Anritsu envision:ensure

58 G/64 Gbaud Multichannel PAM4 BERT

PAM4 PPG MU196020A

PAM4 ED MU196040B NEW

Signal Quality Analyzer-R

MP1900A Series

SQA-R

Outline of MP1900A Series PAM4 BERT

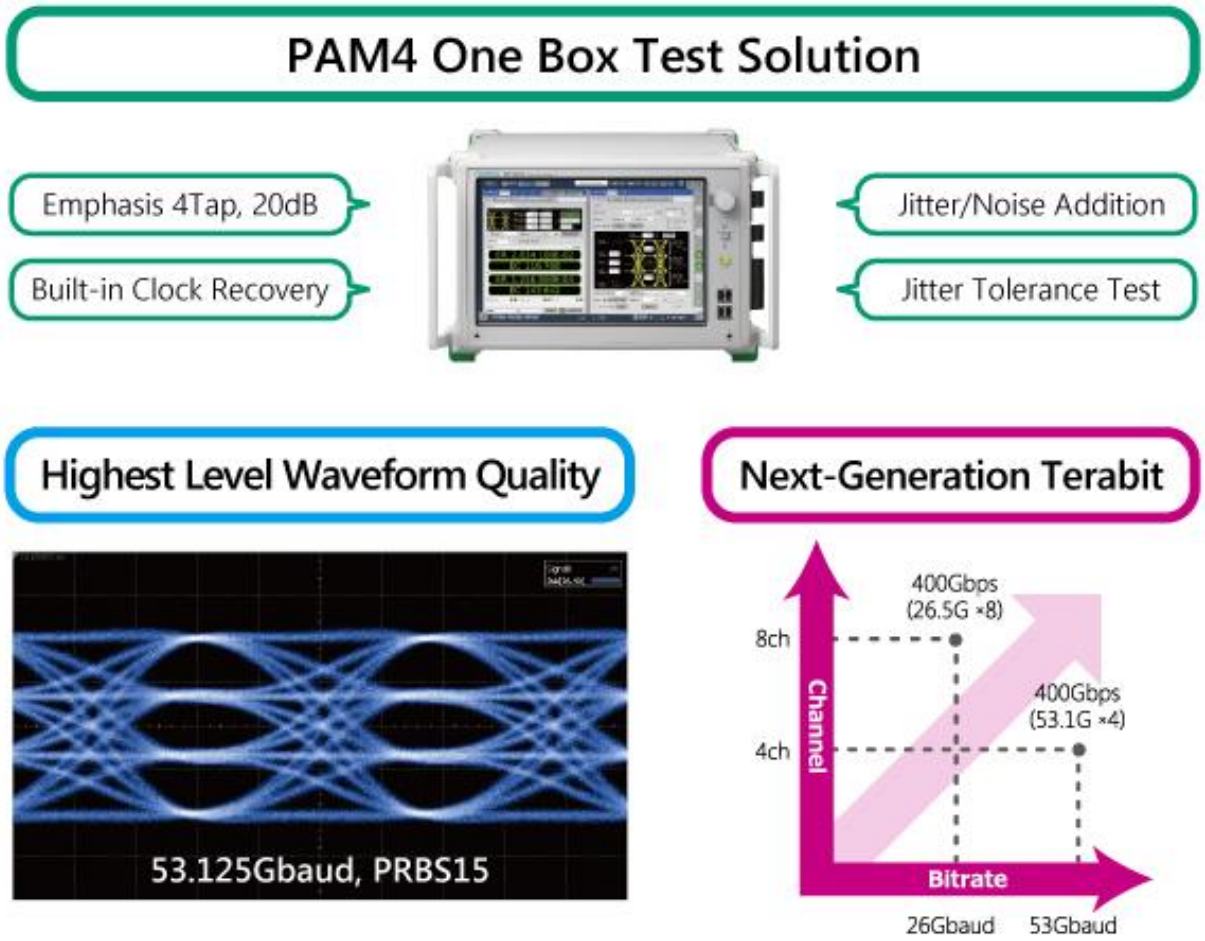
- Supports bit error rate measurements optimized for high-speed 400 GbE and next-generation 800 GbE interfaces
- High-quality data output waveforms up to 64 Gbaud and high input sensitivity performance provide strong support for testing PAM4 device designs
- All-in-one Jitter Addition, Clock Recovery, Emphasis, NRZ/PAM3/PAM4 Pattern Editing, SER functions, etc.
- Easily configured, high-reproducibility PAM4 measurement solution

MP1900A PAM4 Target Applications

200/400/800 GbE, CEI-56G/112G, InfiniBand HDR, 64G Fibre Channel

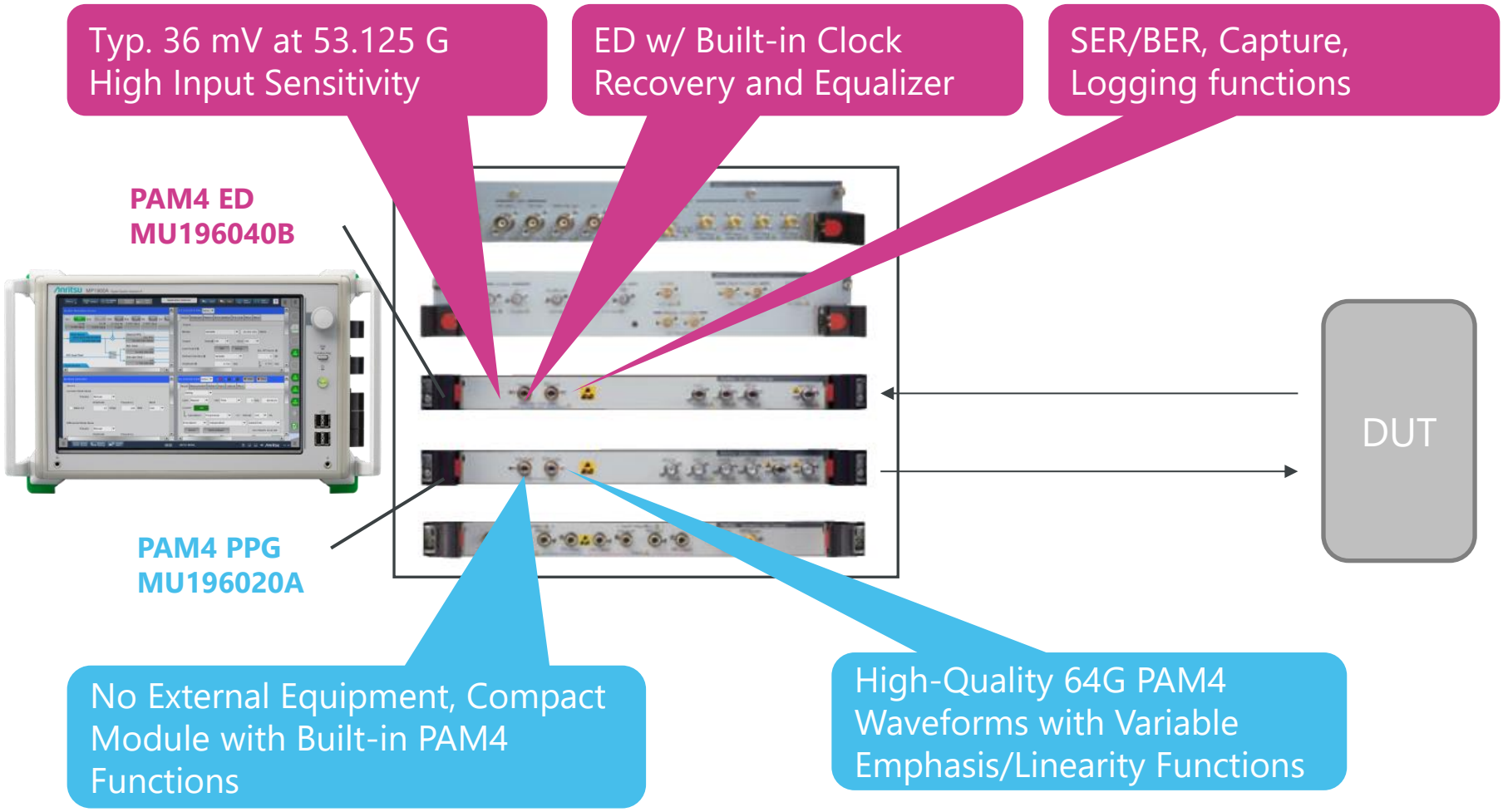
MP1900A PAM4 BERT Features

- All-in-one, high-reproducibility, easily configured test solution
- High-quality waveforms for more accurate measurement
- Easy, low-cost, future-proof expandability supporting high bit rates and multichannels



PAM4 All-in-One BERT Solution

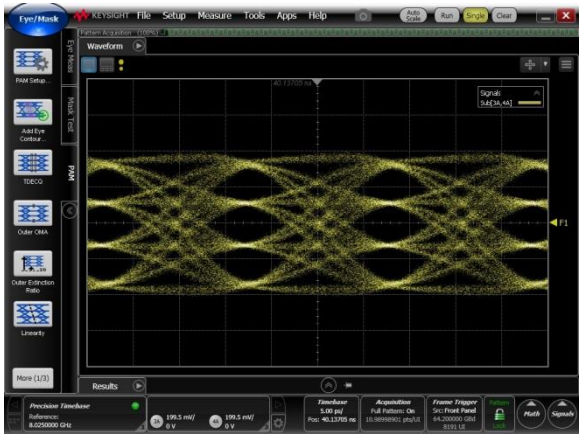
Easy-to-use and configure all-in-one solution with high reproducibility, helping cut test times



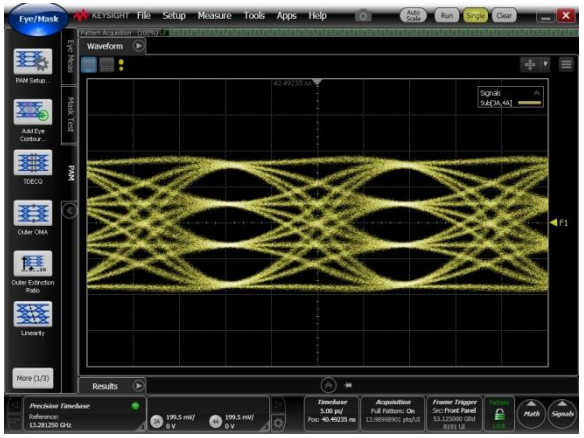
High-Quality Waveform PAM4 PPG MU196020A

Best-in-class waveform quality with low Intrinsic Jitter (typ. 170 fs (rms) and fast Tr/Tf (typ. 8.5 ps) for more accurate evaluation of actual DUT performance

