MP2110A BERTWave
Operation Manual

Ninth Edition

For safety and warning information, please read this manual before attempting to use the equipment.
Keep this manual with the equipment.

ANRITSU CORPORATION

Safety Symbols

To prevent the risk of personal injury or loss related to equipment malfunction, Anritsu Corporation uses the following safety symbols to indicate safety-related information. Ensure that you clearly understand the meanings of the symbols BEFORE using the equipment. Some or all of the following symbols may be used on all Anritsu equipment. In addition, there may be other labels attached to products that are not shown in the diagrams in this manual.

Symbols used in manual

⚠ DANGER This indicates a very dangerous procedure that could result in serious injury or death if not performed properly.

⚠ WARNING This indicates a hazardous procedure that could result in serious injury or death if not performed properly.

⚠ CAUTION This indicates a hazardous procedure or danger that could result in light-to-severe injury, or loss related to equipment malfunction, if proper precautions are not taken.

Safety Symbols Used on Equipment and in Manual

The following safety symbols are used inside or on the equipment near operation locations to provide information about safety items and operation precautions. Ensure that you clearly understand the meanings of the symbols and take the necessary precautions BEFORE using the equipment.

This indicates a prohibited operation. The prohibited operation is indicated symbolically in or near the barred circle.

This indicates an obligatory safety precaution. The obligatory operation is indicated symbolically in or near the circle.

This indicates a warning or caution. The contents are indicated symbolically in or near the triangle.

This indicates a note. The contents are described in the box.

These indicate that the marked part should be recycled.

MP2110A BERTWave
Operation Manual

13 January 2017 (First Edition)
30 March 2018 (Ninth Edition)

For Safety

⚠ WARNING

- ALWAYS refer to the operation manual when working near locations at which the alert mark shown on the left is attached. If the advice in the operation manual is not followed, there is a risk of personal injury or reduced equipment performance. The alert mark shown on the left may also be used with other marks and descriptions to indicate other dangers.

- Overvoltage Category
  This equipment complies with overvoltage category II defined in IEC 61010. DO NOT connect this equipment to the power supply of overvoltage category III or IV.

Electric Shock

- To ensure that the equipment is grounded, always use the supplied 3-pin power cord, and insert the plug into an outlet with a ground terminal. If power is supplied without grounding the equipment, there is a risk of receiving a severe or fatal electric shock or causing damage to the internal components.

Repair

⚠ WARNING
NO OPERATOR SERVICE-
ABLE PARTS INSIDE.
REFER SERVICING TO
QUALIFIED PERSONNEL.

- Only qualified service personnel with a knowledge of electrical fire and shock hazards should service this equipment. This equipment cannot be repaired by the operator. DO NOT attempt to remove the equipment covers or unit covers or to disassemble internal components. There are high-voltage parts in this equipment presenting a risk of severe injury or fatal electric shock to untrained personnel. In addition, there is a risk of damage to precision components.

Calibration

VOID IF SEAL BROKEN
Anritsu
CALIBRATION SERVICES

- The performance-guarantee seal verifies the integrity of the equipment. To ensure the continued integrity of the equipment, only Anritsu service personnel, or service personnel of an Anritsu sales representative, should break this seal to repair or calibrate the equipment. Be careful not to break the seal by opening the equipment or unit covers. If the performance-guarantee seal is broken by you or a third party, the performance of the equipment cannot be guaranteed.

For Safety

⚠ WARNING

Falling Over

- This equipment should always be positioned in the correct manner. If the cabinet is turned on its side, etc., it will be unstable and may be damaged if it falls over as a result of receiving a slight mechanical shock.

  Always set up the equipment in a position where the power switch can be reached without difficulty.

For Safety

⚠ CAUTION

Cleaning
- Always remove the main power cable from the power outlet before cleaning dust around the power supply and fan.
  - Clean the power inlet regularly. If dust accumulates around the power pins, there is a risk of fire.
  - Keep the cooling fan clean so that the ventilation holes are not obstructed. If the ventilation is obstructed, the cabinet may overheat and catch fire.

