Product Introduction

Anritsu envision:ensure

64Gbaud PAM4 DAC G0374A

Signal Quality Analyzer
MP1800A Series

Introduction

- Data center traffic is growing explosively with the spread of Cloud computing services (23% annual increase in IP traffic at data centers). As a result, new high-speed interfaces, such as 400 GbE and CEI-56G, are being investigated as a means for speeding-up processing and communications between servers and networks.

- In addition to speeding-up symbol rates of the conventional NRZ technology, various new technologies, such as Pulse Amplitude Modulation (PAM), are being adopted to increase transfer capacity without raising symbol rates.

- Using the 64Gbaud PAM4 DAC G0374A in combination with the Signal Quality Analyzer MP1800A series supports generation of wideband analog signals, such as high-baud-rate PAM4 signals.

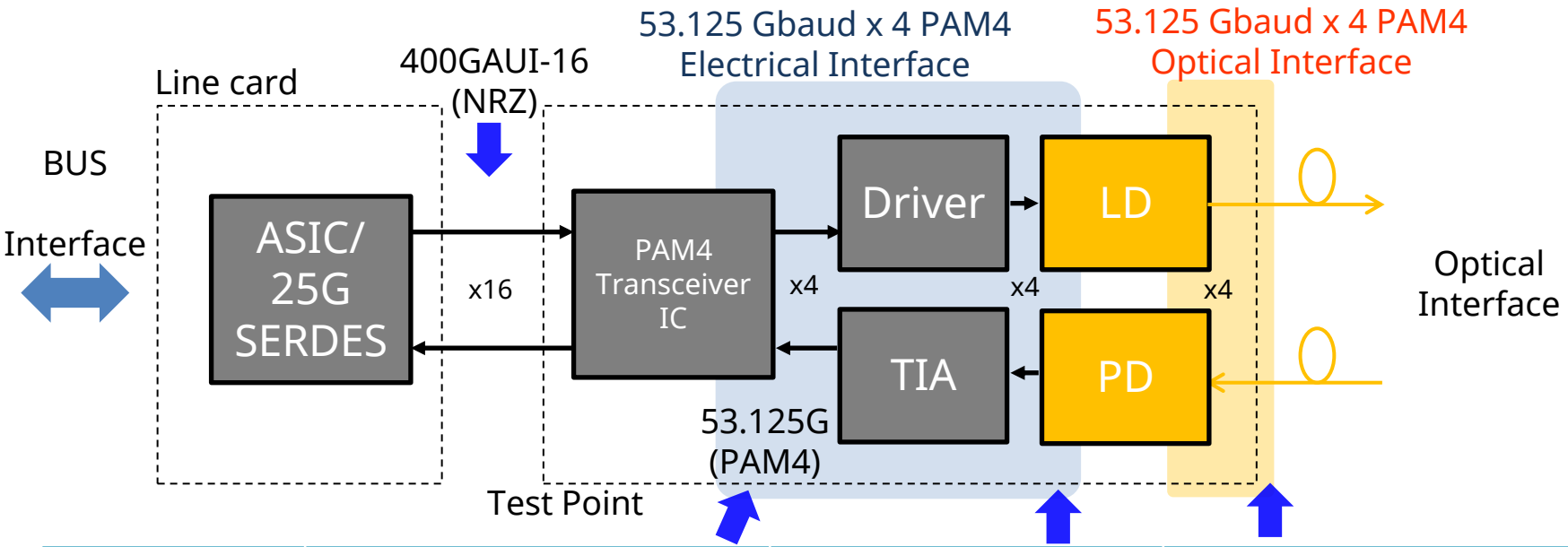
Trends in High-Speed Interface Standards

- Shift to I/Fs at Speeds >32 Gbit/s using PAM4 Technology
  - ✓ Now Defining 200GbE/400 GbE in IEEE 802.3bs (Standards to be Released in 2017)
  - ✓ Optical Internetworking Forum (OIF) Standardizing 400 GbE I/Fs Between Devices

Standard		Baud-rate	Modulation Format
IEEE 802.3bs	400GBASE-SR16	26.6G	NRZ
	400GBASE-FR8,LR8	26.6G	PAM4
	400GBASE-DR4	53.1G	
	200GBASE-FR4,LR4	26.6G	
	200GBASE-DR4	26.6G	
CEI-56G	56G-USR	20-58G	NRZ
	56G-XSR/VSR/MR	40-58G/ 39-56G/ 39-56G	
	56G-XSR/VSR/MR	20-29G/ 20-29G/ 18-29G	PAM4
	56G-LR	18-29G	
	56G-LR	33-38G	ENRZ

