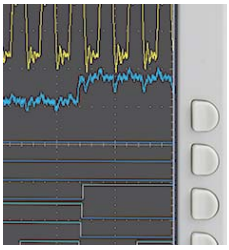
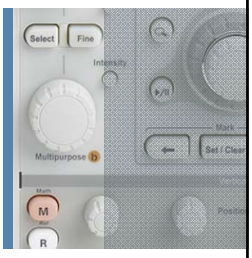
Next Generation Ultra-High speed standards' measurements of Optical and Electrical signals





Apr. 2011, V 1.0, prz

Tektronix

Agenda

- Speeds above 10 Gb/s: Transmitter and Receiver test setup
- Transmitter Test 1,2 : Interconnect, TX Out
- Meet the test equipment:
  - BERT
  - Clock Recovery
  - Oscilloscope
- Setup for Electrical and for Optical test – details
- 25 Gb/s, 40 Gb/s
- Receiver Test Setup
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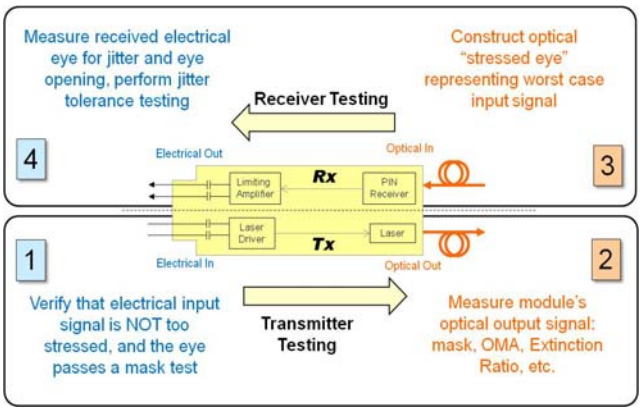
High Speeds in Serial Data

- PCIe III available on latest generation CPUs at 8 Gb/s el. physical (details available in another presentation)
- **THUNDERBOLT** at 10 Gb/s physical interface
- 16GFC (Fibre Channel) at 14.1 Gb/s deployed in SFP+ modules this physical signaling is running at 14.1 Gb/s electrical
- 40 / 100 Gb/s Ethernet running as fast as 25 and 40 Gb/s optical physical signaling (4x25 Gb/s) ; no electrical signaling above 10 Gb/s (e.g. 100 Gb/s is 10x10 G on the electrical interface)
- CEI-25G (short reach, long reach) – 25 Gb/s electrical interface
- 25 Gb/s backplane and cable study group started at IEEE ; this is 25 Gb/s electrical physical signaling

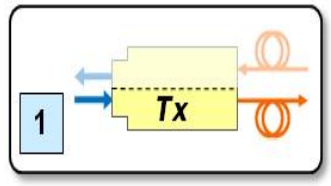
Focus on 14 Gb/s and 25 Gb/s test

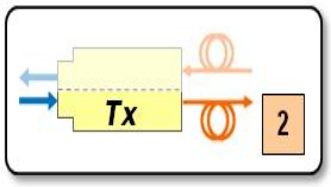


Commercial standards use Transceiver modules

Transmitter Test

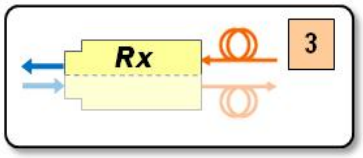
- The input signal used to test the transmitter must be good enough. Measurements of jitter and an eye mask test should be performed to confirm the quality using electrical measurements.
- The output of the transmitter must be tested using several quality metrics such as a mask test, OMA (optical modulation amplitude) or VMA (voltage MA), and if optical, Extinction Ratio.

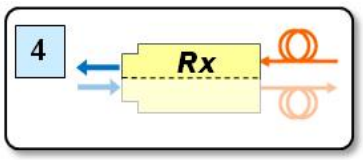




Receiver Test

- Testing the receiver involves sending in a signal that is of ***poor*** enough quality. To do this, a stressed eye representing the worst case signal shall be created.
- Finally, testing the electrical output of the receiver should be performed.