Check Terminal
- Never input a signal of more than the indicated value between the measured terminal and ground. Input of an excessive signal may damage the equipment.

Static Sensitive
- Always take the following anti-static measures to prevent the internal circuit from being damaged when using a connector indicated by the symbol shown on the left.
  - Wear a wrist strap connected to the ground terminal of this equipment.
  - Connect the ground wires of this equipment, external measuring instruments and DUT before connecting a coaxial cable.
  - Eliminate static electricity charged between the cores and outer conductors of an external device and the coaxial cable, before connecting this equipment and the external device.

Replacing Memory Back-up Battery

This equipment uses a Poly-cardoon fluoride lithium battery to backup the memory. This battery must be replaced by service personnel when it has reached the end of its useful life; contact the Anritsu sales section or your nearest representative.

Note: The battery used in this equipment has a maximum useful life of 2 years. It should be replaced before this period has elapsed.

The life of the battery will vary depending on the length of equipment usage and the operating environment.
The following conditions may be observed if the battery has expired:
- When power to the equipment is supplied, the time display may no longer match the actual time.

For Safety

⚠ CAUTION

External Storage Media

This equipment uses USB memory devices as external storage media for storing data and programs.

If this media is mishandled or becomes faulty, important data may be lost. To prevent this chance occurrence, all important data and programs should be backed-up.

Anritsu will not be held responsible for lost data.

Pay careful attention to the following points.
- Never remove the USB memory device from the instrument while it is being accessed.
- The USB memory device may be damaged by static electric charges.
- Anritsu has thoroughly tested all external storage media such as USB memory, Hard disk drive and DVD drive. Users should note that external storage media may not have been tested by Anritsu, thus Anritsu cannot guarantee the performance or suitability of such media.

For Safety

⚠ CAUTION

SSD

The instrument is equipped with a SSD (Solid State Drive) from which, as with any flash memory, data may be lost because of limitation of writing times. The writing limitation of flash memory is approximately one million.

<u>Anritsu will not be held responsible for lost data.</u>

Note: The flash memory used in this equipment has a maximum writing time of one million.

Anritsu can take no responsibility for lost data, and users are recommended to always back up important data at regular intervals. To reduce the possibility of data loss, particular attention should be given to the following points.

- The instrument should only be used within the recommend temperature range, and should not be used in locations where the temperature may fluctuate suddenly.
- Always follow the guidelines to ensure that the instrument is set up in the specified manner.
- Always ensure that the fans at the rear and side of the instrument are not blocked or obstructed in any way.
- Exercise care not to bang or shake the instrument while the power is on.
- Never disconnect the mains power at the plug or cut the power at the breaker with the instrument turned on.

Lifetime of Parts

The life span of certain parts used in this equipment is determined by the operating time or the power-on time. Due consideration should be given to the life spans of these parts when performing continuous operation over an extended period. The safety of the equipment cannot be guaranteed if component parts are used beyond their life spans. These parts must be replaced at the customer's expense even if within the guaranteed period described in Warranty at the beginning of this manual.

For details on life-span, refer to the corresponding section in this manual.

Coaxial switch: One million times (Switching scope optical input connector)

Coaxial switch: Five million times (Switching BERT clock output channel)

For Safety

⚠ CAUTION

Use in a residential environment

This instrument is designed for an industrial environment.
In a residential environment this instrument may cause radio interference in which case the user may be required to take adequate measures.

Use in Corrosive Atmospheres

Exposure to corrosive gases such as hydrogen sulfide, sulfurous acid, and hydrogen chloride will cause faults and failures.
Note that some organic solvents release corrosive gases.

Equipment Certificate

Anritsu Corporation certifies that this equipment was tested before shipment using calibrated measuring instruments with direct traceability to public testing organizations recognized by national research laboratories, including the National Institute of Advanced Industrial Science and Technology, and the National Institute of Information and Communications Technology, and was found to meet the published specifications.

