BERTScope™
12.5 Gb/s
Signal Analysis

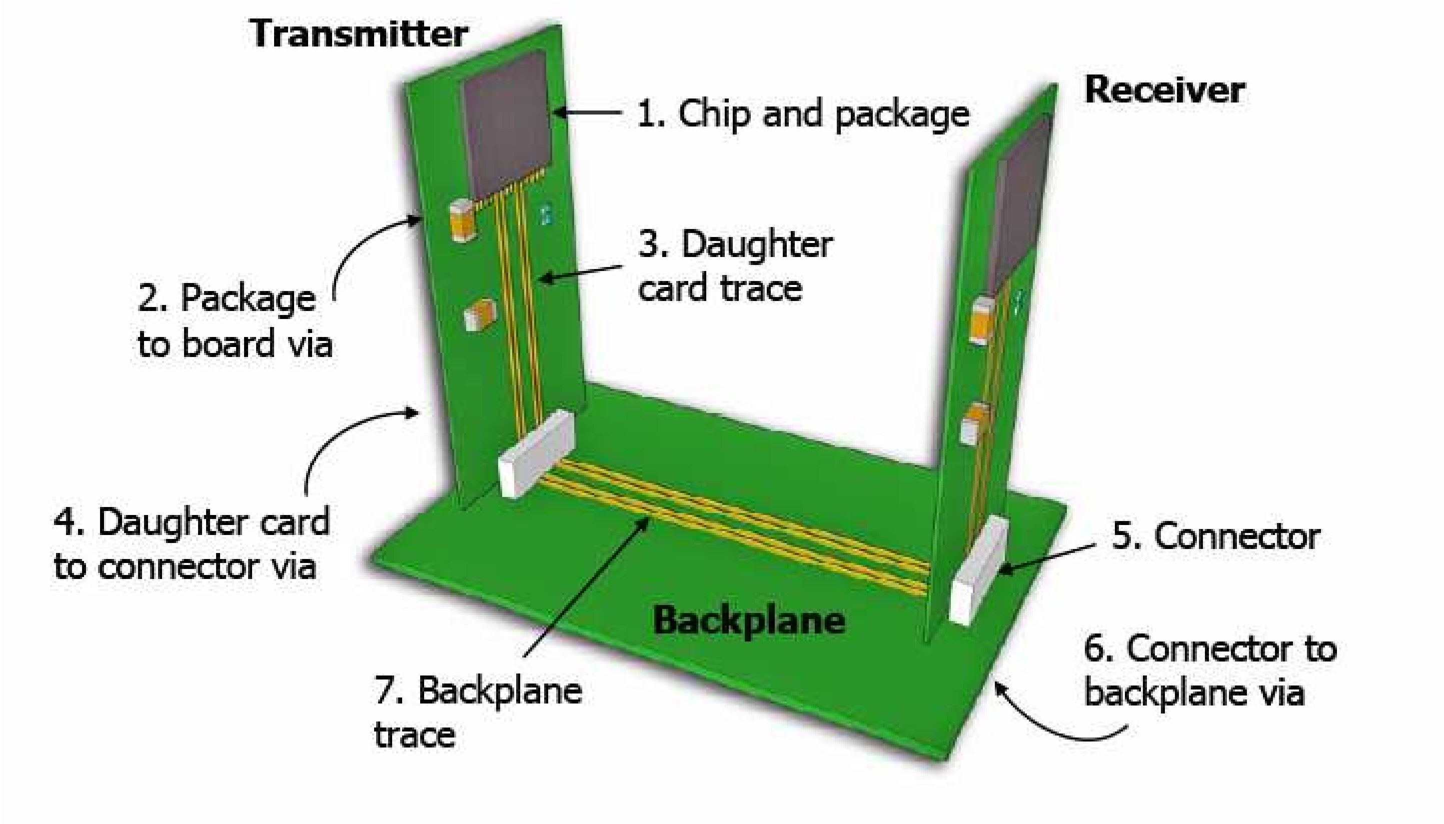
10GE Presentation

Presented by Eric

Introduction

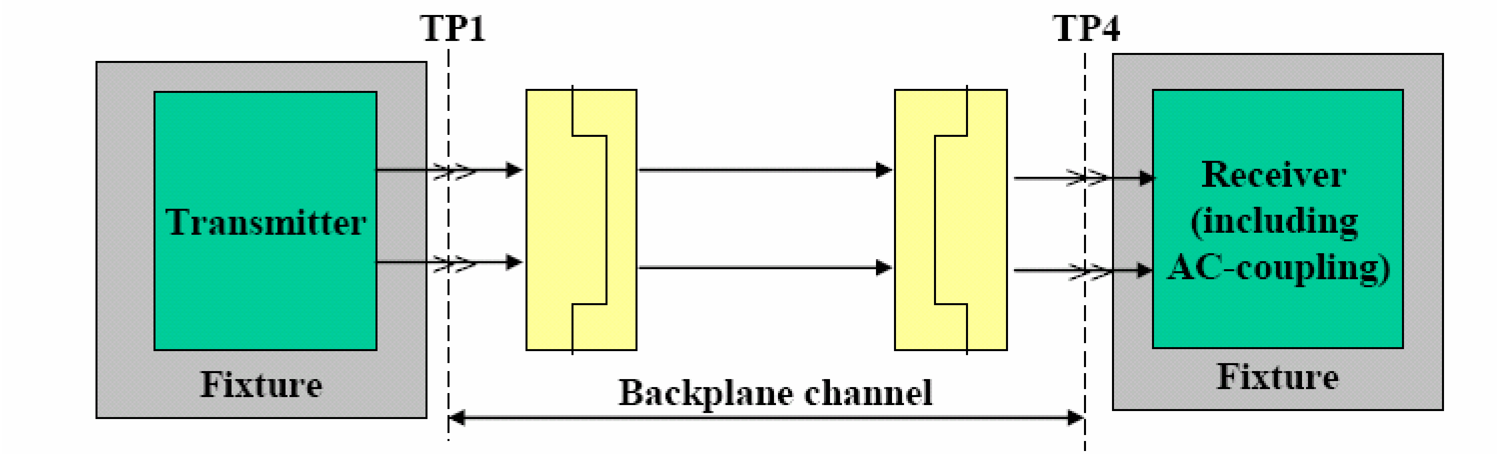
- For a system backplane, these include:
- 1. 10 Gb/s eye of only 100 ps period, making each picosecond of eye closure from jitter a significant issue.
- 2. Frequency dependent channel loss causing significant dispersion, often tackled through the use of pre-emphasis and equalization.
- IEEE Standard 802.3ap-2007 (10GBASE-KR, or ‘KR’) compliance testing includes both physical layer and protocol components.

Backplane Overview



A representation of a backplane highlights the many sources that contribute to overall channel loss between the two transceiver chips

10GBASE-KR Testing Overview



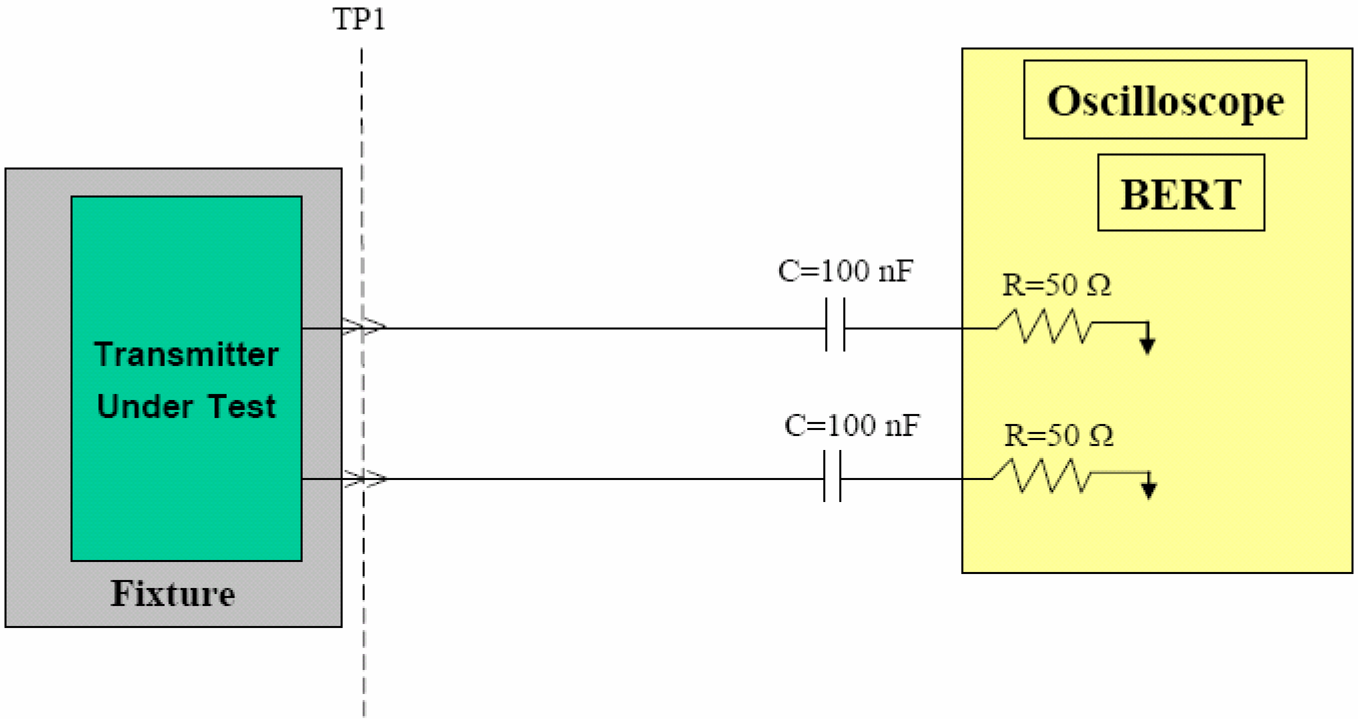
Block diagram showing test points TP1 and TP43

KR Transmitter Compliance Test Specifications

- Signaling Speed
- Differential pk-pk Max. Amplitude
- Differential pk-pk Amplitude (Tx disabled)
- Common Mode Voltage
- Differential Output Return Loss
- Common Mode Output Return Loss
- Output Transition Time
- Transmit Jitter
- Transmit Waveform Requirements (Mask Test)

Compliance testing at test point TP1

Transmitter test setup



Signaling Speed

Specification: 10.3125 Gbps ±100 ppm (10.31147 Gbps to 10.31353 Gbps)

Differential Max Amplitude

Specification: ≤ 1200 mV pk-pk, with a 1010 pattern

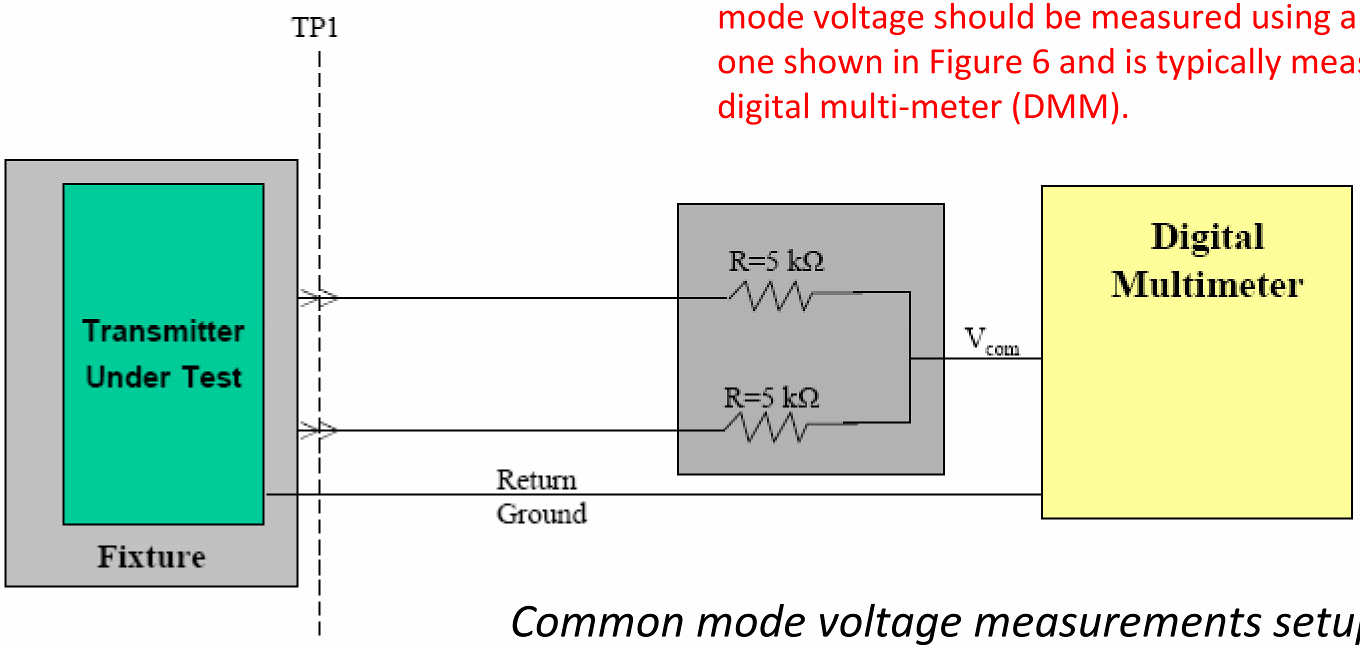
Differential Amplitude (Tx disabled)

Specification: ≤ 30 mV pk-pk, with a 1010 pattern

Common Mode Voltage

Specification: 0 to 1.9 V DC

The common mode voltage is the voltage offset from zero of the transmitter module's power supply common. Common mode voltage should be measured using a fixture such as the one shown in Figure 6 and is typically measured using a digital multi-meter (DMM).