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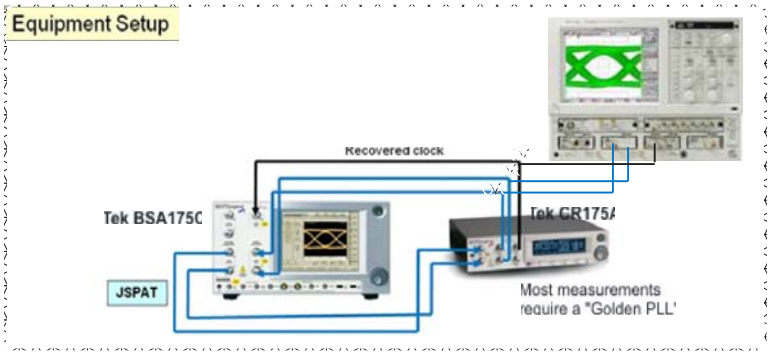
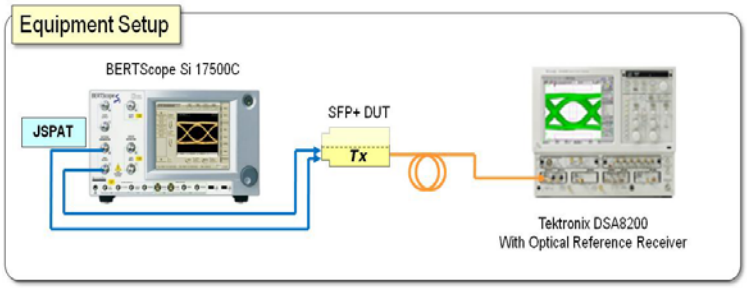
Transmitter Test step 1

- BERTScope generates the signal to the DUT
- Verify with either BERTScope Error Detector or with an electrical input of a Sampling oscilloscope DSA8200

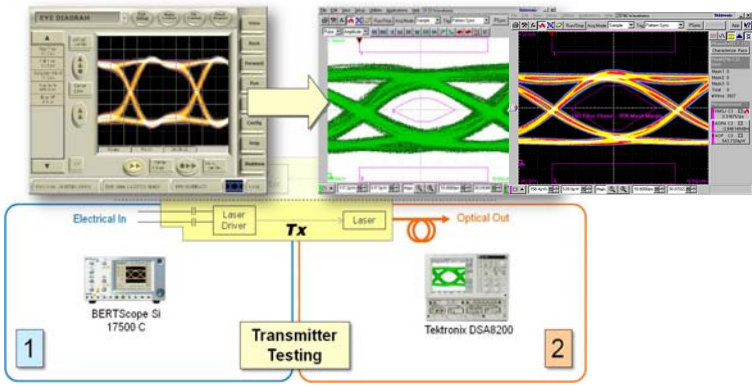


Transmitter Test step 2 – test TX Output

- BERTScope generates the signal to the DUT
- Capture TX Output on a sampling oscilloscope
- Example below – 16GFC Optical



Comparison of Module In and module TX Out



- In this example an electrical signal into an SFP+ module is captured on the BERTScope BSA175C. TX Output is captured first (green trace) on 0th generation 16GFC module, then (black background) on a 1st generation module. Oscilloscope: 80C14 in DSA8200

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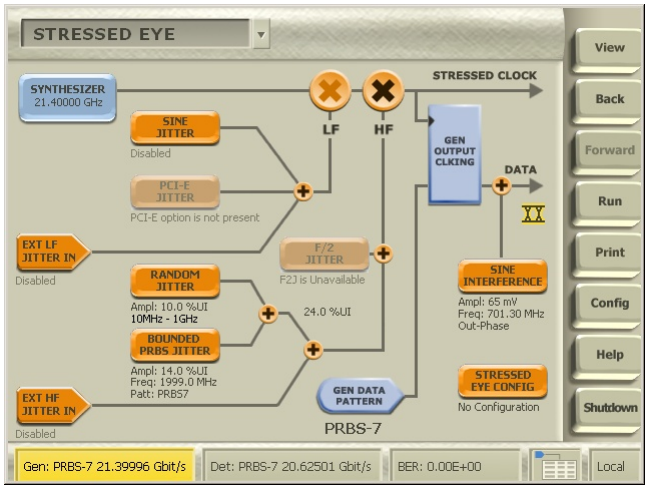
Meet the test equipment – BERTScope: BSA175C or BSA260C