Example of PAM4 Signal Applications

- 53.125 Gbaud 4-lane Electrical and 400GBASE-DR4 Optical Interfaces



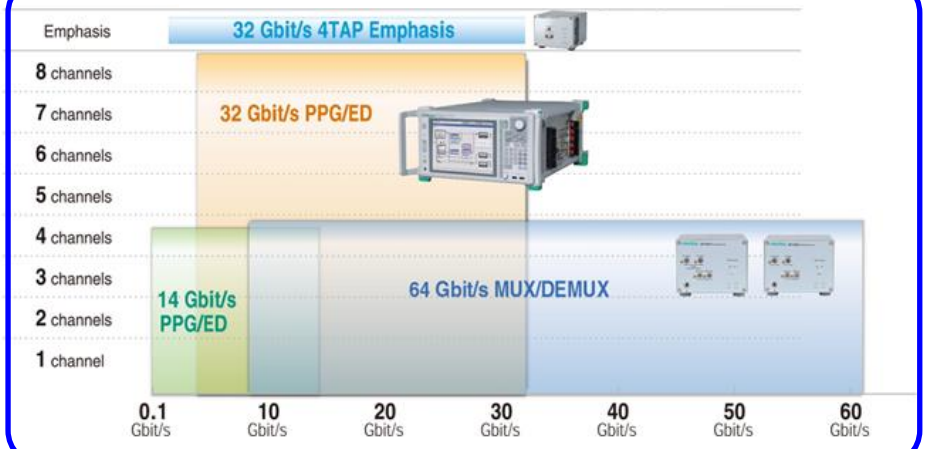
	53 Gbaud 4-lane Electrical Interface	Driver Output, LD Input Electrical Interface	400GBASE-FR8,LR8 Optical Interface
Baud Rate	53.125 Gbaud (106.25 Gbit/s)/Lane		
Lane Number	4		4-lane Single-mode Fiber (1310-nm Wavelength Band)
Main Measurement Items	・BER Test ・Eye Mask (EH, EW, Linearity) ・Tx/Rx Equalizer Function ・Jitter Addition Test (RJ/SJ/DCD) ・Crosstalk Test	・Eye Mask (EH, EW, Linearity) ・I/O Power Characteristics	・Average Optical Power ・OMA (Optical Modulation Amplitude) ・Extinction Ratio ・Optical Stress Test

Implementing High-Speed Bit Rate PAM4/NRZ Technologies

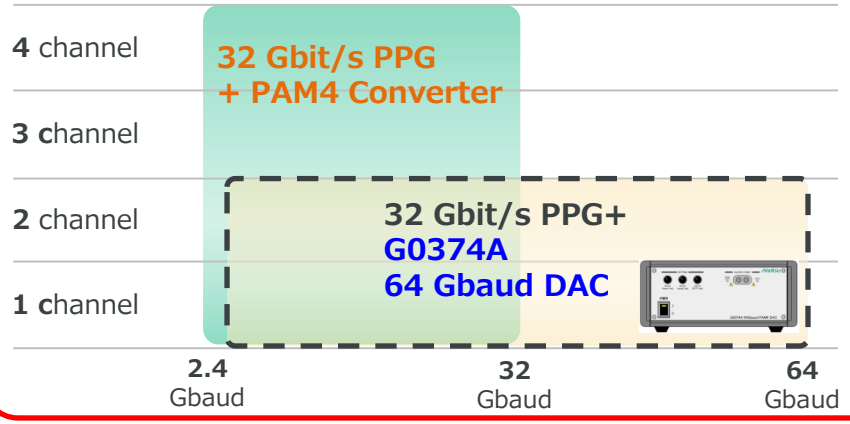
The Signal Quality Analyzer MP1800A series can measure PAM4/NRZ signals at the IEEE and OIF recommended high-speed bit rates using the SQA multichannel and expansion modules.

- Supports both high-baud-rate 64 Gbaud PAM4 and NRZ
- Excellent expandability from 32 Gbaud PAM4 4ch multichannel to 64 Gbaud
- Pulse pattern generation with low Intrinsic Jitter
- Supports Rx tests using Jitter Addition function

NRZ/Multi-channel Solution



PAM4/Multi-channel Solution



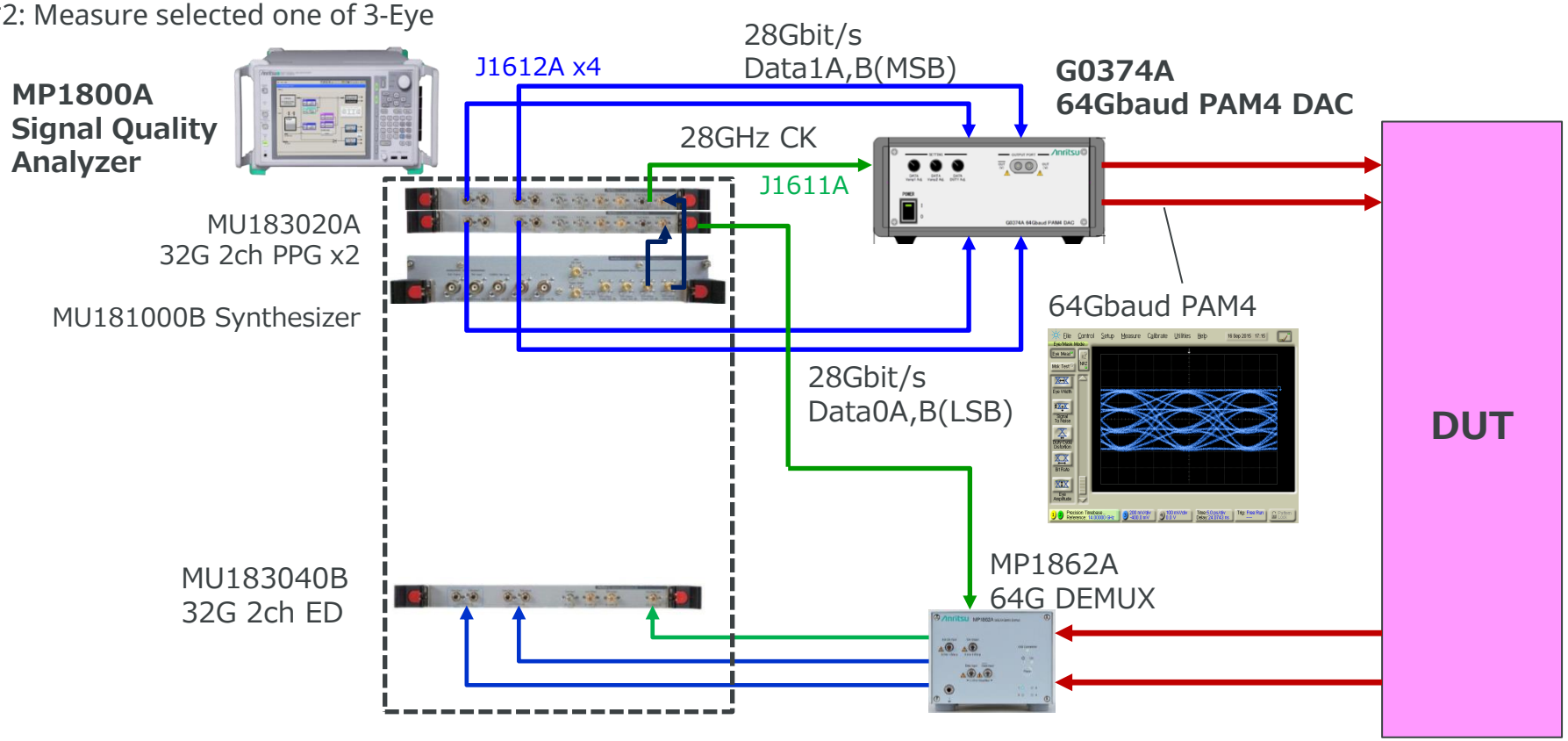
64Gbaud PAM4 BER Measurement Solution (1/2)