Common mode voltage measurements setup

Differential Output Return Loss

Specification:

$RL(f) \geq 9$ for $50\ \text{MHz} \leq f < 2500\ \text{MHz}$

$RL(f) \geq 9 - 12\log10(f/2500\ \text{MHz})$ for $2500\ \text{MHz} \leq f \leq 7500\ \text{MHz}$

Reference impedance is 100 Ω for differential output return loss measurements. Differential output return loss is a measure of the match at the output of the device. It measures the difference between the differential incident signal and the differential signal reflected back to the source. Differential output return loss is typically measured with a vector network analyzer

Equations 72-4 and 72-5, IEEE Std 802.3ap

Common Mode Output Return Loss

Specification:

$RL(f) \geq 6$ for $50\ \text{MHz} \leq f < 2500\ \text{MHz}$

$RL(f) \geq 6 - 12\log10(f/2500\ \text{MHz})$ for $2500\ \text{MHz} \leq f \leq 7500\ \text{MHz}$

Reference impedance is 25 Ω for common mode output return loss measurements. Common mode output return loss is a measure of the match at the output of the device. It measures the difference between the common model incident signal and the common model signal reflected back to the source. Common mode output return loss is typically measured with a vector network analyzer

Equations 72-6 and 72-7, IEEE Std 802.3ap

Output Transition Time

Specification: 24 - 47 ps at 20 – 80% levels

The measurement must be made using a square wave pattern (1111111100000000) with 8-1s and 8-0s and pre-emphasis disabled. Output transition time, also referred to as rise and fall time.

Transmit Jitter

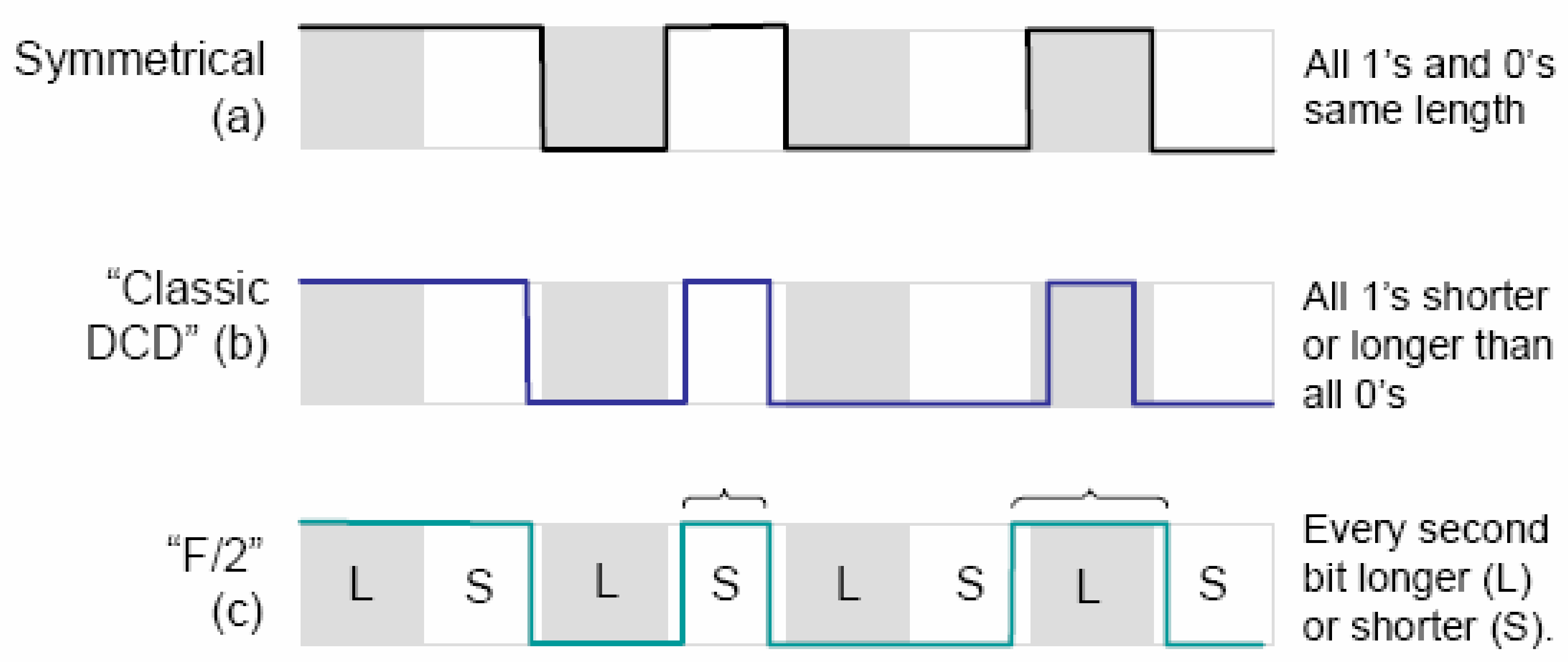
Specification:
TJ < 0.28 UI pk-pk @ BER 10-12
DJ < 0.15 UI pk-pk @ BER 10-12
RJ < 0.15 UI pk-pk @ BER 10-12
DCD < 0.035 pk-pk (included in DJ component)

Jitter measurements should be made using a single-pole high-pass filter with a 3 dB point at 4 MHz. This can be achieved using a recovered clock with a golden PLL to track out the low frequency jitter. The measurement must be made with a specified 66 bit pattern and pre-emphasis disabled. The duty cycle distortion test pattern must be at least eight symbols of alternating polarity.

Duty Cycle Distortion (DCD) is the jitter caused by different bits in the data signal having varying lengths. With 10GBase-KR systems, the type of DCD jitter is known as F/2 or F2 jitter.

Comparing DCD and F/2 Jitter

Duty Cycle Distortion (DCD) has been a term used to describe conditions where the duration of individual bits may vary. A new variant of DCD is becoming common, called F/2, or simply F2. This figure explains how F/2 differs from classic DCD.



Transmit Waveform Requirements (Mask Test)

Specification:
Transmitter waveform template (Figure 11)
Transmitter output waveform requirements (Table 1)

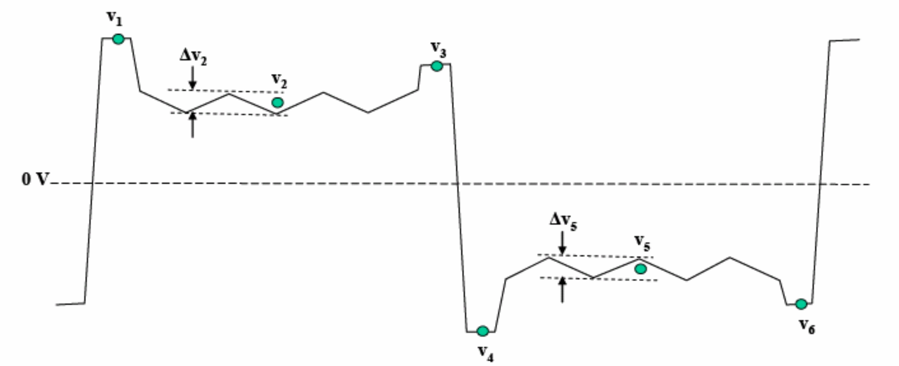


Figure 11. Transmitter output waveform[8]

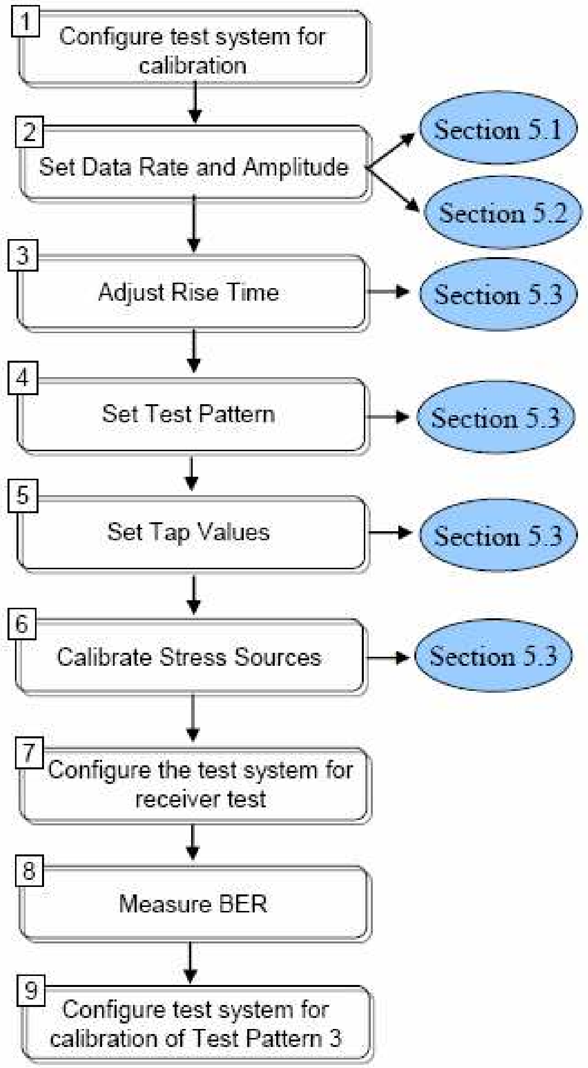
Transmitter output waveform requirements

Parameter	Value	Units
Δv_2 (max)	40	mV (pk-pk)
Δv_5 (max)	40	mV (pk-pk)
$(v_1+v_4)/v_1$ (max)	0.05	
$(v_2+v_5)/v_2$ (max)	0.05	
$(v_3+v_6)/v_3$ (max)	0.05	
v_2(min)	40	mV

The transmit waveform requirements are measured relative to 0V with 3 tap pre-emphasis enabled. The test pattern required is 1111111100000000 (8-1s, 8-0s). 32 specific voltage measurements are performed on the waveform as defined by the three preceding tables.

KR Receiver Compliance Test Specifications

- Differential Input Amplitude (Maximum)
- Bit Error Ratio
- Receiver Coupling
- Differential Input Return Loss



10GBASE-KR receiver compliance test flowchart

Signaling Speed

Specification: 10.3125 Gbps ±100 ppm (10.31147 Gbps to 10.31353 Gbps)

2 Set Data Rate and Amplitude

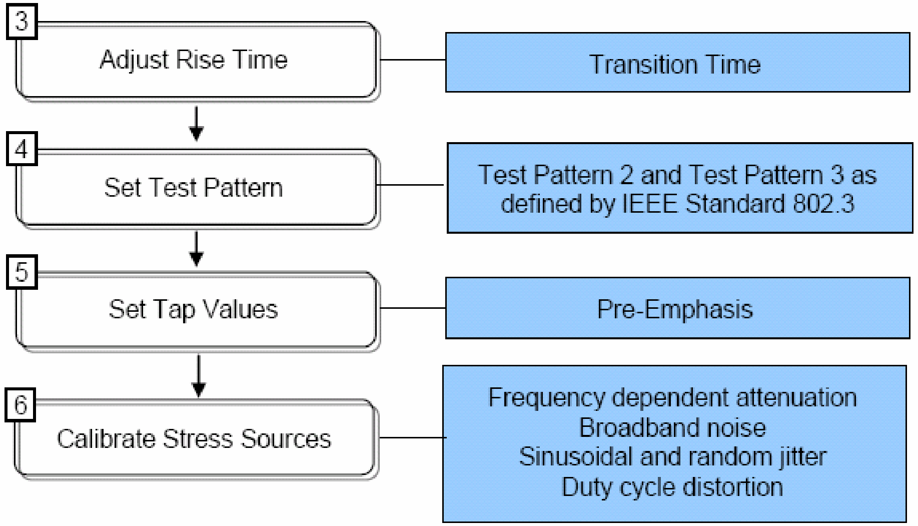
Differential Amplitude (Max)

Specification: 1200 mV (nominal)

