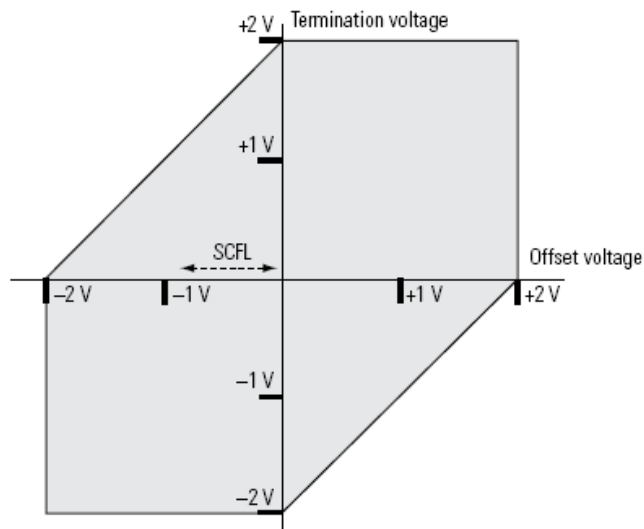


Figure 2. Allowable combinations of termination and offset. Amplitude swings between 0.25 and 2 V allowed; should fit inside shaded area of graph. For example, SCFL uses a 0 V termination, and operates between approximately 0 and -0.9 V; as shown with dotted arrow, it falls within the operating range.

#### Data, Clock Amplitudes and Offsets

Characteristic	Description
Configuration	Differential outputs, each side of pair individually settable for termination, amplitude, offset
Interface	DC coupled, 50 $\Omega$ reverse terminated, APC-3.5 connector. Calibration into 75 $\Omega$ selectable, other impedances by keypad entry. User-replaceable Planar Crown® adapter allows change to other connector types
Preset Logic Families	LVPECL, LVDS, LVTTTL, CML, ECL, SCFL
Terminations	Variable, -2 to +2 V Presets: +1.5, +1.3, +1.0, -2 V, AC coupled
Allowable Amplitudes, Terminations, and Offsets	See Figures 1 and 2

#### Data, Clock Waveform Performance

Model	Rise Time	Jitter
BSA85C	25 ps max, 23 ps typical (10-90%)	<10 ps p-p (typical, for data rates $\geq 1$ Gb/s)
BSA125C, CPG		<0.025 UI (typical, for data rates <1 Gb/s)
BSA175C, CPG		
BSA260C, CPG		8 ps p-p (typical at 25.78 Gb/s data rate)

#### Clock/Data Delay

Characteristic	Description
Range	(Greater than 1 bit period in all cases)
Up to 1.1 GHz	30 ns
Above 1.1 GHz	3 ns
Resolution	100 fs
Self Calibration	At time of measurement, when temperature or bit rate are changed, instrument will recommend a self calibration. Operation takes less than 10 seconds

## Pattern Generator Ancillary Connections

### Front-panel Pattern Generator Connections

#### External Clock Input

Characteristic	Description
	Allows use of an external clock source to clock the BERTScope. Models equipped with stress are able to add impairments to incoming clock, including when external signal has Spread Spectrum Clocking (SSC) in excess of 5000 ppm imposed on it.
Frequency Range	
BSA85C	0.1 to 8.5 GHz
BSA125C, CPG	0.1 to 12.5 GHz
BSA175C, CPG	0.5 to 17.5 GHz
BSA260C, CPG	1 to 26 GHz
Nominal Power	900 mV <sub>p-p</sub> (+3 dBm)
Maximum Power	2.0 V <sub>p-p</sub> (+10 dBm)
Return Loss	Better than -6 dB
Interface	50 Ω SMA female, DC coupled into selectable termination voltage

#### HF Jitter (Option STR Only)

Characteristic	Description
	One of two jitter insertion inputs. Can be used to insert SJ, RJ, BUJ if desired.
Frequency Range	DC to 1.0 GHz
Jitter Amplitude Range	Up to 0.5 UI max
Input Voltage Range	0-2 V <sub>p-p</sub> (+10 dBm) for normal operation 6.3 V <sub>p-p</sub> (+20 dBm) max nondestructive input
Data Rate Range	Up to 8.5, 11.2 (BSA125C, CPG, only), 17.5, or 22 Gb/s
Interface	SMA female, 50 Ω, DC coupled into 0 V

#### Sub-rate Clock Output

Characteristic	Description
	BERTScope standard models have clock divided by 4. BERTScope Option STR models have additional capabilities.
Frequency Range	0.125 to 3.125 GHz (12.5 GHz with Option STR)
Amplitude Range	1 V <sub>p-p</sub> , nominal, centered around 0 V
Transition Time	<500 ps
Interface	SMA female, 50 Ω, DC coupled into 0 V

#### Trigger Output

Characteristic	Description
	Provides a pulse trigger to external test equipment. It has two modes: 1. Divided Clock Mode: Pulses at 1/256th of the clock rate 2. Pattern Mode: Pulse at a programmable position in the pattern (PRBS), or fixed location (RAM patterns) Stress modulation added on models so equipped, when enabled.
Minimum Pulse Width	128 Clock Periods (Mode 1) 512 Clock Periods (Mode 2)
Transition Time	<500 ps
Jitter (p-p, data to trigger)	<10 ps, typical (BSA175C/CPG, BSA260C/CPG)
Output Levels	>300 mV <sub>p-p</sub> , center at 650 mV
Interface	50 Ω SMA female

## Rear-panel Pattern Generator Connections

### Pattern Start Input

Characteristic	Description
	For users wanting to synchronize patterns of multiple data streams from multiple instruments simultaneously.
Logic Levels	LVTTL (<0.5 V Low, >2.5 V High)
Threshold	+1.2 V typical
Max Nondestructible Input Range	-0.5 V to +5.0 V
Minimum Pulse Width	128 serial clock periods
Maximum Repetition Rate	512 serial clock periods
Interface	SMA female, >1 kΩ impedance into 0 V

### Page Select Input

Characteristic	Description
	In A-B Page Select mode, allows external control of pattern. Software control over rising or falling edge trigger, continuous Pattern B after completion of Pattern A, or run B only once before reverting back to A.
Logic Levels	LVTTL (<0.5 V Low, >2.5 V High)
Threshold	+1.2 V typical
Max Nondestructible Input Range	-0.5 V to +5.0 V
Minimum Pulse Width	1 pattern length
Interface	SMA female, >1 kΩ impedance into 0 V

### Sinusoidal Interference Output (Option STR Only)

Characteristic	Description
	SI output from internal generator. Can be used to apply SI after external ISI channel.
Frequency Range	0.1-2.5 GHz
Output Voltage	0-3 V <sub>p-p</sub>
Interface	0-3 V <sub>p-p</sub>

### Low-frequency Jitter Input (Option STR Only)

Characteristic	Description
	Allows use of external low-frequency jitter source to modulate the stressed pattern generator output.
Frequency Range	DC to 100 MHz
Jitter Amplitude Range	Up to 1.1 ns, can be combined with other internal low-frequency modulation
Input Voltage Range	0-2 V <sub>p-p</sub> (+10 dBm) for normal operation 6.3 V <sub>p-p</sub> (+20 dBm) max nondestructive input
Data Rate Range	Up to 8.5 Gb/s (BSA85C/CPG), 12.5 Gb/s (BSA125C/CPG), 17.5 Gb/s (BSA175C/CPG), and 22 Gb/s (BSA260C/CPG)
Interface	SMA female 50 Ω, DC coupled into 0 V

### Low-frequency Sinusoidal Jitter Output (Option STR Only)

Characteristic	Description
	To allow phasing of two BERTScopes together, in-phase or anti-phase.
Frequency	As set for internal SJ from GUI
Amplitude	2 V <sub>p-p</sub> , centered at 0 V
Interface	SMA female