Main Specifications

- Wideband Operating Range: DC to 64 Gbaud(*1), supports latest high-speed interfaces
- 1.4 Vp-p (Differential, Typ.) Output and >6 dB Analog Amplitude Control Functions
- Excellent Output Jitter Performance of only 300 fs (rms)
- Measure PAM4 3-Eye BER(*2) using MP1862A with high input sensitivity (25 mV (typ.))
- NRZ, PAM4, and Emphasis Signal Control and Jitter Addition by Combining with MU183020A/MU183021A 32G PPG

*1: Error-free (BER <10^{-12}) at PRBS2^{15}-1 pattern and 56 Gbaud max (typ.) at G0374A – MP1862A loopback measurement

*2: Measure selected one of 3-Eye



64Gbaud PAM4 BER Measurement Solution (2/2)

G0374A Main Specifications

Items	Conditions	Units	Specifications		
			Min.	Typ.	Max.
Baud rate		Gbaud	DC*1		64
Data input bit rate	D0A/B, D1A/B V_{TH} = 0	Gbit/s			32
Data input voltage		Vp-p	0.6	1.0	2
Clock input frequency	CLK V_{TH} = 0	GHz			32
Clock input voltage		Vp-p	0.3	0.5	1
Output voltage*2	DC Coupling	Vp-p	0.5	0.7	0.9
Jitter*2,3	NRZ	fs rms		300	500
Rise time/fall time*2,3	NRZ, 20%/80%	ps		8	10
Amplitude control		dB		6	
Power consumption		W			8.5
Dimensions		mm	210 (W) x88 (H) x230 (D)		

MP1862A Main Specifications

Items	Conditions	Units	Specifications		
			Min.	Typ.	Max.
Baud rate	 Option 001	Gbaud	8 8		56.2 64.2
Data input amplitude	Single-End	Vp-p	0.125		1.0
Input sensitivity	Eye Height	mV		25	40

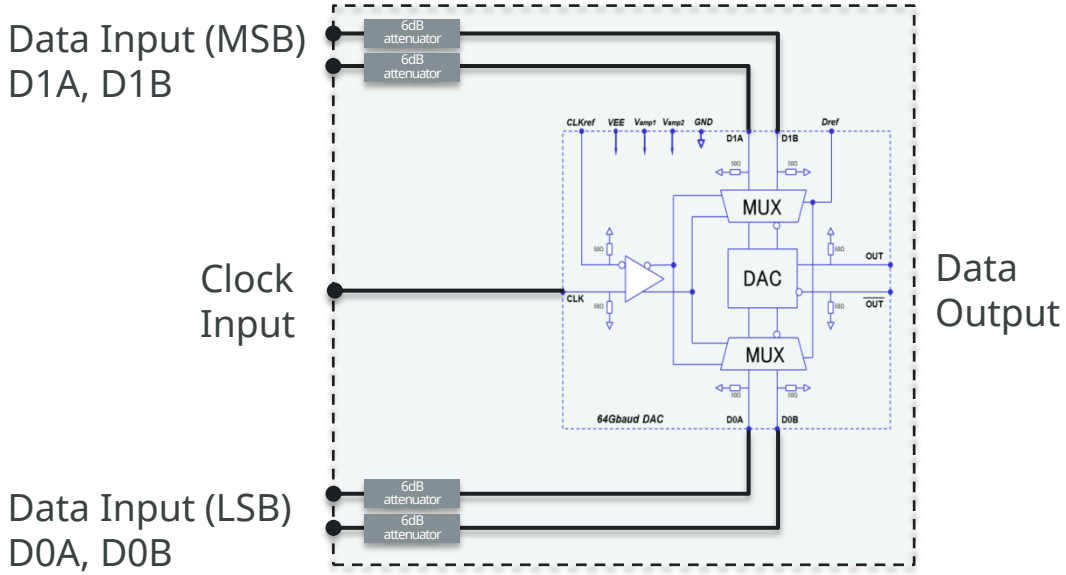
*1: Lower limit of 4.8 Gbaud when used in combination with either MU183020A or MU183021A
*2: Value observed at sampling oscilloscope with Intrinsic Jitter of <200 fs (rms) and 70-GHz bandwidth
*3: Value observed when output pattern set to 0101

Generating Signals by Combining G0374A and MP1800A (1/3)

Combining the G0374A with the MU18302xA 32G PPG multichannel function supports generation of PAM4, NRZ, and 2Tap Emphasis signals supporting high-speed interface standard signal technologies.