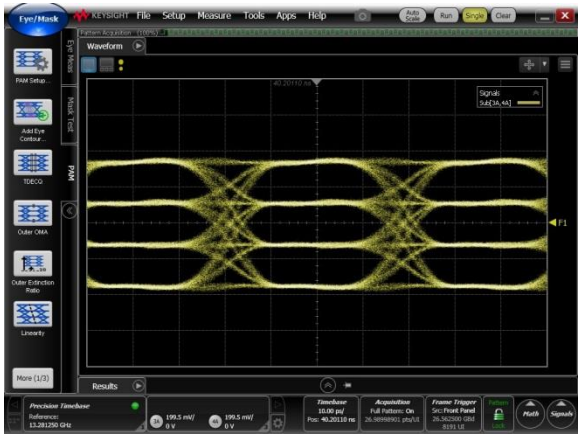
64.2 Gbaud

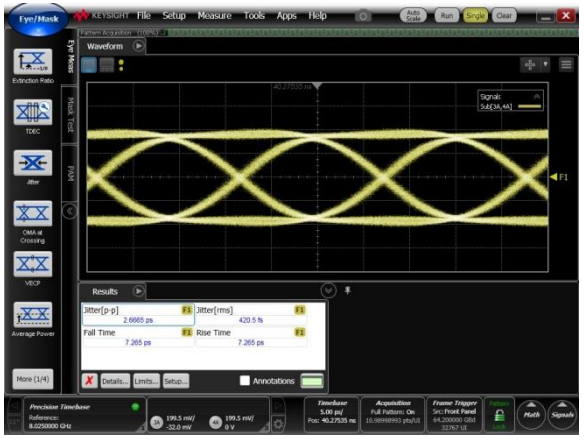


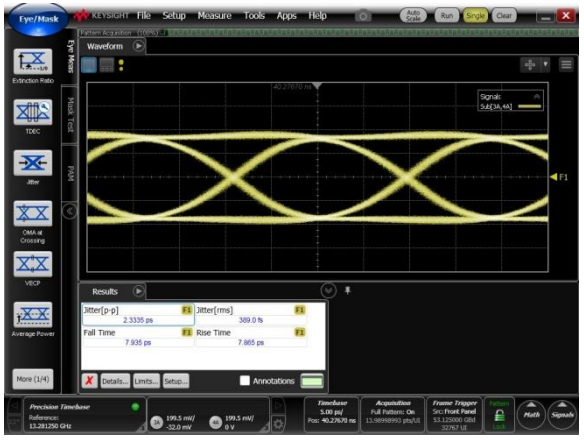
53.125 Gbaud

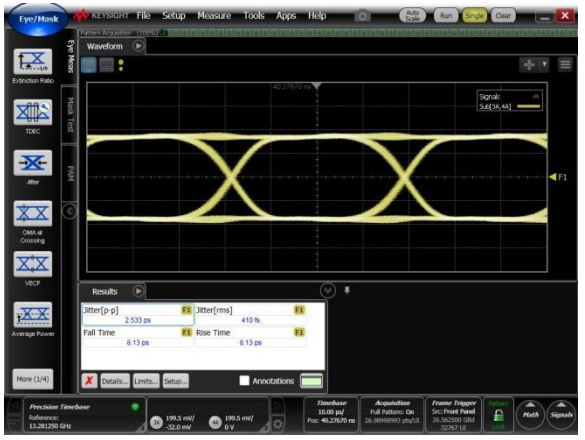


26.5625 Gbaud









Differential 1.4 Vp-p, PRBS13Q pattern, J1789A 40-cm cable + 70 GHz Scope

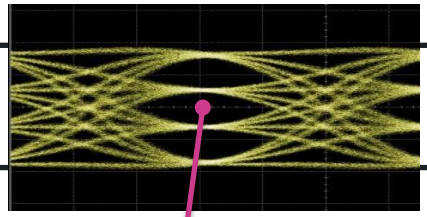
116 Gbit/s PAM4 Best Level High-Sensitivity Input Performance

2019, Oct.
NEW

High sensitivity input of 36 mV (typical at 53.125 Gbaud) simplifies previously difficult PAM4 error troubleshooting measurements.

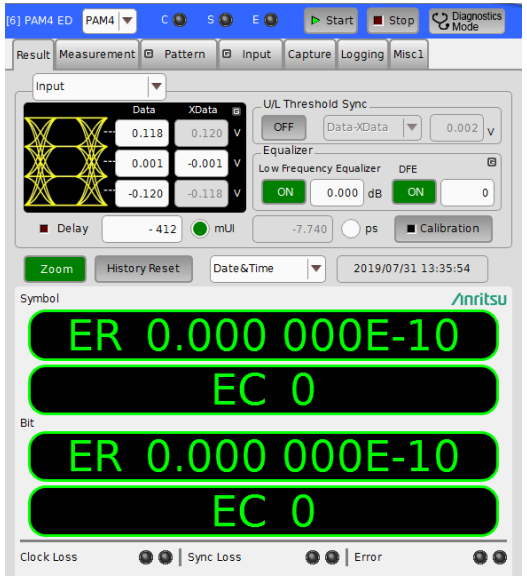
Error-Free at 53.125 Gbaud
Best level PAM4 sensitivity

PAM4 PPG
MU196020A



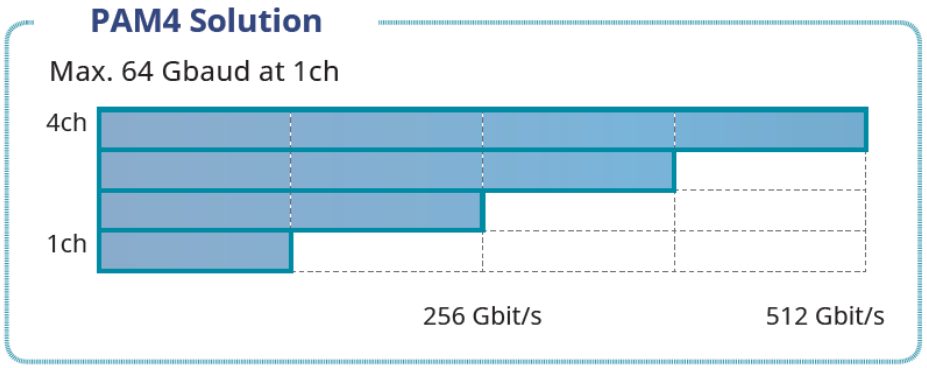
PAM4 ED
MU196040B

Typ. 36 mV EH/ Eye



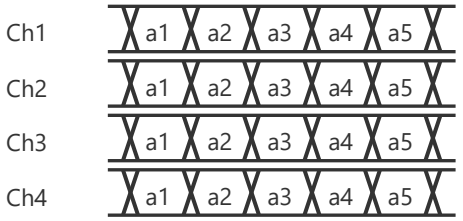
Multichannel Support and Expandability (1/2)

One MP1900A PPG supports up to 4ch for 400 GbE (53 Gbaud x 4 Lanes), and faster evaluations, helping cut future support upgrade costs.



▪ Channel Synchronization

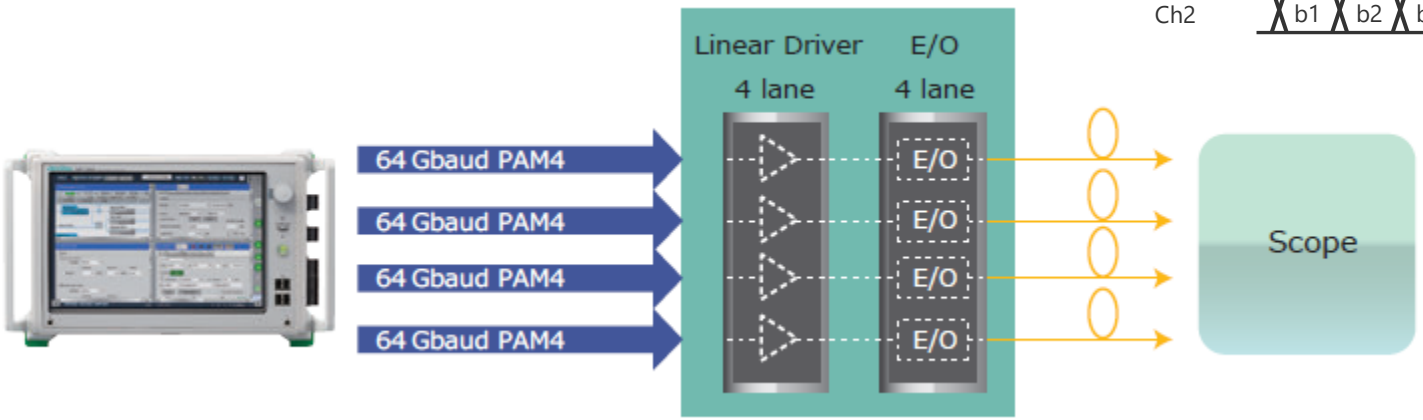
One MP1900A unit supports synchronous output for up to 4ch; two units support up to 8ch.
*Future support for 8ch



▪ 2ch Combination (NRZ)

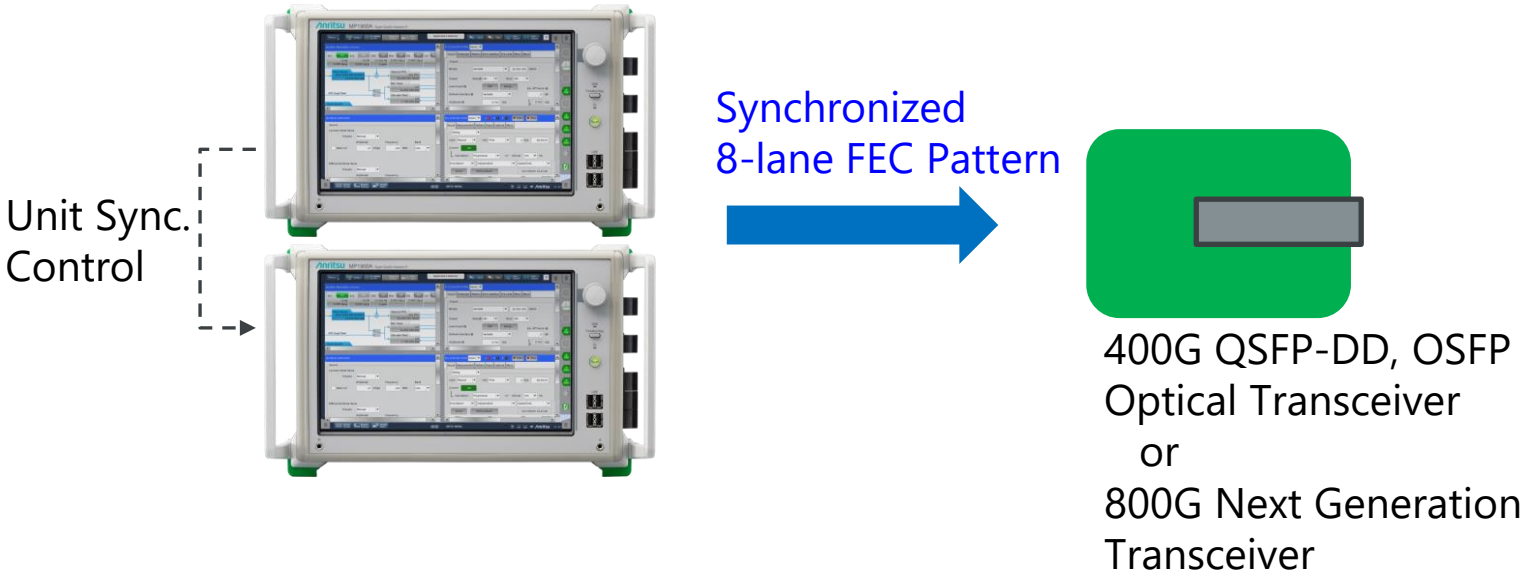
Supports shift to "a1b1 a2b2 . . ." pattern