2 Set Data Rate and Amplitude

Bit Error Ratio

Specification: BER better than 10E-12



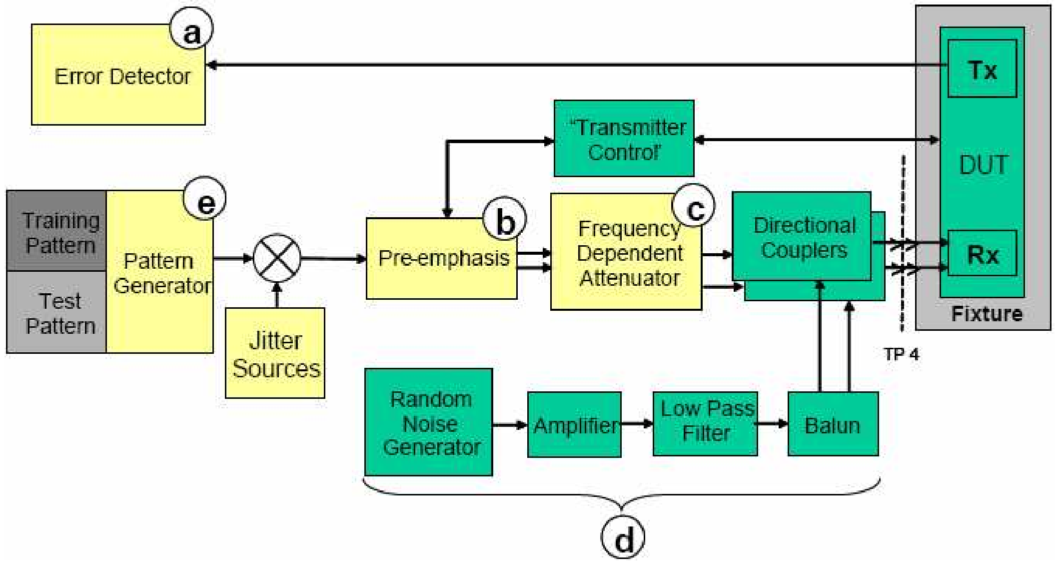
Stress Parameters:

Parameter	Test 1 Values[a]	Test 2 Values[b]	Units
m_{TC} (min)[c]	1.0	0.5	
Amplitude of broadband noise (min)	5.2	12	mV (RMS)
Applied transition time (20% - 80%, min)	47	47	ps
Applied Sinusoidal jitter (min)	0.115	0.115	UI (pk-pk)
Applied Random jitter (min)[d]	0.130	0.130	UI (pk-pk)
Applied Duty Cycle Distortion (min)	0.035	0.035	UI (pk-pk)

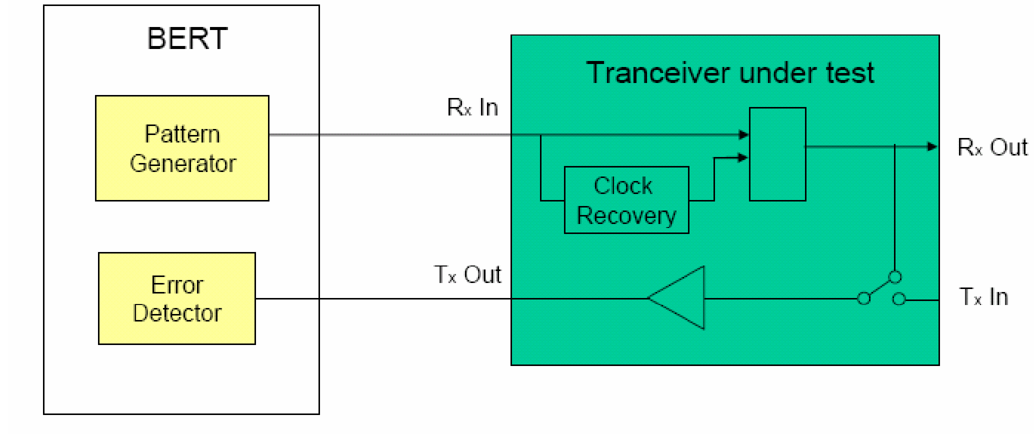
a. Test 1 is with a high loss channel that produces a transmission magnitude of 1.0
b. Test 2 is with a low loss channel that produces a transmission magnitude of 0.5
c. Transmission magnitude (see Appendix A)
d. Specified at a BER of 10^{-12}

Bit Error Ratio (BER) is tested with a stress interference test

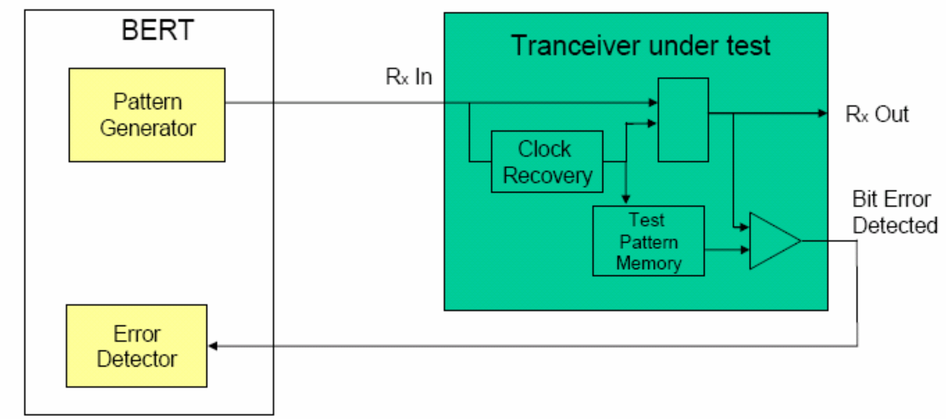
The BER test [a] requires a stressed input signal consisting of:
Pre-emphasis [b]
Frequency dependent attenuation [c]
Broadband noise (band limited) [d]
Sinusoidal and random jitter [e]
Duty cycle distortion [e]



Block diagram showing receiver BER test setup

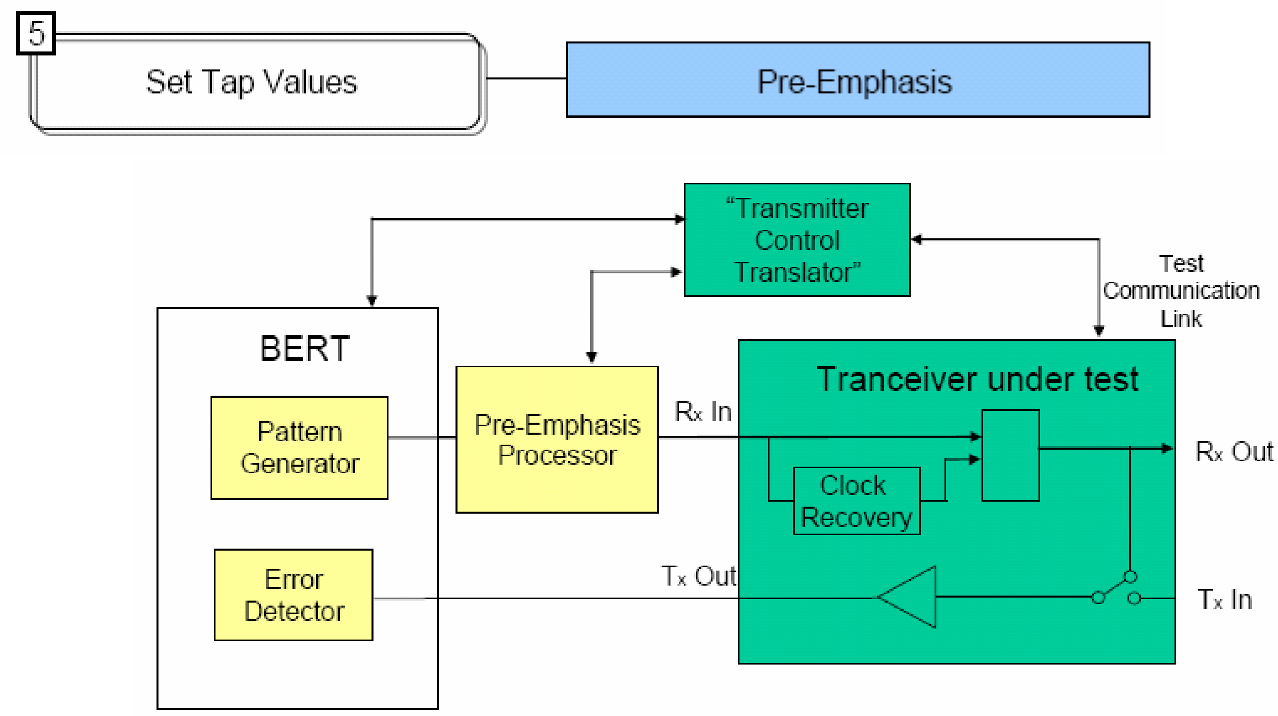


Receiver test using link side loop back



Receiver test using internal BER testing

Pre-emphasis Requirements

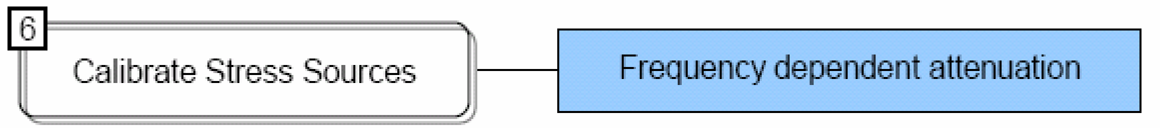


Transmitter equalization communication link

Proper equalization should emulate the inverse transfer function of the test channel, right up to the input of the receiver. This would simply be the inverse of the test channel S21 function, as computed from the standard.

Frequency Dependent Attenuation

Test channel frequency dependent attenuation is defined to emulate the channel loss between a transmitter and the receiver.



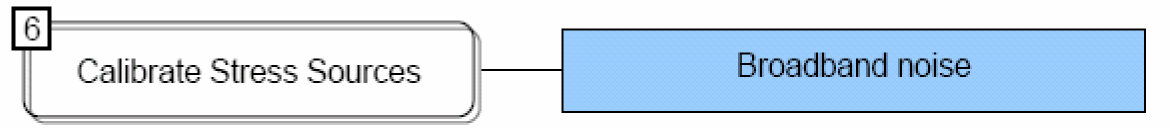
Test channel frequency dependent attenuation is defined to emulate the channel loss between a transmitter and the receiver.

Amax (f) = 20log10(e) x (b1f1/2 + b2f + b3f2 + b4f3)
Where:
b1 = 2 x 10-5
b2 = 1.1 x 10-10
b3 = 3.2 x 10-20
b4 = -1.2 x 10-30

The channel is composed of a test fixture, cables, directional couplers, and additional frequency dependent attenuation to achieve the fitted attenuation specification.

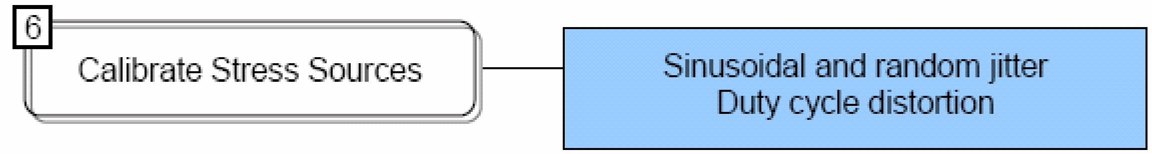
Fitted Attenuation =
(measured fixture loss at 5 GHz) + (measured cable loss at 5 GHz) + (measured directional coupler loss at 5 GHz) + (added frequency dependent attenuation at 5 GHz).

Broadband Noise



Random interference is injected at the receiver end of the test channel using a broadband noise generator capable of producing white Gaussian noise.

Applied Jitter Components



Three jitter components must be added to the stress interference, sinusoidal jitter (SJ), random jitter (RJ) and duty cycle distortion (DCD). There are two types of DCD as discussed in reference [iii]. The 10GBASE-KR specification does not explicitly state, but it is assumed that the type of DCD required by the stress interference is F/2 or F2 jitter.

Receiver Coupling

The KR Standard requires the receiver to be AC coupled and recommends the value to be < 100 nF to limit inrush current. However, if access is available, a capacitance meter may be used to verify a third party design.

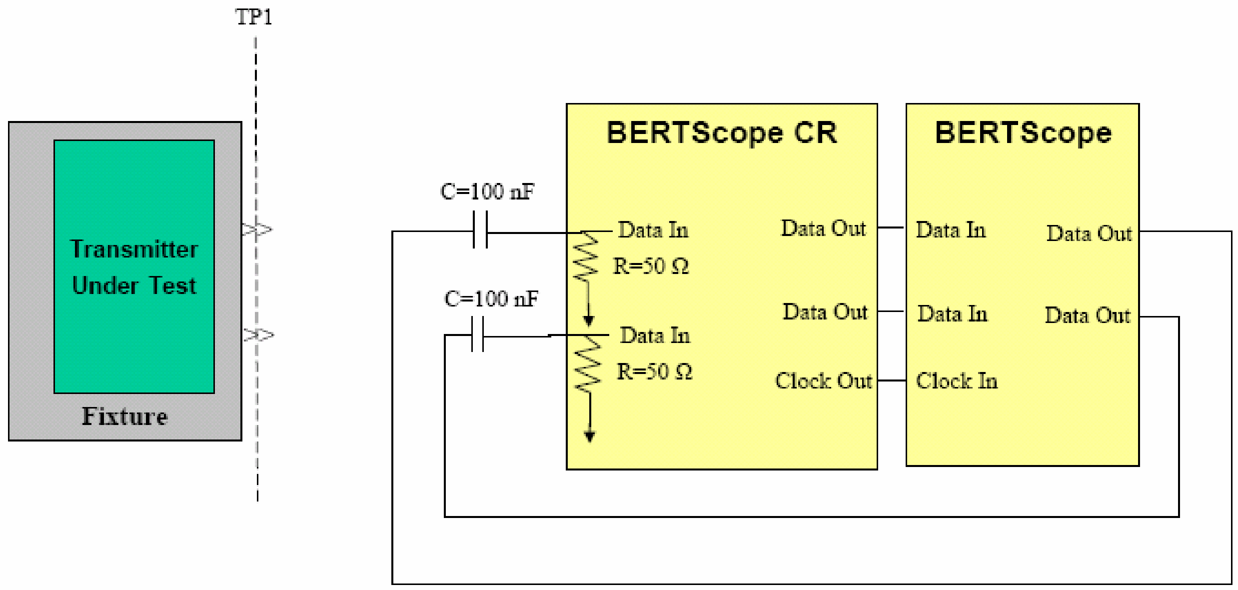
Differential Input Return Loss

Differential input return loss is specified to be 100 Ω differential, < -9 dB to 2.5 GHz and follows a template > 2.5 GHz. Differential return loss is typically measured with a differential Vector Network Analyzer (VNA).

