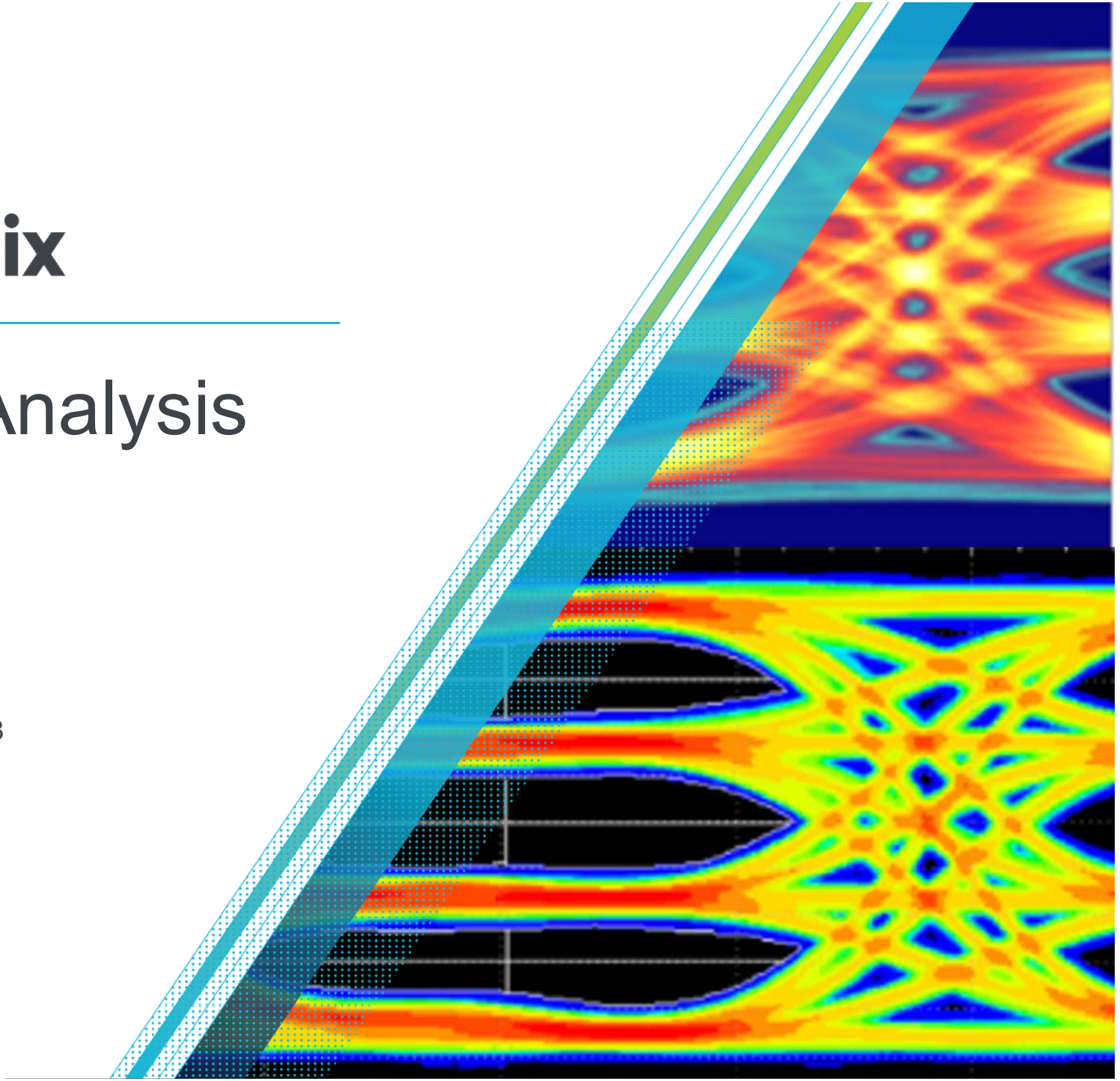
Tektronix

PAM-4 Analysis

12 SEPTEMBER 2018



Slides Subject

- PAM-4 Overview
- ET vs RT Test Solution
  - DSA8300 Sampling Scope
  - DPO70kSX ATI RT Scope
- New OE Modules Introduction
  - DPO7OE1/2 For RT
  - 80C17/18 80C10C For ET
- New PAM4 Test Software Introduction
  - 400G-M4

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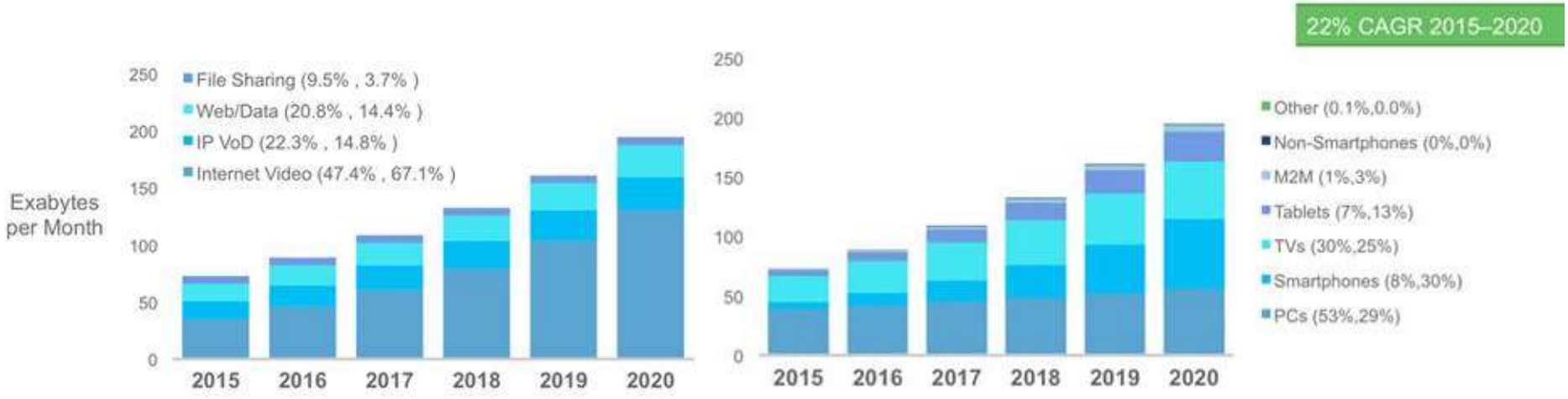
  - 400G-M4

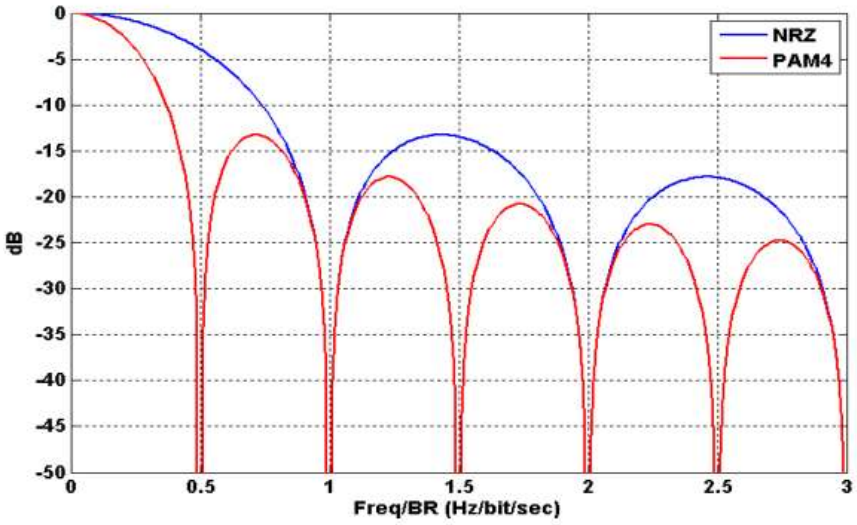
Datacom and Networking Trends

- Global IP traffic to triple over next 5 years
- Smart phone traffic to exceed PC traffic by 2020
- Traffic from wireless devices will account for two thirds of the traffic
- Number of devices on IP networks will be more than 3x global population
- Broadband speeds to double by 2020
- PAM-4 signaling is being considered to double throughput to meet expected growth in IP traffic

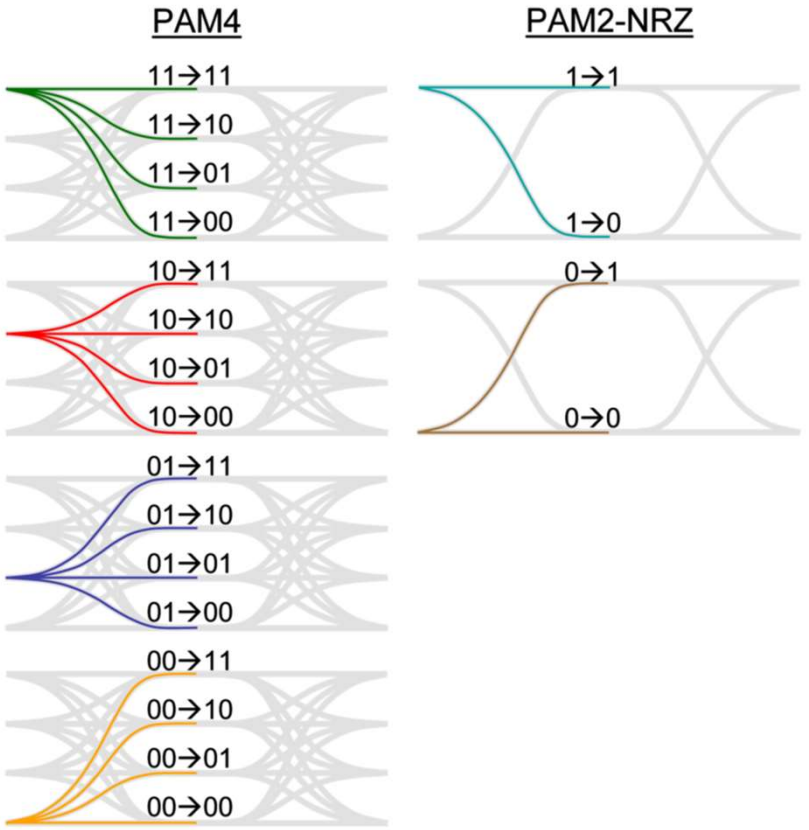


What is PAM4 ?

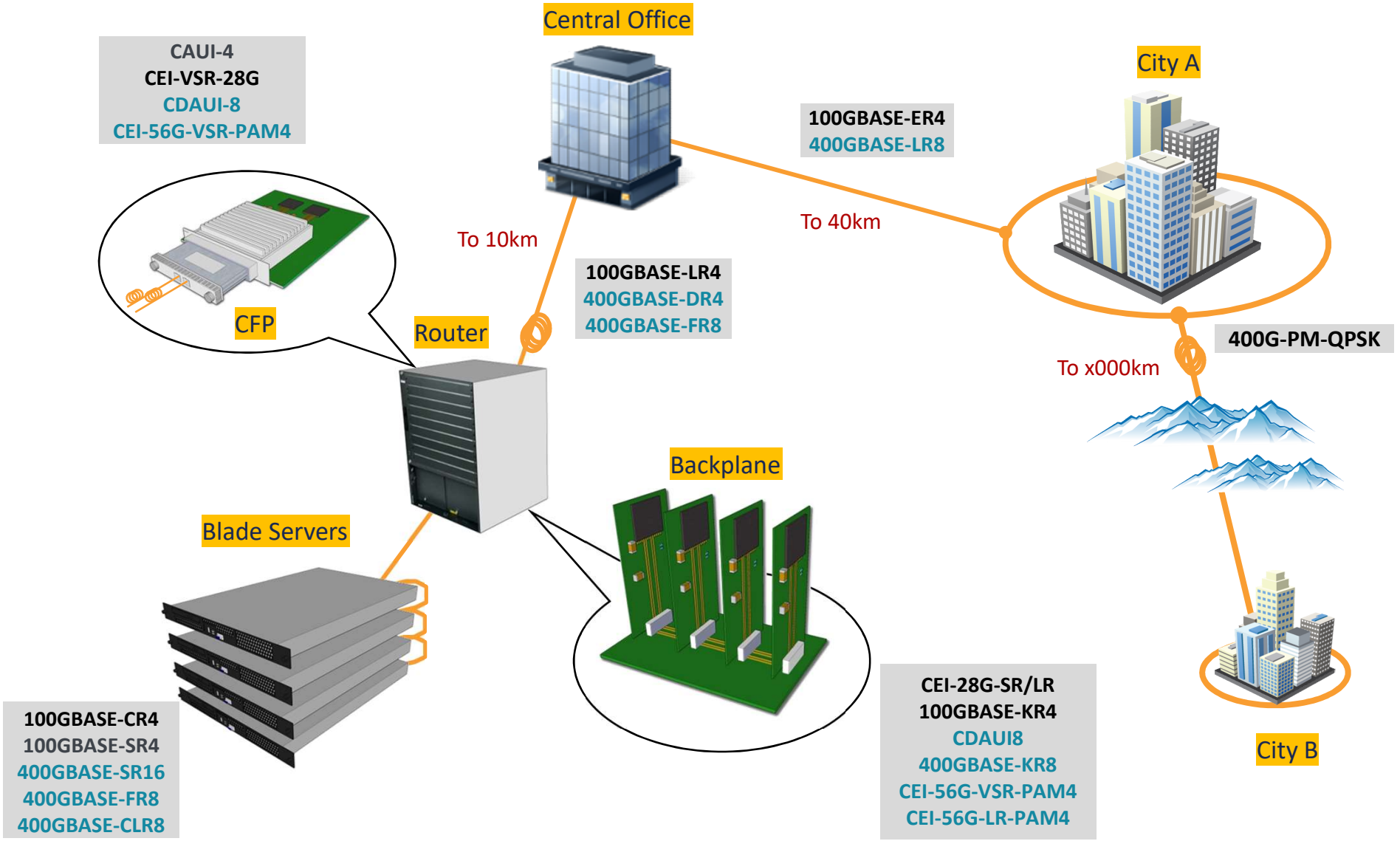
- Pulse Amplitude Modulation
- 4-level signaling
- Transmit 2 bits per UI
- PAM4 requires half of the BW of NRZ for the same data throughput



	PAM-4	NRZ
Bits per UI	2	1
Levels	4	2
Rising/Falling Edges	6	2
Transitions	12	2
Eye Diagrams per UI	3	1