Anritsu Warranty

Anritsu Corporation will repair this equipment free-of-charge if a malfunction occurs within one year after shipment due to a manufacturing fault. However, software fixes will be made in accordance with the separate Software End-User License Agreement. Moreover, Anritsu Corporation will deem this warranty void when:

- The fault is outside the scope of the warranty conditions separately described in the operation manual.
- The fault is due to mishandling, misuse, or unauthorized modification or repair of the equipment by the customer.
- The fault is due to severe usage clearly exceeding normal usage.
- The fault is due to improper or insufficient maintenance by the customer.
- The fault is due to natural disaster, including fire, wind, flooding, earthquake, lightning strike, or volcanic ash, etc.
- The fault is due to damage caused by acts of destruction, including civil disturbance, riot, or war, etc.
- The fault is due to explosion, accident, or breakdown of any other machinery, facility, or plant, etc.
- The fault is due to use of non-specified peripheral or applied equipment or parts, or consumables, etc.
- The fault is due to use of a non-specified power supply or in a non-specified installation location.
- The fault is due to use in unusual environments[Note].
- The fault is due to activities or ingress of living organisms, such as insects, spiders, fungus, pollen, or seeds.

In addition, this warranty is valid only for the original equipment purchaser. It is not transferable if the equipment is resold.

Anritsu Corporation shall assume no liability for injury or financial loss of the customer due to the use of or a failure to be able to use this equipment.

Note:

For the purpose of this Warranty, "unusual environment" means use:

- In places of direct sunlight
- In dusty places
- Outdoors
- In liquids, such as water, oil, or organic solvents, and medical fluids, or places where these liquids may adhere
- In salty air or in places where chemically active gases (sulfur dioxide, hydrogen sulfide, chlorine, ammonia, nitrogen oxide, or hydrogen chloride etc.) are present
- In places where high-intensity static electric charges or electromagnetic fields are present
- In places where abnormal power voltages (high or low) or instantaneous power failures occur
- In places where condensation occurs
- In the presence of lubricating oil mists
- In places at an altitude of more than 2,000 m
- In the presence of frequent vibration or mechanical shock, such as in cars, ships, or airplanes

Anritsu Corporation Contact

In the event that this equipment malfunctions, contact an Anritsu Service and Sales office. Contact information can be found on the last page of the printed version of this manual, and is available in a separate file on the PDF version.

Crossed-out Wheeled Bin Symbol

Equipment marked with the Crossed-out Wheeled Bin Symbol complies with council directive 2012/19/EU (the "WEEE Directive") in European Union.

For Products placed on the EU market after August 13, 2005, please contact your local Anritsu representative at the end of the product's useful life to arrange disposal in accordance with your initial contract and the local law.

Software End-User License Agreement (EULA)

Please read this Software End-User License Agreement (hereafter this EULA) carefully before using (includes executing, copying, registering, etc.) this software (includes programs, databases, scenarios, etc., used to operate, set, etc., Anritsu electronic equipment). By reading this EULA and using this software, you are agreeing to be bound by the terms of its contents and Anritsu Corporation (hereafter Anritsu) hereby grants you the right to use this Software with the Anritsu-specified equipment (hereafter Equipment) for the purposes set out in this EULA.

1. Grant of License and Limitations

1. Regardless of whether this Software was purchased from or provided free-of-charge by Anritsu, you agree not to rent, lease, lend, or otherwise distribute this Software to third parties and further agree not to disassemble, recompile, reverse engineer, modify, or create derivative works of this Software.

2. You may make one copy of this Software for backup purposes only.

3. You are not permitted to reverse engineer this software.

4. This EULA allows you to install one copy of this Software on one piece of Equipment.

2. Disclaimers

To the extent not prohibited by law, in no event shall Anritsu be liable for personal injury, or any incidental, special, indirect or consequential damages whatsoever, including, without limitation, damages for loss of profits, loss of data, business interruption or any other commercial damages or losses, arising out of or related to your use or inability to use this Software.