Reference Input

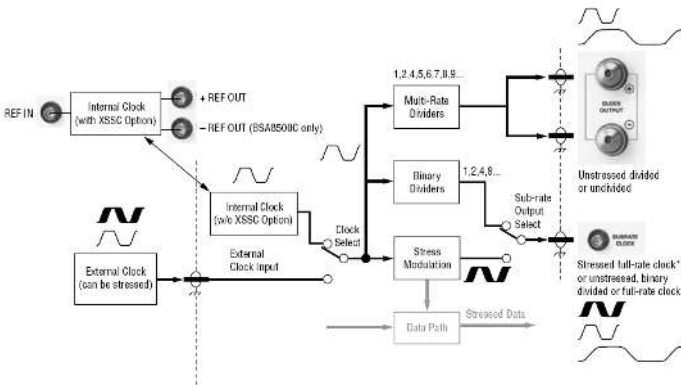
Characteristic	Description
To lock the BERTScope to an external frequency reference from of another piece of equipment.	
Frequency	10, 100, 106.25, 133.33, 156.25, 166.67, or 200 MHz
Amplitude	0.325 to 1.25 V <sub>p-p</sub> (-6 to +6 dBm)
Interface	50 Ω SMA female, AC coupled

Reference Output

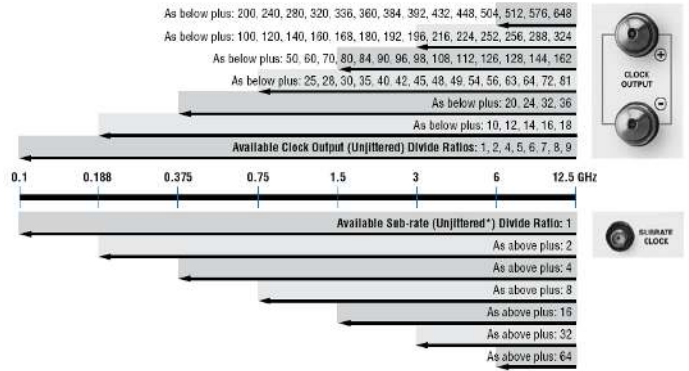
Characteristic	Description
Provides a frequency reference for other instruments to lock to.	
Configuration	Single Ended (Ref-Out not used) (BSA125C, CPG) Differential
Frequency	10, 100, 106.25, 133.33, 156.25, 166.67, or 200 MHz
Amplitude	1 V <sub>p-p</sub> (+4 dBm) nominal, each output, (2 V <sub>p-p</sub> differential)
Interface	50 Ω SMA female, AC coupled

Clock Path Details

BSA85C, CPG

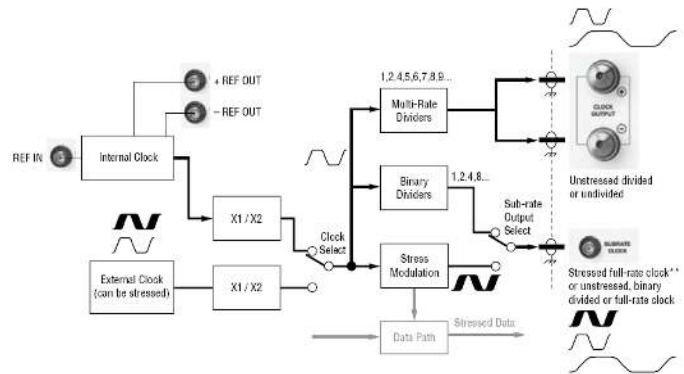


Functional block diagram of the clock path for models with stress capability, BSA85C/CPG.



Available divide ratios from clock-related output, by bit rate, using the internal clock, BSA85C\*\*\*.

BSA125C, CPG, BSA175C, CPG, and BSA260C, CPG



Functional block diagram of the clock path for models with stress capability, BSA85C/CPG, BSA125C/CPG, BSA175C/CPG, BSA260C/CPG.

- \* This output can also provide a full-rate jittered clock.
- \*\* Stress may be added to an external clock on appropriate models. Stress operating range is from 1.5 to 11.2 Gb/s. External clock must have a duty cycle of 50% ±2%.
- \*\*\* All listed ratios available for an external clock input over entire bit rate range, limitations for internal clock only. Minimum specified frequency of the clock output is 100 MHz. Operation below this rate will be uncalibrated.

The BSA125, BSA175, and BSA260 models use an internal Double Data Rate (DDR) architecture to operate at data rates ≥11.2 Gb/s. When operating at 11.2 Gb/s or higher data rate, the clock output will be 1/2 the data rate.

External clock can be specified to be either full or half data rate. When full rate is selected, the pattern generator will operate in DDR mode when the input clock frequency is 11.2 GHz or higher.

These ratios apply to operation from internal clock only. External clock will be output at 1/2 rate when half rate is selected, or when full rate is selected and clock rate is ≥11.2 GHz.

The minimum data rate specified for the main clock output is 500 Mb/s. Output will be uncalibrated when operated at divided rates lower than 500 Mb/s.

Available Multi-rate and Sub-rate Divider Ratios for Main Clock Output, BSA125C, CPG, BSA175C, CPG, and BSA260C, CPG Models

Data Rate (Gb/s)	Ratios for Main Clock Out	Ratios for Sub-rate Clock Out**3
500-750 Mb/s	1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 24, 32, 36	1, 2, 4
0.75-1.5 Gb/s	1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 24, 25, 28, 30, 32, 35, 36, 40, 42, 45, 48, 54, 56, 64, 72, 81	1, 2, 4, 8
1.5-3 Gb/s	1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 24, 30, 32, 32, 35, 36, 36, 40, 42, 45, 48, 50, 54, 56, 60, 64, 70, 72, 80, 81, 84, 90, 98, 100, 108, 112, 120, 126, 128, 140, 144, 160, 162, 168, 180, 192, 196, 216, 224, 252, 256, 288, 324	1, 2, 4, 8, 16
3-6 Gb/s	1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 24, 30, 32, 32, 35, 36, 36, 40, 42, 45, 48, 50, 54, 56, 60, 64, 70, 72, 80, 81, 84, 90, 98, 100, 108, 112, 120, 126, 128, 140, 144, 160, 162, 168, 180, 192, 196, 216, 224, 252, 256, 288, 324, 360, 384, 392, 432, 448, 504, 512, 576, 648	1, 2, 4, 8, 16, 32
6-11.2 Gb/s	1, 2, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, 24, 30, 32, 32, 35, 36, 36, 40, 42, 45, 48, 50, 54, 56, 60, 64, 70, 72, 80, 81, 84, 90, 98, 108, 112, 126, 128, 140, 144, 144, 160, 162, 162, 168, 180, 192, 196, 200, 216, 224, 240, 252, 256, 280, 288, 320, 324, 336, 360, 384, 392, 432, 448, 504, 512, 576, 648	1, 2, 4, 8, 16, 32, 64
11.2-12 Gb/s	2, 4, 8, 10, 12, 14, 16, 18, 20, 24, 28, 32, 36, 40, 48, 60, 64, 64, 70, 72, 72, 80, 84, 90, 96, 100, 108, 112, 120, 128, 140, 144, 160, 162, 168, 180, 196, 200, 216, 224, 240, 252, 256, 280, 288, 320, 324, 336, 360, 384, 392, 432, 448, 504, 512, 576, 648	2, 4, 8, 16, 32, 64
12-26 Gb/s	2, 4, 8, 10, 12, 14, 16, 18, 20, 24, 28, 32, 36, 40, 48, 60, 64, 64, 70, 72, 72, 80, 84, 90, 96, 100, 108, 112, 120, 128, 140, 144, 160, 162, 168, 180, 196, 216, 224, 252, 256, 280, 288, 288, 320, 324, 324, 336, 360, 384, 392, 400, 432, 448, 480, 504, 512, 560, 576, 640, 648, 720, 768, 784, 864, 896, 1008, 1024, 1152, 1296	2, 4, 8, 16, 32, 64, 128

\*\*3 Sub-rate clock connector can also output a full-rate stressed clock up to 11.2 Gb/s, or half-rate stressed clock at rates ≥11.2 Gb/s.