400G Datacenter Networking Ecosystem



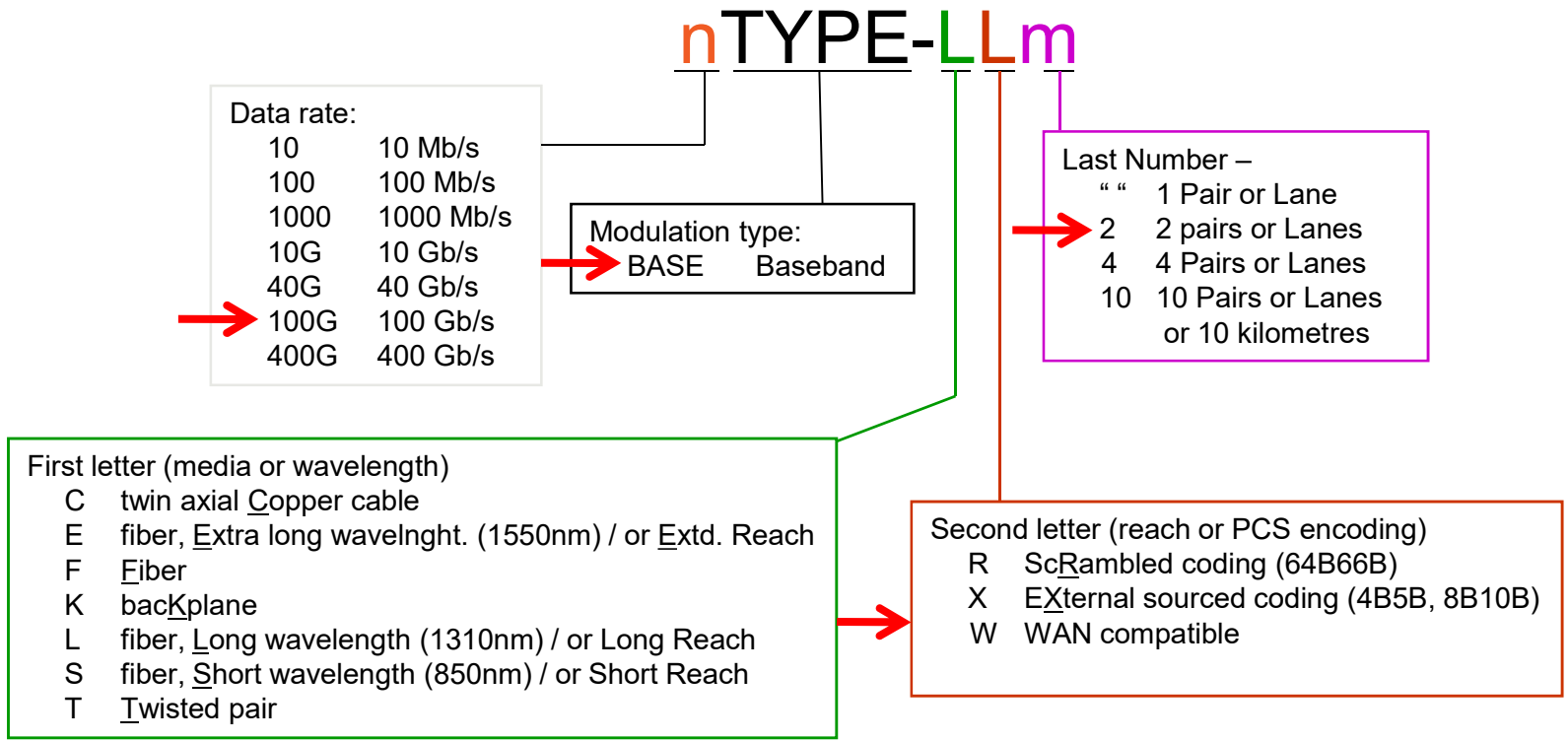
PAM4 Standards

Optical Standard	Modulation	Distance	Data Rate	Multiplex	Signaling Rate
200GBASE-SR4 (802.3cd) similar: 100GBASE-SR2, 50GBASE-SR	PAM4	70m, 100m	N lane x 50Gbps	<n> parallel MMF	26.56 GBd
200GBASE-DR4 (802.3bs)	PAM4	500m	4 lane x 50Gbps	4 parallel SMF	26.56 GBd
400GBASE-DR4 (802.3bs) similar: 100GBASE-DR	PAM4	500m	<n> lane x 100Gbps	4 parallel SMF	53.125 GBd
400GBASE-FR8 (802.3bs) similar: 200GBASE-FR4, 50GBASE-FR	PAM4	2km	<n> lane x 50Gbps	1 SMF 8λ WDM	26.56 GBd
400GBASE-LR8 (802.3bs) similar: 200GBASE-LR4, 50GBASE-LR	PAM4	10km	<n> lane x 50Gbps	1 SMF 8λ WDM	26.56 GBd

Electrical Standard	Modulation	Distance	Data Rate	Multiplex	Signaling Rate
CEI-56G-VSR-PAM4	PAM4	100mm	n lane x 56Gbps	1-n lanes	18-29 GBd
CEI-56G-MR-PAM4	PAM4	500mm	n lane x 56Gbps	1-n lanes	18-29 GBd
CEI-56G-LR-PAM4	PAM4	1m	n lane x 56Gbps	1-n lanes	18-29 GBd
50GAUI-1/100GAUI-2/ 200GAUI-4/400GAUI-8	PAM4	250mm	50Gbps	1,2,4,8 lanes	26.56 GBd
50GBASE-KR/100GBASE-KR2/ 200GBASE-KR4	PAM4	<1m	50Gbps	1,2,4 lanes	26.56 GBd
50GBASE-CR/100GBASE-CR2/ 200GBASE-CR4	PAM4	<3m	50Gbps	1,2,4 lanes	26.56 GBd

Ethernet Nomenclature

- Common interpretation* is as follows:
- Example: 100GBASE-LR2

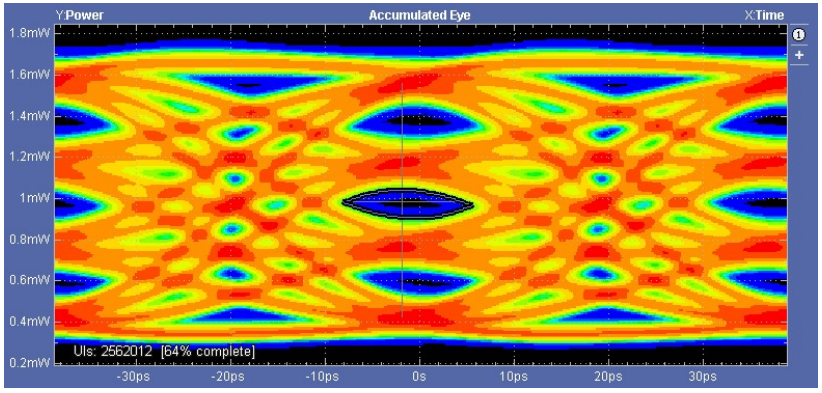


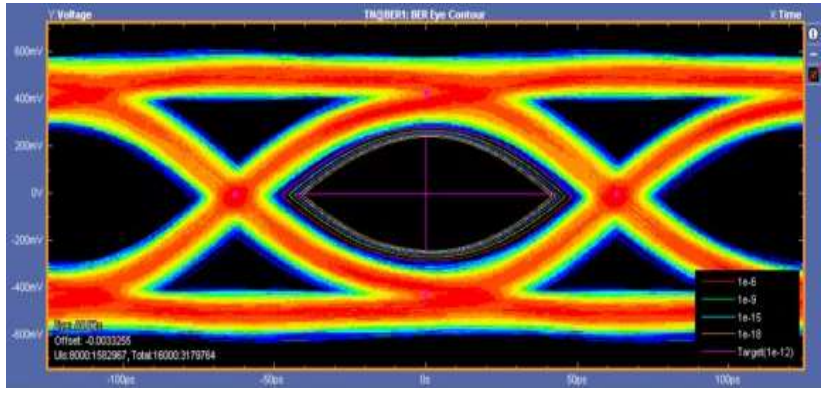
- The IEEE does not specify the meanings of the letters, rather it simply identifies PHYs by combinations of letters.

There is no guarantee that in the future these interpretations will retain whatever meaning they presently have.
Slide based on an Ethernet Alliance slide by Scott Kipp, with Tektronix extensions.

Test Challenges

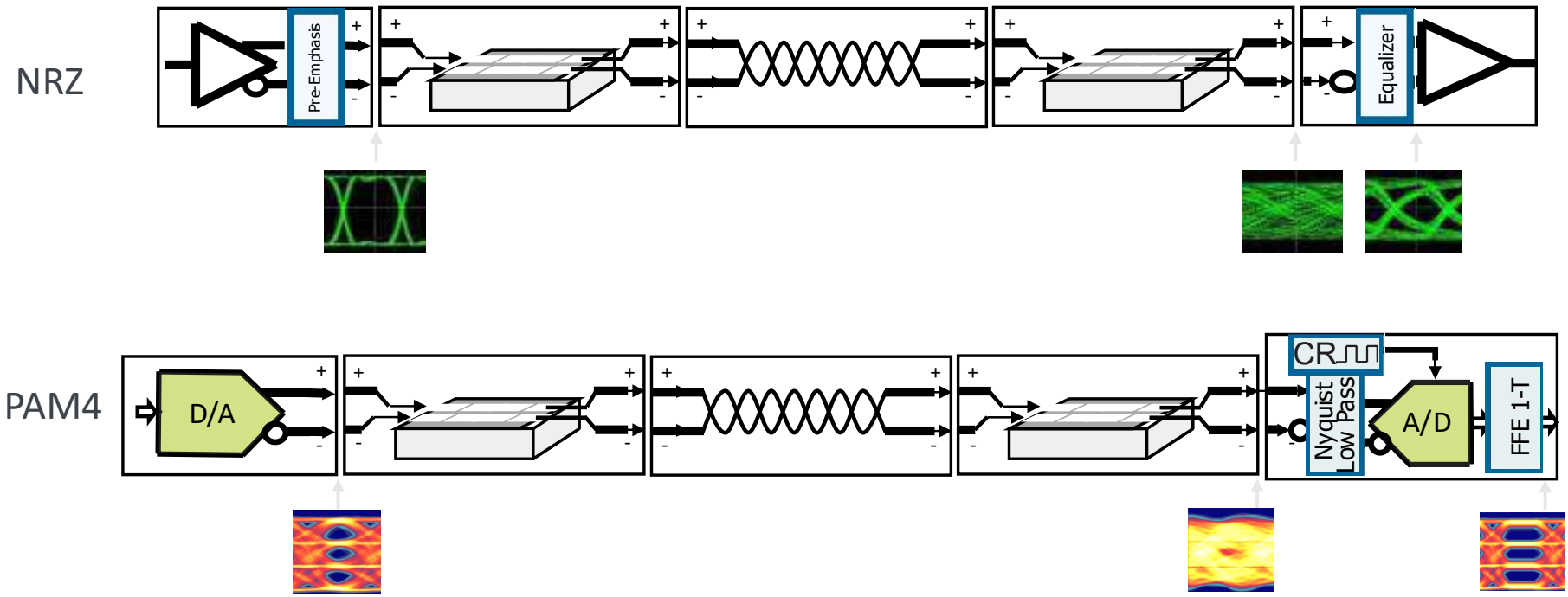
- Two bits are grouped and mapped to one symbol resulting in four signal levels, which form 3 eyes
- Vertical eye opening (eye height) @ BER
  - PAM-4 individual eye height 33% of NRZ at same supply voltage
  - PAM-4 endures lower loss due to half baud rate
- Horizontal eye opening (eye width) @ BER
  - PAM-4 individual eye width 200% of NRZ due to half baud rate
  - PAM-4 eye width is reduced by transitions between non-adjacent levels





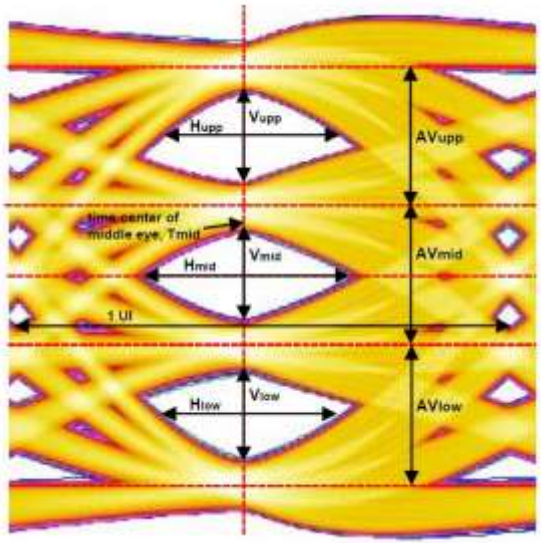
The bandwidth question

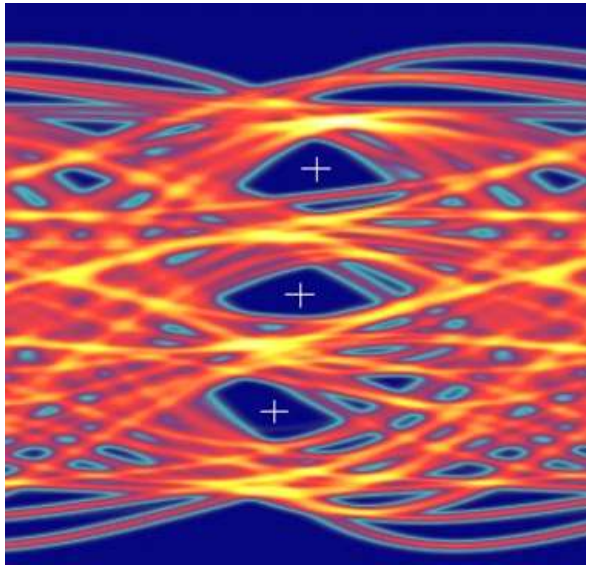
- What has changed?



Test Challenges

- PAM4 is more susceptible to noise due to reduced eye height
- Three different eye's require additional care in making sure that all of them are symmetric
- Multi Level Signaling introduces additional complexity in clock recovery, Pattern detection and Jitter measurements
- As PAM4 evolves newer more complex measurements are being defined into the standards





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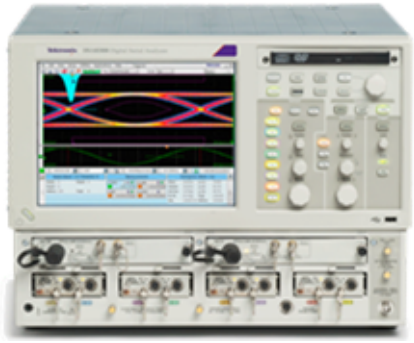
Test Requirements

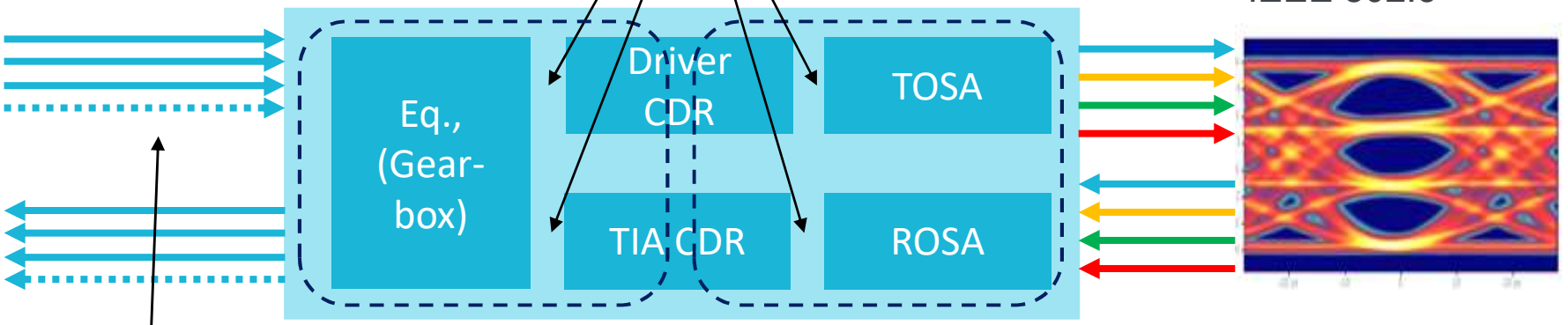
OPTICAL TRANSCEIVERS



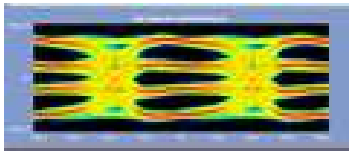
Intermediate test points
Characterization on evaluation boards

Electrical interface
CDAUI, 400GAUI, ….

Optical
LR8/DR4/…
IEEE 802.3



and debug everywhere!!!