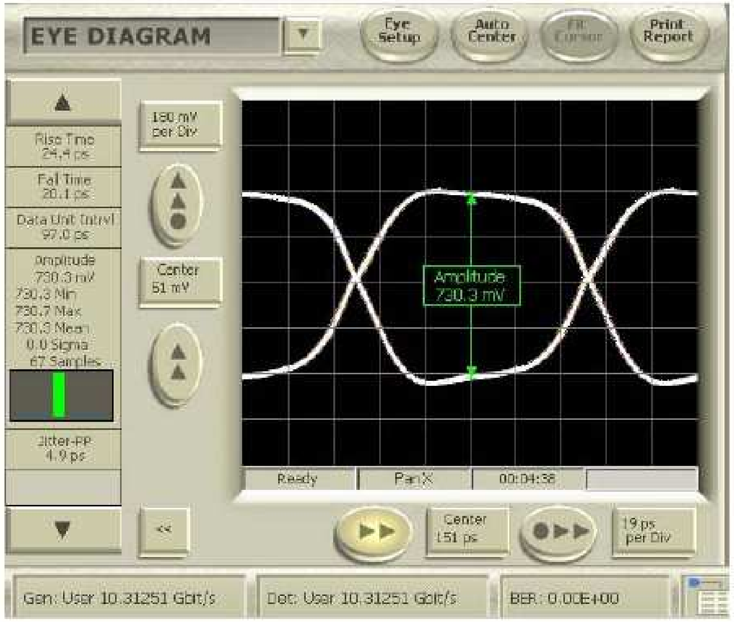
Transmitter Measurement Example

The following steps show how to perform the transmitter compliance tests required by the KR Standard using the SyntheSys Research BERTScope in combination with a BERTScope Clock Recovery Unit.

Step 1. Configure Test Equipment for Calibration



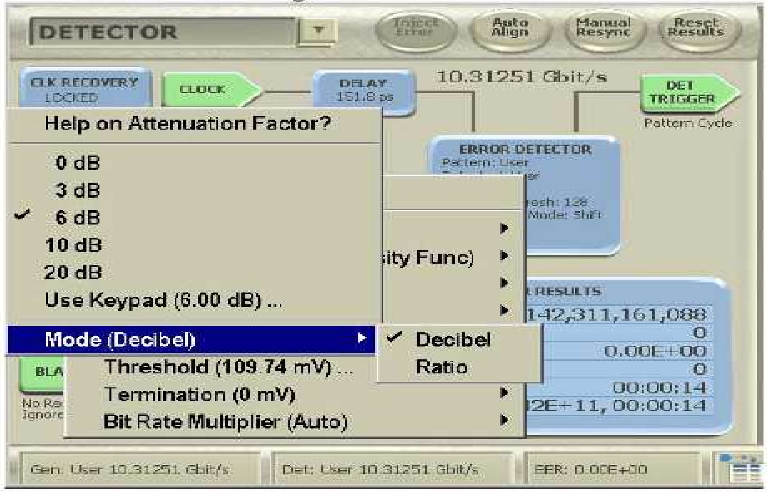
Basic test setup for calibration of 10GBASE-KR transmitter compliance testing

Instrument Settings	Results / Explanation
On the BERTScope CR: • Set the Standard to GE10 **On the BERTScope Generator screen:** • Set the amplitude to 1200 mV peak-to-peak • Set the pattern to a 1010 pattern • Set the Synthesizer to 10.3125 GHz **On the BERTScope Eye Diagram screen:** • View the peak-to-peak amplitude	Losses associated with the BERTScope CR, cables and fixture must be calculated prior to measurement. This value is added as an attenuation factor in the BERTScope and then the actual amplitude at TP1 will be displayed. To calculate the losses in the system, subtract the amplitude displayed from 1200 mV.  Losses associated with the BERTScope CR and cables = 1200 mV – 730.3 mV = 469.7 mV Add the loss of the test fixture at 5 GHz (130 mV for a 1 dB loss) find the total test system loss. Total system loss = 469.7 mV + 130 mV = 599.7 mV Convert to dB = 20 log[(1200-599.7)/1200] = -6 dB

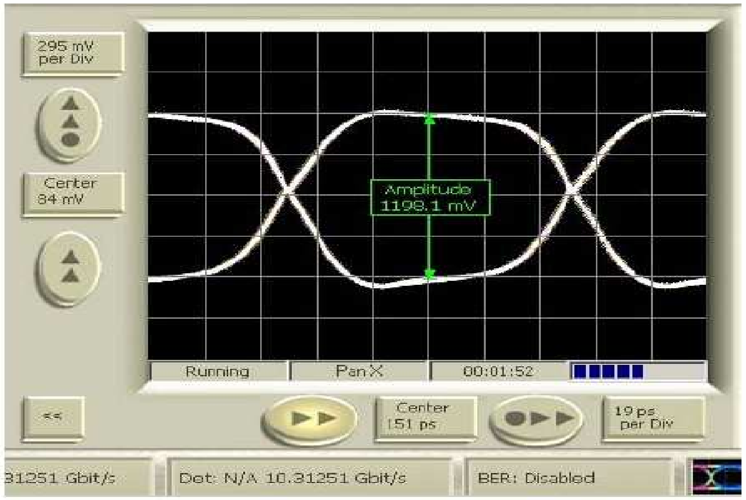
On the BERTScope Eye Diagram screen:

- Set the attenuation factor to 6 dB
- View the peak-to-peak amplitude

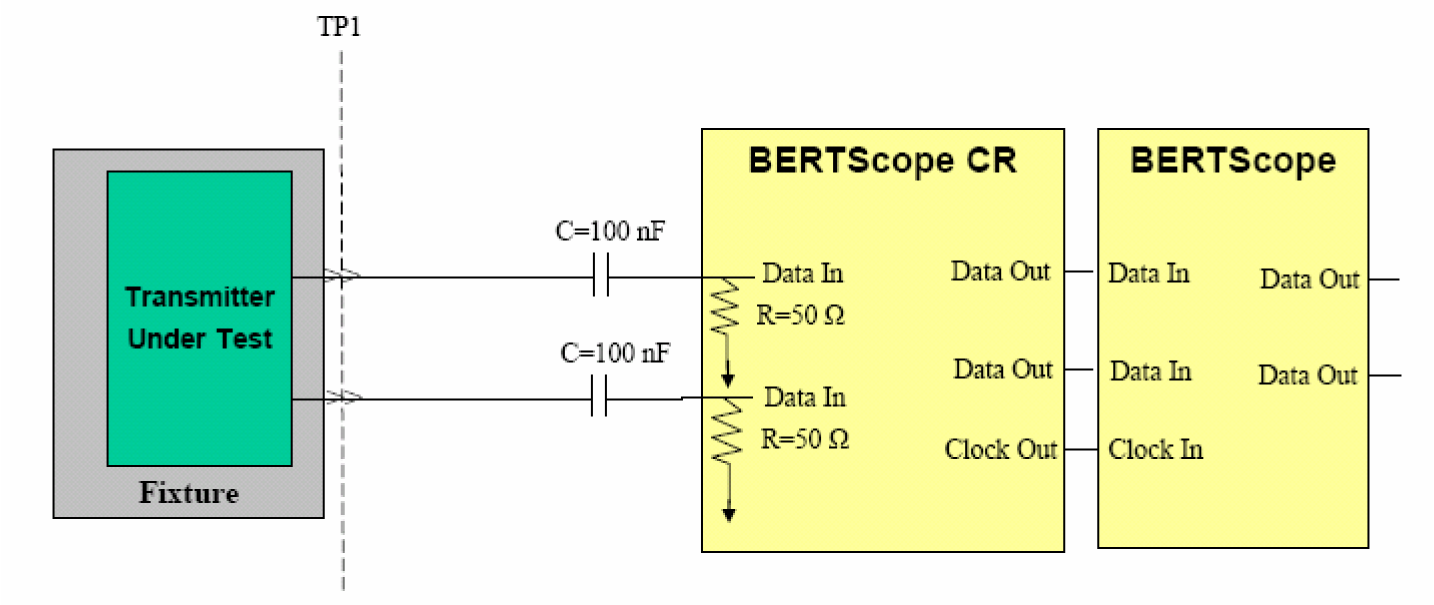
Attenuation Factor Setting



After setting the attenuation factor to the total system loss, the display shows the actual peak-to-peak amplitude output at the end of the cable (TP 1 during measurement).



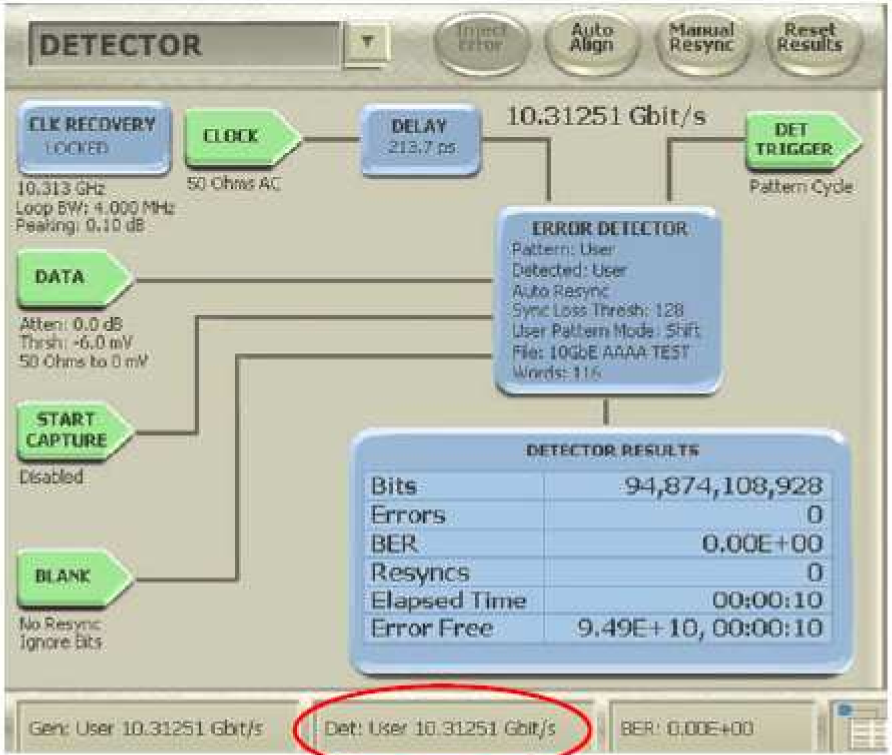
Step 2. Configure Test Equipment for Transmitter Testing



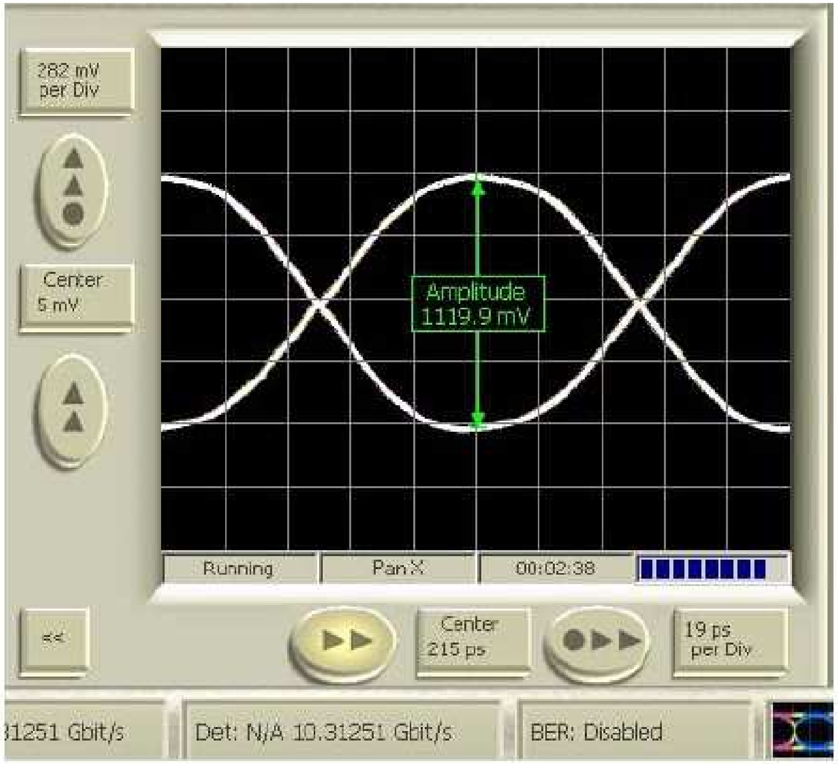
Basic test setup for 10GBASE-KR transmitter compliance testing

Step 3. Measure Signaling Speed

Instrument Settings	Results / Explanation
On the BERTScope Detector screen: • Read the detected data rate	The detected data rate must be 10.3125 +/- 100 ppm



Step 4. Measure Differential Amplitude

Instrument Settings	
On the BERTScope Eye Diagram screen: • View the peak-to-peak amplitude	Since the attenuation factor has been set previously, the display shows the actual peak-to-peak amplitude output of the transmitter. The transmitter amplitude must be less than 1200 mV. 