Pattern Generator Stressed Eye

- Flexible, integrated stressed eye impairment addition to the internal or an external clock
- Easy setup, with complexity hidden from the user with no loss of flexibility
- Verify compliance to multiple standards using the BERTScope and external ISI filters. Standards such as:
  - OIF CEI
  - 6 Gb SATA
  - PCI Express®
  - XFI
  - USB 3.0
  - SONET
  - SAS 2
  - XAUI
  - 10 and 100 Gb Ethernet
  - DisplayPort
- Sinusoidal interference may be inserted in-phase or in anti-phase, or sent externally to be summed after an external ISI reference channel
- Sinusoidal jitter may be locked between two BERTScopes in-phase or anti-phase, as required by OIF CEI

Flexible External Jitter Interfaces

- Front Panel External High Frequency Jitter Input Connector – Jitter from DC to 1.0 GHz up to 0.5 UI (max) may be added, of any type that keeps within amplitude and frequency boundaries
- Rear Panel External SJ Low Frequency Jitter Input Connector – Jitter from DC to 100 MHz up to 1 ns (max) may be added
- Rear Panel SJ Output
- Sinusoidal Interference Output Rear Panel Connector

**Note:** Internal RJ, BUJ, and external high-frequency jitter input limited to 0.5 UI, combined, further limited to 0.25 UI each when both are enabled. Rear-panel low-frequency jitter input can be used to impose additional jitter; sum of external low-frequency jitter, internal low-frequency SJ to 10 MHz, PCIe LFRJ and PCIe LFSJ (with Option XS) is limited to 1.1 ns. This limit does not apply to Phase Modulation (PM) from Option XSSC.

Amplitude and ISI Impairments

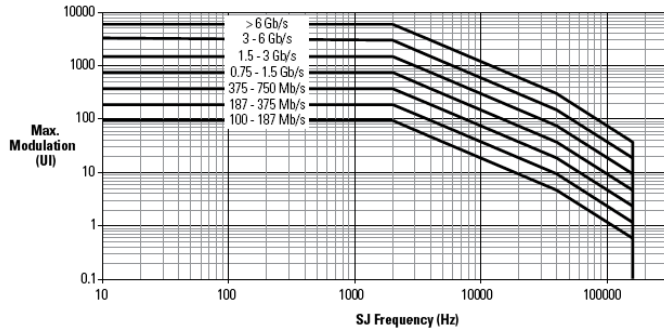
ISI

Add externally: For example, long coax cable length, or Bessel-Thompson 4th Order Filter with -3 dB point at 0.75 of bit rate, etc.

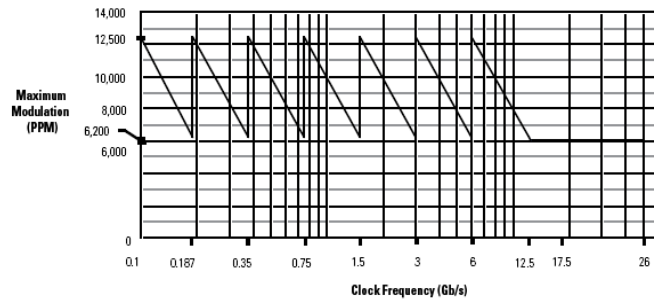
For applications requiring circuit board dispersion, the BSA12500ISI differential ISI accessory board may be used.

Sinusoidal Interference

- Supports full data rate range of BERTScope
- 100 MHz to 2.5 GHz
- Adjustable in 100 kHz steps
- Adjustable from 0 to 400 mV
- Common mode or differential
- Available from rear-panel 50 Ω SMA connector, single ended with data amplitude from 0 to 3 V adjustable from GUI, same frequency range and step size as internal adjustment



Phase Modulation Range with Option XSSC.



Maximum SSC Modulation with Option XSSC.

**Jitter Impairments**

**Bounded Uncorrelated Jitter**

- Supports data rates from 1.5 to 8.5 Gb/s (BSA85C), to 11.2 Gb/s (BSA125C/CPG), 17.5 Gb/s (BSA175C/CPG), and 26 Gb/s (BSA260C/CPG), with limited performance to 622 Mb/s (BSA260C/CPG excluded)
- Internal PRBS-7 Generator
- Variable up to 0.5 UI
- 100 Mb/s to 2.0 Gb/s
- Band-limited by selected filters (see table below)

BUJ Rate	Filter
100 to 499	25 MHz
500 to 999	50 MHz
1,000 to 1,999	100 MHz
2,000	200 MHz

**Random Jitter**

- Supports data rates from 1.5 to 8.5 Gb/s (BSA85C), to 11.2 Gb/s (BSA125C/CPG), 17.5 Gb/s (BSA175C/CPG), and 26 Gb/s (BSA260C/CPG), with limited performance to 622 Mb/s (BSA260C/CPG excluded)
- Variable up to 0.5 UI
- Band-limited 10 MHz to 1 GHz
- Crest factor of 16 (Gaussian to at least 8 standard deviation or  $\sim 1 \times 10^{-16}$  probability)

**Sinusoidal Jitter**

Data Rate	Internal SJ Frequency	Maximum Internal SJ Amplitude
Up to 11.2 (BSA85C, BSA125C) or 17.5 Gb/s	1 kHz to 10 MHz <sup>*4</sup>	1100 ps
	10 MHz to 100 MHz	200 ps
17.5-26 Gb/s	1 kHz to 100 MHz	84 ps

<sup>\*4</sup> Can be combined with other low-frequency modulation.

SJ adjustable from 0 to levels greater than or equal to range in table. See Additional Stress Options (next) for more SJ capabilities.

**Additional Stress Options**

**Enhanced Spread Spectrum Clock Option (Option STR and/or Option XSSC)**

Characteristic	Description
Adds a modulator directly to the synthesizer clock output – modulation affects main and sub-rate clock output (regardless of the state of sub-rate output select), Data Output, and Trigger Output.	
Modes	SSC or Phase Modulation (sinusoidal)
Data Rate Range	Full range of BERTScope
SSC Wave Shape	Triangle or Sine
SSC Frequency Range	20 kHz to 40 kHz
SSC Modulation Range	12,500 ppm at 6 Gb/s 6,200 ppm at 12 Gb/s 6,000 ppm at 12.5 Gb/s and above See Maximum SSC Modulation graph for range at lower clock rates
SSC Modulation Resolution	1 ppm
SSC Modulation Type	Down Spread, Center Spread, Up Spread
PM Frequency Range	10 Hz - 160 kHz
PM Frequency Resolution	1 Hz

**PM Modulation Range – For modulation frequency 10 Hz - 2 kHz**

Data Rate	Maximum Modulation
>6 Gb/s	6000 UI
3 to 6 Gb/s	3000 UI
1.5 to 3 Gb/s	1500 UI
0.75 to 1.5 Gb/s	750 UI
375 to 750 Mb/s	375 UI
187 to 375 Mb/s	187.5 UI
100 to 187 Mb/s	93.75 UI

Reduced for modulation frequencies >2 kHz. See Phase Modulation Range graph.