G0374A Functions	Output Performance
2-bit DA Conversion	Generates up to 4-level signals, such as PAM4, NRZ, 2Tap Emphasis. ←Use MU18302xA multichannel sync function.
4:2 MUX	Performs 2-bit DA conversion of input signal after 4:2 multiplexing. Generates required baud-rate signal using half-rate input. ← Use MU18302xA multichannel sync function.
Gain Control	Tunes (6 dB) analog output individually for MSB and LSB. ←Use Vamp1 (MSB) and Vamp2 (LSB) control.

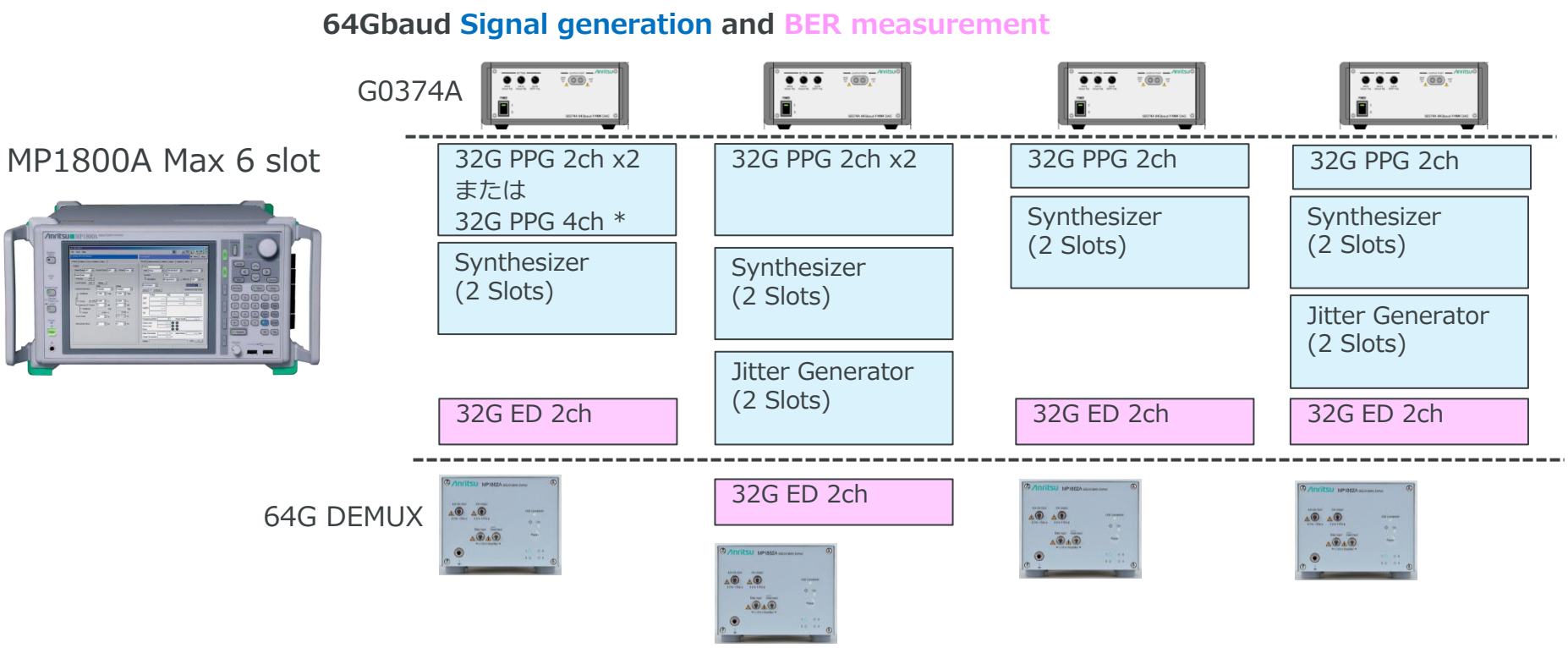
G0374A Block Diagram



Generating Signals by Combining G0374A and MP1800A (2/3)