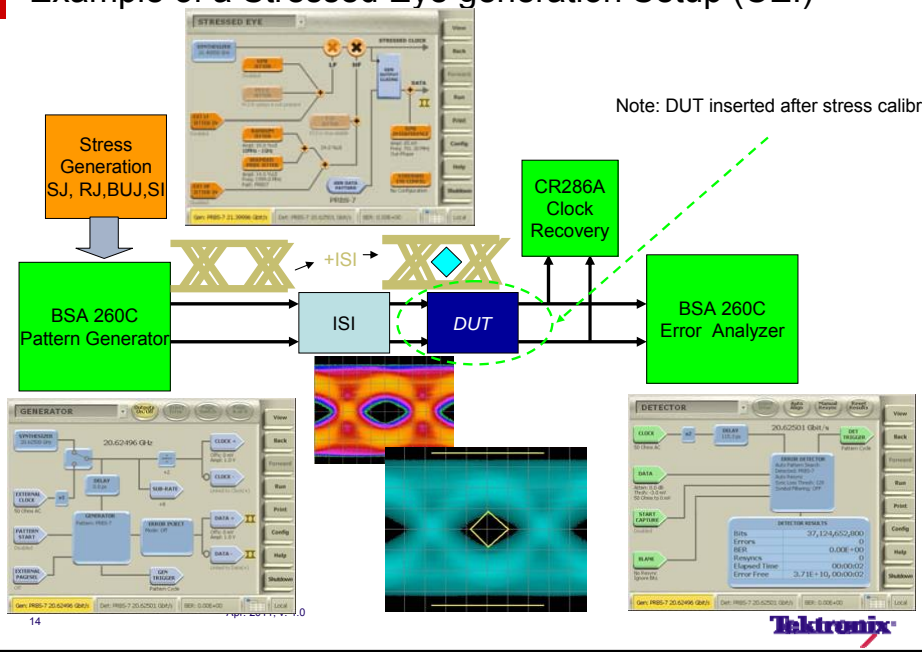
- The BERTScope 175C, and 260C (and slower 85C, 125C) can generate precise amount of jitter for stressed eye generation.
  Alternatively, they can use existing live traffic from a network and add calibrated SJ, RJ, BUJ, F/2 and SI to it, and re-transmit stressed data to the linecard under test – so stressed eye testing can be taken from the device or component level up to the system test level.

Meet the test equipment – BERTScope Stressed Eye generation



Settings clearly visible from the top GUI panel

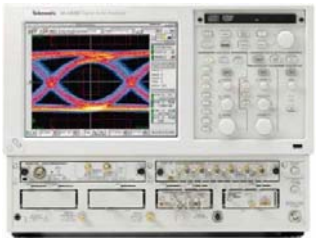
Example of a Stressed Eye generation Setup (CEI)



Meet the test equipment – Clock Recovery: CR175A, CR286A

- The Tektronix CR286A and CR175A CR175A provides compliant clock recovery up to 28.6 Gb/s with configurable loop bandwidth and peaking settings. Many measurements, such as jitter measurements, require the use of a Golden PLL, provided by the CRU.
- The CRU is used with BERTScope BSA, and with the Sampling oscilloscope DSA8200. It is typically not needed for troubleshooting with a Real Time Oscilloscope (RTO), e.g. DPO72004C.

Meet the test equipment – Sampling Oscilloscope: DSA8200 with 80C14 (10g+16GFC) or 80C10B



- The TX signal from an optical DUT is measured with a device that gives maximum margins and accuracy at high bit-rates: a Sampling Oscilloscope
- For Electrical Signals at high speeds Tektronix recommends the 80E07/08 and 80E09/10 family of modules (BW to 60 GHz).
- For optical Signals a Module with an integrated ORR (Optical Reference Receiver) is necessary
- At highest speeds Tektronix today offers these two optical modules:
- a super-sensitive module for 8GFC to 10 to 12.5 Gb/s and also16GFC: the 80C14
- A flexible BW module for 25 and 40 Gb/s, the 80C10B