**F/2 Jitter Generation Option (Option F2, also requires Option STR)**

Characteristic	Description
F/2 or sub-rate jitter is found in high data rate systems which multiplex up 2 or more lower data rate streams. The jitter results for lack of symmetry in the multiplexing clock, giving all of the even bits different pulse width than the odd bits. Unlike conventional DCD, F/2 jitter is independent of the logic state of the bit. F/2 jitter is part of the stress recipe used in testing compliance to some of the newer standards such as 802.3ap (10 Gb backplane Ethernet).	
Supported Data Rates	8.0 and 10.3125 Gb/s
Modulation Range	0-5.0% UI

**Extended Stress Generation Option (Option PCISTR)**

Characteristic	Description
	This option adds additional stress generators required for compliance testing receivers to PCIe 2.0 specifications, internal to the BERTScope.
Clock Frequency Range	Up to 11.2 Gb/s
LFRJ Modulation Range	0-1.1 ns*4
LFRJ Frequency Range	Band-limited to 10 kHz - 1.5 MHz, with roll off to PCIe 2.0 specifications
LFSJ Modulation Range	0-368 ps*4 at 5 Gb/s
LFSJ Frequency Range	1-100 kHz

\*4 Can be combined with other low-frequency modulation.

Characteristic	Description
	The Extended Stress option also adds selectable bandwidth-limiting to the normal, broadband RJ generator.
RJ Frequency, Normal Mode	Band-limited to 10 MHz - 1 GHz
RJ Frequency, PCIe Mode	Band-limited to 1.5-100 MHz with roll off to PCIe 2.0 specifications

**Error Detector**

**Clock and Data Inputs**

**Clock Input**

Characteristic	Description
Configuration	Single ended
Frequency Range	
BSA85C	0.1-8.5 GHz
BSA125C	0.1-12.5 GHz
BSA175C	0.5-17.5 GHz*5
BSA260C	1-26 GHz*5

\*5 A full- or half-rate clock may be used for data rates above 11.2 Gb/s.

**Data and Clock Interfaces**

Characteristic	Description
Connector	APC-3.5 Planar Crown®
Impedance	50 Ω
Threshold Voltage	-2 to +3.5 V
Threshold Presets	LVPECL, LVDS, LVTTTL, CML, ECL, SCFL
Terminations	Variable, -2 V to +3 V Presets: +1.5, +1.3, +1, 0, -2 V, AC coupled
Max Nondestructible Input	-3 V <sub>peak</sub> , +4 V <sub>peak</sub> , applied to any connector

**Clock/Data Delay**

Characteristic	Description
Range	(Greater than 1 bit period in all cases)
Up to 1.1 GHz	30 ns
Above 1.1 GHz	3 ns
Resolution	100 fs
Self Calibration	Supported – At time of measurement, when temperature or bit rate are changed, instrument will recommend a self calibration. Operation takes less than 10 seconds

**Data Inputs**

Characteristic	Description
Date Rate Range	
BSA85C	0.1-8.5 Gb/s
BSA125C	0.1-12.5 Gb/s
BSA175C	0.5-17.5 Gb/s
BSA260C	1-26 Gb/s
Configuration	Differential
Format	NRZ
Polarity	Normal or Inverted
Threshold Alignment	Can auto-align to differential crossing point
Sensitivity	
Single ended	100 mV <sub>p-p</sub> (typical)
Differential	50 mV <sub>p-p</sub> (typical)
Maximum input signal swing	2 V <sub>p-p</sub>
Intrinsic Transition Time	16 ps typical, 10/90%, single ended (equivalent to >20 GHz detector bandwidth). Measured at input, ECL levels
Patterns	
Hardware patterns	Industry-standard Pseudo-random (PRBS) of the following types: 2 <sup>n</sup> - 1 where n = 7, 11, 15, 20, 23, 31
RAM patterns	
User defined	128 bits to 128 Mb, 128-bit increments
Library	Wide variety including SONET/SDH, Fibre Channel based such as k28.5, CJTPAT; 2 <sup>n</sup> patterns where n = 3, 4, 5, 6, 7, 9; Mark Density patterns for 2 <sup>n</sup> where n = 7, 9, 23; and many more
RAM Pattern Capture	Capture incoming data up to 128 Mb in length. Edit captured data, send to pattern generator, error detector, or both
Capture modes	
Capture by length	1 to 1,048,576 words. 1-word default. Words 128 bit in length
Capture by triggers	Captures when "Detector Start" on rear panel goes high, to maximum allowable length or until input goes low
Capture by length from trigger	Capture by length initiated from "Detector Start" input, to pre-specified length
Synchronization	
Auto-resync	User-specified number of 128 bit words containing 1 or more errors per word initiates a re-sync attempt
Manual	User initiates re-sync
Pattern matching	
Grab 'n' Go	Error detector captures specified pattern length and compares next instances to find match (Fast method, but susceptible to ignoring logical errors)
Shift-to-Sync	Error detector compares incoming pattern with reference RAM pattern, looks for match, if none found shifts pattern by one bit and compares again (Slower but most accurate method)
Error Detector Basic Measurements	BER, Bits Received, Re-syncs, Measured Pattern Generator and Error Detector Clock Frequencies

## Error Detector Ancillary Connections

### Front-panel Error Detector Connections

#### Error Correlation Marker Input (Error Analysis)

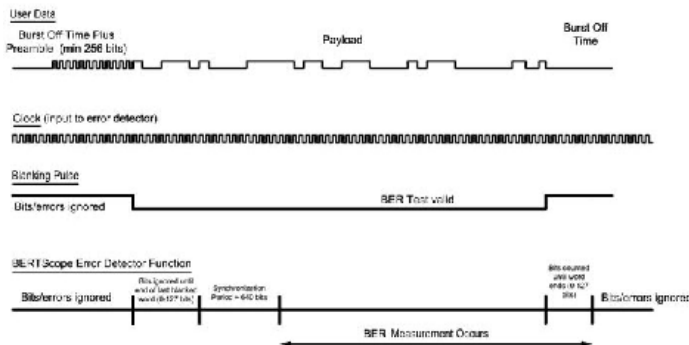
Characteristic	Description
	Allows an external signal to provide a time-tagged marker to be placed in the error data set.
Logic Family	LVTTL (<0.5 V Low, >2.5 V High)
Threshold	+1.2 V
Minimum Pulse Width	128 clock periods
Maximum Repetition Rate	512 serial clock periods
Maximum Frequency	<4000 markers/s recommended
Interface	BNC female, >1 kΩ impedance into 0 V

#### Blank Input

Characteristic	Description
	Useful for recirculating loop fiber experiments or during channel training sequences. Causes errors to be ignored when active. Bit count, error count, and BER not counted. No re-sync occurs when counting is re-enabled.
Logic Family	LVTTL (<0.5 V Low, >2.5 V High)
Threshold	+1.2 V
Minimum Pulse Width	128 clock periods
Maximum Repetition Rate	512 serial clock periods
Interface	BNC female, >1 kΩ impedance into 0 V

#### Error Output

Characteristic	Description
	Provides a pulse when an error is detected. Useful for triggering an alarm while doing long-term monitoring, etc.
Minimum Pulse Width	128 clock periods
Transition Time	<500 ps
Output Levels	1000 mV nominal (0 V to 1 V low-high)
Interface	SMA female



BERTScope Burst Analysis Timing – BERTScope word size is 128 bits. An example timing diagram is shown here for a PRBS payload. Counting of bits will not start until a 128-bit word boundary occurs, meaning that after the blanking pulse transitions, up to 127 bits may pass before synchronization begins. For a PRBS, synchronization typically takes 5 words, or 640 bits. Similarly, bit measurement will continue for up to 127 bits after the blanking signal transitions again. RAM-based patterns take longer to synchronize.