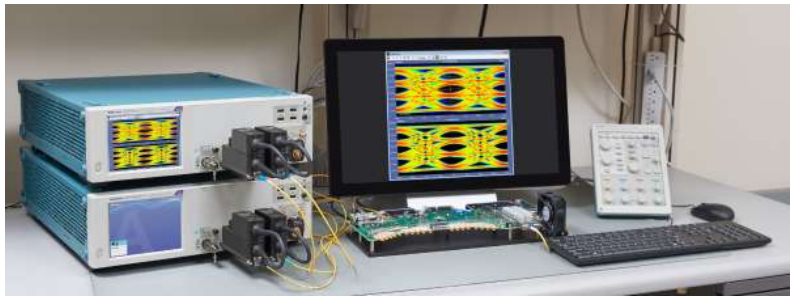
Clock recovery
Channel modelling
Equalization
Error Detection post-equalization
Error rate and location
DSP simulation

Tektronix 400G Acquisition Solutions

Equivalent Time Scope
80GHz Optical Bandwidth 70GHz Electrical Bandwidth <100fs jitter noise floor 20nW to .6uW Optical Resolution Automated test of 80+ Industrial Standards Best overall Optical solution

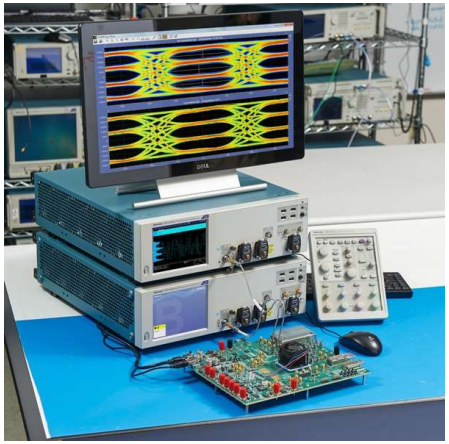
Real Time Scope
70GHz Analog Bandwidth 4.3ps rise time (20%-80%) 200GS/s Sample Rate <125fs jitter noise floor ≥25GHz Edge trigger bandwidth Compact 5 ¼” Oscilloscope package SW clock recovery required (key to 400G) Comprehensive CTLE, DFE, FFE signal processing Lowest noise real time acquisition system

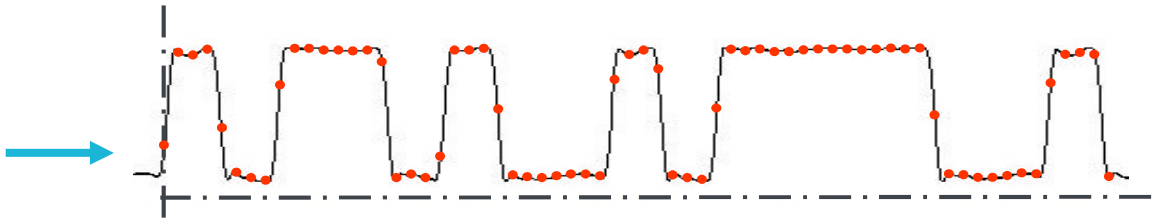
ET



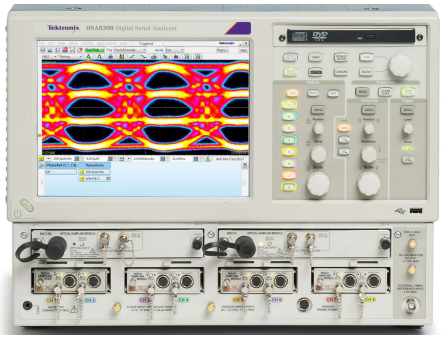
RT

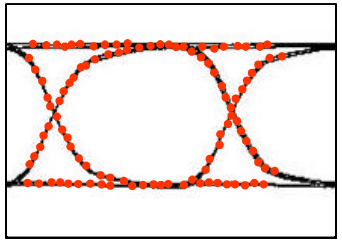
Real-Time Solution

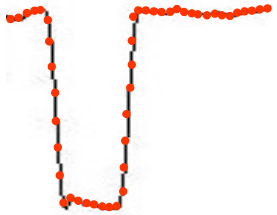




RT





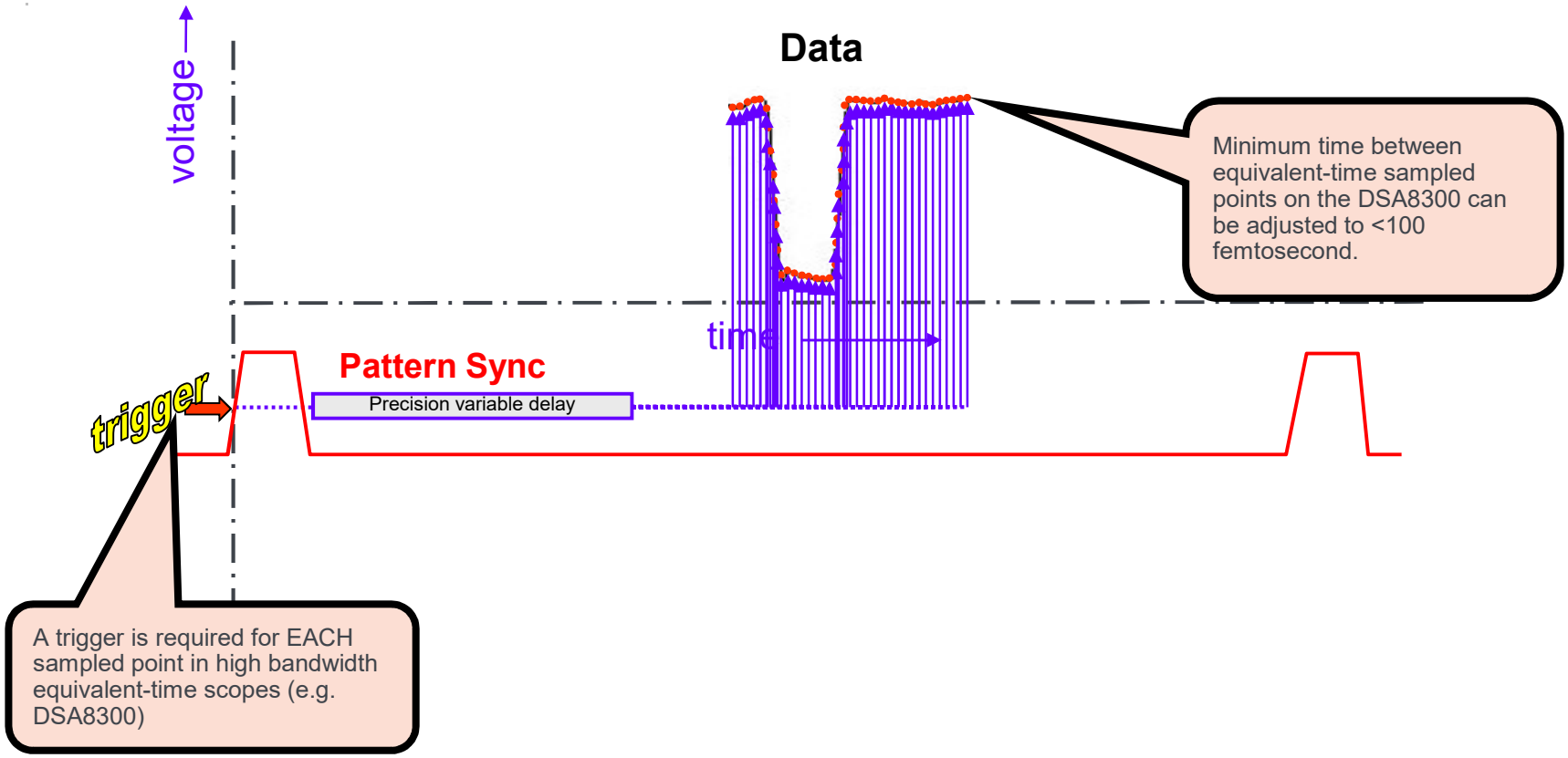


ET

Note – this slide is an animation best viewed in Slide Show mode

ET vs RT Basics: ET with Repetitive Pattern

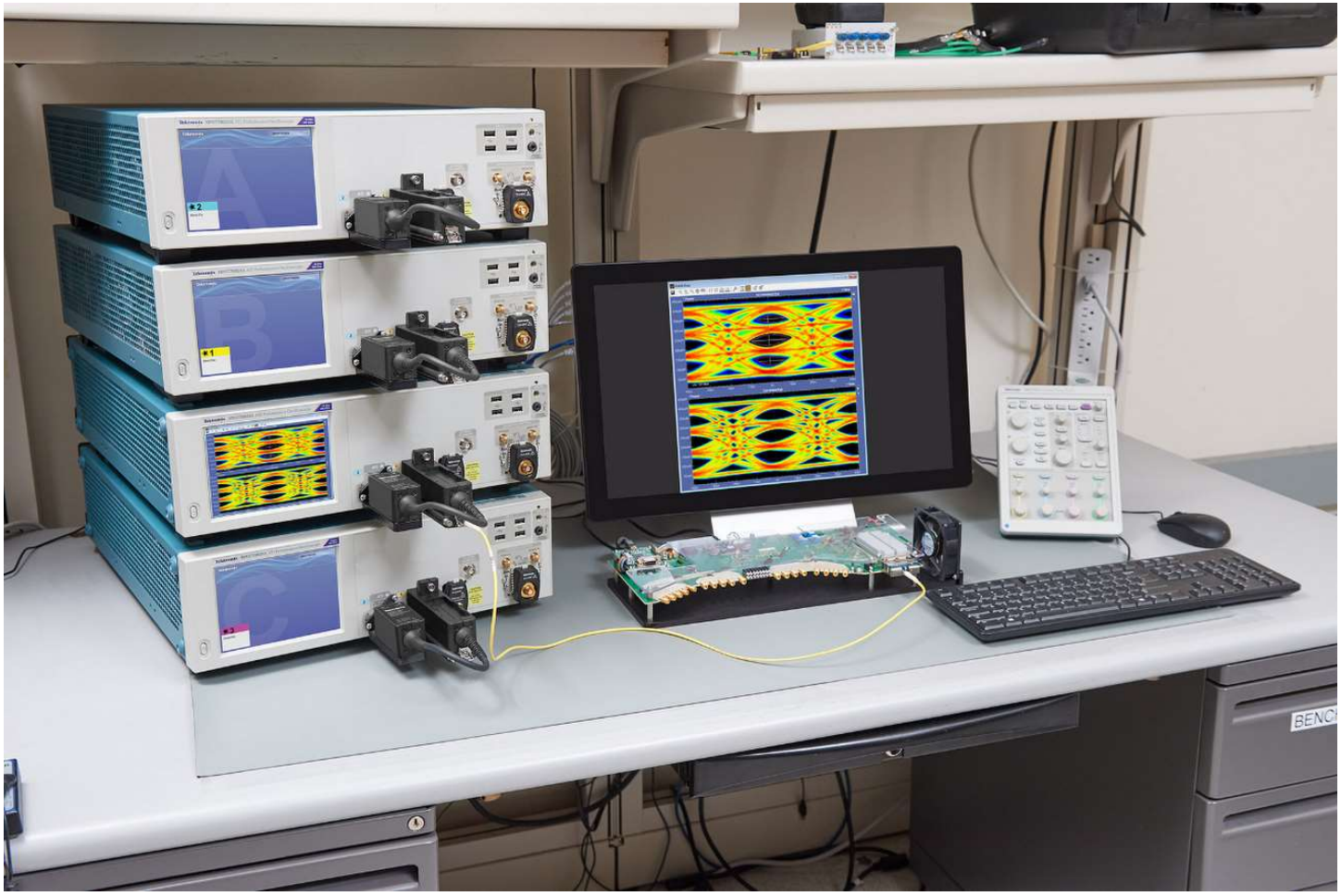
ONE-SAMPLE-PER-TRIGGER REPETITIVE PATTERN REQUIRED FOR PULSE STREAMS



An equivalent-time sampling oscilloscope (such as the DSA8300) requires a trigger signal: this is generally a user-supplied clock, a recovered clock, or a pattern sync signal synchronous to the signal.

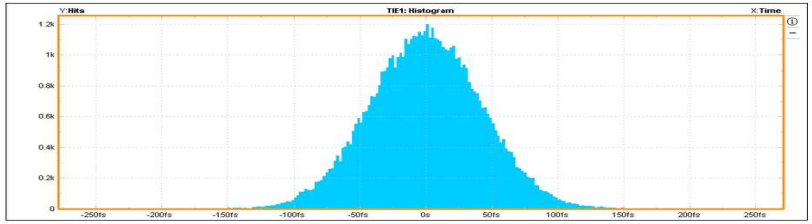
Note – this slide is an animation best viewed in Slide Show mode

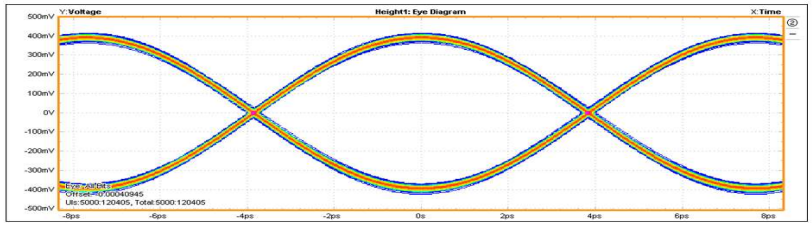
Industries Most Comprehensive PAM4 & NRZ Optical Analysis Solution



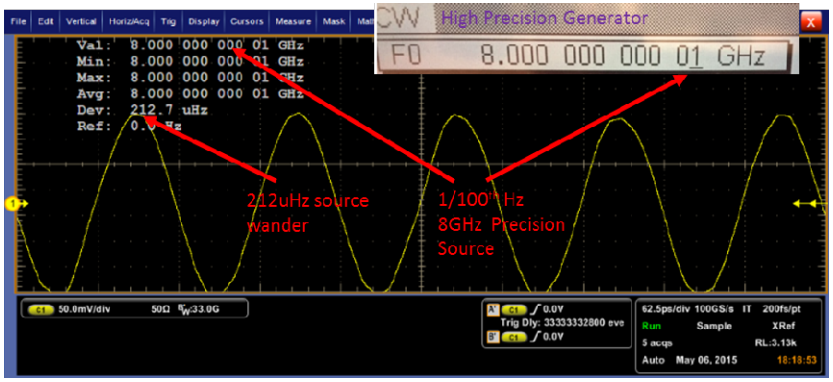
Tektronix 100G/400G Signal Acquisition Systems

Equivalent Time Signal Acquisition • Real Time Signal Acquisition Software Control and Analysis



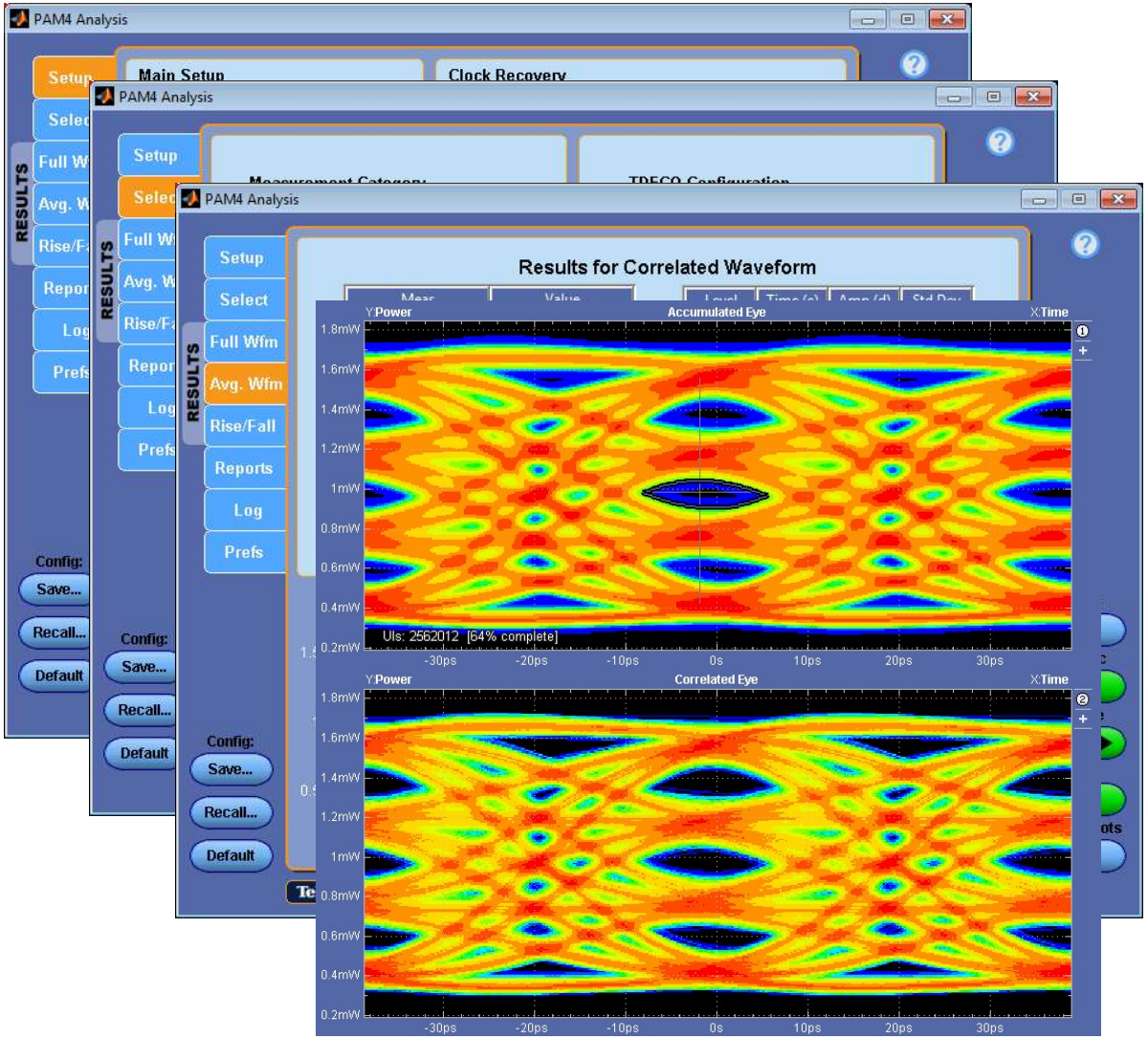


- Multi channel time synchronized operation.
- Unprecedented jitter noise floor.
  - ~ 40fs RMS clock jitter (64 GHz clock)
  - <125fs jitter noise floor (64Gbps PRBS)
- New HW trigger performance level easily triggers on 100G tributary Runt
- New Internal 13-digit precision frequency counter (54bit) provides frequency analysis to 25GHz, with 200fs resolution
- Highly accurate clock stability measurements
  - Accurate to < 1 part per billion