MP1800A Configuration

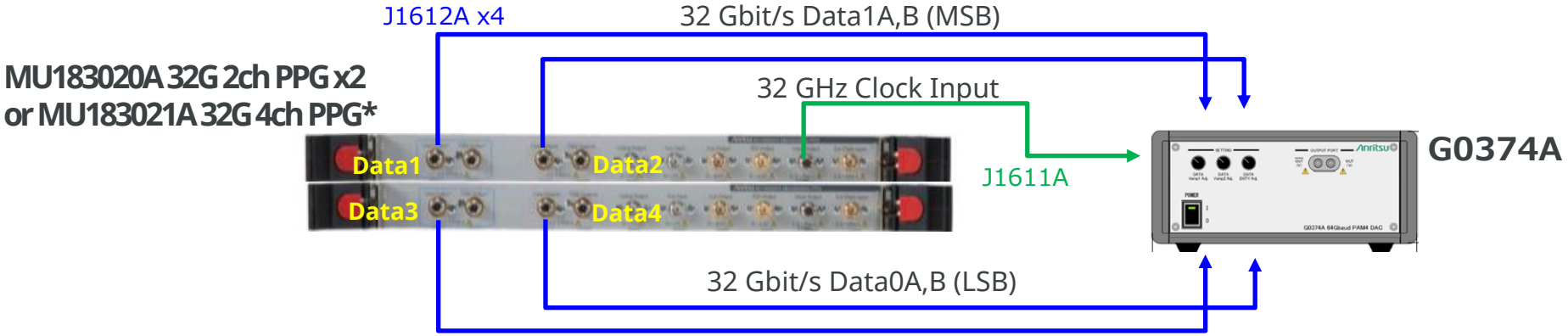
The G0374A is used in combination with the MU18302xA 32G PPG 4ch or 2ch configuration. The input signal phase and pattern are set easily using the multichannel sync function.
The main configuration is shown below.



*For Jitter addition, use the 32G PPG 2ch x 2 configuration as shown in slide 13.

Generating Signals by Combining G0374A and MP1800A (3/3)

➢ 4.8 to 64 Gbaud PAM4/NRZ/Emphasis Configuration



MU183020A Settings

Item	Setting
Data Output Amplitude	1.0 V
Data Output Offset	0 V (Vth)
Combination Setting PAM4 NRZ, Emphasis	 64G 2ch Combination 2ch Combination & 2ch CH Sync
Pattern Setting NRZ Emphasis	 Combination (Data1/2 pattern) = Combination (Data3/4 pattern) After setting NRZ output Change Data3/4 pattern Logic setting to ”NEG”, switch Data3 and 4 cable connections, add +1 UI to Data4 Delay setting

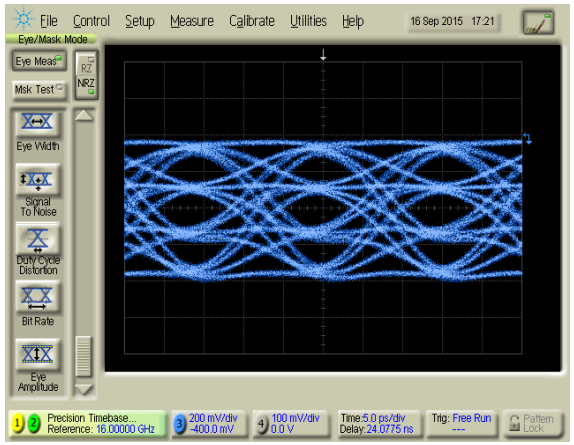
- When completing the set-up, use data input signal cables(Standard accessory J1612A) with a small delay difference (within 3 ps max.).
- Adjust the Data/Clock input phase error using the PPG Delay function while observing the output waveform on an oscilloscope.

*For Jitter addition, use the MU183020A 32G PPG 2ch x 2 configuration as shown in slide 13.

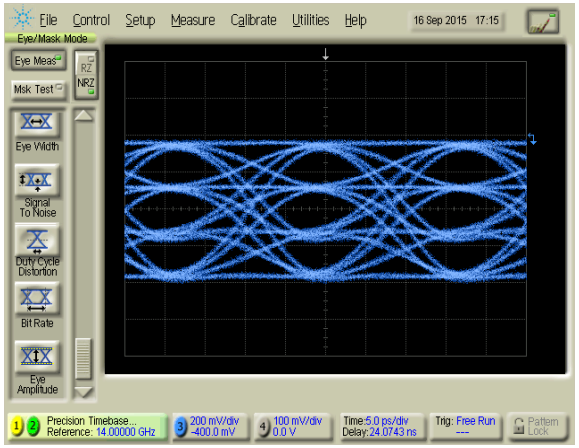
Typical Data Output Performance (1/2)

➢ PAM4 Output Waveforms (41 V -6 ATT +3 4 V V50 Adapter + 70-GHz Band Oscilloscope)