3. Limitation of Liability

a. If a fault (bug) is discovered in this Software, preventing operation as described in the operation manual or specifications whether or not the customer uses this software as described in the manual, Anritsu shall at its own discretion, fix the bug, or exchange the software, or suggest a workaround, free-of-charge. However, notwithstanding the above, the following items shall be excluded from repair and warranty.

   i) If this Software is deemed to be used for purposes not described in the operation manual or specifications.

   ii) If this Software is used in conjunction with other non-Anritsu-approved software.

   iii) Recovery of lost or damaged data.

   iv) If this Software or the Equipment has been modified, repaired, or otherwise altered without Anritsu's prior approval.

   v) For any other reasons out of Anritsu's direct control and responsibility, such as but not limited to, natural disasters, software virus infections, etc.

b. Expenses incurred for transport, hotel, daily allowance, etc., for on-site repairs by Anritsu engineers necessitated by the above faults shall be borne by you.

c. The warranty period for faults listed in article 3a above covered by this EULA shall be either 6 months from the date of purchase of this Software or 30 days after the date of repair, whichever is longer.

4. **Export Restrictions**

   You may not use or otherwise export or re-export directly or indirectly this Software except as authorized by Japanese and United States law. In particular, this software may not be exported or re-exported (a) into any Japanese or US embargoed countries or (b) to anyone on the Japanese or US Treasury Department's list of Specially Designated Nationals or the US Department of Commerce Denied Persons List or Entity List. By using this Software, you warrant that you are not located in any such country or on any such list. You also agree that you will not use this Software for any purposes prohibited by Japanese and US law, including, without limitation, the development, design and manufacture or production of missiles or nuclear, chemical or biological weapons of mass destruction.

5. **Termination**

   Anritsu shall deem this EULA terminated if you violate any conditions described herein. This EULA shall also be terminated if the conditions herein cannot be continued for any good reason, such as violation of copyrights, patents, or other laws and ordinances.

6. **Reparations**

   If Anritsu suffers any loss, financial or otherwise, due to your violation of the terms of this EULA, Anritsu shall have the right to seek proportional damages from you.

7. **Responsibility after Termination**

   Upon termination of this EULA in accordance with item 5, you shall cease all use of this Software immediately and shall as directed by Anritsu either destroy or return this Software and any backup copies, full or partial, to Anritsu.

8. **Dispute Resolution**

   If matters of dispute or items not covered by this EULA arise, they shall be resolved by negotiations in good faith between you and Anritsu.

9. **Court of Jurisdiction**

   This EULA shall be interpreted in accordance with Japanese law and any disputes that cannot be resolved by negotiation described in Article 8 shall be settled by the Japanese courts.

Cautions against computer virus infection

- Copying files and data
  Only files that have been provided directly from Anritsu or generated using Anritsu equipment should be copied to the instrument.
  All other required files should be transferred by means of USB or CompactFlash media after undergoing a thorough virus check.
- Adding software
  Do not download or install software that has not been specifically recommended or licensed by Anritsu.
- Network connections
  Ensure that the network has sufficient anti-virus security protection in place.
- Protection against malware (intentionally harmful software) and virus.
  This equipment runs on Windows Operating System.
  To connect This equipment to network, the following is advised.
  - Activate Firewall.
  - Install important updates of Windows.
  - Use antivirus software.

CE Conformity Marking

Anritsu affixes the CE conformity marking on the following product(s) in accordance with the Decision 768/2008/EC to indicate that they conform to the EMC, LVD, and RoHS directive of the European Union (EU).

CE marking

1. Product Model

Model: MP2110A BERTWave

2. Applied Directive

EMC: Directive 2014/30/EU

LVD: Directive 2014/35/EU

RoHS: Directive 2011/65/EU

3. Applied Standards

- EMC: Emission: EN 61326-1: 2013 (Class A)
    Immunity: EN 61326-1: 2013 (Table 2)

	Performance Criteria*
IEC 61000-4-2 (ESD)	B
IEC 61000-4-3 (EMF)	A
IEC 61000-4-4 (Burst)	B
IEC 61000-4-5 (Surge)	B
IEC 61000-4-6 (CRF)	A
IEC 61000-4-11 (V dip/short)	B, C

*: Performance Criteria

A: The equipment shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the equipment is used as intended. The performance level may be replaced by a permissible loss of performance. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product description and documentation and what the user may reasonably expect from the equipment if used as intended.