PAM4 Analysis

- Single Application for PAM4 analysis
- Dashboard style setup
- Robust Clock Recovery
- Integrated Equalizer
- Fixture embed / De-embed
- Autodetect Waveform properties
- IEEE and OIF-CEI electrical and Optical Measurements
- Comprehensive Analysis and Visualization
- Report with measurement results and plots



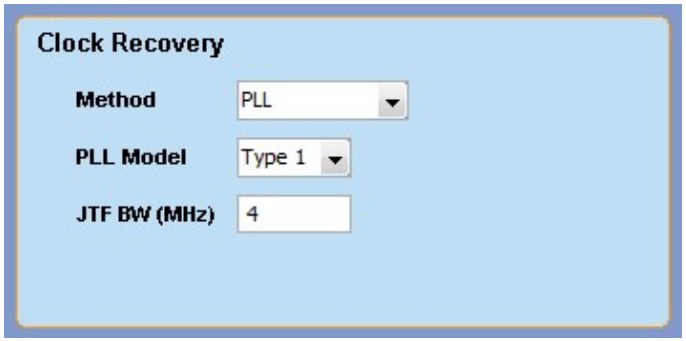
Comprehensive Measurement Suite

PAM4 Optical Measurements	
Error Analysis	• Symbol Errors, • SER • BER
Linearity	
Jitter	• Rj • Dj • Tj@BER
Statistical Eye Analysis	• Vertical Eye Closure • EW6 / EW5 • EH6 / EH5 • V_{upp} / V_{mid} / V_{low} • H_{upp} / H_{mid} / H_{low}
Optical	• ER • OMA • AOP
IEEE Specific	• TDECQ
Correlated Waveform	• Level Deviation • Level Thickness • Time Deviation • Rise and Fall

PAM4 Electrical Measurements	
Error Analysis	• Symbol Errors, • SER • BER
Linearity	
Jitter	• Rj • Dj • Tj@BER
Statistical Eye Analysis	• Vertical Eye Closure • EW6 / EW5 • EH6 / EH5 • V_{upp} / V_{mid} / V_{low} • H_{upp} / H_{mid} / H_{low}
SNDR	• SNDR • P_{max} • σ_e • σ_n
OIF-CEI	• UUGJ • UBHPJ • EOJ
IEEE Specific	• Jrms • J4 • EOJ • Rise Time • Fall Time • SNR_ISI
Correlated Waveform	• Level Deviation • Level Thickness • Time Deviation • Rise and Fall

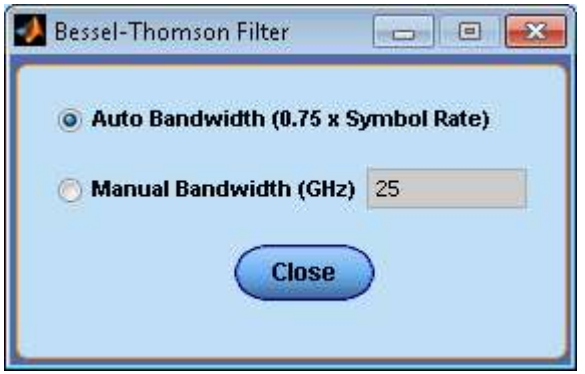
PAM4 Analysis

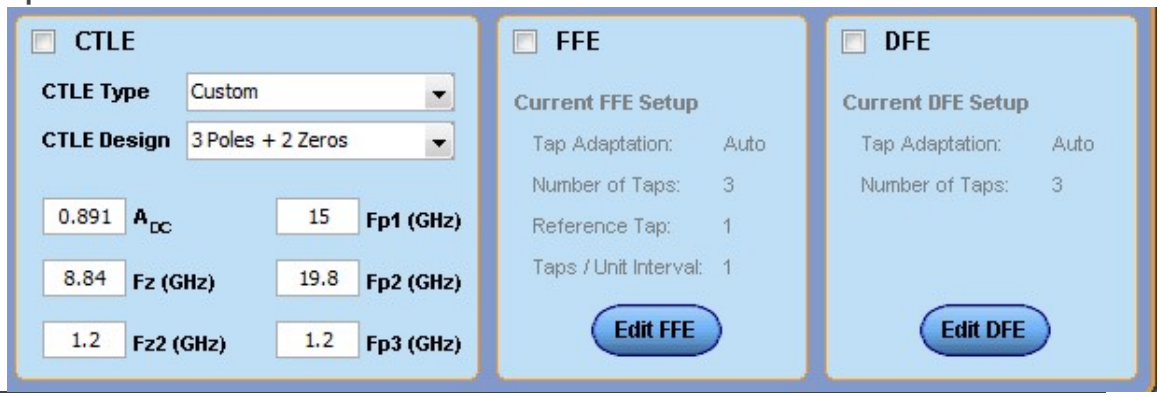
- Clock Recovery
  - Enables recovery of the sample clock from the acquired waveform
  - Uses a noise tolerant software model of PLL with programmable options
- Waveform Filter
  - Test fixtures used for signal access have effect on the signal
  - De-embed to remove effect of test fixtures
  - Embed to study effect of different channels



PAM4 Analysis

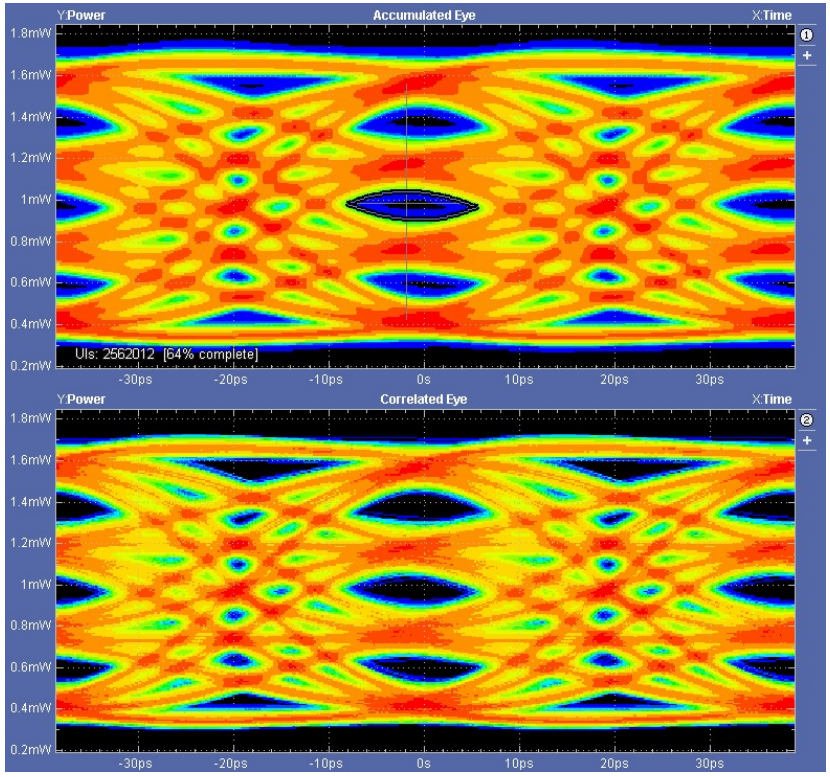
- BT Filter
  - Automatically apply BT filter based on detected bandwidth
- Equalizer
  - Enables the acquired eye to be opened by applying equalizers
  - Generic equalizer with programmable CTLE, FFE DFE offered
  - Load standard specific equalizer settings with single click
  - Auto-optimization of tap values per selected optimization criteria





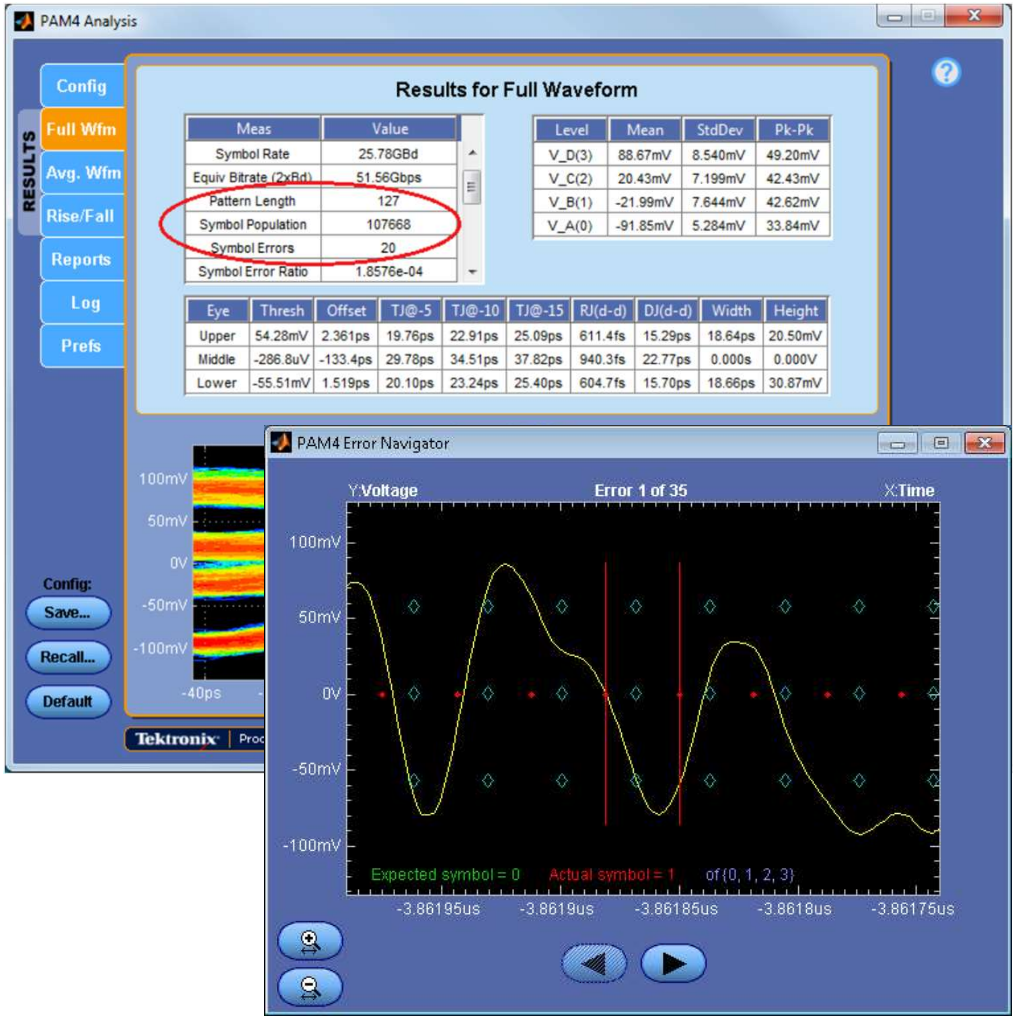
Full vs Correlated Waveform

- Full Waveform
  - Can be defined for waveforms with repeating or non repeating pattern
  - Fold the entire waveform to create eye
- Correlated Waveform
  - Only defined on waveform with repeating patterns
  - Single repeat of the pattern that shows only deterministic effects
  - Fold the single repeat to create eye



Error Detector

- Automatically detect symbol errors
- Visualize Symbol errors on error navigator
- Navigate to individual symbol / bit errors
- Clock recovery, eye centers and expected symbols annotated
- Accumulate SER and BER over multiple acquisition cycles



PAM4 TX Optical – Real Time

Only with the Tektronix DPO7OE1/OE2 …

Robust Clock Recovery

- PAM4 clock recovery that works reliably in the presence of higher ISI or noise found in PAM4 signaling
- PAM4 analysis even if you don't have access to a clock
- Fully configure clock recovery parameters for rates up to 64GBd

PAM4 Bit-Error Detection and Rate Analysis

- Overcome Low PAM4 Signal-to-Noise Ratio and Channel Effects
- Perform powerful PAM4 error rate analysis including debug of individual bit errors

PAM4 Optical Signal Measurements

- ORR (Optical Reference Receiver) performance for 28GBd & 56GBd PAM4/NRZ
- Optical measurements for both NRZ & PAM4 signals: ER, AOP, OMA, Eye Height, and Eye Width
- PAM4 IEEE and OIF-CEI standard specific measurements including TDECQ with best in class optical sensitivity and noise

Advanced Debug Capability

- Use Visual Triggering to isolate PAM4 events of interest
- Full-bandwidth long-time capture and a time-correlated/contiguous record of your signal allowing offline DSP analysis

DSA8300 Digital Serial Analyzer

- Industry's best native time-base jitter performance, 425 fs $_{RMS}$ *typical* (on up to 8 simultaneously acquired channels)
- <100 fs RMS time-base jitter when equipped with the 82A04B
- 16,000 point native record length
- 16 bits of vertical resolution
- 3 GHz Intel Core 2™ Duo CPU
- New user interface look and feel leveraging MS Windows 7 Ultimate Operating System
- XVGA (1024 X 768) 10.4 inch display

Electrical/TDR Products Summary

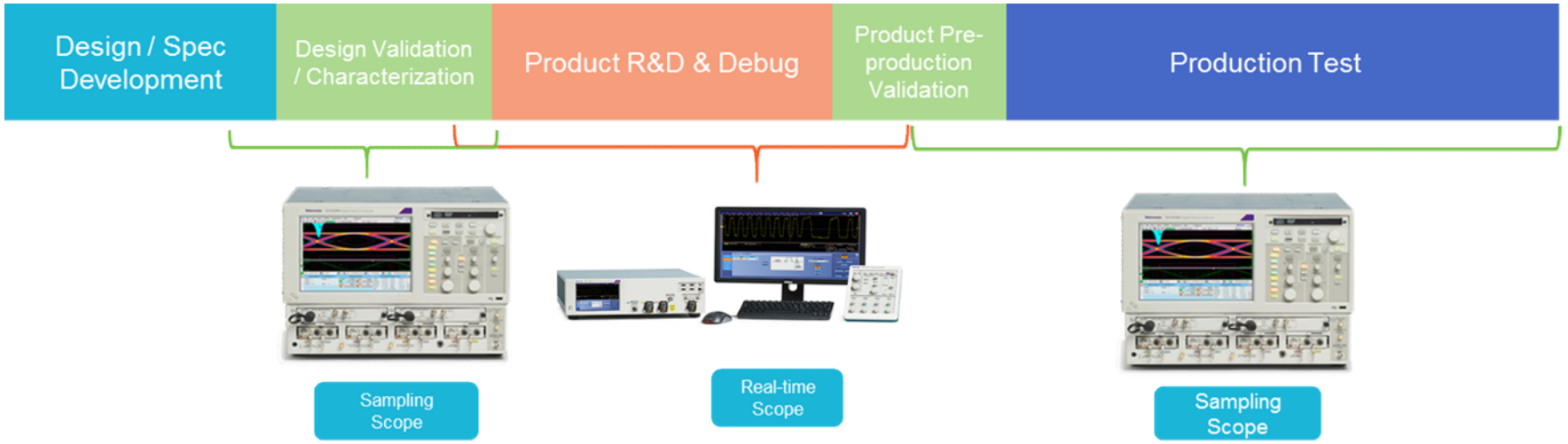
- Enhanced phase reference module and electrical sampling modules
  - 80E11, 80E11X1 – ultra-low jitter (85 fs RMS, typical), 70 GHz dual and single channel samplers
    - Highest bandwidth, ultra-low jitter, high fidelity signal acquisition
  - 80E07B, 80E08B, 80E09B, 80E10B – ultra-low jitter (95 fs RMS, typical) versions of the existing remote samplers