▪ 4-Lane DUT (Driver + E/O) Measurement Example



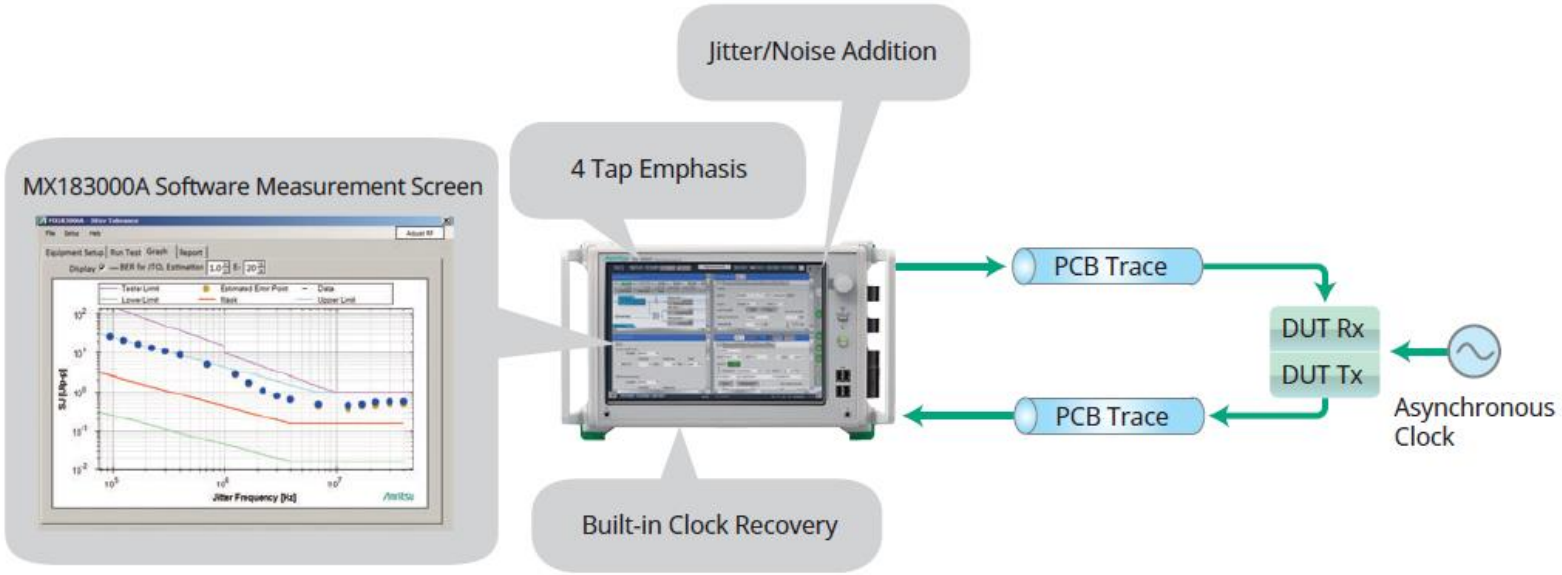
Multichannel Support and Expandability (2/2)

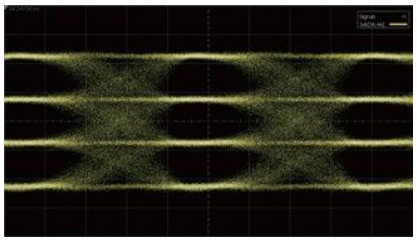
Expanded support for 800G using 8ch synchronization function
(4ch x 53.125 Gbaud PAM4 x two MP1900A units)
Supports QSFP-DD transceiver FEC evaluation using 8-lane FEC Pattern Generation function



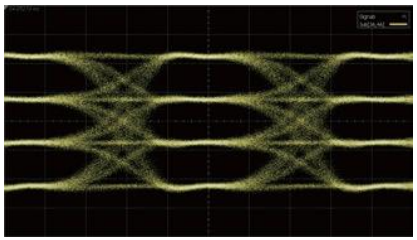
Jitter Tolerance Measurement Function

Supports PAM4 Jitter Tolerance test using just one unit. A measurement system to help cut measurement time is configured easily by combining the Jitter/Noise Addition function, built-in Clock Recovery function, and Jitter Tolerance MX183000A-PL001 software.

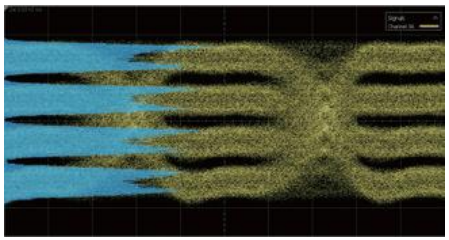




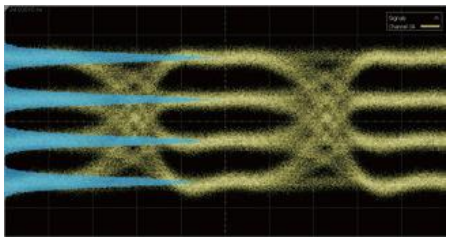
Sine-Wave Jitter (SJ)



Random Jitter (RJ)



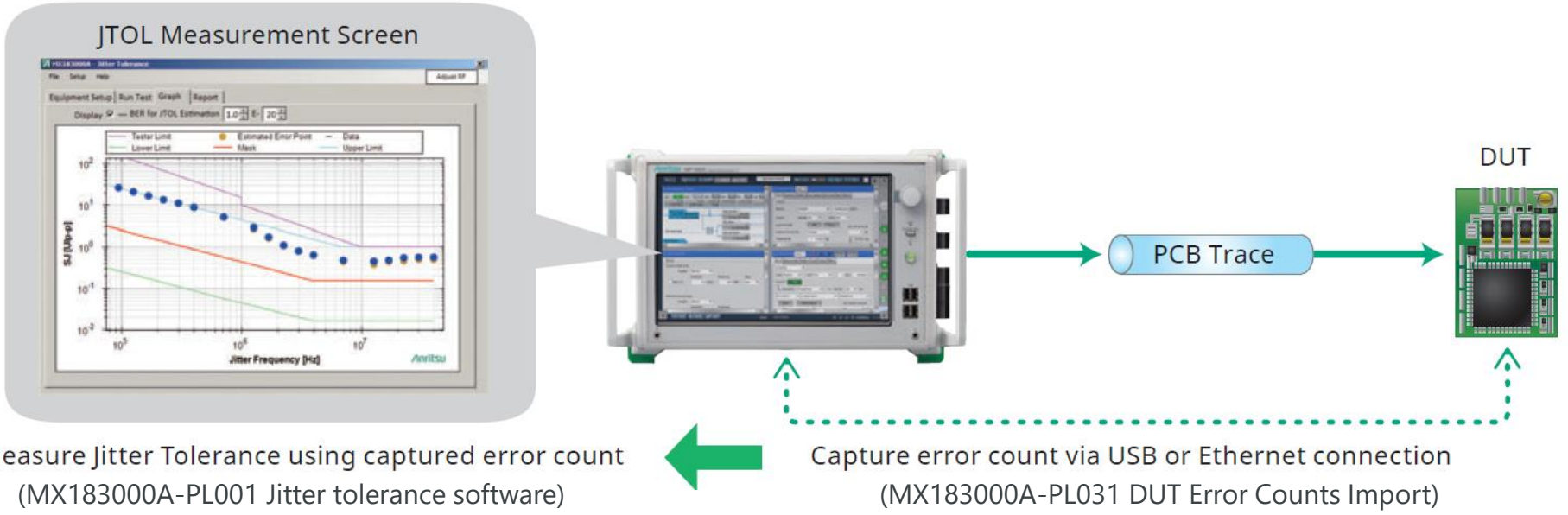
CM/DM Noise



White Noise

Jitter Tolerance Measurement using DUT BER Counter

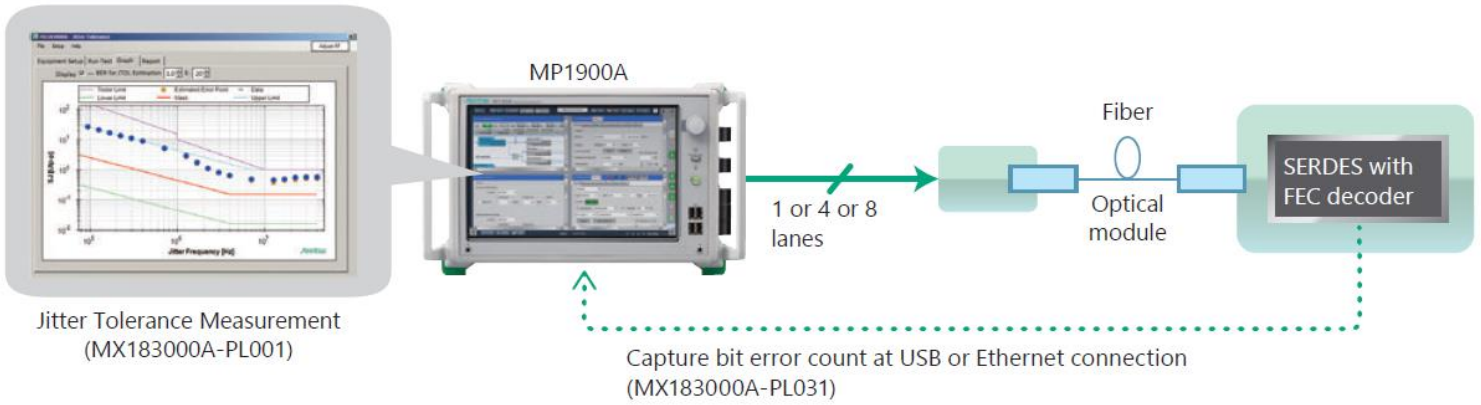
When the DUT has a built-in bit error counter, combination with the MP1900A PPG makes it easy to configure a highly cost-effective Jitter Tolerance measurement environment.



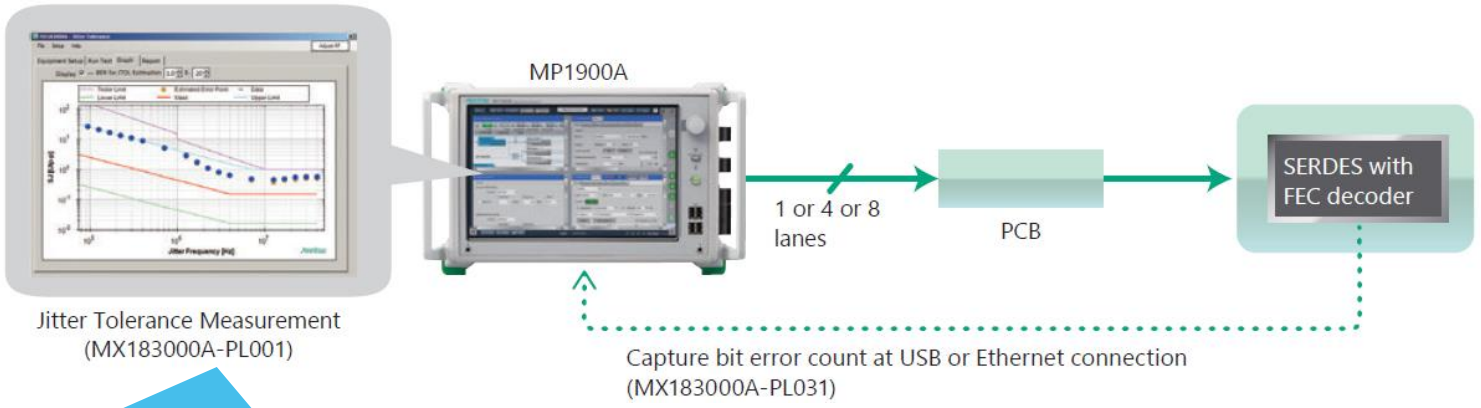
Multilane FEC Evaluation

FEC can be evaluated by combining FEC pattern generation with error insertion, and reading the DUT bit error count.