Step 5. Measure Output Transition Time

The automated rise time measurement of the BERTScope calculates rise time based on the average of the 1 and 0 values. Since the 10GBASE-KR specification requires the average value to be calculated using a subset of the time between zero crossings, the automated measurement could be slightly different from the required measurement. The BERTScope automated measurement can be used as a quick check of rise time. However, if the rise time is close to either limit, a more accurate measurement should be made using markers to manually calculate rise time. The automated measurement is shown below.

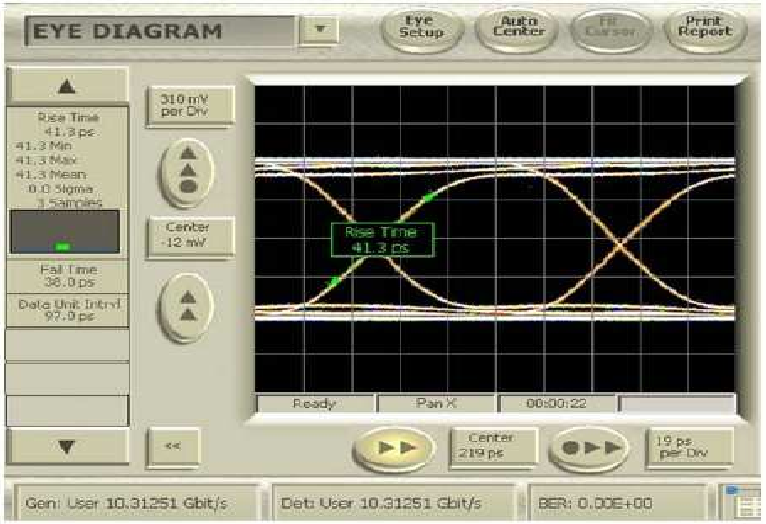
<table>
<tr><th>Instrument Settings</th><th>Results / Explanation</th></tr>
<tr><td>

On the BERTScope Eye Diagram screen:

- From Eye Setup, select rise time to be 20% to 80%
- View the rise time

</td><td>

The rise time must be between 24 and 47 ps.



At 24 ps (the low end of the spec), the rise time is close enough to the intrinsic rise time of the BERTScope that the instrument rise time must be considered. Rise times are rms values and are therefore added in quadature so,

Measured rise time = sqrt[(intrinsic rise time)^2 + (actual DUT rise time)^2]

The BERTScope is specified to have a 20%-80% rise time of 10.6 ps.

Rearranging the equation and solving for a DUT rise time of 24 ps we have:

Measured rise time = sqrt[(24^2 + 10.6^2)]
Measured rise time = 26.2 ps

Repeating the process for 47 ps (the upper end of the spec), we now know that the displayed rise time should be between 26.2 ps and 48.2 ps to meet the KR Standard.

</td></tr>
</table>

BERTScope™

12.5 Gb/s
Signal Analysis

Step 6. Measure Transmit Jitter

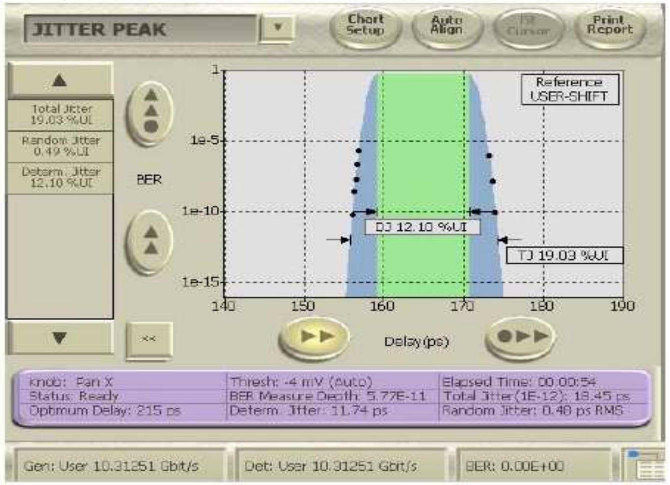
<table>
<tr><th>Instrument Settings</th><th>Results / Explanation</th></tr>
<tr><td>

On the BERTScope Jitter Peak screen:

- View Total Jitter (TJ)
- View Deterministic Jitter (DJ)
- View Random Jitter (RJ)

</td><td>

Each of the jitter components can be read off the Jitter Peak display. Random jitter is displayed in RMS so it must be multiplied by 14 to convert the value to peak-to-peak jitter.



</td></tr>
<tr><td>

On the BERTScope Eye Diagram:

- Turn on time markers

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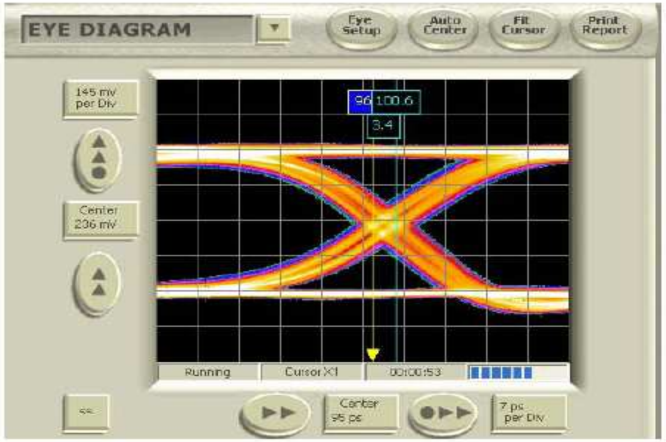
Duty Cycle Distortion must be less than 3.5%. Using the eye diagram and placing markers at the crossover points, the DCD can be measured.



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Step 7. Measure Transmit Waveform

The 32 amplitude measurements as shown in Table 5, Table 6, and Table 7 can be made with the BERTScope using cursors on an averaged waveform. The BERTScope is clocked using an internal 8:1 divider.

Table 5. Transmitter output waveform requirements

Parameter	Value	Units
Δv_2 (max)	40	mV (pk-pk)
Δv_5 (max)	40	mV (pk-pk)
$(v_1+v_4)/v_1$ (max)	0.05	
$(v_2+v_5)/v_2$ (max)	0.05	
$(v_3+v_6)/v_3$ (max)	0.05	
v_2(min)	40	mV

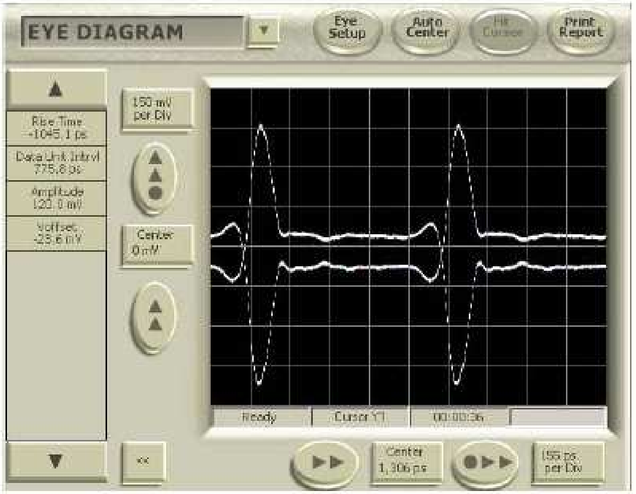
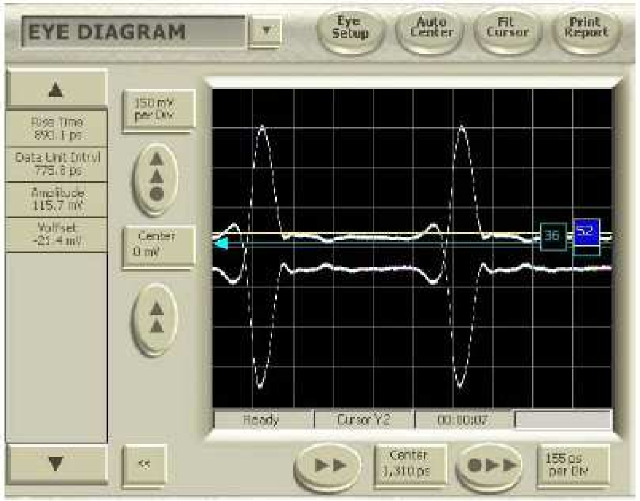
Table 6. Transmitter output waveform requirements related to coefficient updates

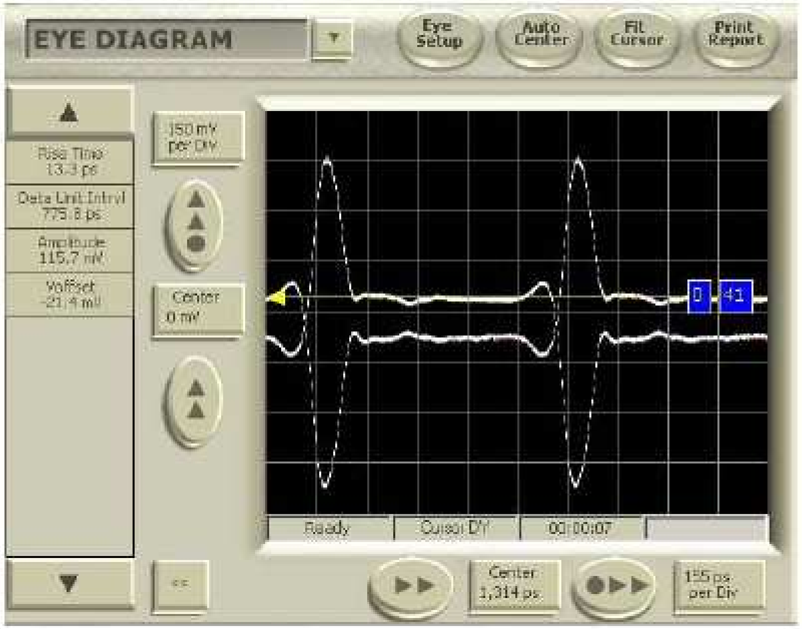
Coefficient update[1]			Requirements[2]		
c(1)	c(0)	c(-1)	$v_1(k)-v_1(k-1)$ (mV)	$v_2(k)-v_2(k-1)$ (mV)	$v_3(k)-v_3(k-1)$ (mV)
increment	hold	hold	-20 to -5	5 to 20	5 to 20
decrement	hold	hold	5 to 20	-20 to -5	-20 to -5
hold	increment	hold	5 to 20	5 to 20	5 to 20
hold	decrement	hold	-20 to -5	-20 to -5	-20 to -5
hold	hold	increment	5 to 20	5 to 20	-20 to -5
hold	hold	decrement	-20 to -5	-20 to -5	5 to 20

1. Step size requirements for the tap under test apply regardless of the current value of the other taps
2. This difference is measured relative to the voltage prior to the assertion coefficient update k equal to hold

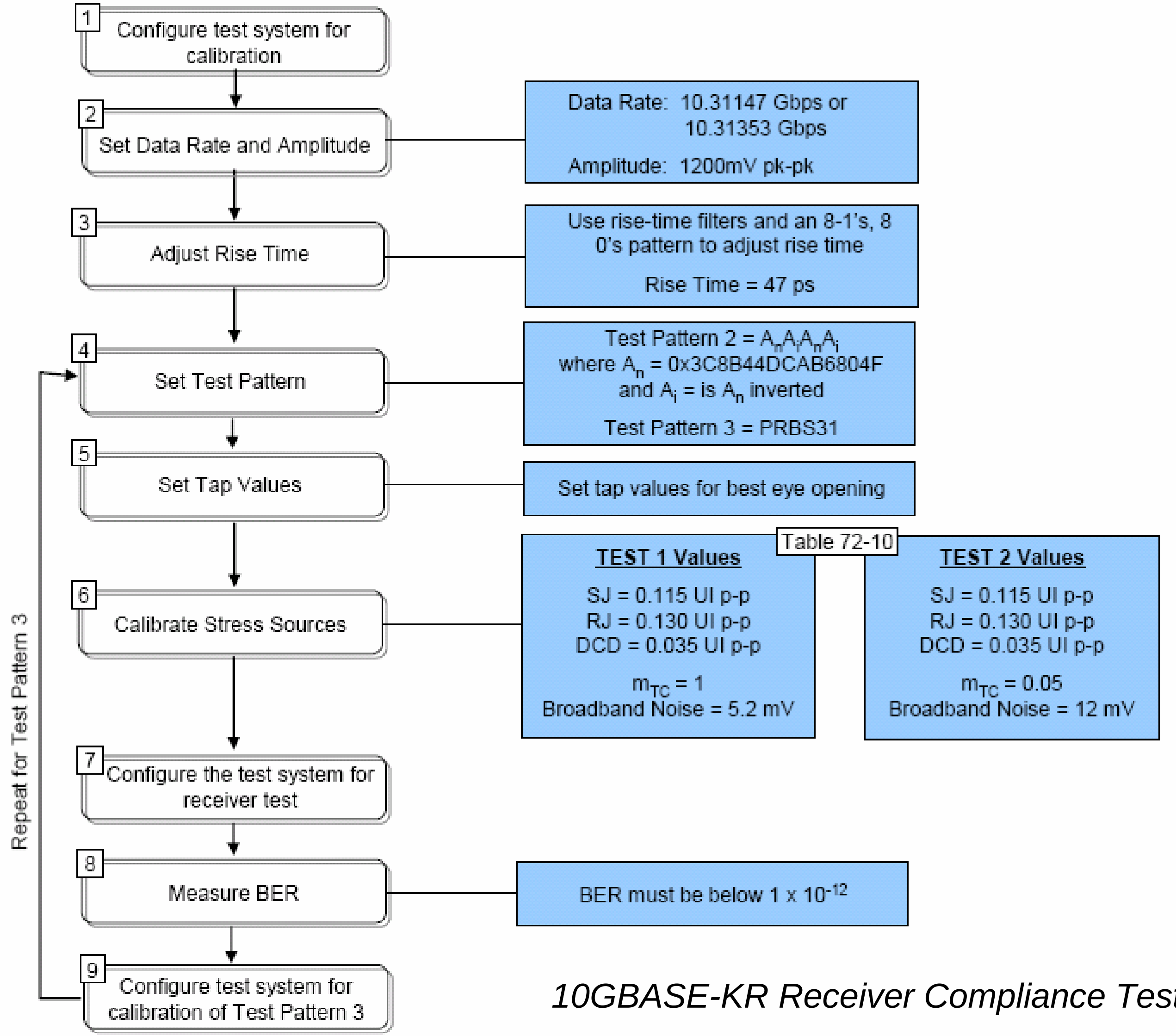
Table 7. Transmitter output waveform requirements related to coefficient status