    - Remote samplers minimize aberrations due to cabling and test fixturing.
    - Select modules to meet bandwidth and noise requirements (20 GHz – 60 GHz)
    - 80E08B and 80E10B include highest performance integrated TDR capability
  - 80E03. 80E04
    - 20 GHz Electrical and TDR dual channel modules
    - Monolithic design TDR and electrical modules
  - 82A04B – enhanced phase reference module that enables <100 fs instrument jitter
    - Highest performance, multi-channel, low jitter solution

DSA8300 Optical Module Portfolio

Single and Multi-mode, Broad Wavelength (750 - 1650 nm) Modules	
80C07B	Supports standard rates to 2.7 Gb/s, high sensitivity, optional integrated clock recovery
80C08D	Supports all of the 8/10 Gb/s applications, high sensitivity, optional integrated clock recovery, optional Integrated CR
80C12B	Supports standard rates from 155 Mb/s – 11.3 Gb/s, high sensitivity - data pick-off for external CRU e.g. CR125A
80C14	Supports rates from 8.5 Gb/s – 14.063 Gb/s, high sensitivity – data pick-off for external CRU e.g. CR175A
80C15	Supports standard rates from 25.73 Gb/s – 28.05 Gb/s (maximum optical bandwidth > 32 GHz)
Single-mode, Long Wavelength (1100 - 1650nm) Modules	
80C11B	Optical bandwidth to 30GHz, supports 10Gbit/s up to14G+ standards, optional Integrated CR
80C10C	Optical bandwidth to 80GHz, supports all 40 and 100 Gb/s (4 x 25 Gb/s) standards, optional CR trigger pickoff for e.g. CR286A CRU, optional high sensitivity photo-receiver for use with external equipment (e.g. for optical BER testing with BERTScope)

Proposed Solutions



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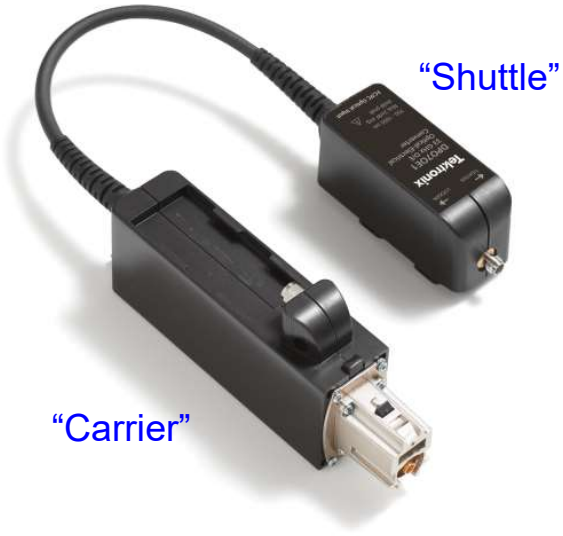
Introducing DPO7OE1 Optical Probe

- Broad wavelength O/E optimized for 28G Data Center Network App's
- 33 GHz Optical bandwidth, DC coupled
- Single mode, multi-mode, 750nm – 1650nm
- Compatible with TekConnect and ATI inputs
- Use with DPO/MSO70kC/D/DX and DPO70kSX

TekConnect – 33 GHz O/E



ATI – 28G ORR

ATI – Mechanical support deck

DPO7OE1 Optical Probe – Key Specs

Feature / Function	Key Specs
Connector Type	FC/PC & FC/APC
Input Fiber Type	9 µm - 50 µm (SMF & MMF)
Wavelength Range	750 nm – 1650 nm (Opt FC/PC) 1260 nm – 1650 nm (Opt FC/APC)
Calibrated Wavelengths	850 nm, 1310 nm, 1550 nm (Opt FC/PC) 1310 nm, 1550 nm (Opt FC/APC)
Optical Bandwidth	33 GHz
RMS Optical Noise (Typ @ 1310nm @ 28GBd ORR @ Min uW/div on ATI/TekConnect)	6.6 µW / 6.6 µW
Dynamic Range	4 mW [TekConnect] 2.5 mW [ATI]
Max Power (avg / peak)	2 mW / 4 mW
Coupling	DC
RT PAM4/NRZ Measurements	ER, AOP, OMA, Eye Height (EH6) for all 3 PAM-4 eyes, Eye Width (EW6) for all 3 PAM-4 eyes

DPO7OE1 Target Applications

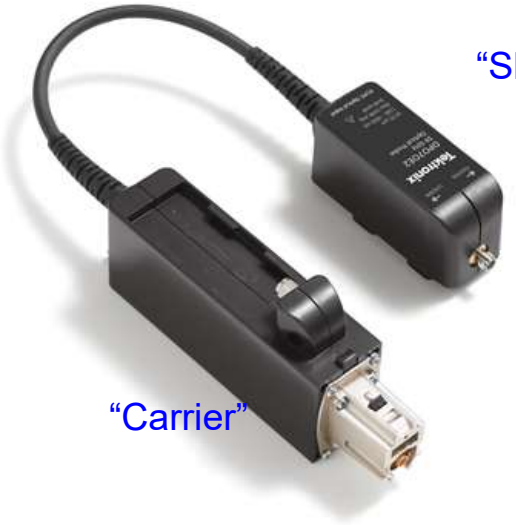
- 100G R&D users developing 2nd & 3rd generations of 100G lower power and/or lower cost devices
- R&D users using a sampling oscilloscope (ET) but also want to utilize real time (RT) oscilloscope's unique debug features including continuous real time acquisition, triggering, clock recovery and error detection

Distance	Technology	Per Lane Rate Modulation	Nomenclature	DPO7OE1
40km	Ethernet	PAM2 at 25.78GBd (25.7Gbps)	**100GBASE-ER4**	√
10km	Ethernet	PAM2 at 25.78GBd (25.78Gbps)	**100GBASE-LR4**	√
100m (MMF)	Ethernet	PAM2 at 28GBd (28Gbps)	**100GBASE-SR4**	√
100m (MMF)	Ethernet	PAM2 at 28GBd (28Gbps)	**400GBASE-SR16**	√
10km	Ethernet	PAM4 at 26 GBd (53Gbps)	**400GBASE-LR8**	√
2km	Ethernet	PAM4 at 26 GBd (53Gbps)	**400GBASE-FR8**	√

- Sampling oscilloscopes (ET) continue to have lower optical noise and lower cost than real time (RT) oscilloscopes making them excellent characterization tools, thus **complementing** the debug features of a real time oscilloscope

Introducing DPO7OE2 Optical Probe

- Optimized for 56G Data Center Network App's
- 59 GHz Optical bandwidth, DC coupled
- Single mode, 1200nm – 1650nm
- Compatible with TekConnect and ATI inputs
- Use with DPO70kSX



ATI – 56G ORR

ATI – Mechanical support deck

DPO7OE2 Optical Probe – Key Specs

Feature / Function	Key Specs
Connector Type	FC/PC & FC/APC
Input Fiber Type	9 µm - 50 µm (SMF & MMF)
Wavelength Range	1200 nm – 1650 nm (Opt FC/PC) 1200 nm – 1650 nm (Opt FC/APC)
Calibrated Wavelengths	1310 nm, 1550 nm (Opt FC/PC) 1310 nm, 1550 nm (Opt FC/APC)
Optical Bandwidth	59 GHz
RMS Optical Noise (Typ @ 1310nm @ 28GBd ORR @ Min uW/div on ATI)	10 µW
Dynamic Range	2.5 mW [ATI]
Max Power (avg / peak)	2 mW / 3 mW [ATI]
Coupling	DC
RT PAM4/NRZ Measurements	ER, AOP, OMA, Eye Height (EH6) for all 3 PAM-4 eyes, Eye Width (EW6) for all 3 PAM-4 eyes

DPO7OE2 Target Applications

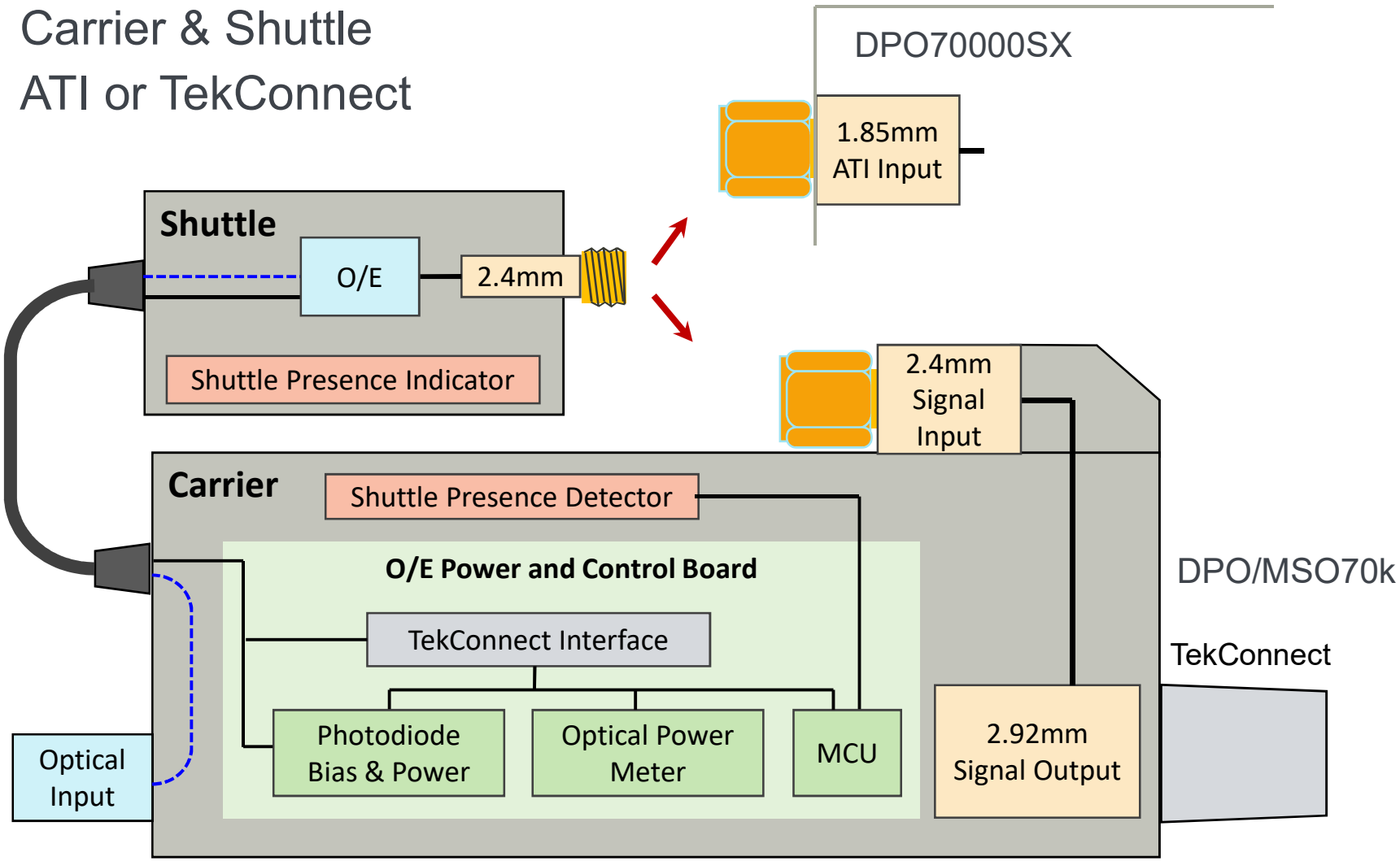
- 400G R&D users developing devices transitioning from 28GBd → 56GBd and/or NRZ → PAM4
- R&D users using a sampling oscilloscope (ET) but also want to utilize real time (RT) oscilloscope's unique debug features including continuous real time acquisition, triggering, clock recovery and error detection

Optical Standard	Modulation	Distance	Data Rate	Multiplex	Signaling Rate	DPO7OE2
200GBASE-SR4 (802.3cd) similar: 100GBASE-SR2, 50GBASE-SR	PAM4	70m, 100m	N lane x 50Gbps	<n> parallel MMF	26.56 GBd	√
200GBASE-DR4 (802.3bs)	PAM4	500m	4 lane x 50Gbps	4 parallel SMF	26.56 GBd	√
400GBASE-DR4 (802.3bs) similar: 100GBASE-DR	PAM4	500m	<n> lane x 100Gbps	4 parallel SMF	53.125 GBd	√
400GBASE-FR8 (802.3bs) similar: 200GBASE-FR4, 50GBASE-FR	PAM4	2km	<n> lane x 50Gbps	1 SMF 8λ WDM	26.56 GBd	√
400GBASE-LR8 (802.3bs) similar: 200GBASE-LR4, 50GBASE-LR	PAM4	10km	<n> lane x 50Gbps	1 SMF 8λ WDM	26.56 GBd	√

- Sampling oscilloscopes (ET) continue to have lower optical noise and lower cost than real time (RT) oscilloscopes making them excellent characterization tools, thus **complementing** the debug features of a real time oscilloscope