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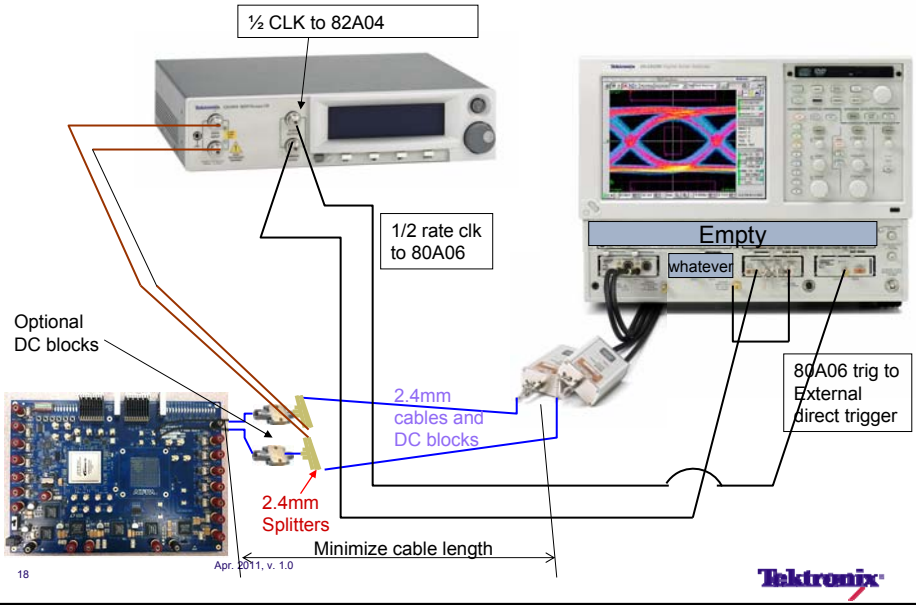
Equipment Setup recommended for high quality <u>electrical</u> acquisition at speeds over 12 Gb/s:

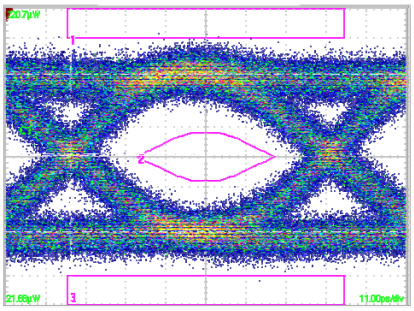


Optical acquisition: bit-rate specific modules.
Tek 80C14:new 8 G to 16GFC Single/Multi-mode Solution

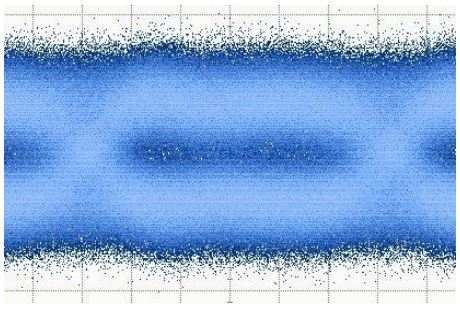
Description	Tek 80C14	Alternative
Optical Bandwidth	14 GHz (matches standard)	20 GHz
Specified ITU Compliant ORRs For 14 G, 10G	Yes	Not stated
RMS Noise at 1310 typ	2 to 3 uW	8 uW
Sensitivity (at 1310 nm) (about 2dB worse at 850 nm)	-14 dBm	-9 dBm
Max Power (AOP)	+5 dBm	+5 dBm
Dynamic Range	19 dB	14 dB
Wavelength Range	700 to 1650 nm	750 to 1650 nm
Number of Optical Channels	1	1
Number of Electrical Channels	0	1
Max. Acq. Speed	200 kS/s	~50 kS/s

Performance of the 80C14 Optical Module
Unmatched Sensitivity for 16G FibreChannel

New Tektronix 80C14



Lower sensitivity alternatives



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Fastest signals at 25 Gb/s, 40 Gb/s Optical

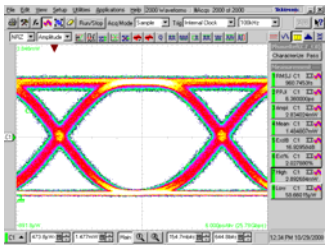
- ITU bit-rates are around 40 Gb/s
- Ethernet 802.3ba around 10 Gb/s and 25 Gb/s
- Ethernet 802.3b around 40 Gb/s

Question: how to handle so many bit-rates?