Coefficient status			Requirements		
c(1)	c(0)	c(-1)	$R_{pre} = v_3/v_2$	$R_{pst} = v_1/v_2$	v_2 (mV)
disabled	minimum	disabled	0.90 to 1.10	0.90 to 1.10	220 to 330
disabled	maximum	disabled	0.95 to 1.05	0.95 to 1.05	400 to 600
minimum	minimum	disabled	--	4.00 (min)	--
disabled	minimum	minimum	1.54 (min)	--	--

Instrument Settings	Results / Explanation
On the BERTScope CRJ • Set the clock divider to 8 to see a single waveform and its inverse **On the BERTScope Eye Diagram screen:** • View waveform • Measure the waveform at all required levels	Waveform with a divide-by-8 clock.  Measure Δv_2 using cursors as shown. $\Delta v_2 = 36$ mV. 

	Measure v_2 using cursors as shown. v_2 = 41 mV.  All other parameters can be measured in a similar way.

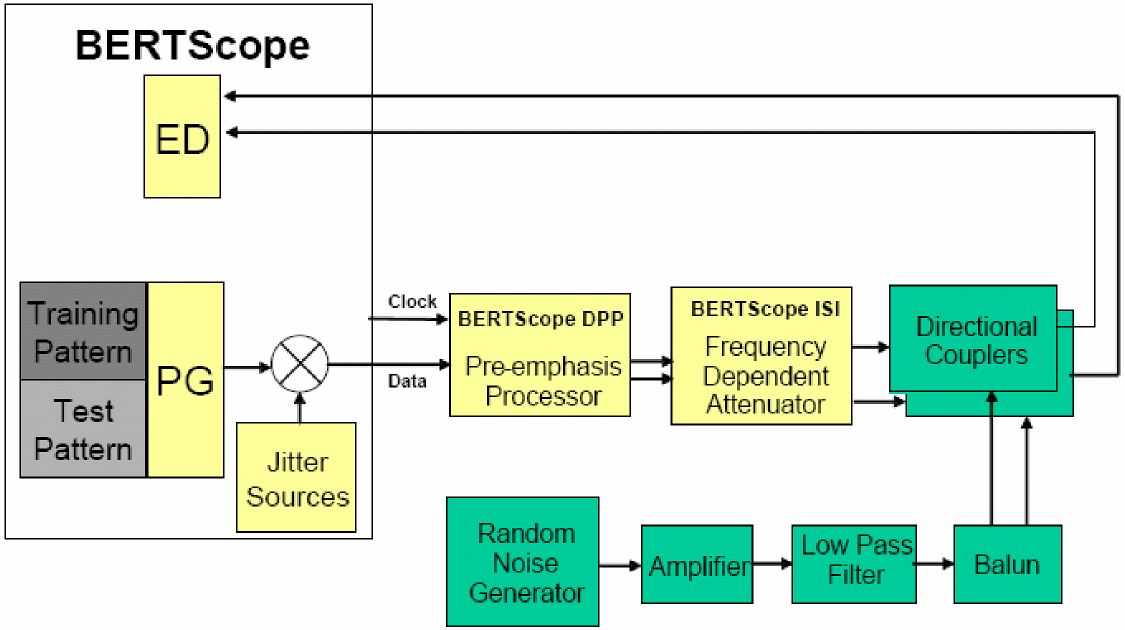
Receiver Measurement Example



10GBASE-KR Receiver Compliance Test Flowchart

Step 1. Configure test equipment for calibration

The following steps show how to perform the receiver compliance tests required by the KR Standard using the SyntheSys Research BERTScope in combination with a digital pre-emphasis processor, the BERTScope DPP, and a white noise source.



Basic test setup for 10GBASE-KR receiver compliance calibration

ISI Channel Characteristics

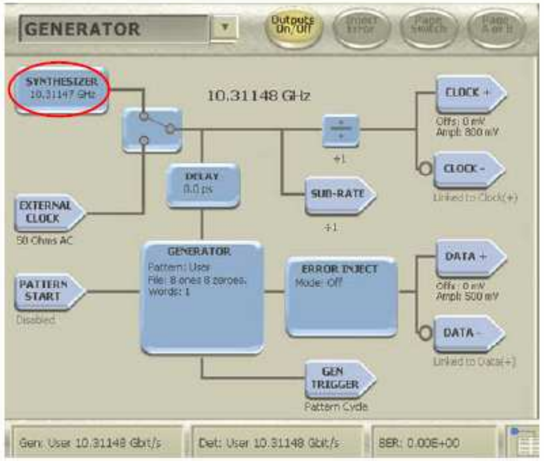
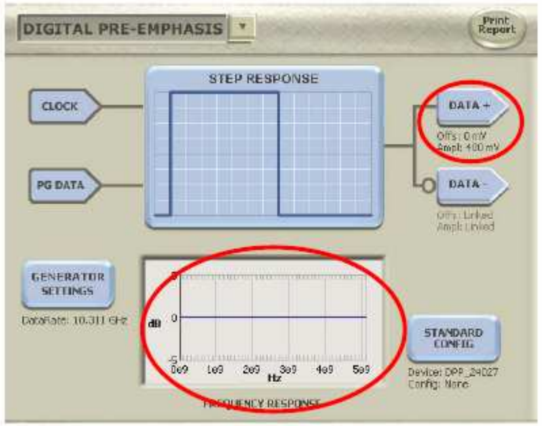
The BERTScope ISI board provides the required additional frequency dependent attenuation

using the 40” and 17” ISI traces in series is a good starting point for achieving the required additional attenuation. The total loss, excluding the fixture, can then be characterized using the BERTScope. The fixture must be characterized independently using a vector network analyzer (VNA) with proper de-embedding and added to the measured total loss of the remaining components. Using a 1010 pattern at 10.3125 Gb/s, measure the amplitude of the signal at the output of the BERTScope DPP. Next, insert the channel (fixture, cables, ISI and couplers), and measure the amplitude again. Calculate the attenuation, 20*log[(amplitude after channel)/(amplitude before channel)], then add the fixture loss.

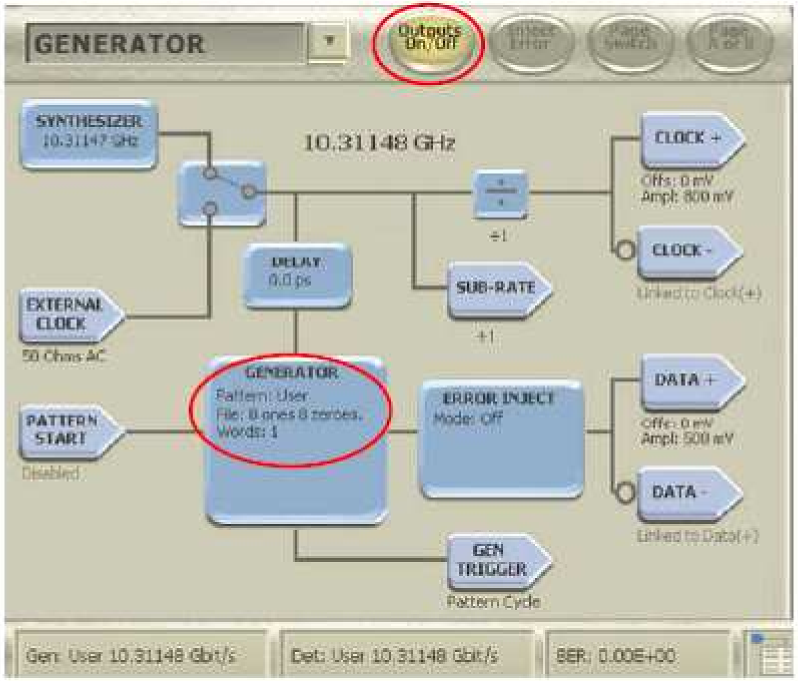
Broadband Noise Generator

A suitable broadband noise generator is the Noisewave NW10G-M, If additional amplification is required to meet the specification, a broadband linear amplifier can be added after the broadband noise generator. A suitable amplifier is the Picosecond Puslelabs 5867-107 broadband linear amplifier

Step 2. Set Data Rate and Amplitude

Instrument Settings	Results / Explanation
On the BERTScope Generator Screen: • Set the data rate to 10.31147 Gb/s	The data rate is set to 10.3125 +/- 100 ppm so that the receiver is tested to the extremes of the possible data range. 
On the BERTScope DPP: • Set the data amplitude to 400 mV (800 mV p-p) • Set the taps to 1, 0, 0	The amplitude is set at the output of the DPP, with the tap settings initially set to produce no gain or attenuation. The amplitude is set to 800 mV p-p adjusted by b_{TC} (see Appendix A). 

Step 3. Adjust the Rise Time

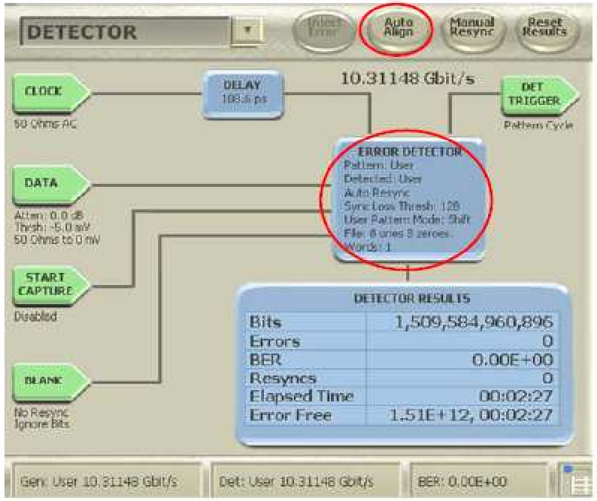
Instrument Settings	Results / Explanation
On the BERTScope Generator Screen: • Set the pattern to 8-1s, 8-0's • Turn outputs ON	

<table>
<tr>
<td>

On the BERTScope Detector Screen:

- Assure the pattern is also set to 8-1s, 8-0s
- Perform an Auto Align

</td>
<td>



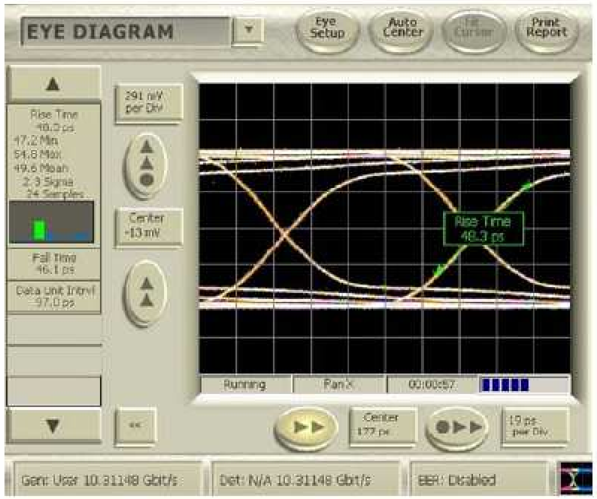
</td>
</tr>
<tr>
<td>

On the BERTScope:

- View Eye Diagram
- Measure Rise Time from 20% - 80%
- Add Rise Time filters to slow the rise time to 47 ps.