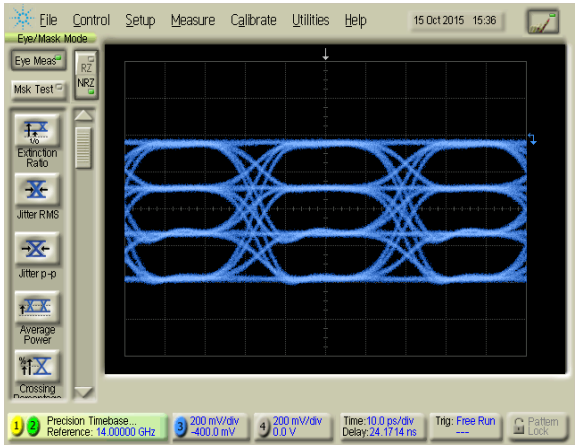
64 Gbaud



56 Gbaud

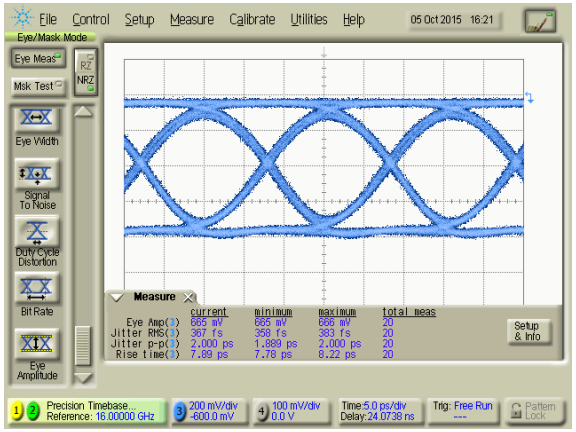


28 Gbaud

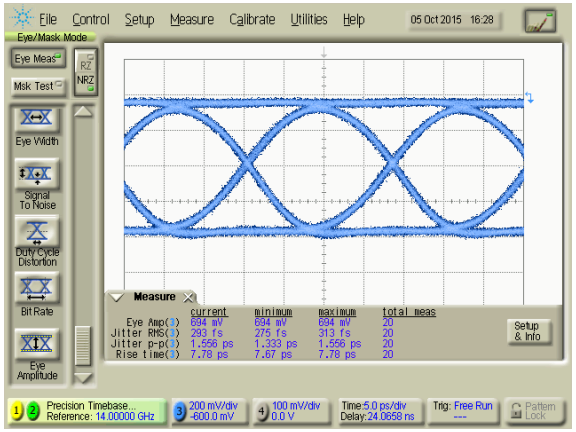


➢ NRZ Output Waveforms (41 V -6 ATT +3 4 V V50 Adapter + 70-GHz Band Oscilloscope)

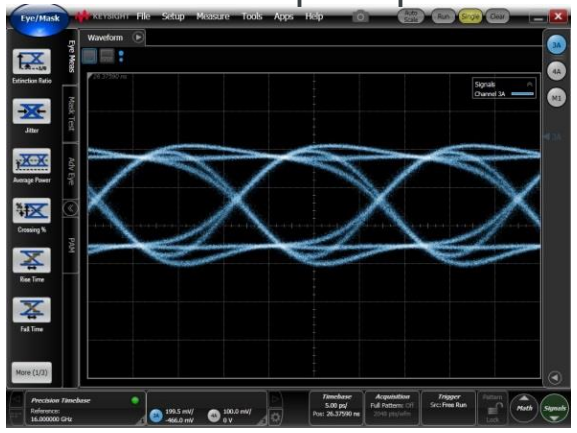
64 Gbaud



56 Gbaud



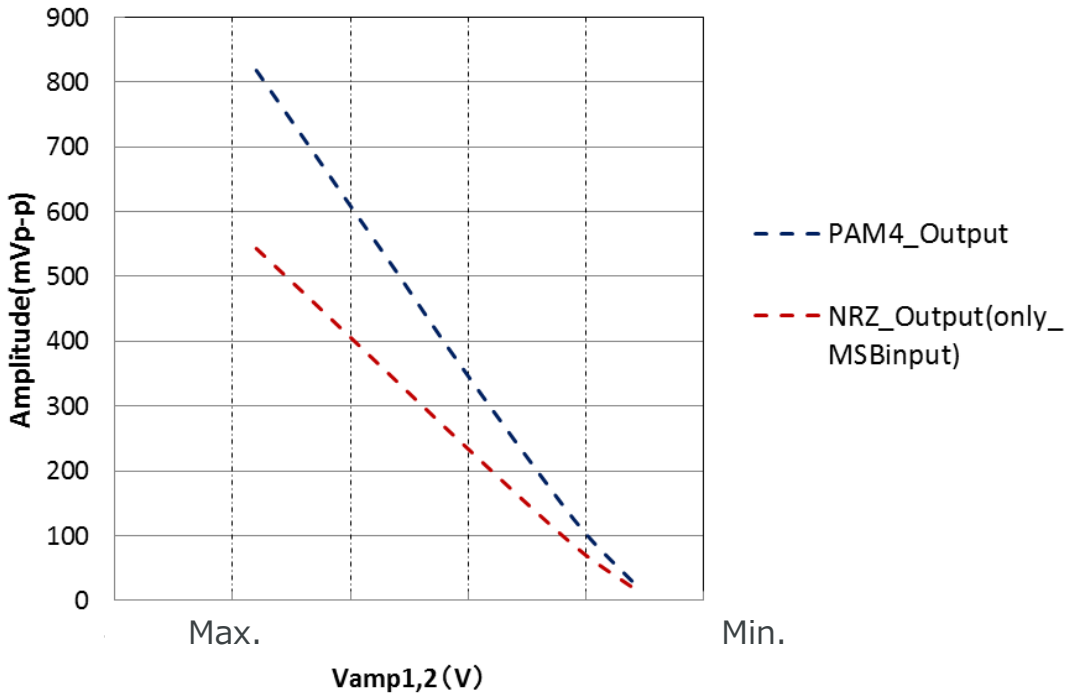
56Gbaud 2Tap Emphasis



Typical Data Output Performance (2/2)

➢ PAM4 Output Amplitude

The analog output can be controlled using the Vamp1 and Vamp2 volumes.
Vamp1 and Vamp2 correspond to the MSB and LSB, respectively. To output a PAM4 waveform that is broadly vertical symmetric eye open, set the same value for Vamp1 and Vamp2.
The following shows the reference values for the PAM4 output amplitude (single-end) when using Vamp1 and Vamp2 control, and at NRZ output using only MSB input for the configuration on slide16.