#### Trigger Output

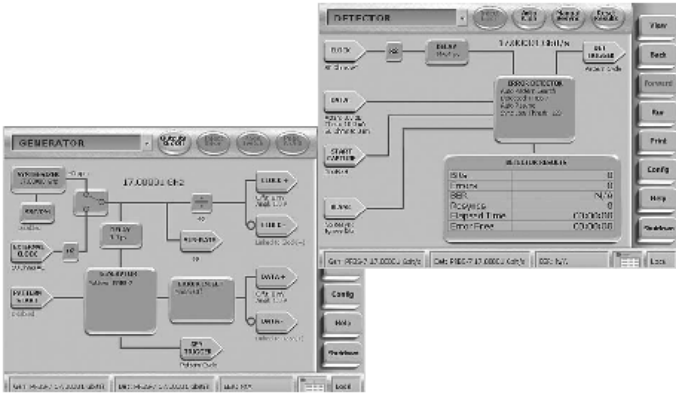
Characteristic	Description
	Provides a pulse trigger to external test equipment. It has two modes: 1. Divided Clock Mode: Pulses at 1/256th of the clock rate. 2. Pattern Mode: Pulse at a programmable position in the pattern (PRBS), or fixed location (RAM patterns).
Minimum Pulse Width	128 clock periods (Mode 1) 512 clock periods (Mode 2)
Transition Time	<500 ps
Output Levels	>300 mV amplitude, 650 mV offset
Interface	50 Ω SMA female

### Rear-panel Error Detector Connections

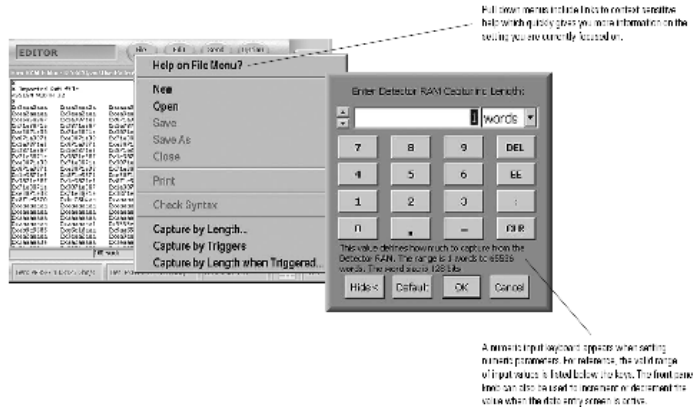
#### Detector Start Input\*6

Characteristic	Description
	Used to trigger the acquisition of incoming data into the error detector reference pattern memory. High level starts capture.
Amplitude	LVTTL (<0.5 V Low, >2.5 V High)
Threshold	+1.2 V
Minimum Pulse Width	128 serial clock periods
Maximum Repetition Rate	512 serial clock periods
Interface	SMA female, >1 kΩ impedance into 0 V

\*6 Not present for BERTScope CPG models.



UI Setup Screens



Editor Screen

**User Interfaces**

**Taking Usability to New Heights**

- Easy navigation
- Logical layout and operation
- Multiple ways of moving between screens
- Relevant information right where you need it
- Color coding to alert you to the presence of nonstandard conditions

**Editor Screen**

- Used for pattern editing of standard and AB Page Select patterns, also mask editing
- Views in Binary, Decimal, or Hexadecimal
- Support for variable assignments, repeat loops, seeding of PRBS patterns
- Capture and editing of incoming data – for example, to make a repeating pattern out of real-world traffic
  - Capture is available by trigger, by length, or by length following a trigger
  - Capture is by number or words, 1 word is 128 bits. For example, a PRBS-7 (127 bits long) would be captured as 127 words, and would have overall length of 16,256 bits

**BERTScope Built-in Parametric Measurements**

All BERTScopes come with eye diagrams and mask test capabilities as standard, along with error analysis.

**Eye Diagram**

- 280x350 pixel waveform display
- Deep acquisition
- Automatic Measurements include:
  - Rise Time
  - Fall Time
  - Unit Interval (Data, and also Clock)
  - Eye Amplitude
  - Noise Level of 1 or 0
  - Eye Width
  - Eye Height
  - Eye Jitter (p-p and RMS)
  - 0 Level, 1 Level
  - Extinction Ratio
  - Vertical Eye Closure Penalty (VECP)
  - Dark Calibration
  - Signal-to-Noise Ratio
  - $V_{p-p}$ ,  $V_{max}$ ,  $V_{min}$ , Crossing Levels
  - Rising and Falling Crossing Level (picoseconds)
  - Overshoot 0 Level and 1 Level
  - Average Voltage/Power
  - Cross Amplitude, Noise Level 1 or 0, Voltage
  - Optical Modulation Amplitude (OMA)
  - Sample Count
  - Offset Voltage
  - De-emphasis Ratio

**Mask Testing**

- Library of standard masks (e.g. XFP, or edit custom masks)
- Addition of positive or negative mask margin
- Import of measured BER Contour to become process control mask
- At least 1000x the sample depth of traditional sampling oscilloscope masks is ideal for ensuring the absence of rare event phenomena

**Optical Units**

An external optical receiver may be added to the input of the BERTScope detector. Through the user interface it is easy to input and save the characteristics of the receiver. Once accomplished, relevant units on physical layer displays are changed to optical power in dBm,  $\mu$ W, or mW. Coupling may be AC or DC, and the software steps the user through dark calibration.

For electrical signals, attenuation values can be entered to properly scale eye diagrams and measurements when external attenuators are used.

**Variable-depth Eye and Mask Testing**

For eye diagrams and mask testing, the depth of test may be varied in manual mode; the instrument will take the specified number of waveforms then stop. The range is 2,000 to 1,000,000 bits (complete waveforms). Alternatively, the default mode is Continuous, and the eye or mask test increases in depth over time.

## Physical Layer Test Option

### BER Contour Testing

- Executed with same acquisition circuitry as eye diagram measurements for maximum correlation
- As-needed delay calibration for accurate points
- Automatic scaling, one-button measurement
- Extrapolates contours from measured data, increasing measurement depth with run time and repeatedly updating curve fits
- Easy export of fitted data in CSV format
- Contours available from  $10^{-6}$  to  $10^{-16}$  in decade steps

### Basic Jitter Measurements

- Testing to T11.2 MJSQ BERTScan methodology (also called 'Bathtub Jitter')
- Deep measurements for quick and accurate extrapolation of Total Jitter at user-specified level, or direct measurement
- Separation of Random and Deterministic components, as defined in MJSQ
- As-needed delay calibration for accurate points
- Easy export of points in CSV format
- Easy one-button measurement
- User-specified amplitude threshold level, or automatic selection
- Selectable starting BER to increase accuracy when using long patterns, as defined in MJSQ

### Q-factor Measurement

- One-button measurement of a vertical cross section through the middle of the eye
- Easy visualization of system noise effects
- Export of data in CSV format

### Compliance Contour

- Validation of transmitter eye performance to standards such as XFP/XFI and OIF CEI
- Overlay compliance masks onto measured BER contours and easily see whether devices pass the BER performance level specified

## Live Data Analysis Option

The Live Data option is designed to measure parametric performance of traffic that is either unknown or non-repeating. This can include traffic with idle bits inserted such as in systems with clock rate matching. It is also suitable for probing line cards, etc.

The option uses one of the two front-end decision circuits to decide whether each bit is a one or zero by placing it in the center of the eye. The other is then used to probe the periphery of the eye to judge parametric performance. This method is powerful for physical layer problems, but will not identify logical problems due to protocol issues, where a zero was sent when it was intended to be a one.

Live data measurements can be made using BER Contour, Jitter Peak, Jitter Map, and Q-factor. Eye diagram measurements can be made on live data without the use of this option, providing a synchronous clock is available.