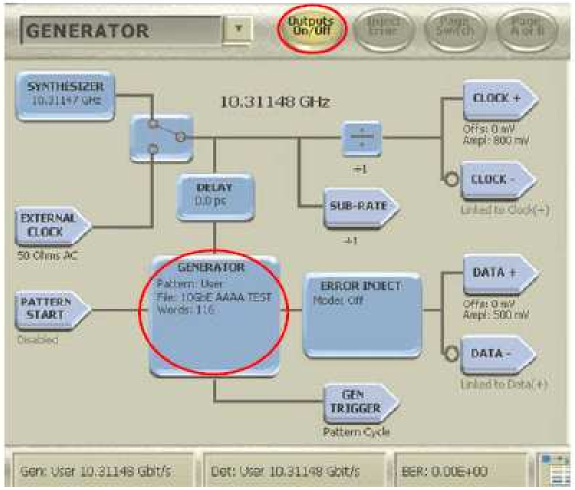
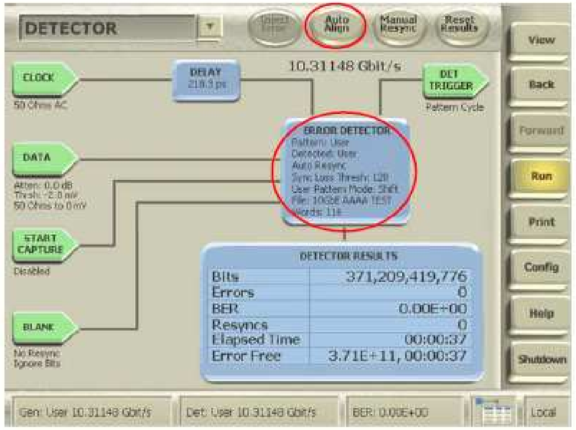
</td>
<td>

Since the added ISI will slow the rising edge considerably, the effect of a rise time filter is minimal. In this example a 63 ps, 10 -90% rise time filter was used to achieve the 47 ps, 20 – 80% rise time required.



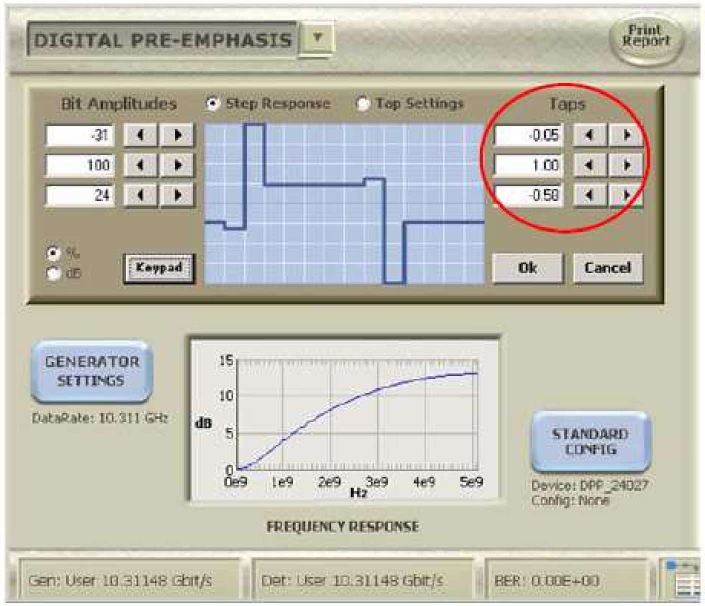
</td>
</tr>
</table>

Step 4: Set the Pattern

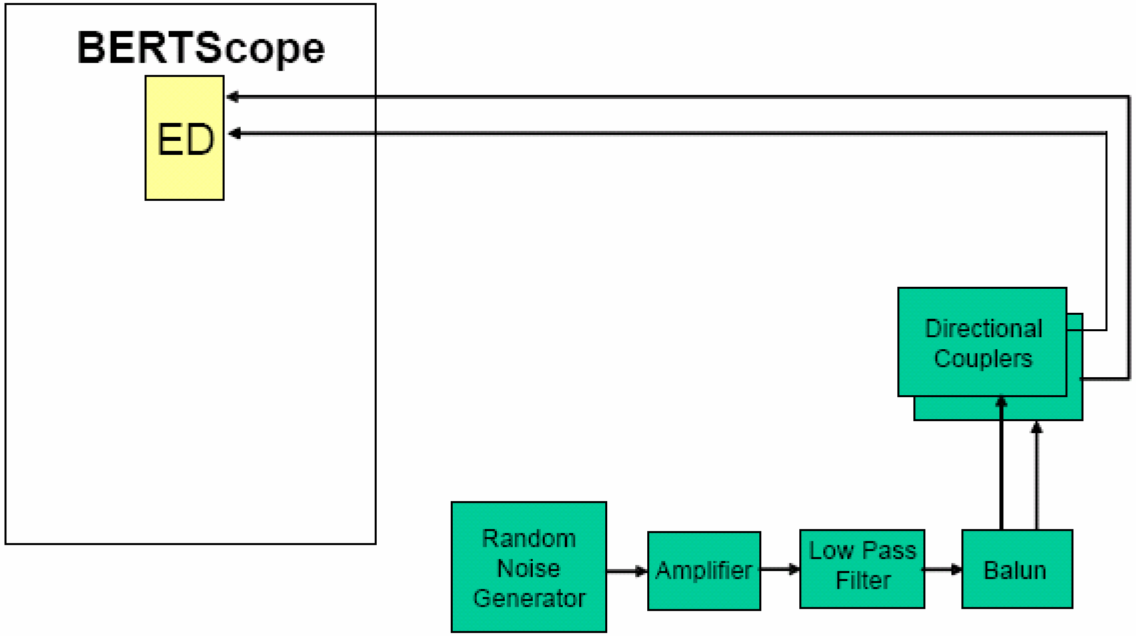
Instrument Settings	Results / Explanation
On the BERTScope Generator Screen: • Set the pattern to Test Pattern 2 • Turn outputs ON	Set the first pattern required for 10GBASE-KR, Test Pattern 2 as defined by the KR Standard is $A_nA_iA_nA_i$ where A_n = 0x3C8B44DCAB6804F and A_i is A_n inverted. 
On the BERTScope Detector Screen: • Assure the pattern is also set to Test Pattern 2 • Perform an Auto Align	Assure the detector is detecting Test Pattern 2 and perform an Auto Align since the pattern has changed. 

Step 5. Set the Tap Values

Testing the receiver pre-emphasis control is beyond the scope of this application note. For this example, the BERTScope acts as the transmitter and equalization will be set manually by applying appropriate taps in the BERTScope DPP. The taps are set to create a filter with an inverse frequency response to that of the channel resulting in no loss to the receiver. The tap values were determined by using the frequency response plot on the DPP screen and creating an inverse frequency response to the test channel requirements stated in the KR Standard.

Instrument Settings	Results / Explanation
On the BERTScope: • View the DPP screen • Set the tap values to -0.05, 1, -0.58	

Step 6. Calibrate Stress Sources



White noise calibration setup

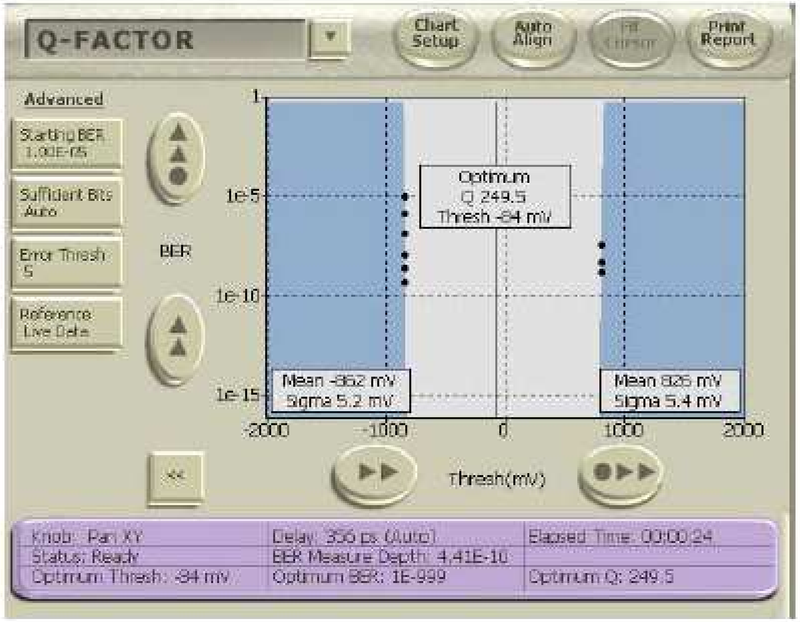
<table>
<tr><th>Instrument Settings</th><th>Results / Explanation</th></tr>
<tr><td>

Calibrate the Noise Source:

- Connect the noise source as shown above
- Turn on the broadband noise source
- Set the pattern to 1100
- Set the clock to divide by 2
- View Q-factor
- Set Reference to Live Data
- Adjust the amplitude of the noise source until the Sigma values are at least 5.2 mV

</td><td>

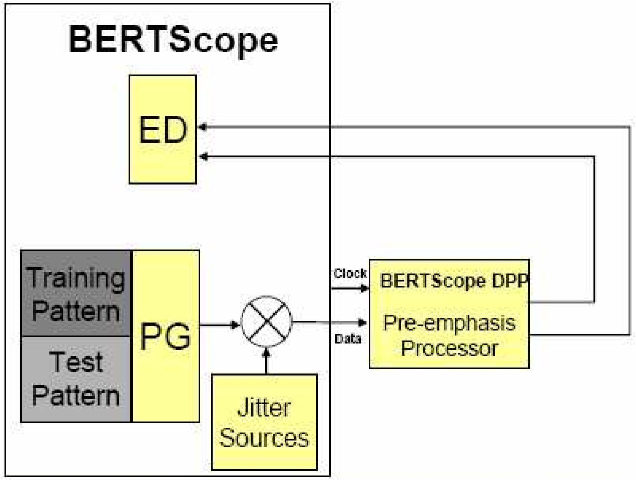
Q-factor shows the RJ, RMS noise on a signal [14]. With the noise source fed directly into the BERTScope, the Q-factor Sigma numbers are the RMS noise of the broadband noise source. A 1100 pattern with a divide-by-2 clock is used so that pattern noise is not introduced. Since a divide-by-2 clock is used, synchronization will not occur, but Q-factor can still be measured using Live Data mode.



</td></tr>
</table>

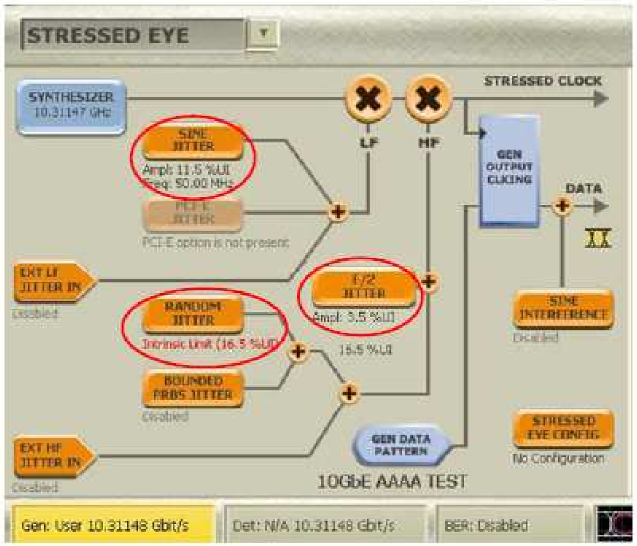
On the BERTScope Generator Screen:

- **Configure the Setup to Set Jitter at TP as Shown in diagram.**
- Set the pattern back to Test Pattern 2
- Set the clock back to divide by 1



On the BERTScope Stressed Setup Screen:

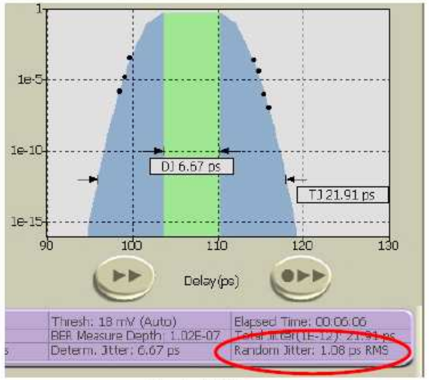
- Enable Sine Jitter (SJ)
- Set SJ amplitude to 11.5% UI
- Enable Random Jitter (RJ)
- Set RJ to 13% UI
- Enable F/2 Jitter
- Set F/2 jitter to 3.5%



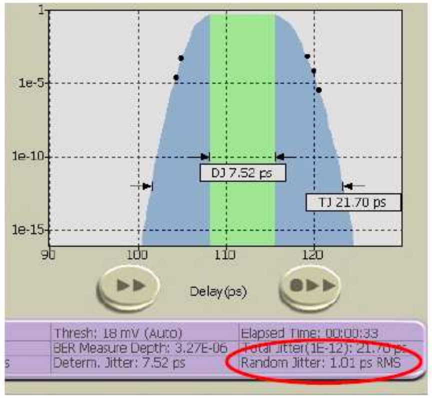
RJ may change to "intrinsic" indicating that the random jitter inherent in the test system exceeds the requested jitter level.

On the BERTScope Jitter Peak Screen:

- Set the Jitter Peak to only measure a single edge by clicking the purple bar and selecting Operation Mode -> Single Bit
- The index defaults to 0. Run Jitter Peak and record RJ_r
- Select bit 3 by clicking the purple bar, selecting Bit on the menu, and entering 3 in the dialog. Run Jitter Peak again. Record RJ_f.
- Calculate RJ using the equation shown.