Evaluating Optical FEC Signal Transmission



Evaluating Electrical FEC Signal Transmission



Evaluate Jitter Tolerance, etc., using captured error count

PAM4 PPG/ED Specifications

PAM4 PPG MU196020A

- Baud-rate: 2.4 Gbaud to 32.1/58.2/64.2 Gbaud
- Output amplitude: 0.14 Vp-p to 1.6 Vp-p (Differential)
- Emphasis: 4Tap, ±20 dB (1 post/2 pre-cursor), ISI/Channel Emulator
- Intrinsic jitter(rms): 170 fs (typ., NRZ)
- Tr/Tf (20-80%): 8.5 ps (typ., NRZ)
- Multichannel synchronization
- FEC pattern generation

PAM4 ED MU196040B

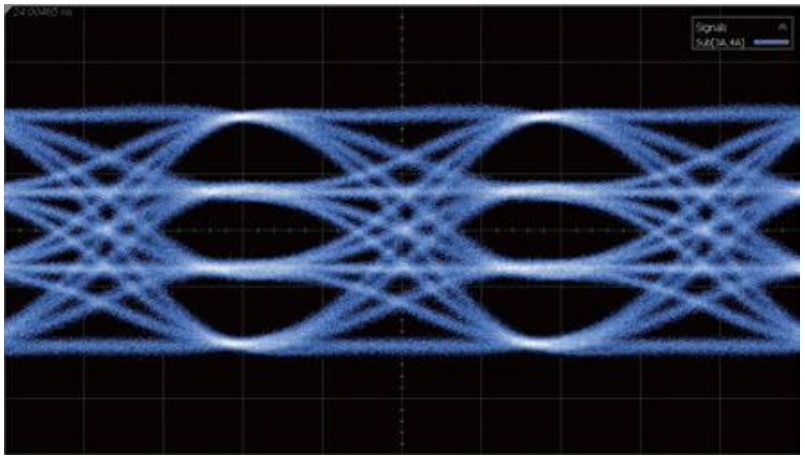
NEW

- Baud-rate: 2.4 Gbaud to 32.1/58.2 Gbaud PAM4 and 64.2 Gbaud NRZ
- Input amplitude (max.): 1.0 Vp-p (NRZ, PAM4)
- Input sensitivity(Eye Height) : 23 mV (typ., 26.5625 Gbaud), 36 mV (typ., 53.125 Gbaud)
- Built-in Clock Recovery: 2.4 G to 29 Gbaud or 32.1 Gbaud/ 51 G to 58.2 Gbaud extension
- Analog bandwidth: >40 GHz (nominal)
- Built-in Equalizer: Low Frequency Equalizer(2 dB)+DFE(1.4 dB)
- SER measurement, logic error analysis using Diagnostics Mode, Capture , Logging function

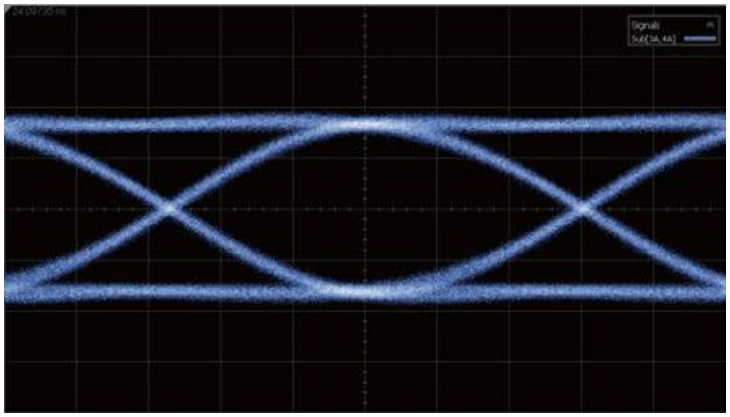
PAM4 PPG Functions and Performance

PAM4/NRZ Data Output

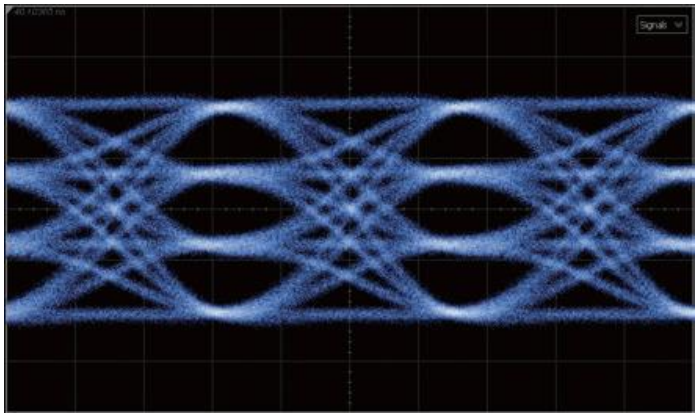
Supports next-generation applications over 50 Gbaud, such as 400 GbE, CEI-112G, etc.



53.125 Gbaud PAM4



58 Gbaud NRZ

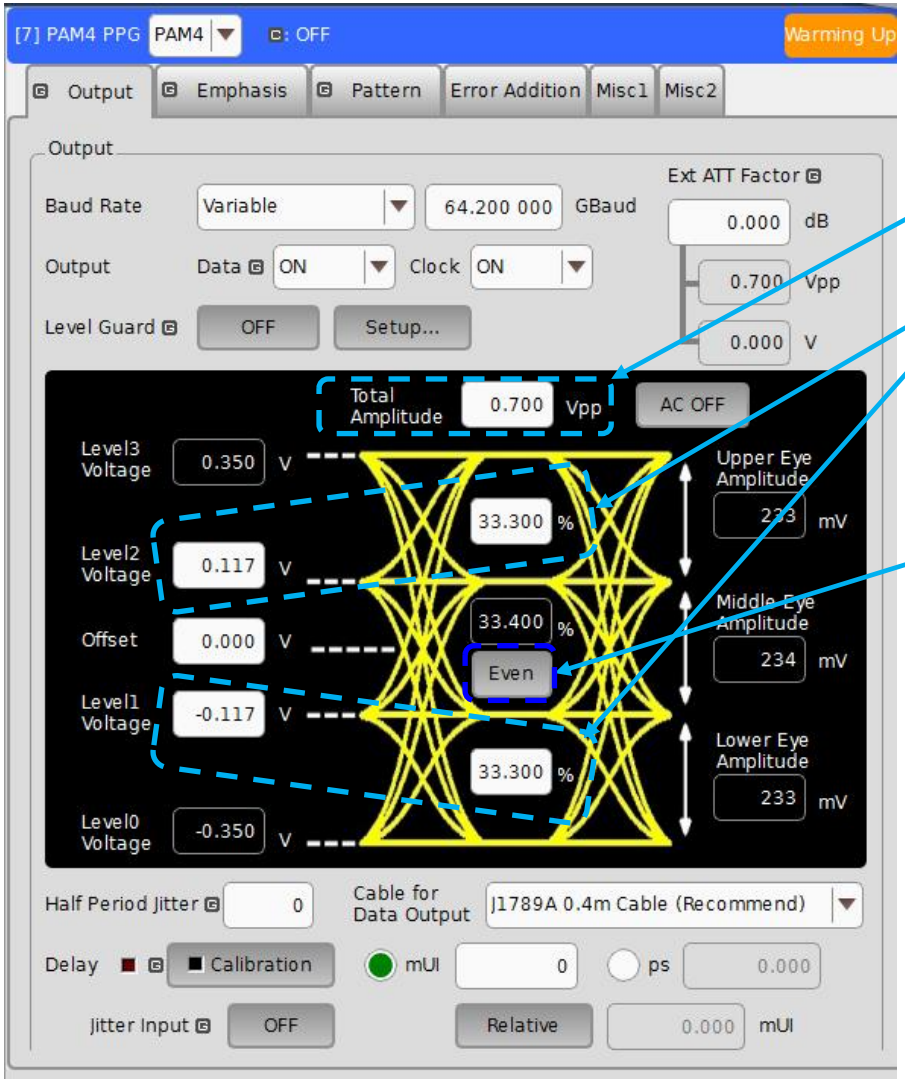


58 Gbaud PAM4

Typical Output Waveform (J1789A 40-cm Cable, 1400-mV Differential, PRBS15)

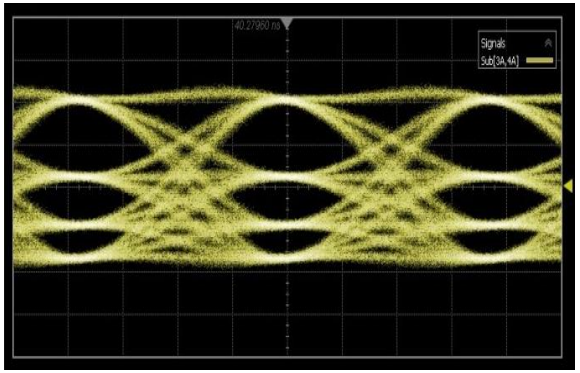
Easy PAM4 Level Control

Control Baud Rate, Level, Offset, Half Period Jitter, and Delay from one screen



- PAM4 Total Amplitude setting
- Independent PAM4 3Eye Amplitude control with voltage and % values
- Easy return to equal level using [Even] button

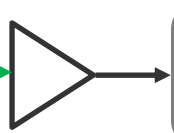
Level Control Reference Waveform



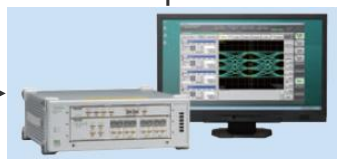
Linearity and Emphasis Controls

Supports TOSA device evaluations and stressed input tests using various channel insertion losses