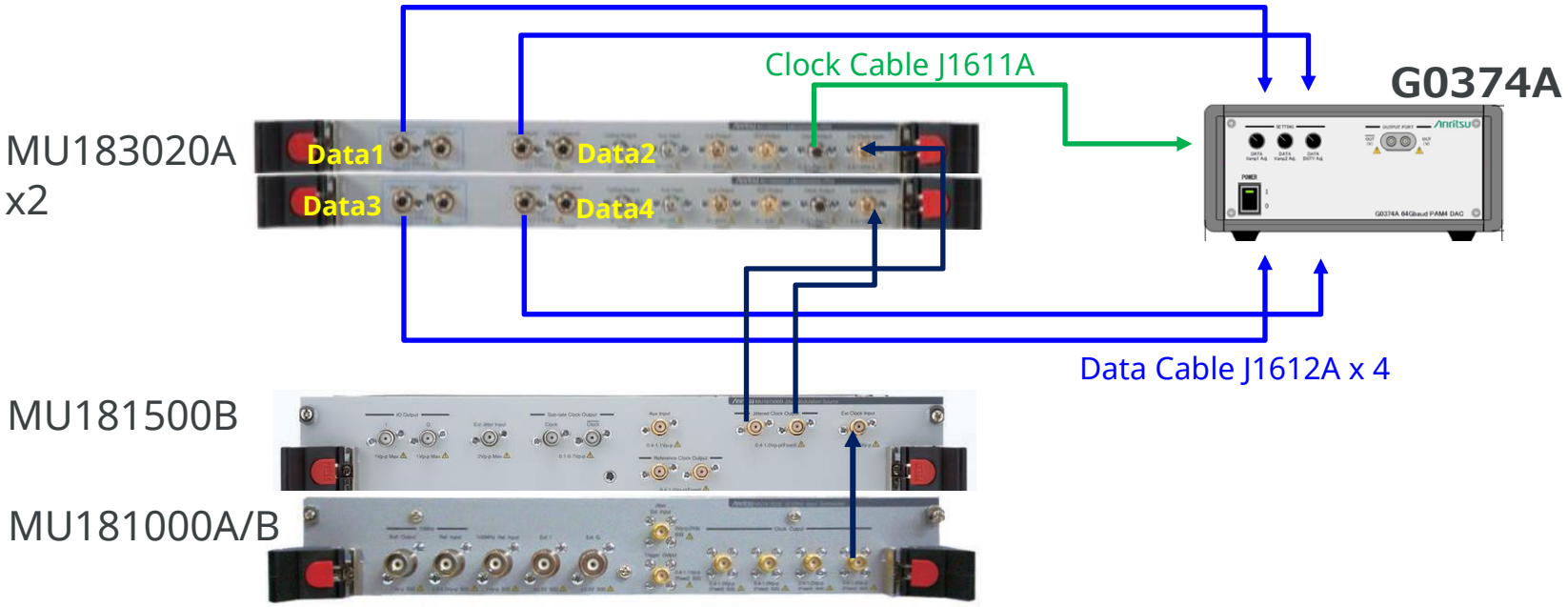


How to Add Jitter

Jitter load tests can be executed by using the G0374A in combination with the Jitter Modulation Source MU181500B and adding Jitter to the PAM4 output signal.
When adding Jitter to the G0361A output, take the following precautions about the input Clock and input Data skew.
Additionally, tolerance tests can be performed by controlling the output signal DCD using the CLKref voltage.

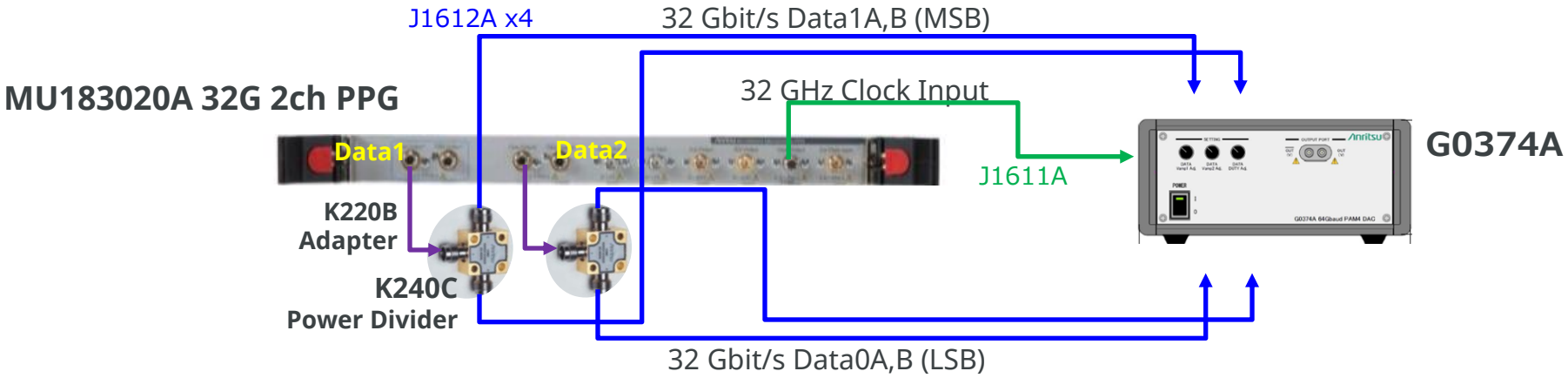
➢ Jitter Addition Configuration

Recommended cables: Data Input (4 pcs) Coaxial Cable 80 cm (Standard accessory J1612A x4)
Clock Input Coaxial Cable 130 cm (Standard accessory J1611A)
(When using MU183020A, the Clock and Data cable difference should be 50 cm ±10 cm.)