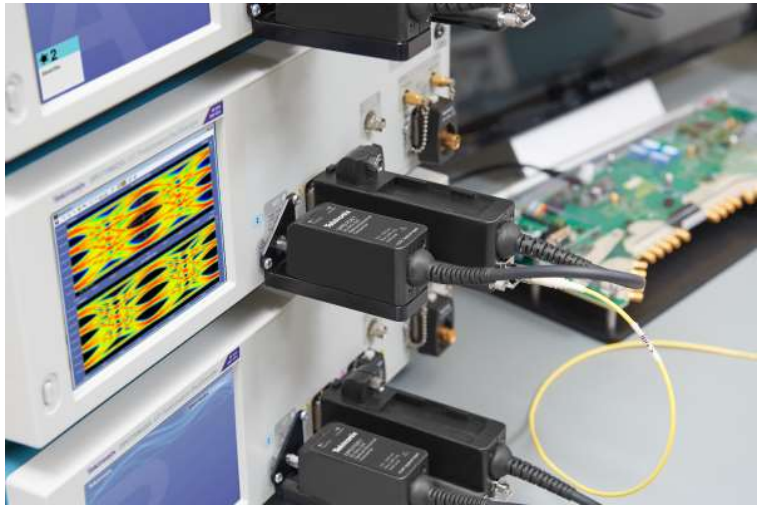
DPO7OE1/OE2 Block Diagram

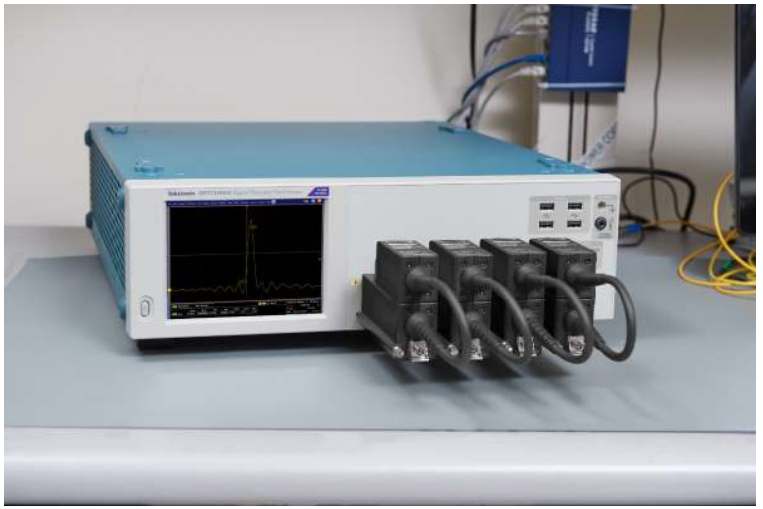
- Carrier & Shuttle
- ATI or TekConnect

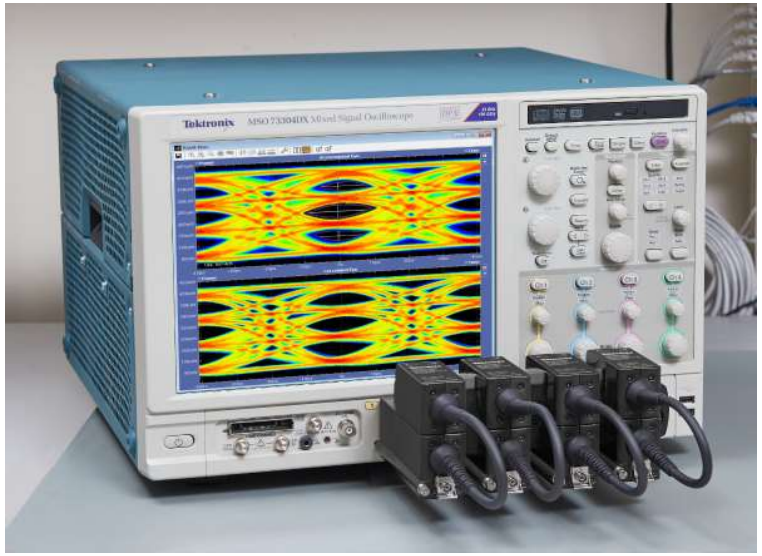


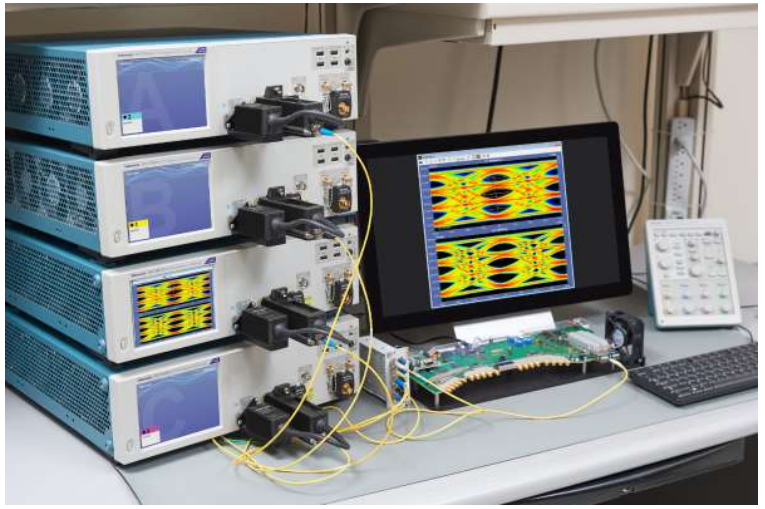
DPO7OE1/OE2 – Typical Configurations

MSO/DPO70KC/D/DX AND DPO70KSX - ATI OR TEKCONNECT





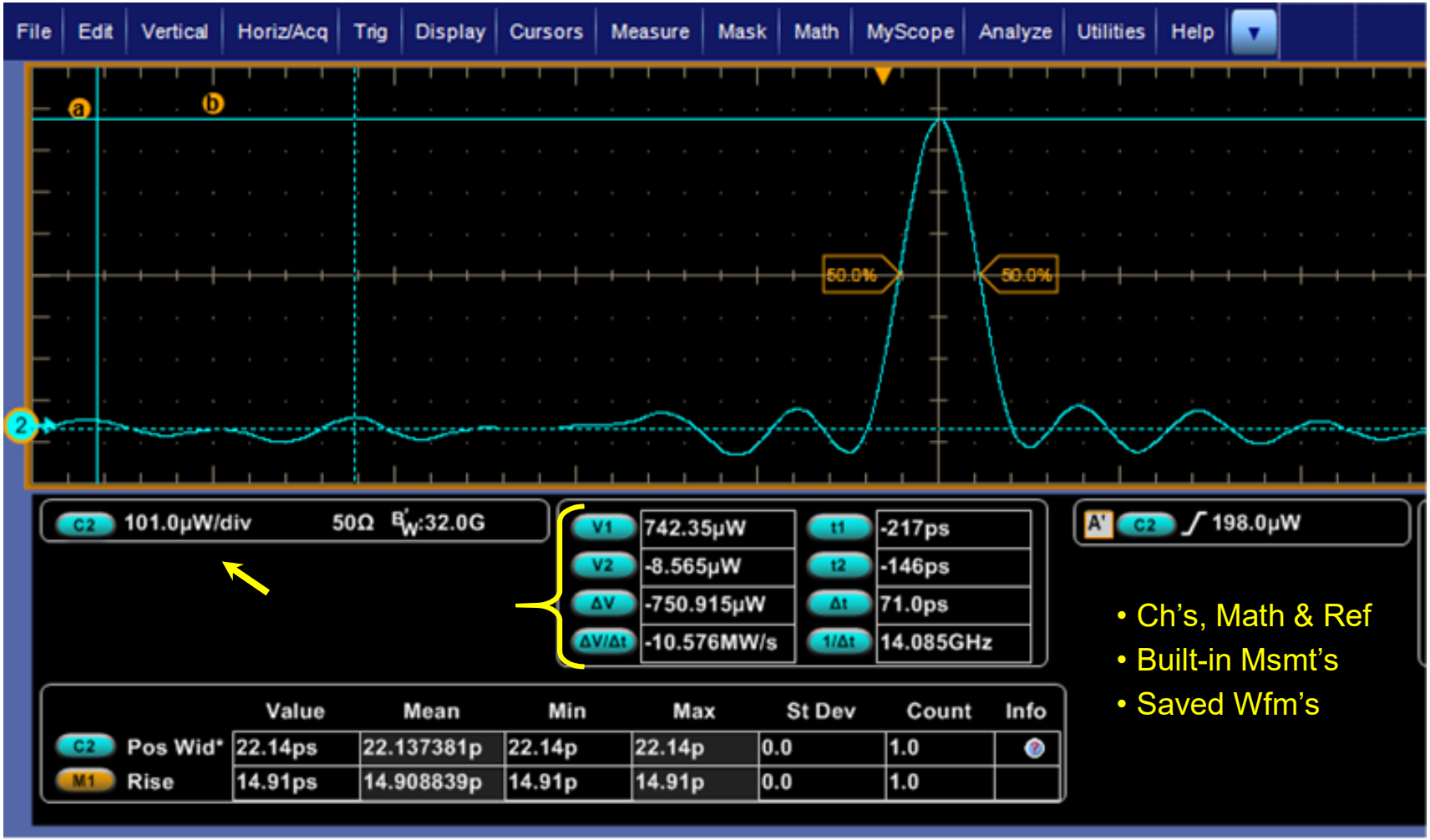




Fully Scalable System to Meet Changing Needs

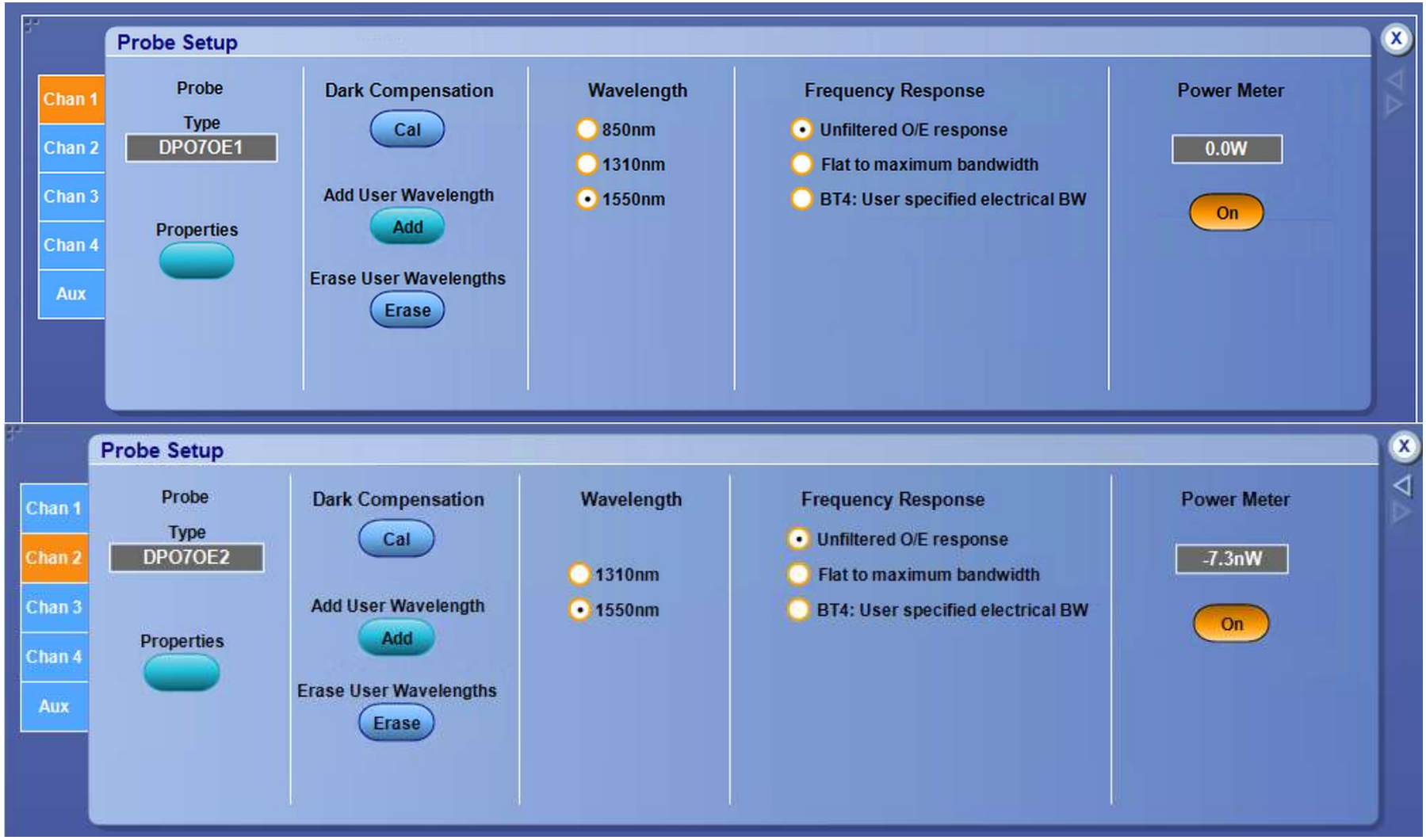
- DPS77004SX system building block
  - 2 channels @ 70GHz, 200GS/s
  - 4 channels @ 33GHz, 100GS/s
- Aggregate units to build system
- Distribute units for individual needs

DPO7OE1/OE2 – Optical Power Scaled in Watts



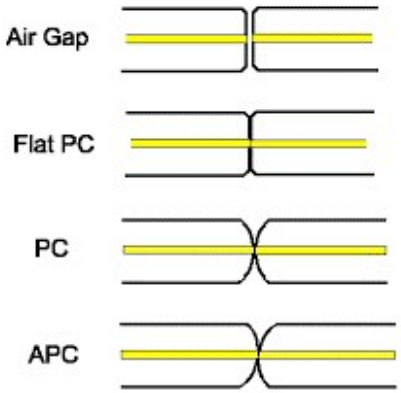
- Ch's, Math & Ref
- Built-in Msmt's
- Saved Wfm's

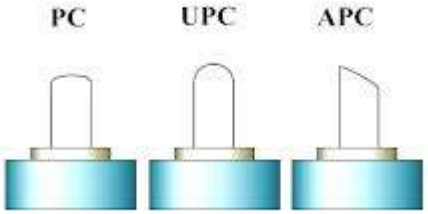
DPO7OE1/2 – Control Panel (Frequency Response)

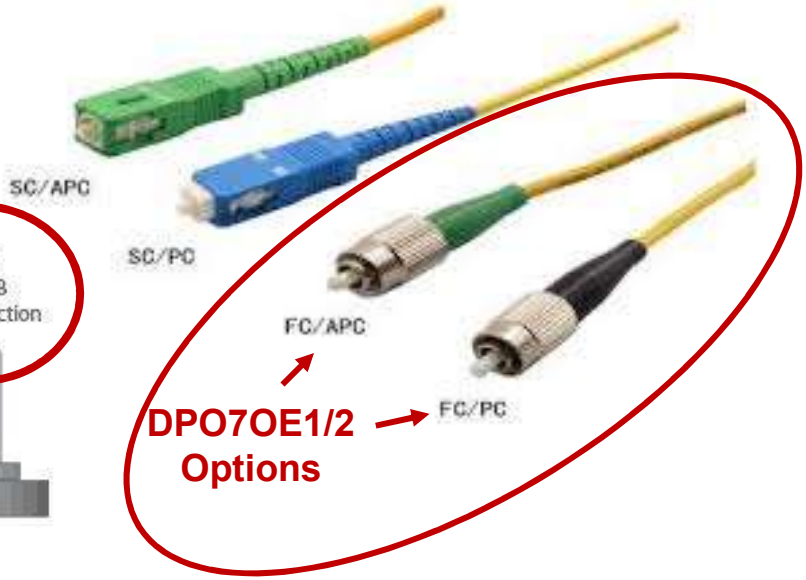


Optical Input Connector Types

- Two (2) ordering options:
  1. FC/PC – “Physical Contact”
  2. FC/APC – “Angled Physical Contact”







Tektronix

80C17/18 80C10C Support 26G/53GBd PAM4

New Optical Modules for DSA8300 Series

24-AUG-2018

Overview

KEY OBJECTIVES

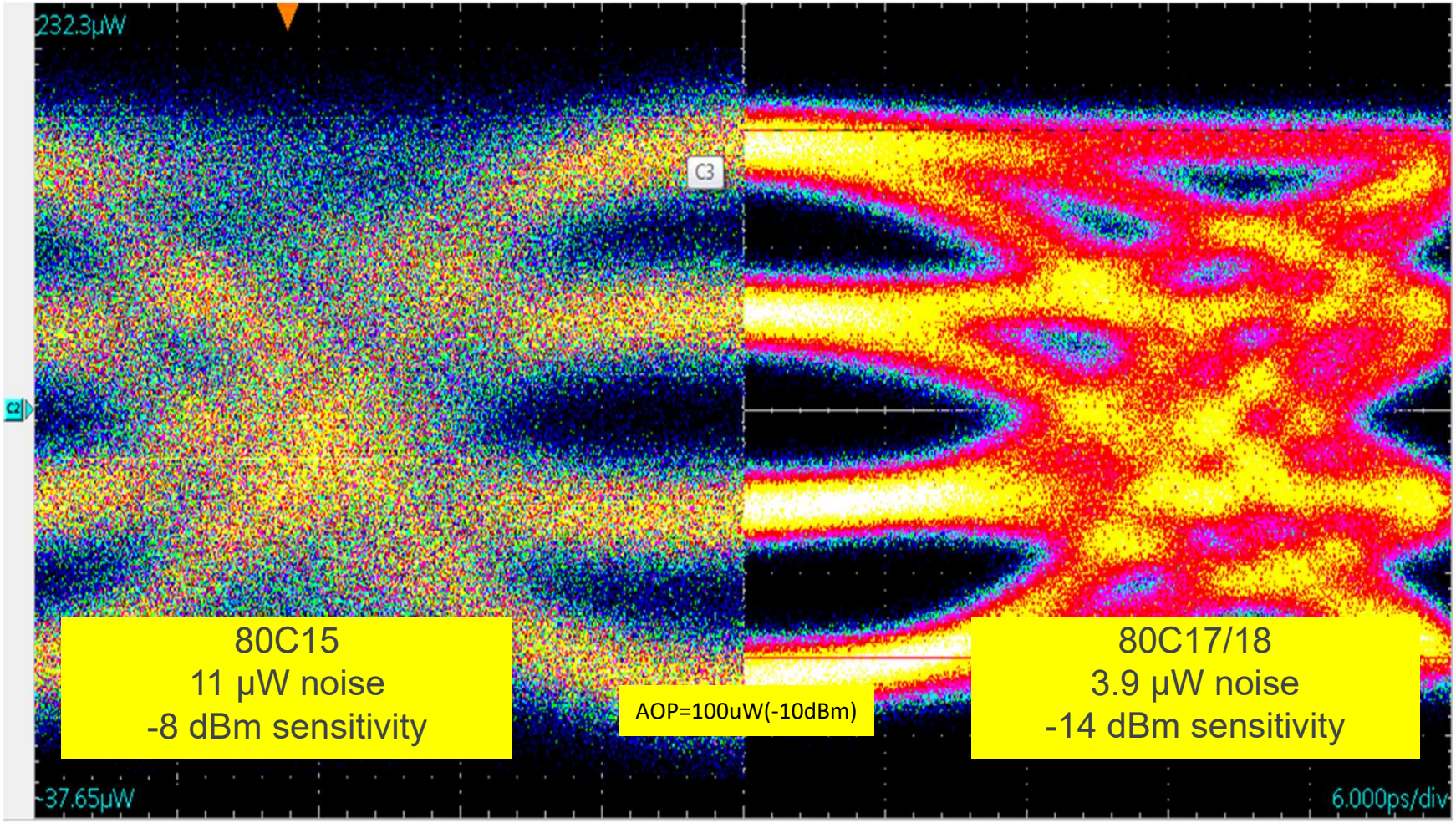
- Better optical performance than previous generation
  - Lower noise
  - Higher mask margin
  - More optical channels
- 26GBd & 53GBd NRZ measurements with higher margin, higher yield, at lower optical powers
- 26GBd & 53GBd PAM4 measurements with multi-level analysis, TDECQ, and eye mask at 56Gbd
- Optimized for parallel, multi-port testing in manufacturing environment.