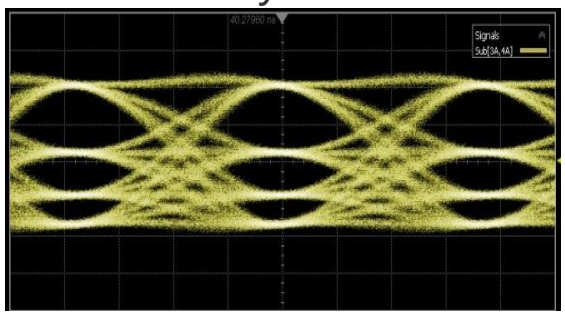
MU196020A
PAM4 PPG

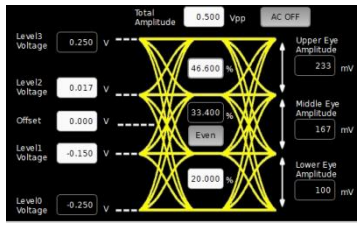


Scope

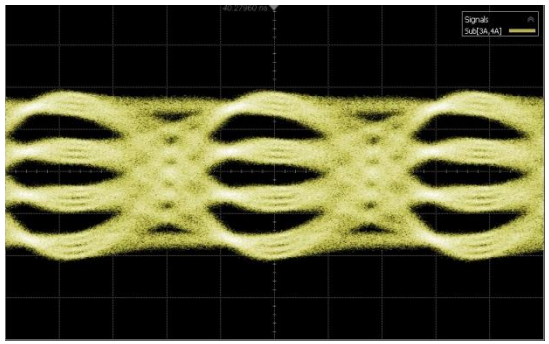


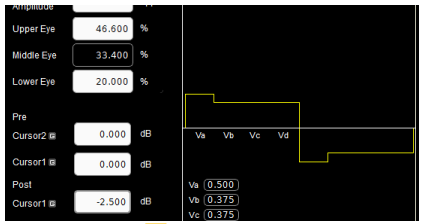
53G, Linearity control



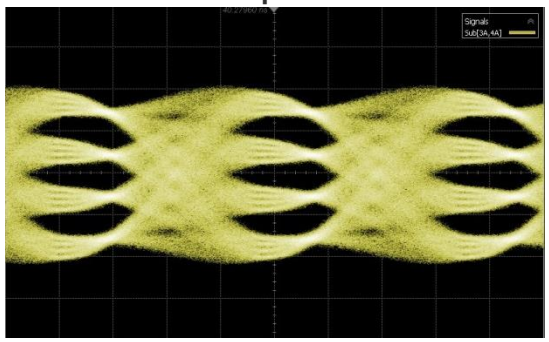


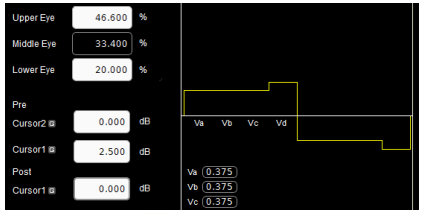
53G, Post1 Emphasis control





53G, Pre1 Emphasis control

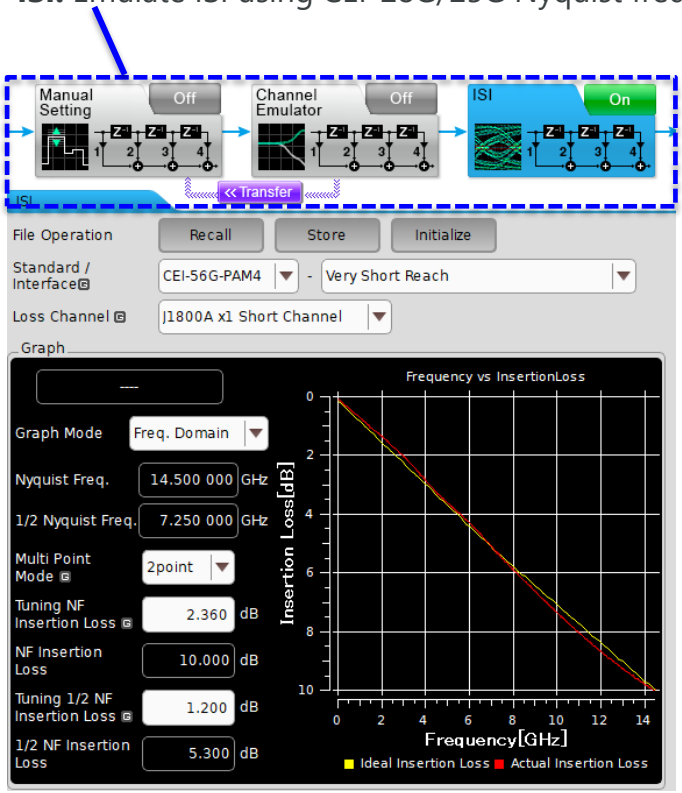


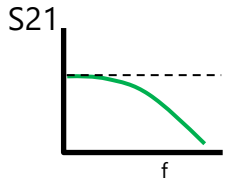


ISI, Channel Emulator

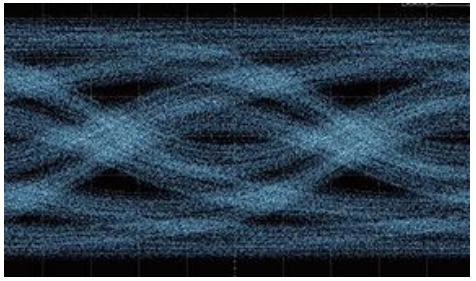
Shorter development period by eliminating need for multiple test PC boards with simple and high-reproducibility design tests of high-speed device channel loss dependency

- **Manual Setting:** Correct signal for target Eye Height/Width using 10Tap Emphasis function
- **Channel Emulator:** Emulate S2P and S4P loss insertion, and perform Emphasis compensation
- **ISI:** Emulate ISI using CEI-28G/25G Nyquist frequency loss setting

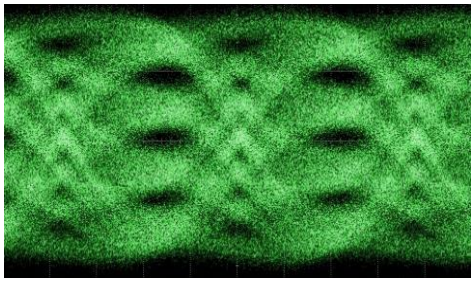




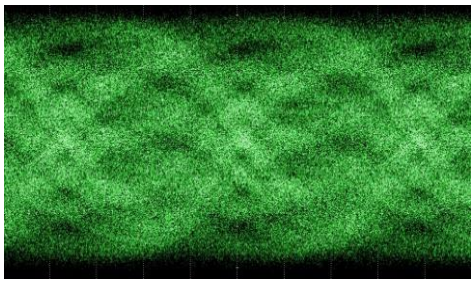
Emulates Channel Loss
or
Generates Loss Calibration Signal
(ISI option)



NRZ CEI-28G 14-dB Loss



PAM4 26.6G 4-dB Loss



PAM4 26.6G 6-dB Loss

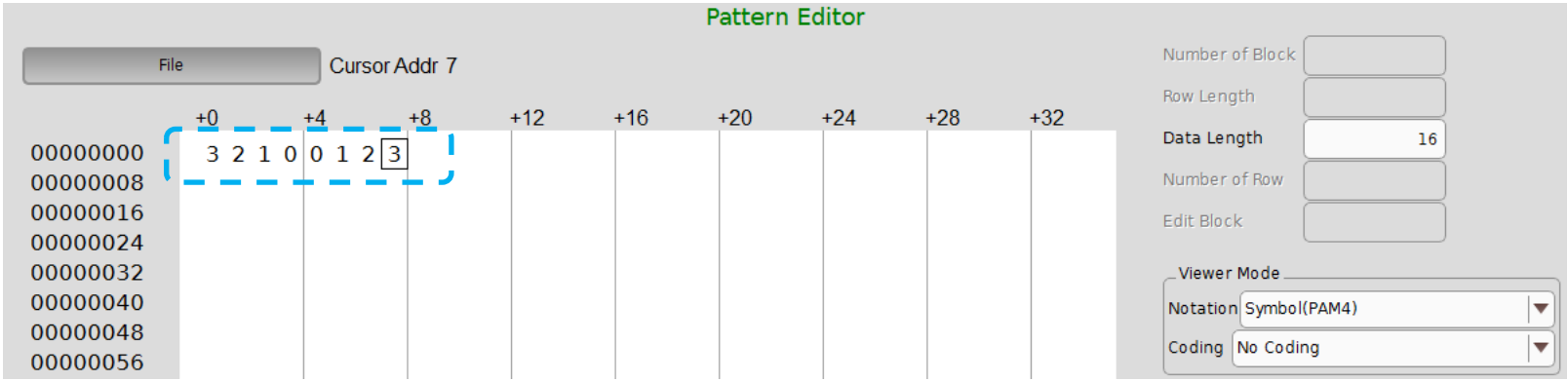
Typical ISI Function Waveforms

PAM4 Test Patterns (1/2)

Supports PAM4 test patterns specified by 200 and 400 GbE standards

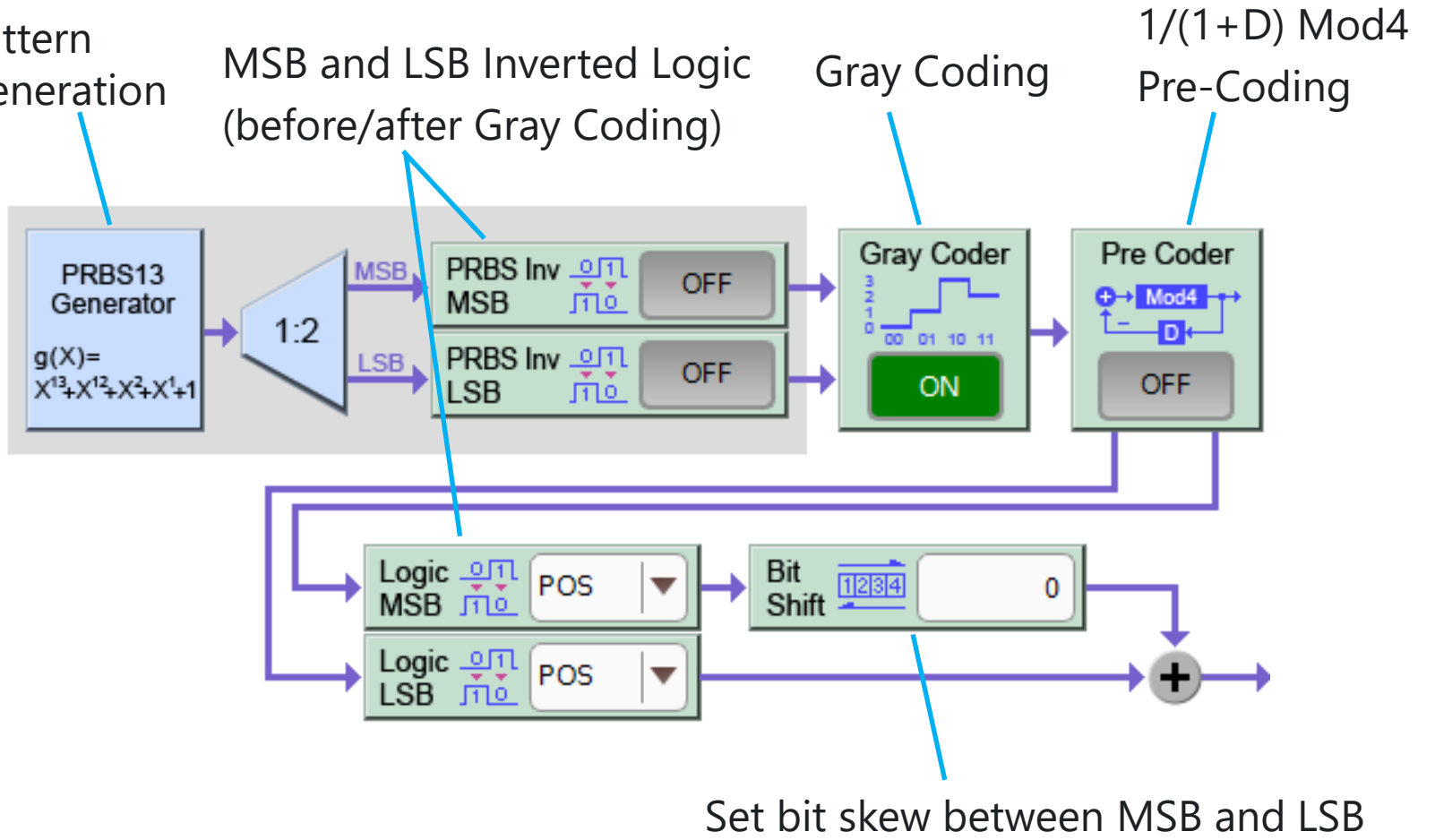
Supported Test Patterns	
CEI	QPRBS13-CEI, QPRBS31-CEI
IEEE	IEEE802.3bs/cd: PRBS13Q, PRBS31Q, SSPRQ, Square Wave IEEE802.3bj: QPRBS13, JP03A, JP03B, Transmitter Linearity
RS-FEC	RS-FEC Scrambled Idle 50G 1 Lane (26.5625 Gbaud, 50GBASE-KR/CR/SR/FR/LR) RS-FEC Scrambled Idle 100G 1 Lane (53.125 Gbaud, 100GBASE-DR) RS-FEC Scrambled Idle 200G 4 Lanes (26.5625 Gbaud, 200GBASE-SR4/DR4/FR4/LR4) RS-FEC Scrambled Idle 400G 4 Lanes (53.125 Gbaud, 400GBASE-DR4) RS-FEC Scrambled Idle 400G 8 Lanes (26.5625 Gbaud, 400GBASE-FR8/LR8)
InfiniBand	PRBS13Q (InfiniBand), PRBS23Q, PRBS31Q(InfiniBand)
Fibre Channel	PRBS31Q (Fibre Channel)
General Purpose	PRBS7, 9, 10, 11, 13, 15, 20, 23, 31, Data (User defined) 4 to 256 Msymbol

Edit Data pattern using PAM4 symbol 0, 1, 2, and 3 values.