Answer: 80C10B handles both 25 Gb/s and 40 Gb/s
Slower rates: 80C12 or 80C14

25 Gb/s and 40 Gb/s: 80C10B: performance *and* versatility

- *Performance: 80C10B*
  - Up to 80 GHz Optical Bandwidth
  - Industry's Best Noise Performance @ 40G and beyond
  - Best signal fidelity
- *Versatility: 80C10B F1*
  - Only single module solution to 100GbE (4x25), OC768, G.709 FEC, OTU3, and 40GbE in a single module



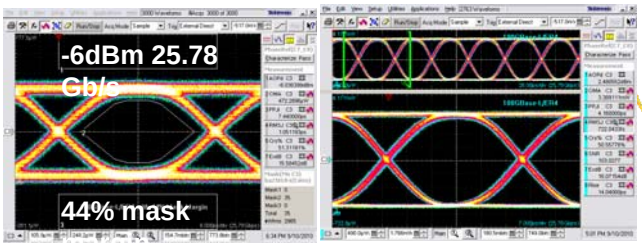
25.78Gb/s

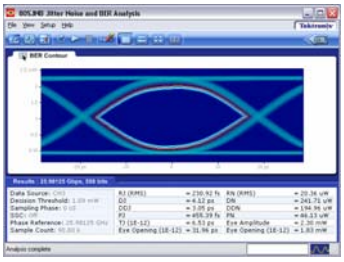
- *Lower cost: 80C25GBE*
  - 100GbE (4x25) compliance test solution; no 40 Gb/s support.
- *Complete solution*
  - Data and Data_ outputs for CRUs and/or BERT

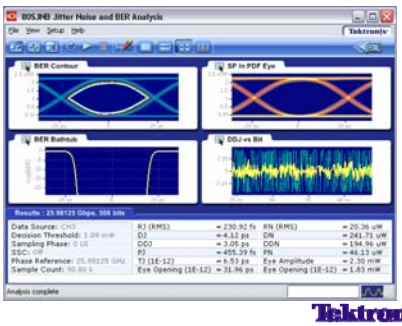
NEW

80C10B Performance: Cleanest 25G & 40G Eye Diagrams

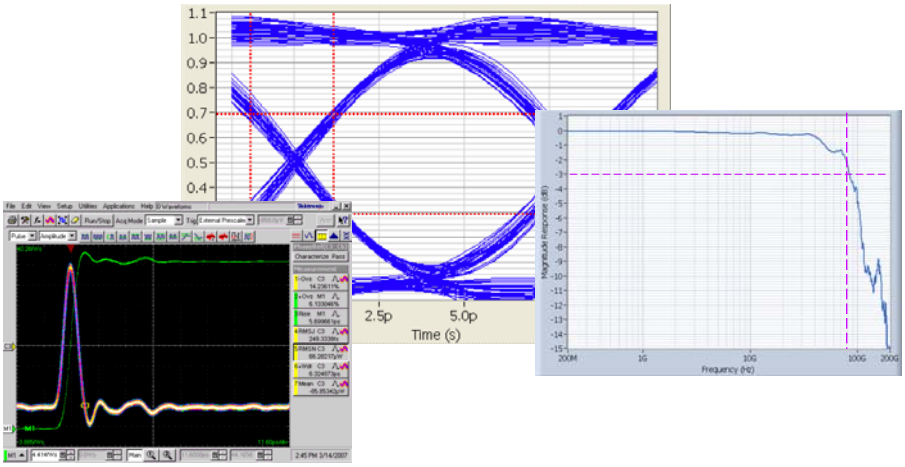
- IEEE802.3bg 40GBASE-FR filter included in all 80C10B modules







80C10B Performance: Capturing the true DUT signal above 40 Gb/s

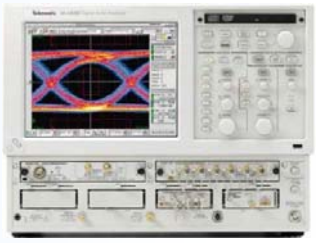


Performance even for 120 Gb/s NRZ signaling.
(image: impulse response from 80C10B at full BW convolved with a PRBS)

Module reaches 100 GHz BW for about 5 to 6 dB down from the nominal

Equipment flexibility: 8.5 to 40 to 100GbE Optical Compliance testing in ONE Instrument