80C17/18 vs 80C15

Feature / Function	80C17/18 *Target Specs*	80C15 *Current Specs*
# Channels	1 or 2	1
Input Fiber Type	MM + SM 9, 50 µm (no 62.5 µm)	MM + SM 9, 50, 62.5 µm
Wavelength Range	800nm - 1650nm	800nm - 1650nm
Unfiltered Optical Bandwidth	>30 GHz	>32 GHz
Unfiltered Risetime (typical)	14 ps	14 ps
Optical Reference Receivers	25.78 – 28.05 Gb/s	25.78 – 28.05 Gb/s
RMS Optical Noise Typical @ 1310 nm @ 25.78 Gb/s	3.9 µW	11 µW
Mask Test Sensitivity Typical @ 1310nm	-14 dBm	-8 dBm
Power Meter Zero Level Performance - Sample rate reduced by increasing channels	None	2 ch – half 4 ch - quarter

80C17/18 vs 80C15

Impact of Noise and Sensitivity



80C17/18 @ 53GBd

Single/multi-mode, multirate datacom and telecom 25 Gb/s, 100 Gb/s, and PAM4 for 50G/100G/200G/400

80C17/18 can support 53G/56GBd PAM4 by using impulse filter to extend optical bandwidth to 45Ghz（-3db）.

80C17, 80C18

Opt. IMP	Impulse response correction. In conjunction with DSA8300 400G-M4 may be used to extend optical channel bandwidth up to 45 GHz (-3dBo).

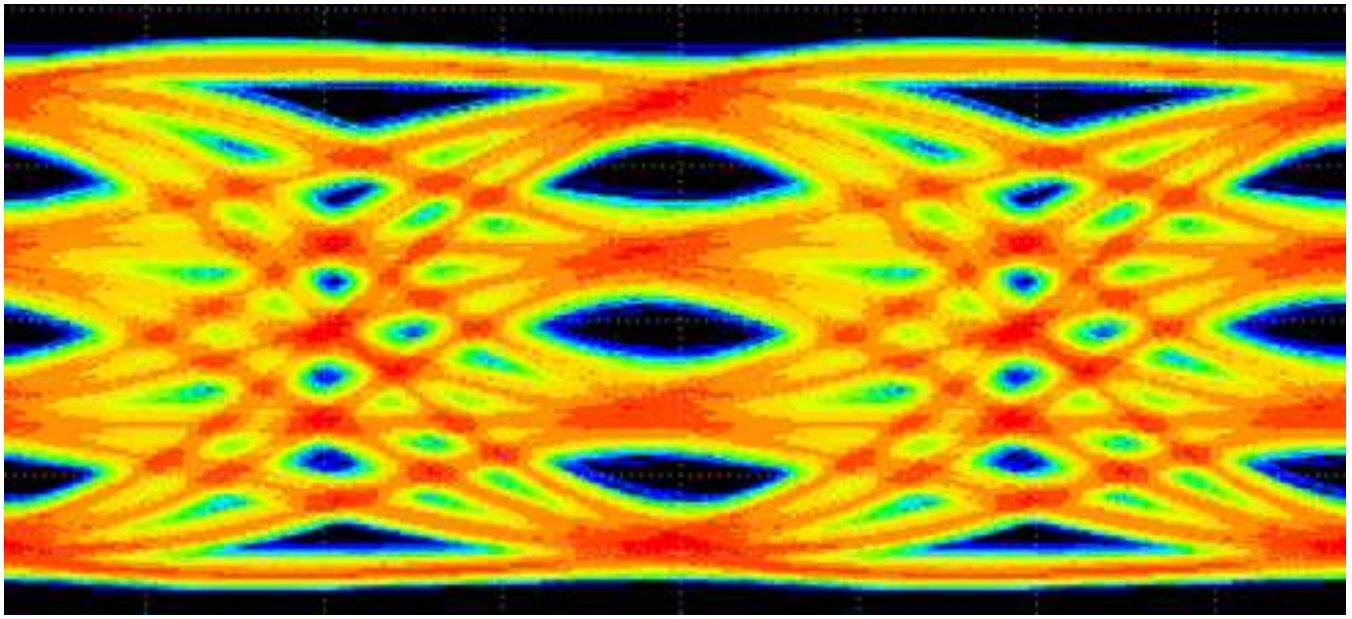
400G-M4 BWE Configure

80C10C

Feature/ Spec	80C10C *Current Specs*
# Channels per Module / System	1
Unfiltered Optical Bandwidth (-3dBo)	80 GHz
Wavelength Range	1290 to 1620 nm
Calibrated Wavelengths	1310 nm / 1550 nm
Optical Noise (RMS) @ 1310 nm @ 37 GHz, Typical / Maximum	29.9 µW / 52 µW
Optical Sensitivity @ 1310 nm	-6 dBm
Max input power, non-destruct, average/peak	30 mW
Dynamic range (full scale)	15 mW
Optical return loss	>30 dB
Acquisition delay adjustment range on each channel	---
Power meter range	+13 dBm to -21 dBm
Input Fiber Type	9 µm
Clock Recovery Trigger Pick-off Option	Yes

80C10C
Impact of bandwidth

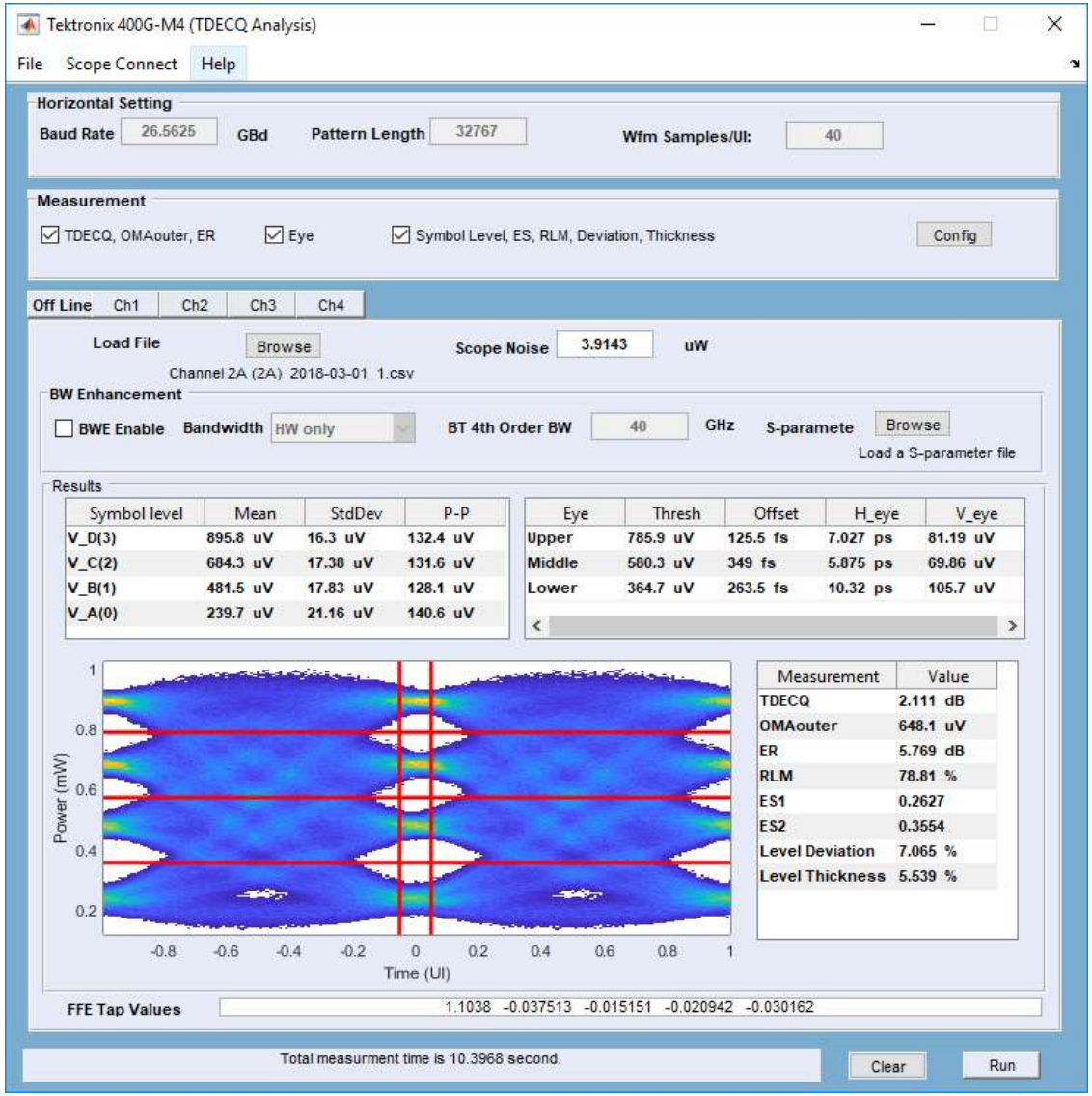
The higher hardware bandwidth can get better Eye parameters before equalization with 53G/56Bd PAM4 signal，it is better for optical materials and chips analysis



DSA8300 400G-M4 Overview

- DSA8300 400G-M4 Software application
- New 64-bit PC based PAM4 Optical Manufacturing Solution
  - Support for online mode through 4 channel simultaneous acquisition
  - Limited set of measurements targeted at PAM4 Optical Signal measurement
    - Levels
    - Level Deviation
    - Level Thickness
    - Linearity
    - OMA
    - ER
    - Eye Width / Eye Height
    - TDECQ
- Support for auto-optimization and user defined equalizer taps values
- Support for user defined bandwidth enhancement filters- adjustable filters
- Support for BWE Filters
- Independent control for vertical channel set up
- Dashboard style UI with simplified setup

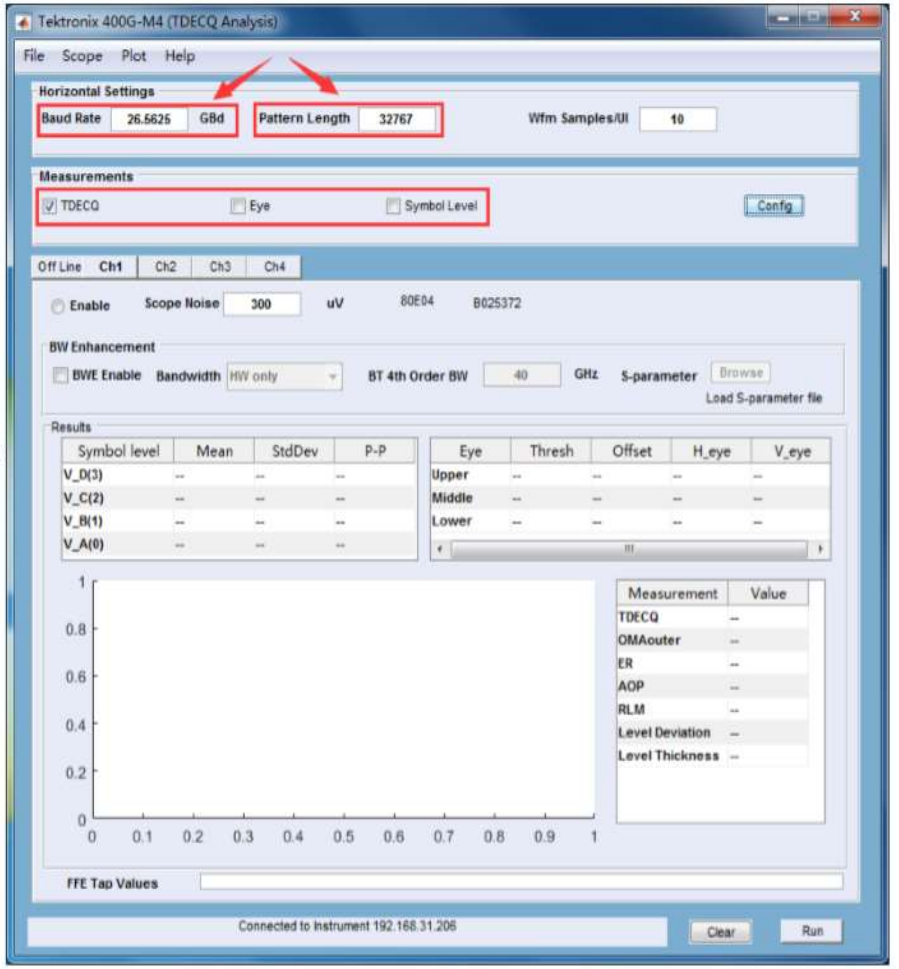
DSA8300 400G-M4 UI



400G-M4 UI

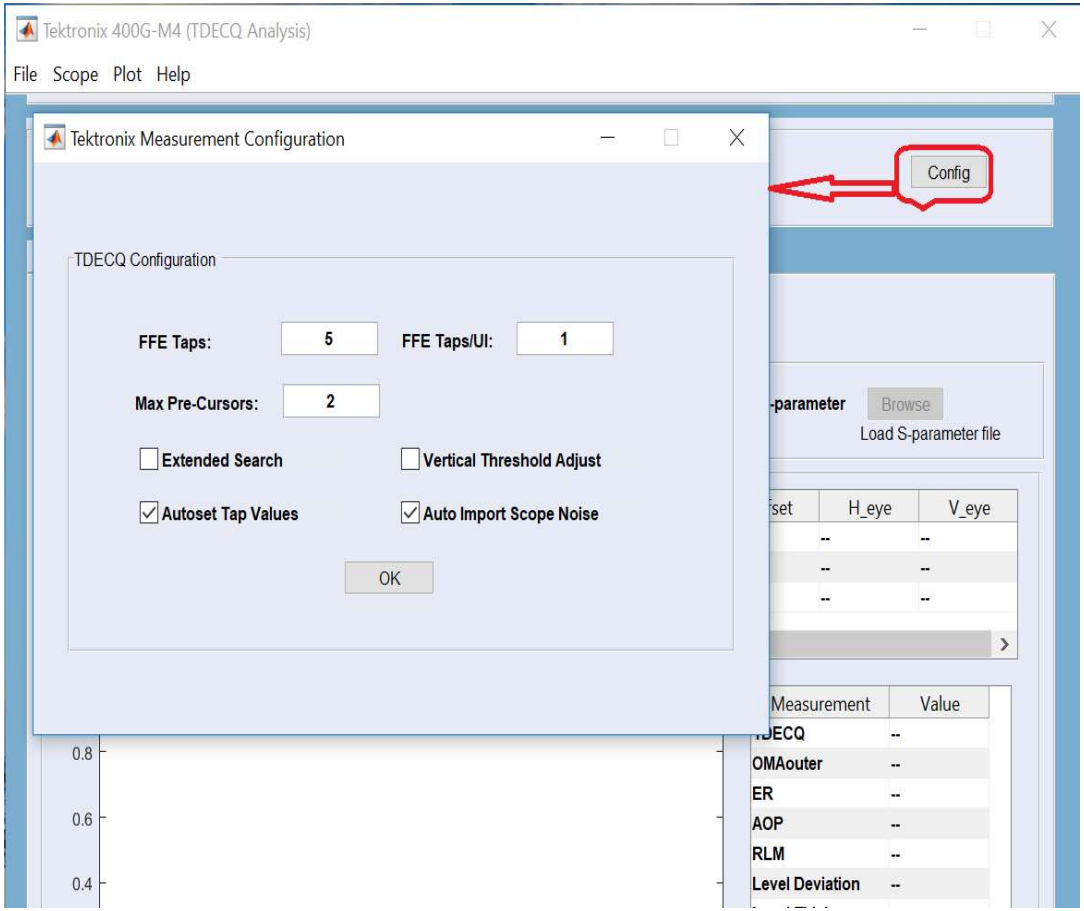
400G-M4 setting

- Baud Rate / Pattern Length and test items
  - Baud Rate: Key in the baud rate of your DUT, default is 26.5625GBd
  - Pattern Length: Key in the pattern length of your DUT, default is 32767 UI
  - TDECQ: if check this item you will get the results: TDECQ/OMAouter/ER/AOP
  - Eye: if you check this item you will get the results:Threshold/Offset/Eye-horizontal/Eye-vertical
  - Symbol Level: if you check this item you will get the results:RLM/Level Deviation/Level Thickness and 4 levels value