PAM4 Test Patterns (2/2)

- BER measurement for different pattern generation methods depending on DSPs
- Efficient detection of pattern generation circuit differences as well as logic errors, such as inverted logic and bit skew

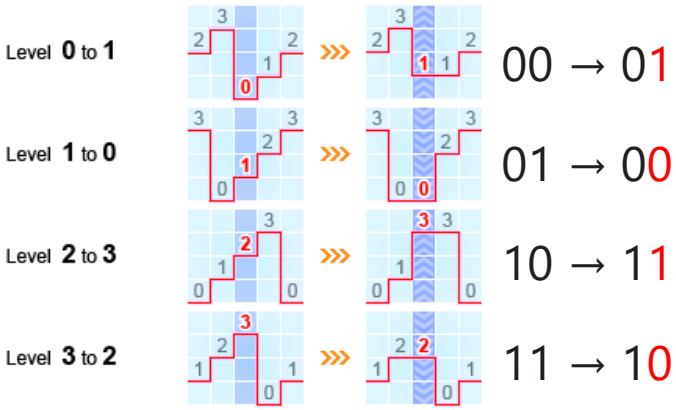


PAM4 Error Insertion Function

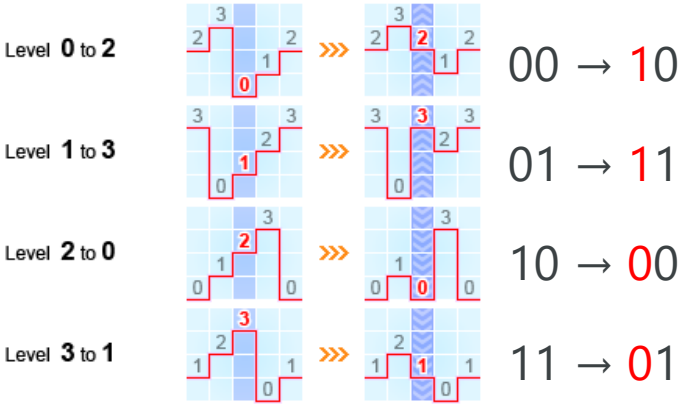
With PAM4, not only do errors occur at single level changes, there are also cases where double level changes occur due to MSB errors.

Using the [Error Addition] tab to insert errors in each of these cases helps confirm communications and inspection of error results.

- LSB Error Insertion



- MSB Error Insertion

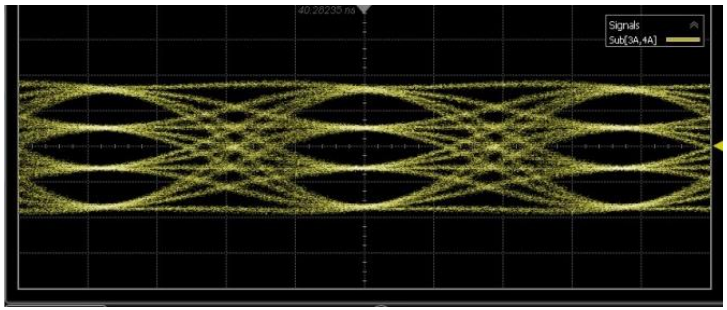


Cable Settings for Monitoring

Adjusts Emphasis to automatically correct loss of 80-cm cable connecting separate DUT

Using
40-cm cable
@53G

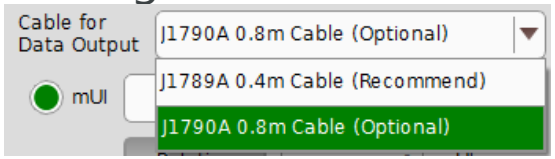
Cable for data output setting: J1789A 0.4 m



← J1789A 40-cm cable best for evaluating this waveform

↙ Closed Eye opening with long cable (ex. 80-cm cable)

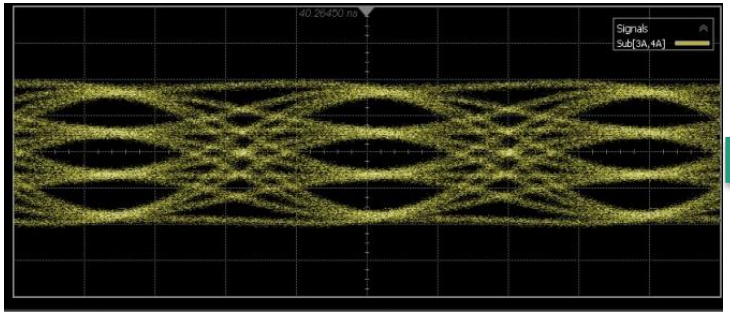
↓ Can automatically calibrate settings for effect of 80-cm cable



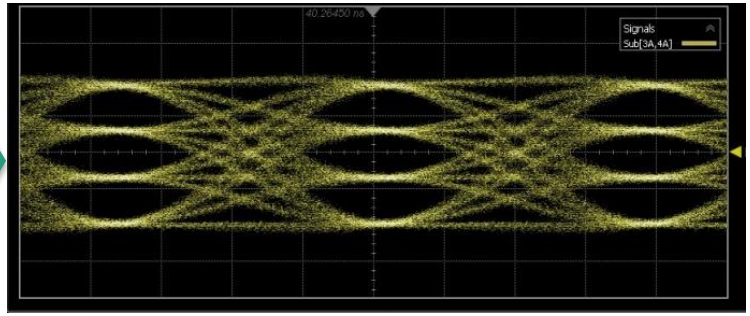
Select J1790A cable setting

Using
80-cm cable
@53G

Cable for data output setting: J1789A 0.4 m



Cable for data output setting: J1790A 0.8 m



PAM4 ED Functions and Performance

Outline of 116-Gbit/s PAM4 Error Detector for 400GbE/800GbE

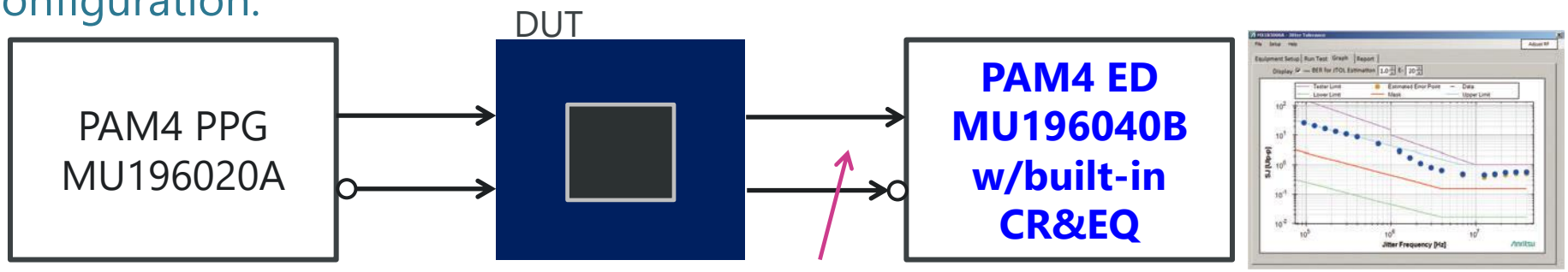
- **High-performance BERT for 116-Gbit/s PAM4 error-free measurement**
  Simplify previously difficult PAM4 error troubleshooting
- **Industry-best high input sensitivity of 36 mV EH@53.125 Gbaud**
  Support more accurate evaluations up to 116-Gbit/s PAM4.
- **All-in-one 58-Gbaud PAM4 receiver test solution with built-in Clock Recovery and Equalizer functions**
  Support faster testing and debugging with easy measurement system configuration

- Wideband operation: 2.4 to 64.2 Gbaud for NRZ
  2.4 to 58.2 Gbaud for PAM4
- Support CEI-112G-VSR Stressed Receiver Input Test
- Built-in 58-Gbaud PAM4 Clock Recovery
- PAM4 symbol Capture function
- Multichannel measurement (up to 4ch/unit)

Target Applications: 100/200/400/800GbE, CEI-112G-VSR

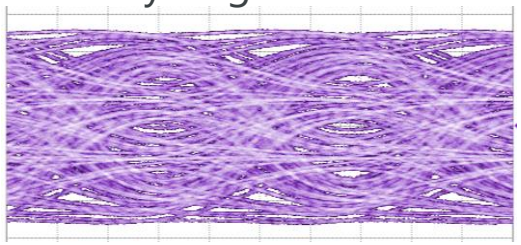
All-in-One BERT w/ PAM4 Built-in Clock Recovery & Equalizer

Connections with external equipment and components are eliminated.
PAM4 Jitter Tolerance measurements are simplified by the easy system configuration.



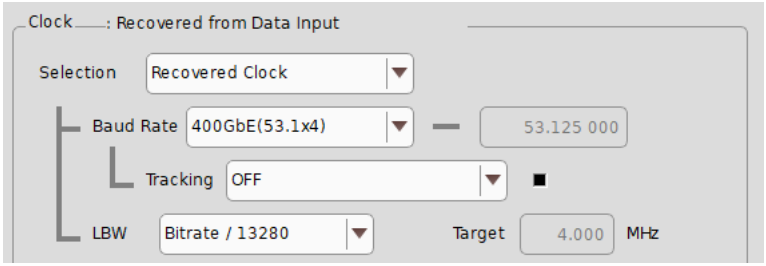
- Jitter
- ISI Control

Support BER measurement of closed-Eye signal with stress

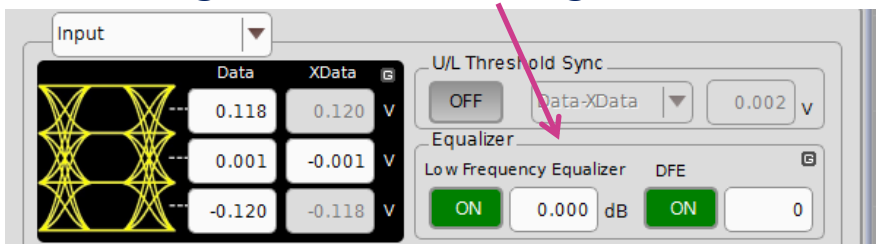


Support PAM4 Jitter Tolerance test

- Built-in Clock Recovery to re-time DUT signal for 58-Gbaud PAM4 JTOL testing



- Equalizer function to open Eye of VSR stressed signal for measuring BER



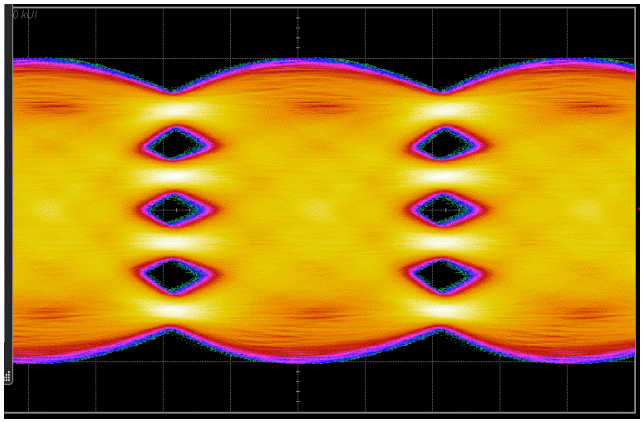
CEI-112G-VSR Stressed Input Test Support

The true DUT low-error-rate Rx performance can be tested using the worst-case signal with added stress.