The Live Data Analysis option requires the Physical Layer Test option and must be used with a full-rate clock.

## PatternVu Equalization Processing Option

PatternVu\*7 adds several powerful processing functions to the BERTScope:

**CleanEye** is an eye diagram display mode, which averages waveform data to present an eye diagram with the non-data-dependent jitter removed. This allows the user to view and measure data-dependent jitter such as Inter-Symbol Interference, giving an intuitive idea of the compensatable jitter present, for example. It is effective on any repeating pattern up to 32,768 bits long.

**Single Value Waveform Export** is a utility which converts the CleanEye output to an export file in Comma Separated Vector (CSV) format. The output file, of up to  $10^5$  bit points, can then be imported into Microsoft Excel or software analysis and simulation tools such as StateEye or MATLAB®. This allows offline filtering of real captured data and the implementation of standards-based processing such as Transmitter Waveform Dispersion Penalty (TWDP) required by 802.3aq, the recent Long Reach MultiMode (LRM) 10 Gb Ethernet standard.

The **FIR Filter** equalization processor allows the emulation of the communication channel to view and measure the eye as the detector in the receiver would, by applying a software linear filter to the data before it is displayed. For example, the FIR Filter can be used to emulate the lossy effects of a backplane channel, or alternatively, emulate the receiver's equalization filter, facilitating the design and characterization of receiver-side equalization.

The filter characteristics are controlled by entering the individual weighting coefficients of a series of taps in the FIR filter. Up to 32 taps with tap spacing from 0.1 to 1.0 unit intervals (UI) can be programmed to allow fine resolution of the filter shape. The FIR Filter can be applied to repeating patterns up to 32,768 bits long.

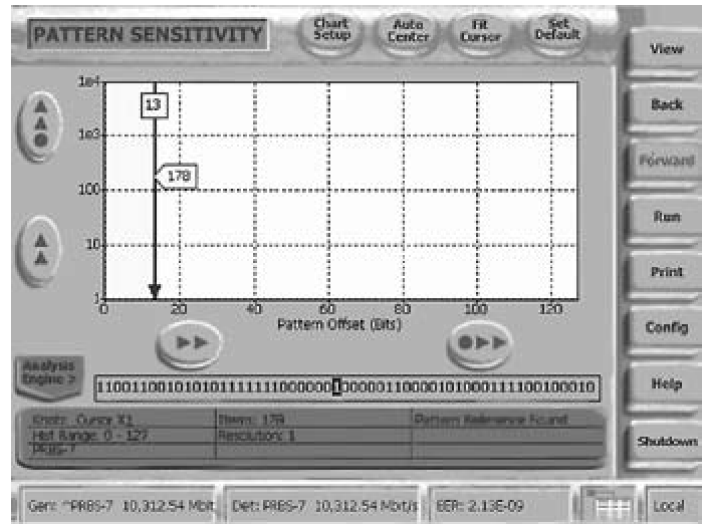
**Single Edge Jitter Measurement** allows truly deep BER-based jitter measurements to be applied to individual data edges at data rates above 3 Gb/s. The Single Edge Jitter Peak measurement function enables computation of jitter on a user-selectable single edge in the pattern, for repeating patterns up to 32,768 bits long. The resulting jitter measurement excludes data-dependent effects, showing only the uncorrelated jitter components such as Random Jitter (RJ), Bounded Uncorrelated Jitter (BUJ), and Periodic Jitter (PJ).

**Flexible Measurements** enables users to specify exactly the portion of the CleanEye waveform to use for accurate measurement of amplitude, rise and fall time, and de-emphasis ratio. Preprogrammed formulas for standards such as PCI Express and USB 3.0 are included.

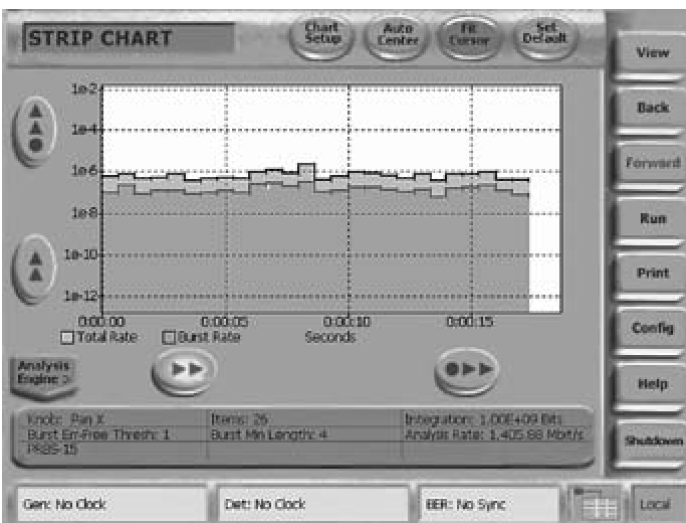
\*7 PatternVu operates at data rates of 900 Mb/s and higher.



Error Statistics view showing link performance in terms of bit and burst occurrences.



The Pattern Sensitivity view is a powerful way of examining whether error events are pattern related. It shows which pattern sequences are the most problematic, and operates on PRBS and user-defined patterns.



Strip Chart view showing bit and burst error performance over time. This can be useful while temperature cycling as part of troubleshooting, for example.

### Error Analysis

Error analysis is a powerful series of views that associate error occurrences so that underlying patterns can be easily seen. It is easy to focus in on a particular part of an eye diagram, move the sampling point of the BERTScope there, and then probe the pattern sensitivity occurring at that precise location. For example, it is straightforward to examine which patterns are responsible for late or early edges.

Many views come standard with the BERTScope Family.

### Analysis Views

- **Error Statistics:** A tabular display of bit and burst error counts and rates
- **Strip Chart:** A strip chart graph of bit and burst error rates
- **Burst Length:** A histogram of the number of occurrences of errors of different lengths
- **Error Free Interval:** A histogram of the number of occurrences of different error-free intervals
- **Correlation:** A histogram showing how error locations correlate to user-set block sizes or external marker signal inputs
- **Pattern Sensitivity:** A histogram of the number of errors at each position of the bit sequence used as the test pattern
- **Block Errors:** A histogram showing the number of occurrences of data intervals (of a user-set block size) with varying numbers of errors in them

### Error Location Capture

Characteristic	Description
Live Analysis	Continuous
Error Logging Capacity	Max. 2 GB file size
Error Events/Second	10,000
Maximum Burst Length	32 kb

## Error Analysis Options

### Forward Error Correction Emulation

Because of the patented error location ability of the BERTScope, it knows exactly where each error occurs during a test. By emulating the memory blocks typical of block error correcting codes such as Reed-Solomon architectures, bit error rate data from uncorrected data channels can be passed through hypothetical error correctors to find out what a proposed FEC approach would yield. Users can set up error correction strengths, interleave depths, and erasure capabilities to match popular hardware correction architectures.

### 2-D Error Mapping

This analysis creates a two-dimensional image of error locations from errors found during the test. Error mapping based on packet size or multiplexer width can show if errors are more prone to particular locations in the packet or particular bits in the parallel bus connected to the multiplexer. This visual tool allows for human eye correlation, which can often illuminate error correlations that are otherwise very difficult to find – even with all the other error analysis techniques.

### Jitter Tolerance Template Option

Many standards call for SJ to be stepped through a template with different SJ amplitudes at particular modulation frequencies. This is easy with the built-in Jitter Tolerance function which automatically steps through a template that you designed, or one of the many standard templates in the library.