32G 2ch PPG x 1 Set-up (1/3)

- For 2.4 to 32.1 Gbaud PAM4



MU183020A Settings

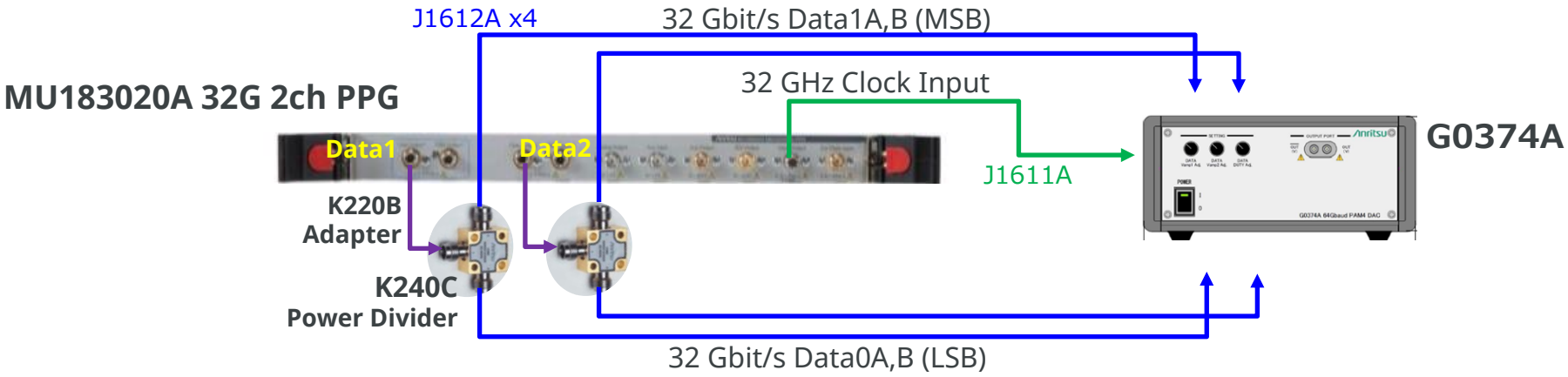
Item	Setting
Data Output Amplitude	2.0 V*
Data Output Offset	0 V (Vth)
Combination Setting	2ch Combination
Pattern Setting	Any

*The Data1 and Data2 amplitude setting is 2 Vp-p assuming halving by the Power Divider. (The G0374A may be damaged if the maximum input is exceeded.)

- When completing the set-up, use data input signal cables(Standard accessory J1612A) with a small delay difference (within 3 ps max.).
- Adjust the Data/Clock input phase error using the PPG Delay function while observing the output waveform on an oscilloscope.

32G 2ch PPG x 1 Set-up (2/3)

➢ For 4.8 to 64 Gbaud NRZ



MU183020A Settings

Item	Setting
Data Output Amplitude	2.0 V*
Data Output Offset	0 V (Vth)
Combination Setting	2ch Combination
Pattern Setting	Any

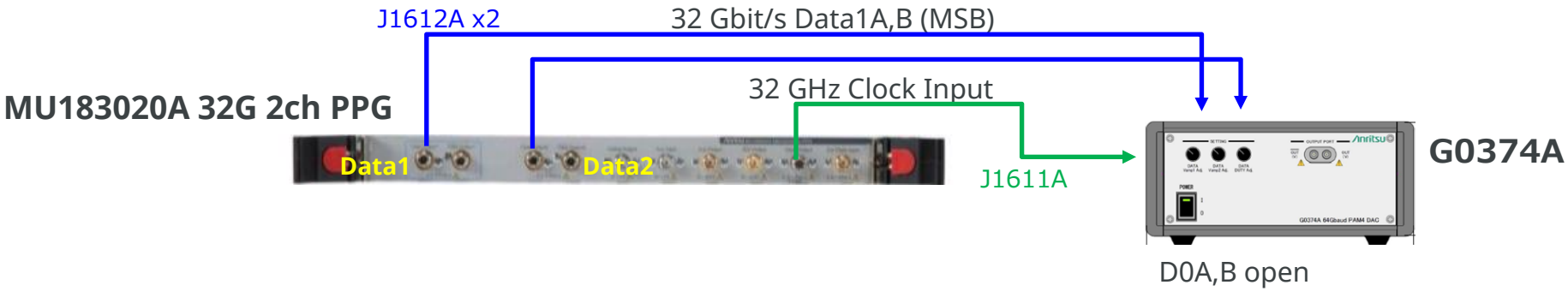
*The Data1 and Data2 amplitude setting is 2 Vp-p assuming halving by the Power Divider. (The G0374A may be damaged if the maximum input is exceeded.)

- When completing the set-up, use data input signal cables(Standard accessory J1612A) with a small delay difference (within 3 ps max.).
- Adjust the Data/Clock input phase error using the PPG Delay function while observing the output waveform on an oscilloscope.

32G 2ch PPG x 1 Set-up (3/3)

➢ For 4.8 to 64 Gbaud NRZ

Reference: G0374A max. output amplitude 0.6 Vp-p (NRZ (only MSB input) amplitude control)



MU183020A Settings

Item	Setting
Data Output Amplitude	1.0 V
Data Output Offset	0 V (Vth)
Combination Setting	2ch Combination
Pattern Setting	Any

*Set Vamp2 at G0374A front panel to Min.

- When completing the set-up, use data input signal cables(Standard accessory J1612A) with a small delay difference (within 3 ps max.).
- Adjust the Data/Clock input phase error using the PPG Delay function while observing the output waveform on an oscilloscope.

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