CEI-112G-VSR Worst-Case Rx input specification

Item	Spec. (112G-VSR-PAM4)
Baud Rate	36 to 58 Gbaud
Channel Loss	12 dB at 26.5625 GHz
EH6	>37 mV
EW6	>0.2 UI (>3.76 ps)
Target BER	<E-6

Worst-case performance signal



Higher sensitivity performance (E-8 or lower) than receiver model defined by CEI VSR standard (E-6)

PAM4 ED
MU196040B

Built-in Equalizer

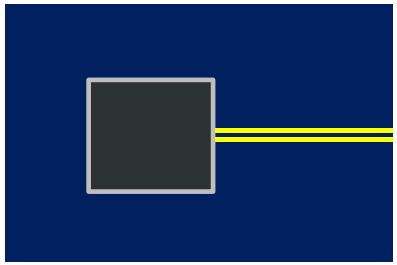
Combination of built-in Equalizer function and high input sensitivity performance supports higher accuracy measurements.

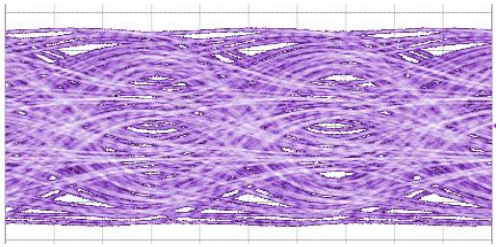
Error-Free at 53.125 Gbaud for inputting signals path through 3 dB loss (typ.).

MU196040B

Built-in Equalizer diagram

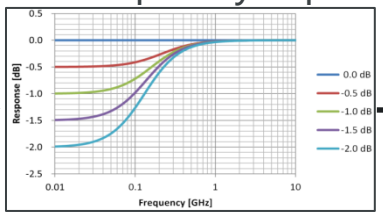
DUT

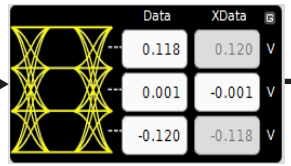




ISI Stressed eye signal

Low-frequency Equalizer





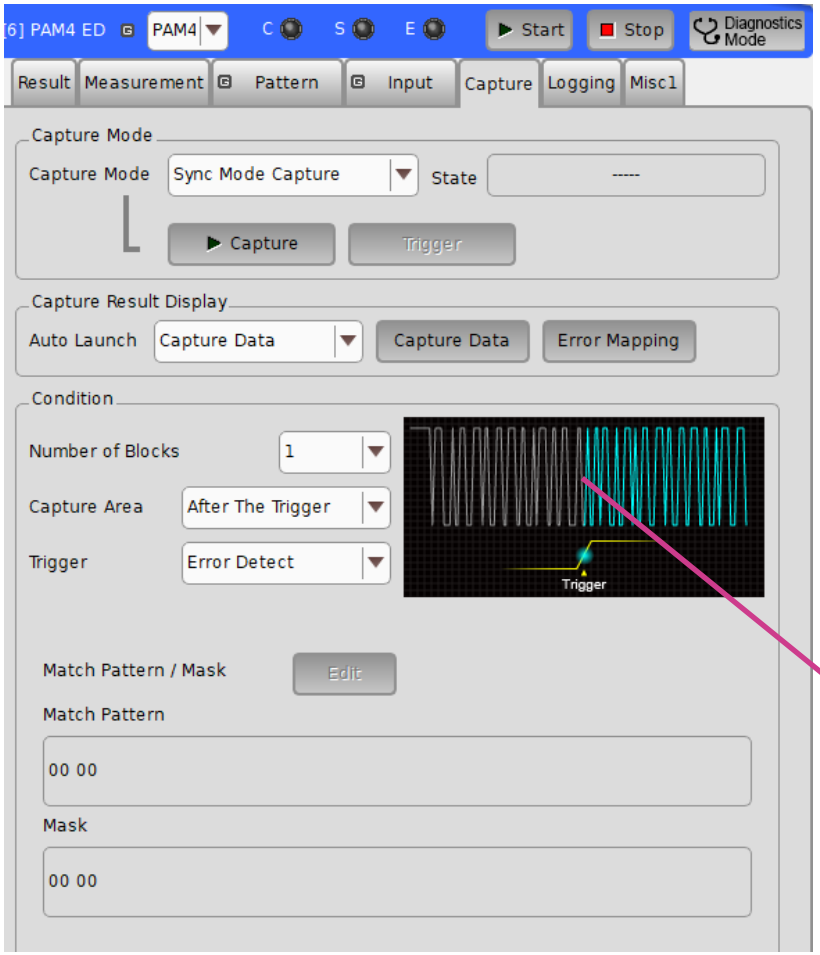
DFE

BER Measurement

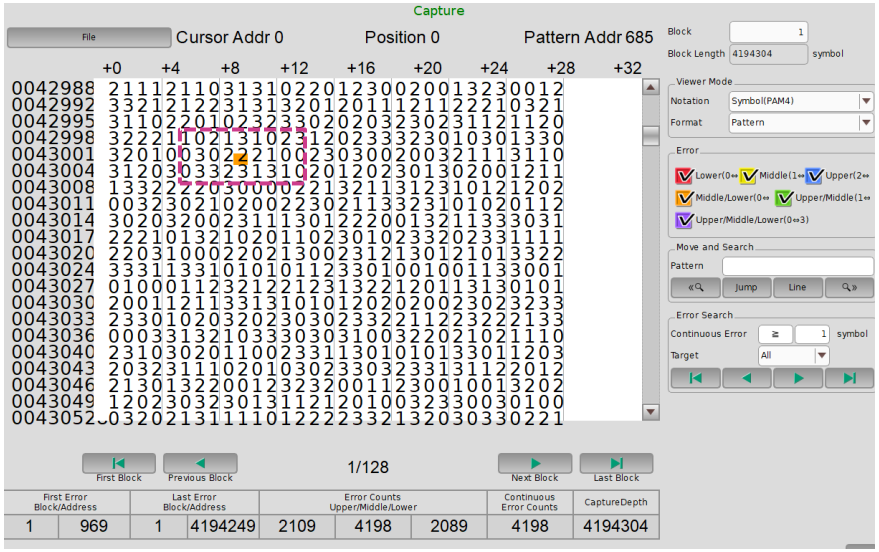
Decision feedback Equalizer

PAM4 Symbol Capture Function

Capture function supports identification of PAM4 error symbols and cuts verification time.



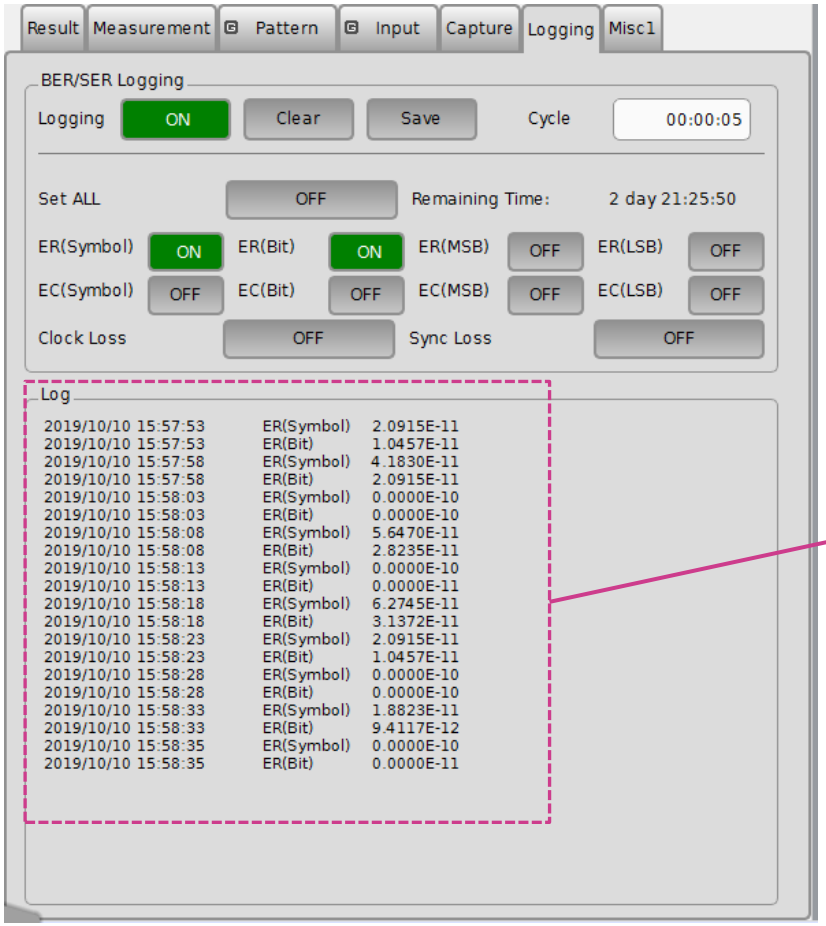
Can specify error symbol position and level change of captured signal



Start capturing inputting symbols using Error detection, Match pattern, or External trigger.

Measurement Result Logging Function

Periodic saving of BER/SER, etc., measurement results can evaluate changes and stability of DUT time-dependent performance.



Sets measurement cycle and starts logging

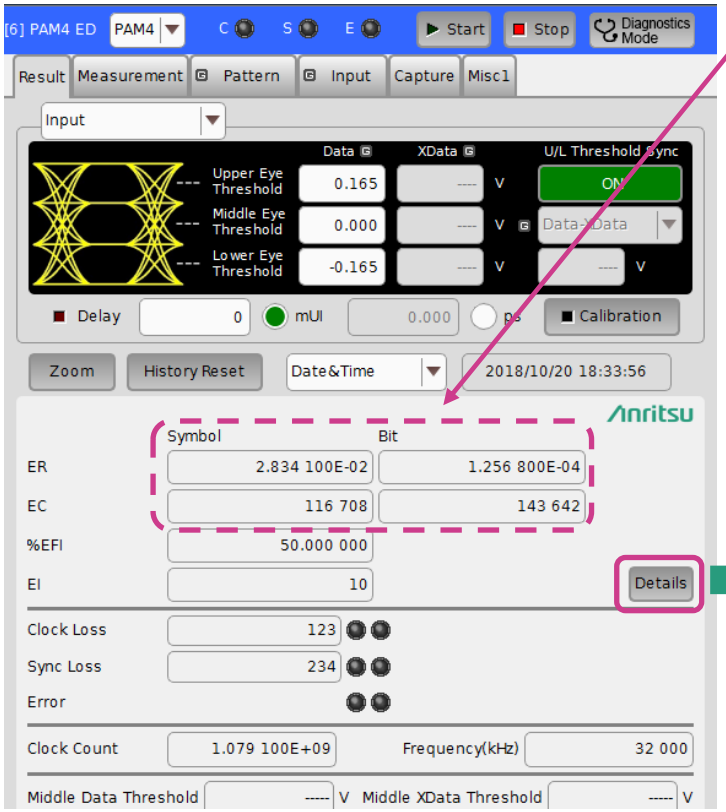
Saves results to file

Measurement item selection

Times-periodically saved measurement results

Error Analysis Function (1/2)