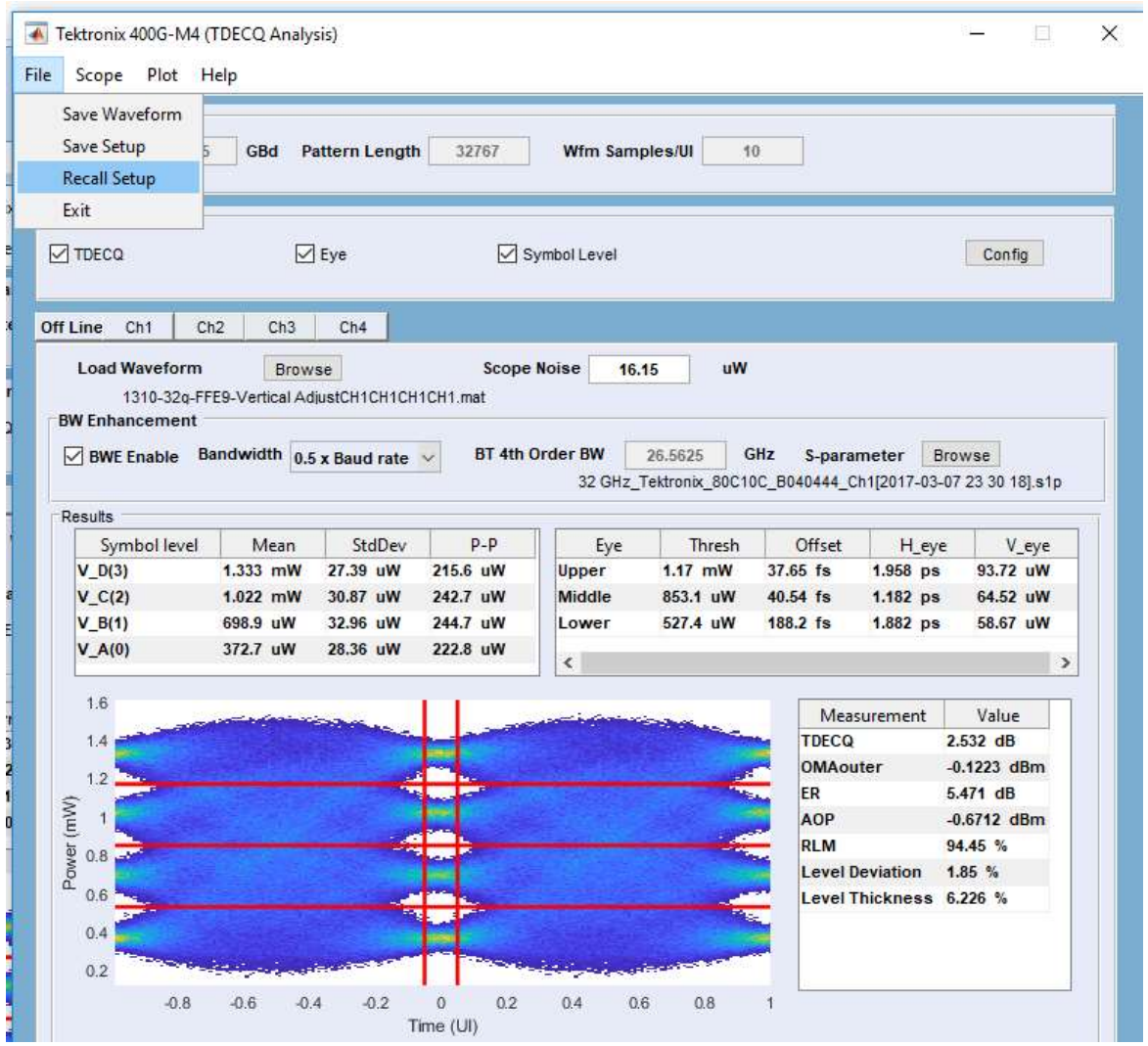
400G-M4 UI

TDECQ Configuration



- FFE Tap: Equalization setting
- Extend search: Tdecq optimized
- Vertical Threshold Adjust: Follow the newest IEEE spec to make 1% vertical eye threshold adjustment
- Autoset Tap Values Automatically adjust and set FFE tap value with each run
- Auto Import Scope Noise: Automatically import scope and optical modules noise floor, it will be minus in Tdecq calculate

Setup for quick setting

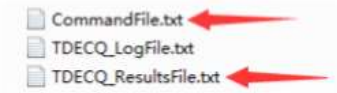


400G-M4 can save setup to a *.gm4 file and recall the setup file to quick setting test requirements such as data rate/ pattern length/ test items/ FFE config/ imp filter.
It will save more times and make configures easy.

Send command to 400G-M4

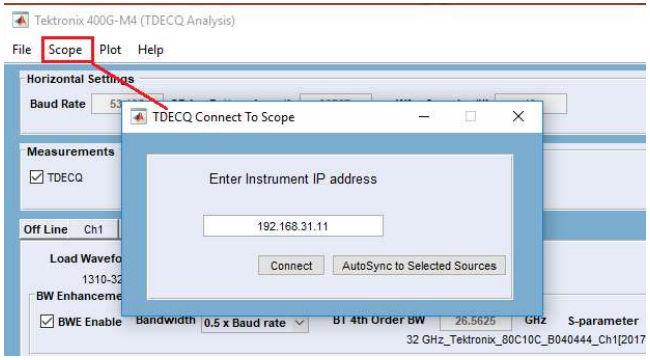
- There is a txt file located in the path
  - C:\Users\"your name"\AppData\Local\Temp\
  - Just write the command: :variable:value "tdecq","analyze“ to the file, then 400G-M4 will begin to run, the effect like you click the “Run” button on the UI

- Once the test finished, all active results will write to the file “TDECQ_ResultsFile.txt”
  - Just open this file and then you get results



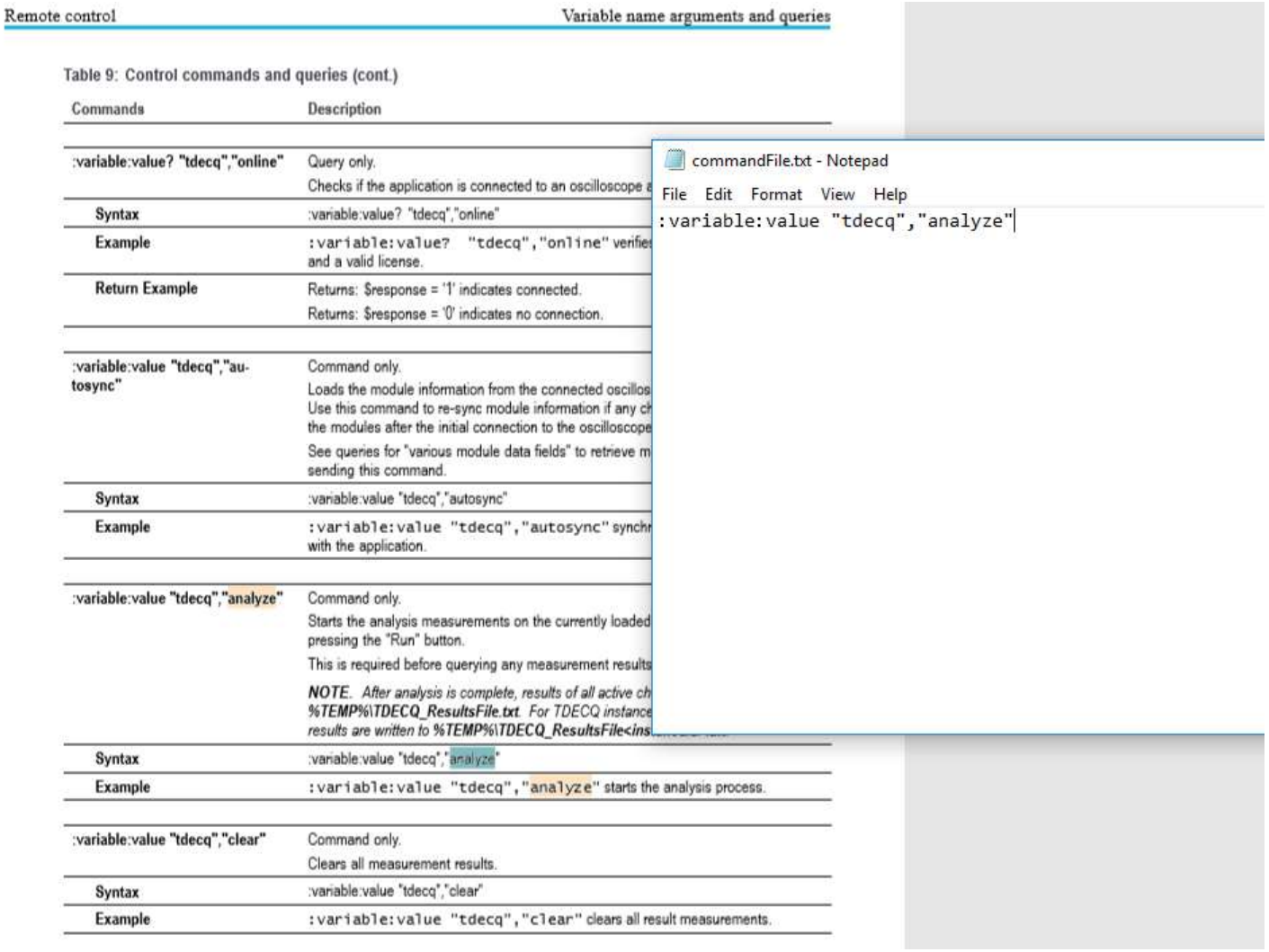
❖ 400G-M4 connect to DSA8300 by Lan
Both command and data communicate by Lan

- Add the IP address of your DSA8300 for search



Command Control

Almost all of DSA8300 operations can control by write 400G-M4 commandFile



Remote control — Variable name arguments and queries

Table 9: Control commands and queries (cont.)

Commands	Description
:variable:value? "tdecq","online"	Query only. Checks if the application is connected to an oscilloscope a
Syntax	:variable:value? "tdecq","online"
Example	:variable:value? "tdecq","online" verifies and a valid license.
Return Example	Returns: $response = '1' indicates connected. Returns: $response = '0' indicates no connection.
:variable:value "tdecq","autosync"	Command only. Loads the module information from the connected oscillos Use this command to re-sync module information if any ch the modules after the initial connection to the oscilloscope See queries for "various module data fields" to retrieve m sending this command.
Syntax	:variable:value "tdecq","autosync"
Example	:variable:value "tdecq","autosync" synchr with the application.
:variable:value "tdecq","analyze"	Command only. Starts the analysis measurements on the currently loaded pressing the "Run" button. This is required before querying any measurement results *NOTE. After analysis is complete, results of all active ch* *%TEMP%\TDECQ_ResultsFile.txt. For TDECQ instance* *results are written to %TEMP%\TDECQ_ResultsFile<ins*
Syntax	:variable:value "tdecq","analyze"
Example	:variable:value "tdecq","analyze" starts the analysis process.
:variable:value "tdecq","clear"	Command only. Clears all measurement results.
Syntax	:variable:value "tdecq","clear"
Example	:variable:value "tdecq","clear" clears all result measurements.

commandFile.txt - Notepad

File Edit Format View Help

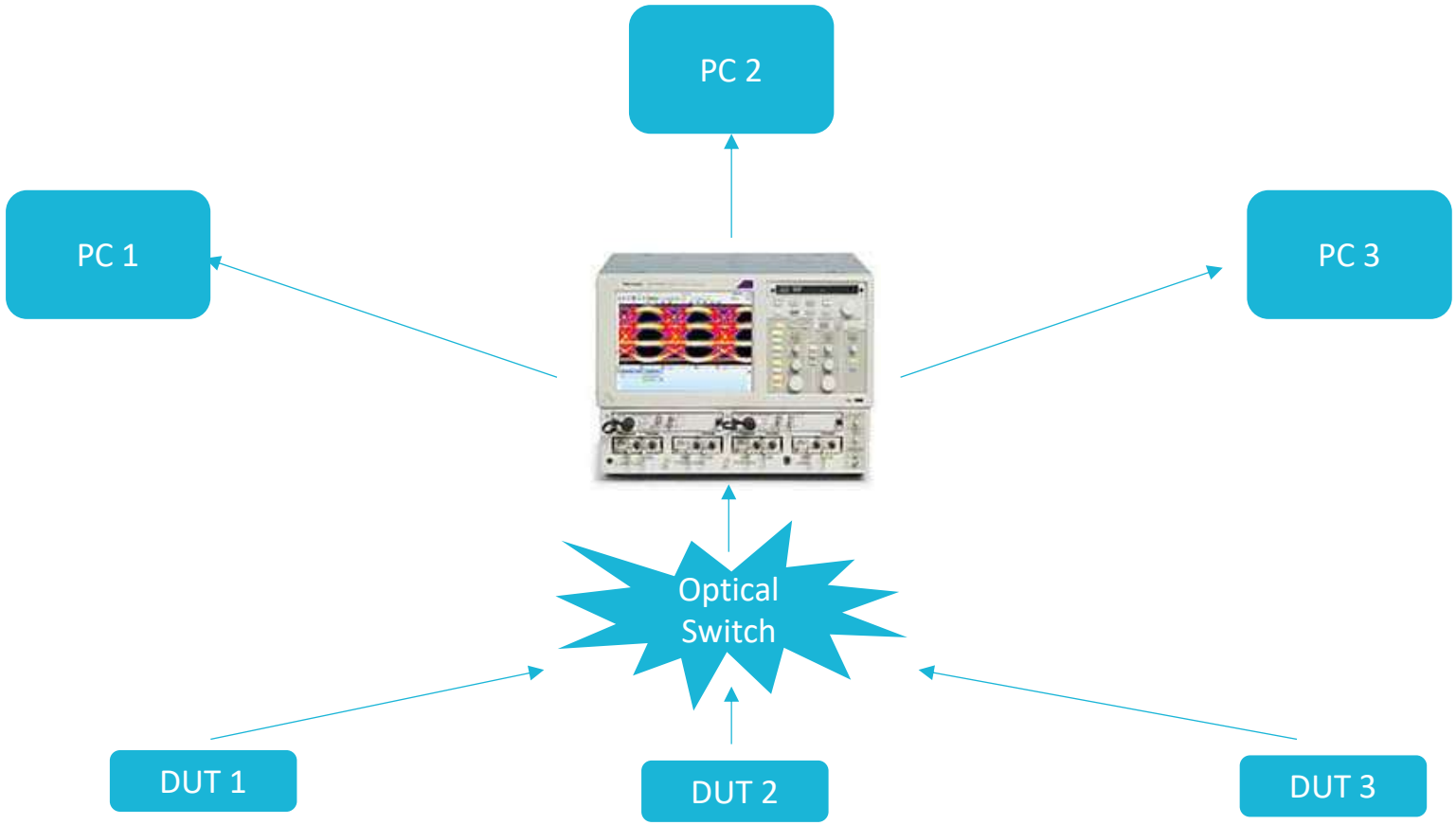
```
:variable:value "tdecq","analyze"
```

Test Time Improvements

	80SJNB- Fast TDECQ		DSA 8300 400G-M4	
	1 Channel	4 Channels	1 Channel	4 Channels
PRBS-15	20 sec	80 sec	12 sec	24 sec
Measurements	TDECQ		TDECQ	
	OMAouter		OMAouter	
	ER		ER	
	AOP		AOP	

400G-M4 separate acquisition and analysis，it can make 4 channels parallel test，it will save more times for production automation test.

Multi-PC control One DSA8300



Q&A

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Thanks!