DSA8200 Digital Serial Analyzer
+ 80C14 Optical Module (New 16GFC Module)
+ 80C10B-F1 Optical Module



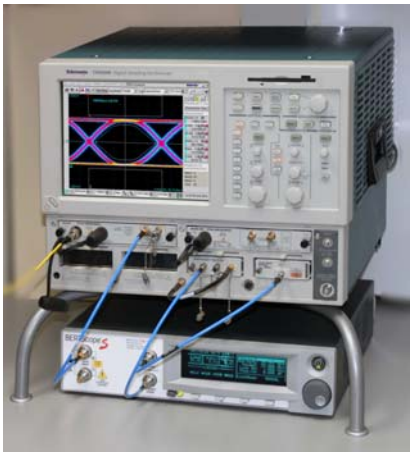
The only ALL-IN-ONE solution with:

- All Reference Receiver Filters from 8.5Gb/s thru 44.5Gb/s
- Highest Repeatability & Best Sensitivity
- SMF and MMF support to 14G
- 4x throughput over alternative
- Calibrated Extinction-Ratio Measurements [1]

[1] Highest bandwidth supported currently: 10G+

Summary of Sampling setup

- Basic Mask test
- Complete (Jitter test etc.)



Standards >8 Gb/s

Optical Reference Receivers from 8.5Gb/s to 44.5Gb/s for Physical Layer Compliance Testing of

- Telecom,
- Datacom,
- Storage Area Network Transmitters

Around 10 Gb/s:
Tek Solution: 80C08C, 80C12 and **80C14**

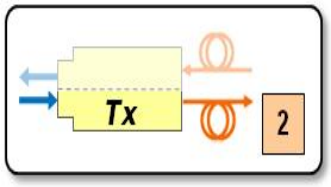
New speeds Include 25 Gb/s and 40 Gb/s

… and
Tektronix Solution is **80C10B**

	Standard	Line Rate
IEEE 802.3ae,aq	OC-192 / STM-64 10GBASE-W	9.953 Gb/s
	10GBASE-{E,L,S}R 10GBASE-LRM	10.3125 Gb/s
T11 FC	OTU2 FEC	11.096 Gb/s
	8GFC 10GFC 16GFC	8.50 Gb/s 10.519 Gb/s 14.1 Gb/s
ITU Related	OC192 + G.975 FEC OTU2 (OC192 + G.709 FEC)	10.664 Gb/s 10.709 Gb/s
IEEE 802.3ba	10GBASE-SR16 10GBASE-LR4 10GBASE-ER4 10GBASE-LR4 + FEC 10GBASE-ER4 + FEC 40GBASE-SR4 40GBASE-LR4	10 x 10.3125 Gb/s 4 x 25.781 Gb/s 4 x 27.738 Gb/s 4 x 10.3125 Gb/s
IEEE 802.3bq	40GBASE-FR	41.25 Gb/s
	OC-768 / STM-256 VSR-2000	39.813 Gb/s
	OTU3 (OC-768 + G.709 FEC) VSR-2000 + FEC 4x10 LAN PHY (OTU3)	43.018 Gb/s 44.50 Gb/s

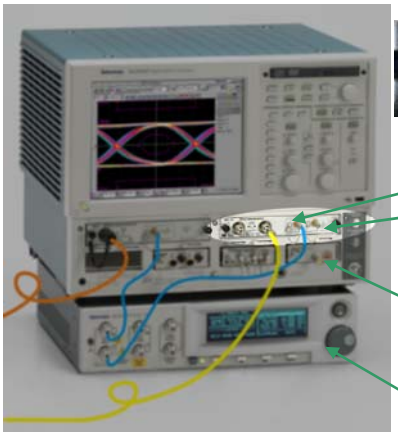
Electrical versus Optical test Q…

- Electrical input or output is available on BERTScope, RTO (Real-Time Oscilloscope), and on Sampling oscilloscope modules



- Optical input is only available on 80C.. Sampling modules; how to connect the RTO or the BERTScope to the signal?
- Answer: Latest Tek Optical modules offer buffered DATA Out (and Data_ Out_)
- These signals can be used for Clock Recovery, but also to drive an RTO (oscilloscope) for troubleshooting, or a BERTScope Error Detector for BER measurements.