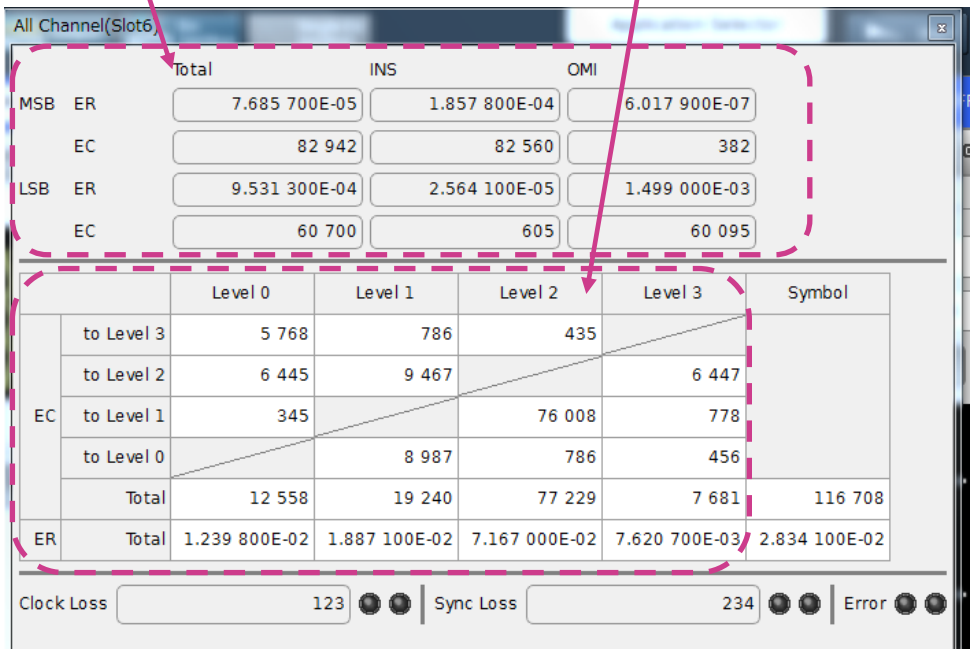
Useful measurement of both symbol errors (MU196040B-041) and bit errors for specifying error causes by comparing both measurement results
Press [Details] for more detailed analysis by confirming results for 12 error types.



PAM4 bit-error measurement results

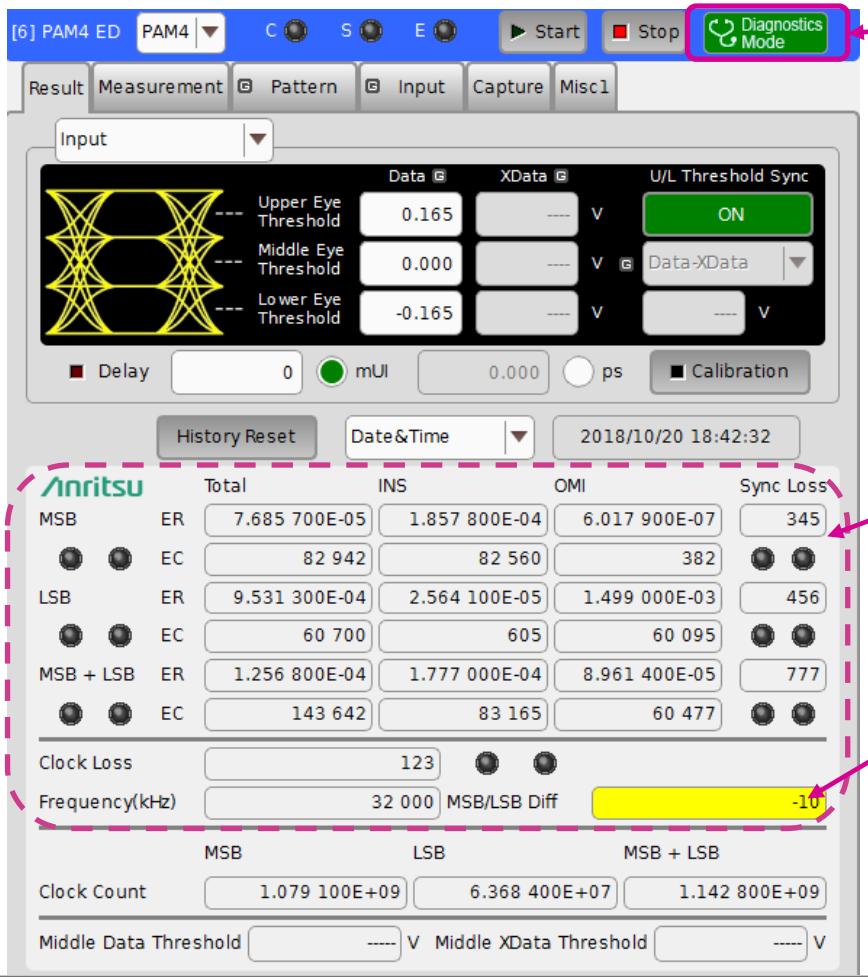
Separate error-rate measurements for MSB and LSB

Simultaneous measurement of 12 error types



Error Analysis Function (2/2)

The Diagnostics Mode is useful for troubleshooting logic errors, such as inverted logic and MSB/LSB bit skew, etc. When these types of logic errors prevent synchronization, the cause can be determined using the separate MSB and LSB error results and the bit skew result between MSB and LSB.



Diagnostics Mode button

Separate MSB and LSB error results

MSB/LSB bit skew detection

Appendix

Typical Configuration of 64 G PPG/58 G ED

Model	Name	Option	Qty	Remark
MP1900A	Signal Quality Analyzer-R	-	1	
MU181000B	12.5GHz 4 port Synthesizer	-	1	
MU181500B	Jitter Modulation Source	-	1	For jitter injection
MU196020A	PAM4 PPG	002, 011, 040, 042	1	
MU196040B	PAM4 ED	002, 011, 021, 023, 041	1	

Software for jitter tolerance test

Model	Name
MX183000A-PL001	Jitter Tolerance Test
MX183000A-PL031	DUT Error Counts Import

Optional parts

Model	Name
J1789A	Electrical Length Specified cable (0.4m, V connector)
J1790A	Electrical Length Specified cable (0.8m, V connector)
J1800A	ISI Board V
J1793A	Pick OFF Tee（V）

64 G PPG/58 G ED Module Option

Model	Name
MU196020A	PAM4 PPG
MU196020A-001	32G baud
MU196020A-002	58G baud
MU196020A-003	64G baud
MU196020A-011	4Tap Emphasis
MU196020A-030	Data Delay
MU196020A-040	Adjustable ISI
MU196020A-042	FEC Pattern Generation
MU196020A-050	Intel-Module Synchronization

Model	Name
MU196040B	PAM4 ED
MU196040B-001	32G baud
MU196040B-002	58G baud (max. 64.2Gbit/s NRZ/58.2Gbaud PAM4)
MU196040B-011	Equalizer
MU196040B-021	29G Clock Recovery (2.4 G to 29 Gbaud)
MU196040B-022	32G Clock Recovery (2.4 G to 32.1 Gbaud)
MU196040B-023	58G Clock Recovery Extension (51 G to 58 Gbaud)
MU196040B-041	SER Measurement

PAM4 PPG MU196020A Specifications

Item	Specification
Operation Rate (PAM4/NRZ)	2.4 Gbaud to 32.1/58.2/64.2 Gbaud (option selection)
No. of Channels	1
Output Amplitude	70 mVp-p to 800 mVp-p (Single-end) 140 mVp-p to 1600 mVp-p (Differential)
Offset	–2 V to +3.3 V
Emphasis	4 Tap, –20 to +20 dB
Channel Emulator	Generates waveform with insertion loss and simulates waveform with corrected insertion loss Set by loading S-Parameter file (S2P, S4P)
ISI	Simulates ISI generation waveform Set using loss (–8.00 to 8.00 dB) at CEI-specified Nyquist frequency Used in combination with channel board, such as J1800A/J1758A (optional accessories parts), or Noise Module MU195050A
Independently Variable PAM4 3 Eye	20% to 50% (PAM4 Amplitude 0/3 level = 100%)
PAM4 Pattern	SSPRQ, PRBS13Q, PRBS31Q, RS-FEC, etc.
PAM4 Pattern Error Addition	MSB Error, LSB Error, LSB&MSB Error, RS-FEC Symbol Error
Tr/Tf (20% to 80%)	8.5 ps (typ., NRZ)
Random Jitter	170 fs rms (typ., NRZ)
I/O Connector	V (f)
Jitter Addition Function	SJ, RJ, BUJ, SSC (with MU181500B)
Noise Addition Function	CMI, DMI, White Noise (with MU195050A (32.1G max.) and J1792A)

PAM4 ED MU196040B Specifications

Item	Specification	Remarks
Baud rate	2.4 to 32.1 Gbaud/64.2 Gbaud (NRZ) 2.4 to 32.1 Gbaud/58.2 Gbaud (PAM4)	Select upper limit as option
Input Signal Method	NRZ, PAM4	
Number of Inputs	2 (Data, xData)	
Input Amplitude	1.0 Vp-p (max.)	
Input Sensitivity	36 mV (typ. at 53.125 G), 23 mV (typ. at 26.5625 G)	Eye Height of each PAM4 Eye
Stressed Margin	BER < 1 E-8	When inputting minimum eye signal defined in CEI-112G-VSR
Analog Band	>40 GHz (nominal)	
Clock Recovery Operation Range	2.4 to 29 Gbaud or 2.4 to 32.1 Gbaud 51 to 58.2 Gbaud Extension	Option
Equalizer	DFE (1.4 dB) + Low-frequency-Equalizer (2 dB)	
BER/SER Measurement	Total BER, MSB/LSB BER, SER (option) Logging, Capture (8 M bits/4 M PAM4 symbols)	
Patterns	PRBS, Data (max. 268 Mbit (symbol)), PAM4 Pattern (PRBS13Q, PRBS31Q, SSPRQ, QPRBS13-CEI, QPRBS31-CEI), Gray Code/PAM4 Pre-Code	
Connector	V (f)	

PAM4 Test Patterns

PRBS13Q, PRBS31Q, SSPRQ:

PAM4 patterns defined by IEEE802.3bs, 802.3cd 200 GbE, and 400 GbE standards

QPRBS13-CEI:

Pattern for Tx output measurement and Rx input calibration defined by CEI-56G PAM4 standard

JP03A:

"0303…" pattern string for evaluating transmitter RJ

JP03B:

Pattern (shown below) of 62 symbols composed of string of 15 contiguous "03" followed by 16 contiguous "30" for evaluating transmitter Even-Odd jitter

0303030303030303030303030303030303030303030303030303030303030303030

Square:

"3333333300000000" pattern string for OMA evaluation of optical interfaces (OMA: Optical Modulation Amplitude)

Transmitter Linearity Test Pattern:

Pattern of 160 symbols with following sequence of 10 PAM4 symbols repeated in 16UI lengths

{0, 1, 2, 3, 0, 3, 0, 3, 2, 1}

The newest specification for the Linearity Test uses a PRBS13Q pattern.

$R_{LM} = \min((3 \times ES1), (3 \times ES2), (2 - 3 \times ES1), (2 - 3 \times ES2))$ (120D-5)

$V_{mid} = (V_0 + V_3)/2$, $ES1 = (V_1 - V_{mid})/(V_0 - V_{mid})$, $ES2 = (V_2 - V_{mid})/(V_3 - V_{mid})$

Gray-xxxx:

PAM4 signals use four levels to express 2-bit pairs, but sometimes a 2-bit change such as 01→10 may be detected incorrectly for one level. To prevent this, a Gray code (00→00, 01→01, 10→11, 11→10) is used as the pattern at the Tx side.

Anritsu

envision : ensure

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