### Standard Library of Templates

- 10GBASE LX4 802.3ae 3.125 Gb/s
- 10 GbE 802.3ae 10.3125 Gb/s
- 40 GbE 802.3ba LR4 10.3125 Gb/s
- 100 GbE 802.3ba LR4/ER4 25.78125 Gb/s
- CEI 11G Datacom Rx Ingress (D) 11 Gb/s
- CGE Telecom Rx Egress (Re) 11 Gb/s\*<sup>8</sup>
- CEI 11G Telecom Rx Ingress (Ri) 11 Gb/s\*<sup>8</sup>
- CEI 11G Total Wander 11.1 Gb/s
- CEI 11G Total Wander 9.95 Gb/s
- CEI 6G Total Wander 4.976 Gb/s
- CEI 6G Total Wander 6.375 Gb/s
- CEI 25G Total Wander 25.78125 Gb/s
- FBB DIMM1 3.2 Gb/s
- FBB DIMM1 4.0 Gb/s
- FBB DIMM1 4.8 Gb/s
- FBB DIMM2 3.2 Gb/s
- FBB DIMM2 4.0 Gb/s
- FBB DIMM2 4.8 Gb/s
- Fibre Channel 1.0625 Gb/s
- Fibre Channel 2.125 Gb/s
- Fibre Channel 4.25 Gb/s
- Fibre Channel 8G 8.5 Gb/s
- Fibre Channel 16G 14.025 Gb/s
- OTN OTU-1 2.666G\*<sup>8</sup>

- OTN OTU-2 10.709 Gb/s
- OTN(10BASE-R) 11.1 Gb/s
- SAS (SCSI) 1.5 Gb/s
- SAS (SCSI) 3 Gb/s
- SDH 0.172 STM-1 155M\*<sup>8</sup>
- SDH 0.172 STM-16 2.4832 Gb/s\*<sup>8</sup>
- SDH 0.172 STM-4 622 Mb/s\*<sup>8</sup>
- SDH 0.172 STM-64 9.956 Gb/s\*<sup>8</sup>
- SDH STM-16 2.48832 Gb/s\*<sup>8</sup>
- SDH STM-64 9.9532 Gb/s\*<sup>8</sup>
- SONET OC-48 2.48832 Gb/s\*<sup>8</sup>
- SONET OC12 622 Mb/s\*<sup>8</sup>
- SONET OC192 9.9532 Gb/s\*<sup>8</sup>
- SONET OC192 9.95 Gb/s\*<sup>8</sup>
- SONET OC3 155 Mb/s\*<sup>8</sup>
- SONET OC48 2.4832 Gb/s\*<sup>8</sup>
- USB 3.0 5 Gb/s
- XAUI 3.125 Gb/s
- XFI ASIC Rx In Datacom (D) 10.3125 Gb/s
- XFI ASIC Rx In Datacom (D) 10.519 Gb/s
- XFI ASIC Rx In Telecom (D) 10.70 Gb/s
- XFI ASIC Rx In Telecom (D) 9.95328 Gb/s\*<sup>8</sup>
- XFI Host Rx In Datacom (C) 10.3125 Gb/s
- XFI Host Rx In Datacom (C) 10.519 Gb/s
- XFI Host Rx In Telecom (C) 10.70 Gb/s\*<sup>8</sup>
- XFI Host Rx In Telecom (C) 9.95328 Gb/s\*<sup>8</sup>
- XFI Module Tx In Datacom (B') 10.3125 Gb/s
- XFI Module Tx In Datacom (B') 10.519 Gb/s
- XFI Module Tx In Telecom (B') 10.70 Gb/s\*<sup>8</sup>
- XFI Module Tx In Telecom (B') 9.95328 Gb/s\*<sup>8</sup>

### Some of the areas of adjustment include:

- BER confidence level
- Test duration per point
- BER threshold
- Test device relaxation time
- Imposition of percentage margin onto template
- Test precision
- Control over A/B Pattern switch behavior

Also included is the ability to test beyond the template to device failure at each chosen point, and the ability to export data either as screen images or CSV files.

\*<sup>8</sup> Requires Option XSSC.

## Jitter Map Option

### Automated Jitter Decomposition with Long Pattern Jitter Triangulation

Jitter Map<sup>9</sup> extends BER-based jitter decomposition beyond Dual Dirac measurement of Total Jitter (TJ), Random Jitter (RJ), and Deterministic Jitter (DJ) to a comprehensive set of subcomponents. It can also measure and decompose jitter on extremely long patterns, such as PRBS-31, providing that it can first run on a shorter synchronized data pattern.

#### Features include:

- DJ breakdown into Bounded Uncorrelated Jitter (BUJ), Data Dependent Jitter (DDJ), Inter-Symbol Interference (ISI), Duty Cycle Distortion (DCD), and Sub-Rate Jitter (SRJ)<sup>10</sup> including F/2 (or F2) Jitter
- BER based for direct (non-extrapolated) Total Jitter (TJ) measurement to 10<sup>-12</sup> BER and beyond
- Separation of correlated and uncorrelated jitter components eliminates mistaking long pattern DDJ for RJ
- Visualization of RJ RMS measured on individual edges of the data pattern
- J2 and J9 jitter measurements for 100 GbE applications
- Additional levels of breakdown not available from other instruments such as: Emphasis Jitter (EJ), Uncorrelated Jitter (UJ), Data Dependent Pulse Width Shrinkage (DDPWS), and Non-ISI
- Intuitive, easy-to-navigate jitter tree

<sup>9</sup>Jitter Map operates at data rates of 900 Mb/s and higher.

<sup>10</sup>SRJ and F/2 Jitter operate up to 8.5 Gb/s (BSA85C), 11.2 Gb/s (BSA125C, BSA175C, BSA260C).

## Stressed Live Data Option

The BERTScope Stressed Live Data software option enables engineers to add various types of stress to real data traffic in order to stress devices with bit sequences representative of the environment they will encounter once deployed. Using live traffic with added stress tests the boundaries of device performance and lends added confidence to designs before they are shipped.

- Pull range of calibrated stress available on the BERTScope, including Sinusoidal Jitter (SJ), Random Jitter (RJ), Bounded Uncorrelated Jitter (BUJ), Sinusoidal Interference (SI), F/2 Jitter, and Spread Spectrum Clocking (SSC)
- Data rate support up to the maximum of the BERTScope
- Full-rate clock required up to 11.2 Gb/s, half-rate clock required above 11.2 Gb/s

## Symbol Filtering Option

Symbol filtering enables asynchronous BER testing, including Jitter Tolerance testing, on incoming data streams that have a nondeterministic number of clock compensation symbols inserted into the bit stream, as is common in 8b/10b encoded systems when placed in loopback for receiver testing.

- Supports asynchronous receiver testing for USB 3.0, SATA, and PCI Express
- User-specified symbols are automatically filtered from the incoming data to maintain synchronization
- The error detector maintains a count of filtered bits for accurate BER measurement
- Operates at data rates up to 11.2 Gb/s

## General

### PC Related

Characteristic	Description
Display	TFT touch screen 640×480 VGA
Touch Sensor	Analog resistive
Processor	Pentium® P4 1.5 GHz or greater
Hard Disk	40 GB or greater
DRAM	1 GB
Operating System	Windows XP Professional
Remote Control Interfaces	IEEE-488 (GPIB) or TCP/IP

### Supported Interfaces

- DVI/VGA display
- USB 2.0 (4 total, 2 front, 2 rear on BSA175; 1 front, 1 rear on other BERTScope models)
- 100BASE-T Ethernet LAN
- IEEE-488 (GPIB)
- Parallel printer
- Serial RS-232
- PS-2 mouse/keyboard combined connector

### Physical

Dimension	mm	in.
Height	220	8.75
Width	394	15.5
Depth	520	20.375
Weight	kg	lb.
Instrument Only	25	55
Shipping	34.5	76
Other		
Power	<450 W	
Voltage	90 to 240 V AC, 50 to 60 Hz	

### Environmental

Characteristic	Description
Warm-up Time	20 minutes
Operating Temperature Range	10 to 40 °C
Humidity	Noncondensing at 40 °C, 15 to 95%
Certifications	EU EMC Directive (CE-Marked) UL: Underwriters Labs (US) Certification CSA (Canada)

### Support

Characteristic	Description
Period	1 year (extendable to 3 years with orderable option)
Calibration Interval	1 year

## Ordering Information

### Bit Error Rate Tester

BERTScope BSA Series.