Single bit 0



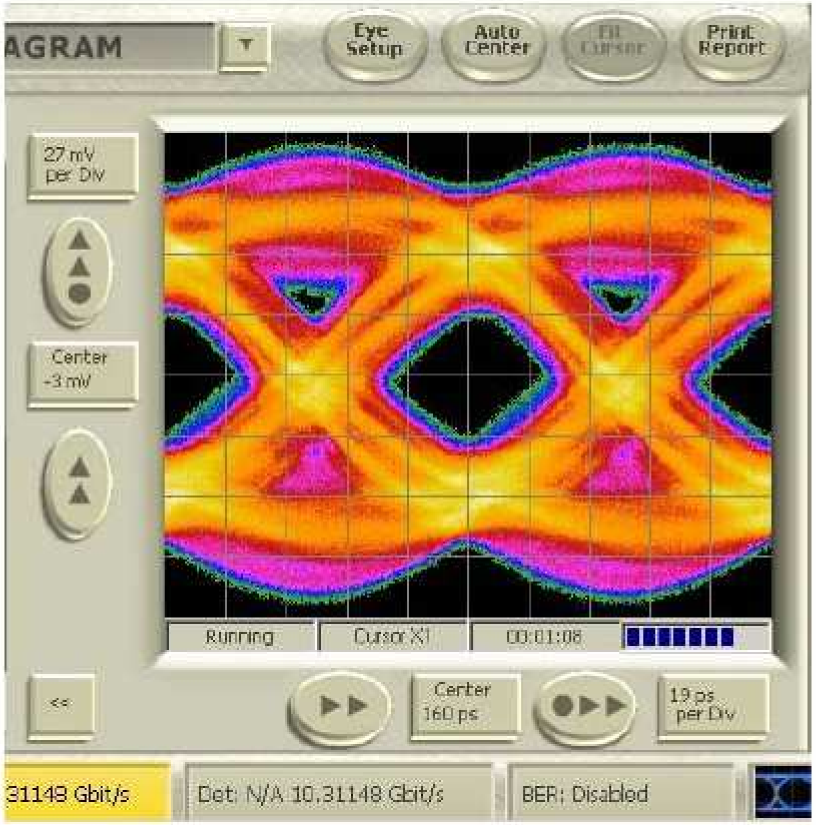
Single bit 3

$RJ(rms) = sqrt((RJ_r^2 + RJ_f^2)/2)$
$RJ\ (rms) = sqrt((1.08^2 + 1.01^2)/2) = 1.05$ ps

Calculate RJ (UI p-p) = 14 * RJ (rms)
RJ (UI p-p) = .146 = 14.6 %

This is the applied RJ at TP 1.

Note that the applied RJ is lower than the intrinsic RJ noted on the Stressed Eye screen. This is due to the effects of the BERTScope DPP (pre-emphasis).

Reconfigure the setup as in step 1. • The resulting eye diagram is shown.	The resulting eye diagram is shown below. 

Step 7. Configure the Equipment for Receiver Testing

For devices with built-in BER capability, connect the equipment as shown in Figure 28 and then continue with Step 8a. For devices that support loopback, connect the equipment as shown in Figure 29 and then continue with Step 8b. For both devices, assure that the connection point entering the device is the same point that was connected to the Error Detector on the BERTScope for calibration.

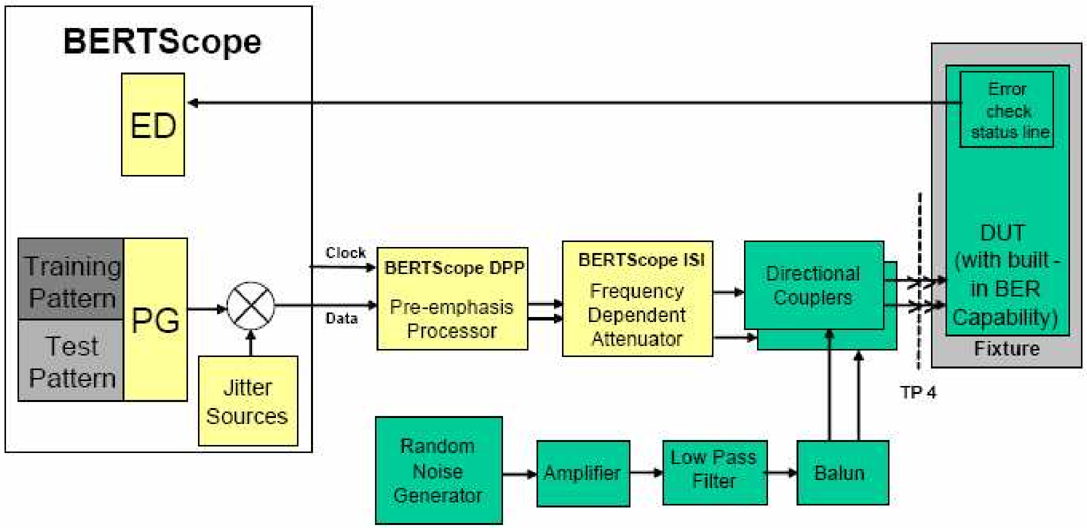


Figure 28. Basic test setup for 10GBASE-KR receiver compliance test for a DUT with built-in BER capability

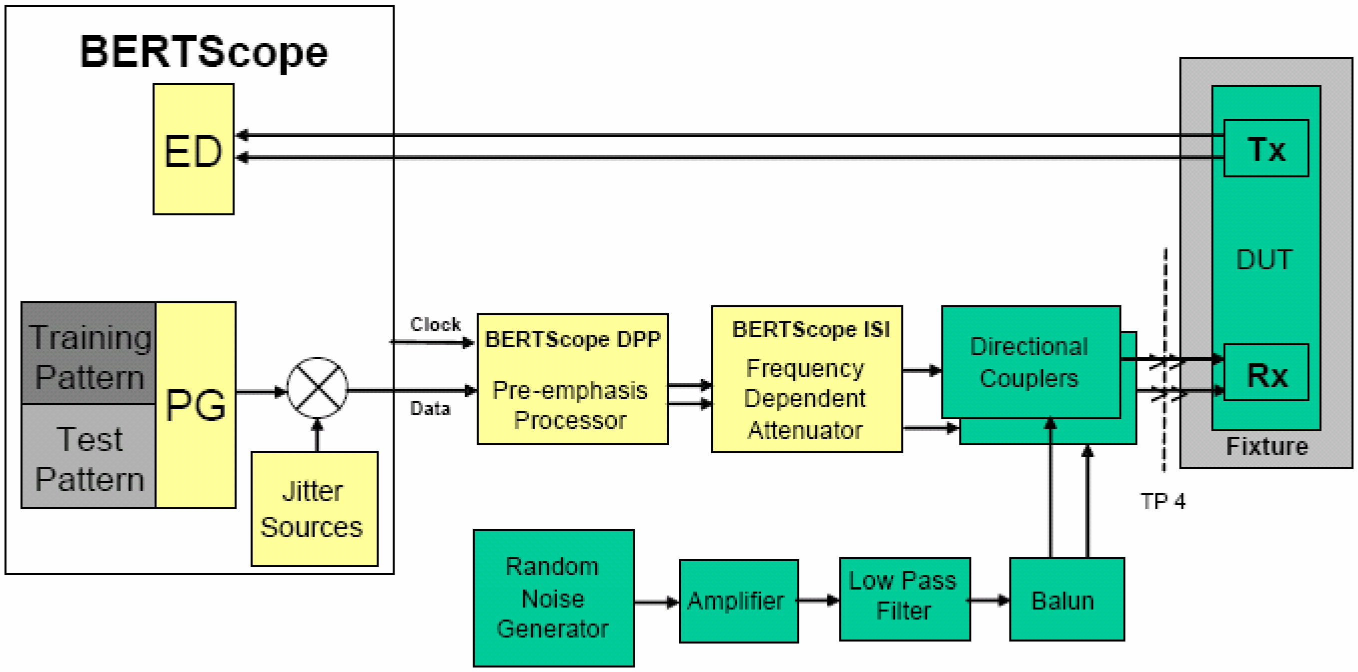
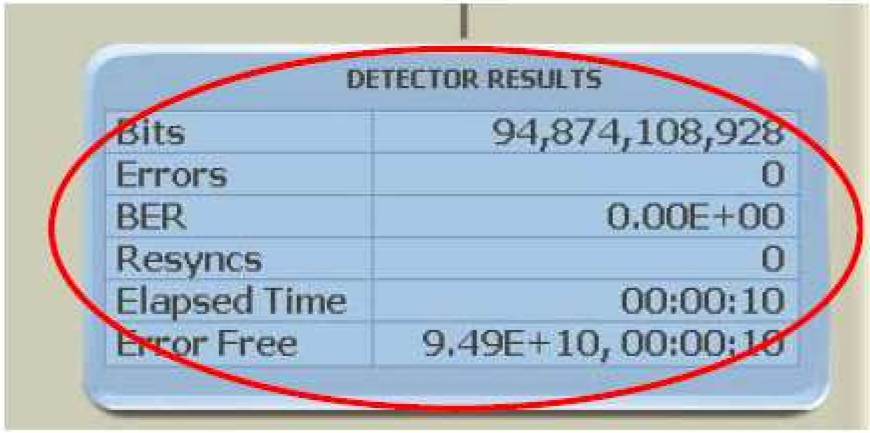


Figure 29. Basic test setup for 10GBASE-KR receiver compliance test for a DUT that supports loopback

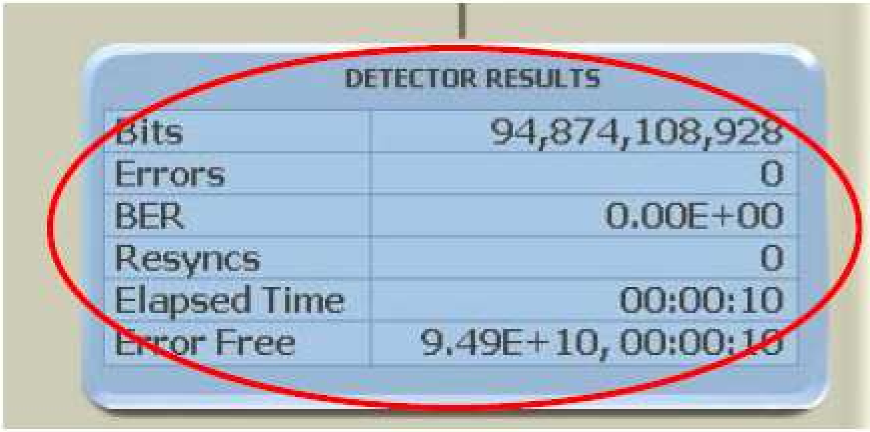
Step 8a. Measure BER on a Device with Built-in BER Capability

For devices that support loopback, skip this step and continue with Step 8b.

<table>
<tr><th>Instrument Settings</th><th>Results / Explanation</th></tr>
<tr><td>On the BERTScope Error Detector:
• Set the data pattern to “all zeros”

On the Receiver:
• Initiate BER test mode</td><td>This setup assumes that the error output of the device will be a logical one when an error is detected. If the error output is a logical zero, then set the data pattern to “all ones”. The device must pass at a BER of better than 10^{-12}. If an error is detected by the device, the error output line will go True, and the error detector on the BERTScope will show an error. Monitor the Error Detector Results until it runs error free for 10^{12} bits (97 seconds for a 10.3125 Gb/s signal).

</td></tr>
</table>

Step 8b. Measure BER on a Device that Supports Loopback

Instrument Settings	Results / Explanation
On the BERTScope Error Detector: • Set the data pattern to Test Pattern 2. • Select Auto Align **On the Receiver:** • Initiate BER test mode	The device must pass at a BER of better than 10^{-12}. If an error occurs in the pattern, the BERTScope will detect it. Monitor the Error Detector Results until it runs error free for 10^{12} bits (97 seconds for a 10.3125 Gb/s signal). 

Recommended Test Equipment

Item	Supplier	Part Number	Description	Website
BERTScope S	SyntheSys Research	BSA12500B Option F2 (required) Option XSSC (optional)	Signal integrity analyzer with stressed eye and F2 jitter (Optional Spread Spectrum Clocking)	www.bertscope.com
BERTScope DPP	SyntheSys Research	DPP12500A (DPP 12500A-4T)	1-12.5 Gb/s 3-tap digital pre-emphasis processor (4-tap model also available)	www.bertscope.com
BERTScope CR	SyntheSys Research	CR12500A (CRJ12500A)	Clock Recovery Instrument (Optional jitter spectral analysis model)	www.bertscope.com
BERTScope ISI	SyntheSys Research	ISI Test Board	Differential ISI board	www.bertscope.com
Matched Cable Set [15]	SyntheSys Research	CR1200ACBL	Matched cable set	www.bertscope.com
Amplifier	Picosecond Pulse Labs	5867-107	15 GHz amplifier, 15 dB gain	www.picosecond.com
Balun	Prodyn Technologies	BIB-100G	Balun, 250 KHz to 10 GHz	www.prodyntech.com
Directional Couplers	Krytar	1821	1 – 18 GHz	www.krytar.com
Low Pass Filter	Picosecond Pulse Labs	5915-110-5.16 GHz	5.16 GHz Low Pass Filter	www.picosecond.com
Noise Source	Noisewave	NW10G-ATE	10 GHz programmable noise generator	www.noisewave.com
Rise Time Filter	Picosecond Pulse Labs	5915-110-63 ps	63 ps (10 – 90%) Rise Time Filter	www.picosecond.com
Test Fixture	Customer Supplied			