Electrical versus Optical test … and Answer: buffered Data Out outputs on new optical modules



(Partial wiring shown)

80C14 for 16GFC; or (shown here) is 80C10B and 80C10B-F1 for 25 and 40 Gb/s standards:

- Both Data and Data_ available
- Can be used as shown here (to the CRU), or to connect to a BERT or to an RTO

Clock Recovery Unit (CRU)

- Tek CR125A, CR175A, or CR286A-HS, up to 28.6 Gb/s

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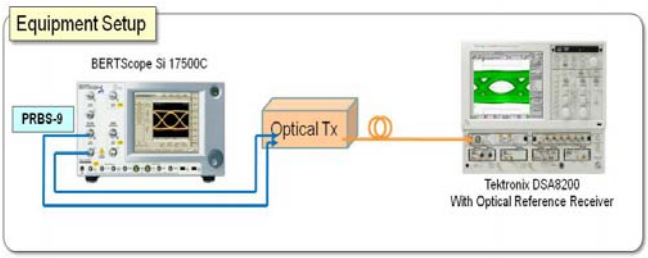
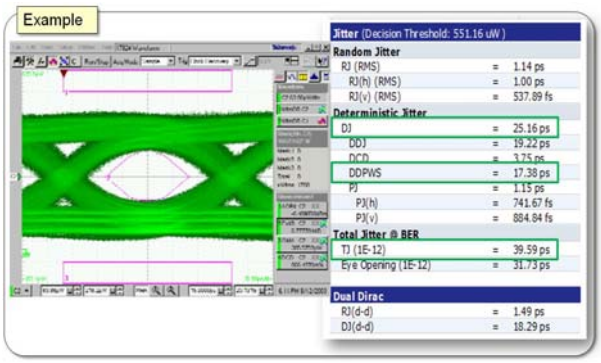
Receiver Test: Stressed Eye Calibration

- Sampling Oscilloscope is recommended for the Stressed Eye Calibration, …
- …in case of electrical Stressed Eye an BERTScope error detector can also be used.
- In case of optical RX test, an additional component is needed – the E/O (electrical to optical) transceiver.
- Please contact the factory for recommended equipment.

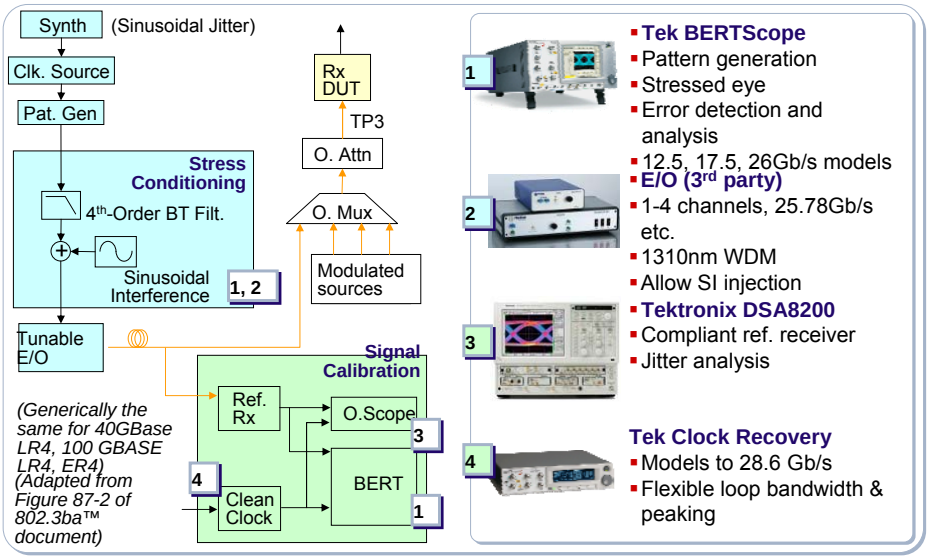


Receiver Test: Stressed Eye Calibration

- Example of a generated Stressed Eye with several measurements. Many of the jitter measurements are built into jitter tools (80SJNB on the DSA8200 Sampling Oscilloscope; the Jitter Map in the BERTScope BSA175 or BSA260.



Stressed Eye Generation is Standard Specific; 100 GbE example:



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Please visit Tektronix website www.tek.com for application notes and other details.