#### Models

Model	Description
BSA85C	Single Channel, BERTScope 8.5 Gb/s Bit Error Ratio Analyzer
BSA85CPG	BERTScope 8.5 Gb/s Pattern Generator
BSA125C	BERTScope 12.5 Gb/s Bit Error Ratio Analyzer
BSA125CPG	BERTScope 12.5 Gb/s Pattern Generator
BSA175C	BERTScope 17.5 Gb/s Bit Error Ratio Analyzer
BSA175CPG	BERTScope 17.5 Gb/s Pattern Generator
BSA260C	BERTScope 26.0 Gb/s Bit Error Ratio Analyzer
BSA260CPG	BERTScope 26.0 Gb/s Pattern Generator

**All Models Include:** Quick Start Guide, power cord, mouse, PS2 "Y" cable, three (3) short low-loss cables, DVI adapter.

#### Options

Option	Description	BSA85C	BSA85CPG	BSA125C	BSA125CPG	BSA175C	BSA175CPG	BSA260C	BSA260CPG
F2	F/2 Jitter Generation at 8G/10.3125G (requires STR)	X	X	X	X	X	X	X	X
STR	Stressed Signal Generation (includes option ECC, MAP, PL, XSSC, JTOL, SF)	X	X*11	X	X	X	X	X	X
XSSC	Extended Spread Spectrum Clocking (SSC) (included in STR)	X	X	X	X	X	X	X	X
PCISTR	Add PCIe Extended Stress Generation	X	X	X	X	X	X		X
J-MAP	Add Jitter Decomposition SW	X		X		X		X	
ECC	Add Error Correction Coding Emulation SW (included in STR)	X		X		X		X	
JTOL	Add Jitter Tolerance Templates SW (used only with STR)	X		X		X		X	
LDA	Add Live Data Analysis SW (included in STR)	X		X		X		X	
MAP	Add Error Mapping Analysis SW (included in STR)	X		X		X		X	
PL	Add Physical Layer Test Suite SW (included in STR)	X		X		X		X	
PVU	Add PatternVu Equalization Processing SW	X		X		X		X	
SF	Add Symbol Filtering option SW (used with STR)	X*12		X		X		X	
SLD	Add Stressed Live Data option SW	X		X		X		X	
CA1	Provides a single calibration event or coverage	X	X	X	X	X	X	X	X
C3	Calibration Service 3 Years	X	X	X	X	X	X	X	X
R3	Repair Service 3 Years (including warranty)	X	X	X	X	X	X	X	X
-R3DW	Repair Service Coverage 3 Years (includes product warranty period). 3-year period starts at time of customer instrument purchase	X	X	X	X	X	X	X	X

\*11 Option STR is mandatory on BSA85CPG.

\*12 Included with Option STR for this model

## Recommended Accessories

### Clock Recovery Instruments

Accessory	Description
CR125A	12.5 Gb/s Clock Recovery Instrument
CR175A	17.5 Gb/s Clock Recovery Instrument
CR286A	28.6 Gb/s Clock Recovery Instrument

### Clock Recovery Instrument Options

Option	Description	CR125A	CR175A	CR286A
PCIE	PCIe PLL analysis (requires jitter spectrum option, operates at 2.5G and 5G only)	X	X	X
HS	Add High Sensitivity Clock Recovery		X	X
XLBW	Add Extended Loop Bandwidth in the Clock Recovery	X	X	X
12GJ	Add 11.2G spectrum analysis to CR125A	X		
17GJ	Add 11.2G spectrum analysis to CR175A		X	
28GJ	Add 11.2G spectrum analysis to CR286A			X
CA1	Provides a single calibration event or coverage	X	X	X
C3	Calibration Service 3 Years	X	X	X
R3	Repair Service 3 Years (including warranty)	X	X	X
-R3DW	Repair Service Coverage 3 Years (includes product warranty period). 3-year period starts at time of customer instrument purchase	X	X	X

### Digital Pre-emphasis Processors

Accessory	Description
DPP125B	1-12.5 Gb/s 3-Tap and optional 4-Tap Digital Pre-emphasis Processor

### Digital Pre-emphasis Processor Options

Option	Description
4T	4-Tap Digital Pre-emphasis Processor
CA1	Provides a single calibration event or coverage
C3	Calibration Service 3 Years
R3	Repair Service 3 Years (including warranty)
-R3DW	Repair Service Coverage 3 Years (includes product warranty period). 3-year period starts at time of customer instrument purchase

### Accessories

Accessory	Description
CR125ACBL	High-performance Delay Matched Cable Set (required for BERTScope and CRU in SSC applications)
100PSRTFILTER	100 ps Rise Time Filter
BSA12500ISI	Differential ISI Board
PMCABLE1M	Precision Phase Matched Cable Pair, 1 m
SMAPOWERDIV	SMA Power Dividers
BSASATATEE	BSA-SATA-Tee for OOB Signaling
BSARACK	BSA-Rackmount Kits

Contact Tektronix:

- ASEAN / Australasia (65) 6356 3900
- Austria 00800 2255 4835\*
- Balkans, Israel, South Africa and other ISE Countries +41 52 675 3777
- Belgium 00800 2255 4835\*
- Brazil +55 (11) 3759 7600
- Canada 1 800 833 9200
- Central East Europe, Ukraine, and the Baltics +41 52 675 3777
- Central Europe & Greece +41 52 675 3777
- Denmark +45 80 88 1401
- Finland +41 52 675 3777
- France 00800 2255 4835\*
- Germany 00800 2255 4835\*
- Hong Kong 400 820 5835
- India 000 800 650 1835
- Italy 00800 2255 4835\*
- Japan 81 (3) 6714 3010
- Luxembourg +41 52 675 3777
- Mexico, Central/South America & Caribbean (52) 56 04 50 90
- Middle East, Asia, and North Africa +41 52 675 3777
- The Netherlands 00800 2255 4835\*
- Norway 800 16098
- People's Republic of China 400 820 5835
- Poland +41 52 675 3777
- Portugal 80 08 12370
- Republic of Korea 001 800 8255 2835
- Russia & CIS +7 (495) 7484900
- South Africa +41 52 675 3777
- Spain 00800 2255 4835\*
- Sweden 00800 2255 4835\*
- Switzerland 00800 2255 4835\*
- Taiwan 886 (2) 2722 9622
- United Kingdom & Ireland 00800 2255 4835\*
- USA 1 800 833 9200

\* European toll-free number. If not accessible, call: +41 52 675 3777

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**For Further Information.** Tektronix maintains a comprehensive, constantly expanding collection of application notes, technical briefs and other resources to help engineers working on the cutting edge of technology. Please visit [www.tektronix.com](http://www.tektronix.com)



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(주)누비콤

서울 본사 서울특별시 영등포구 경인로 775(문래동 3가, 에이스하이테크시티 3동 201호)  
TEL: 070-7872-0701 FAX: 02-2167-3801 E-mail: sales@nubicom.co.kr

대전 사무소 대전광역시 유성구 대덕대로 593(도룡동 386-2) 대덕테크비즈센터 203호  
TEL: 070-7872-0712 FAX: 042-863-2023 E-mail: inyeom@nubicom.co.kr

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