B: The equipment shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the equipment is used as intended. The performance level may be replaced by a permissible loss of performance. During the test, degradation of performance is however allowed. No change of actual operating state or stored data is allowed. If the minimum performance level or the permissible performance loss is not specified by the manufacturer, either of these may be derived from the product description and documentation and what the user may reasonably expect from the equipment if used as intended.

C: Temporary loss of function is allowed, provided the function is self-recoverable or can be restored by the operation of the controls.

Harmonic current emissions:
  EN 61000-3-2: 2014 (Class A equipment)
  : No limits apply for this equipment with an active input power under 75 W.

- LVD: EN 61010-1: 2010 (Pollution Degree 2)
- RoHS: EN 50581: 2012 (Category 9)

4. Authorized representative

Name: Murray Coleman
               Head of Customer Service EMEA
               ANRITSU EMEA Ltd.
Address, city: 200 Capability Green, Luton
               Bedfordshire, LU1 3LU
Country: United Kingdom

RCM Conformity Marking

Anritsu affixes the RCM mark on the following product(s) in accordance with the regulation to indicate that they conform to the EMC framework of Australia/New Zealand.

RCM marking

1. Product Model

Model: MP2110A BERTWave

2. Applied Standards

EMC: Emission: EN 61326-1: 2013 (Class A equipment)

About Eco label

Excellent Eco Product
Lightweight
Power saving
Small size

The label shown on the left is attached to Anritsu products meeting our environmental standards.

Details about this label and the environmental standards are available on the Anritsu website at https://www.anritsu.com.

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About This Manual

The manual set for the BERTWave Series consists of the following five operation manuals:

MP2110A BERTWave Operation Manual
(M-W3831AE) (This Manual)

This manual is intended for those who use the MP2110A BERTWave, and explains the installation procedure, handling precautions, connector connection procedures, panel operations, maintenance procedures, specifications and various functions.

MP2100B BERTWave Operation Manual
(M-W3772AE)

This manual is intended for those who use the MP2100B BERTWave, and explains the installation procedure, handling precautions, connector connection procedures, panel operations, maintenance procedures, specifications and various functions.

MX210001A Jitter Analysis Software
Operation Manual (M-W3569AE)

This manual explains the operation method and remote control commands for the MX210001A Jitter Analysis Software.

MX210002A Transmission Analysis Software
Operation Manual (M-W3571AE)

This manual explains the operation method and remote control commands for the MX210002A Transmission Analysis Software.

BERTWave series Remote Control
Operation Manual (M-W3773AE)

This manual explains the commands to control the BERTWave, status register structure, and sample programs.

This operation manual assumes the reader has the following basic knowledge:

- Optical communications, handling optical parts
- Bit error measurement method
- Oscilloscope operation
- Windows file operations and the Windows Control Panel

Manual Notation System

The MP2110A BERTWave is referred to as the MP2110A in this manual.

The user interface such as button and tag names are in bold.
Example: **PPG**, **System Menu**

The connector names on the panel are in **Arial – Bold**.
Example: **Data Out**, **Ch A In**

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Appendix

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VI.

This chapter explains the MP2110A BERTWave configuration, features, and technical terms used in this manual.

1

Outline

1.1 Introduction of BERTWave

The BERTWave is a measuring instrument that combines the functions of a pulse pattern generator (PPG), bit error detector (ED) and sampling oscilloscope all-in-one instrument.

The PPG generates a digital signal with editable data transmission speed, pulse voltage level, and send data pattern.
The ED compares the received data bit string with the expected data a bit string and calculates the number of different bits (bit error count). It calculates the bit error rate from the number of received bits and the bit error account. The voltage level for recognizing "0" and "1" of the digital signal, and the data bit string (pattern) can be edited.

The sampling oscilloscope displays the periodic signal waveform. An Eye diagram can be displayed by summing the signal waveforms and signal waveforms can be analyzed and mask tested.
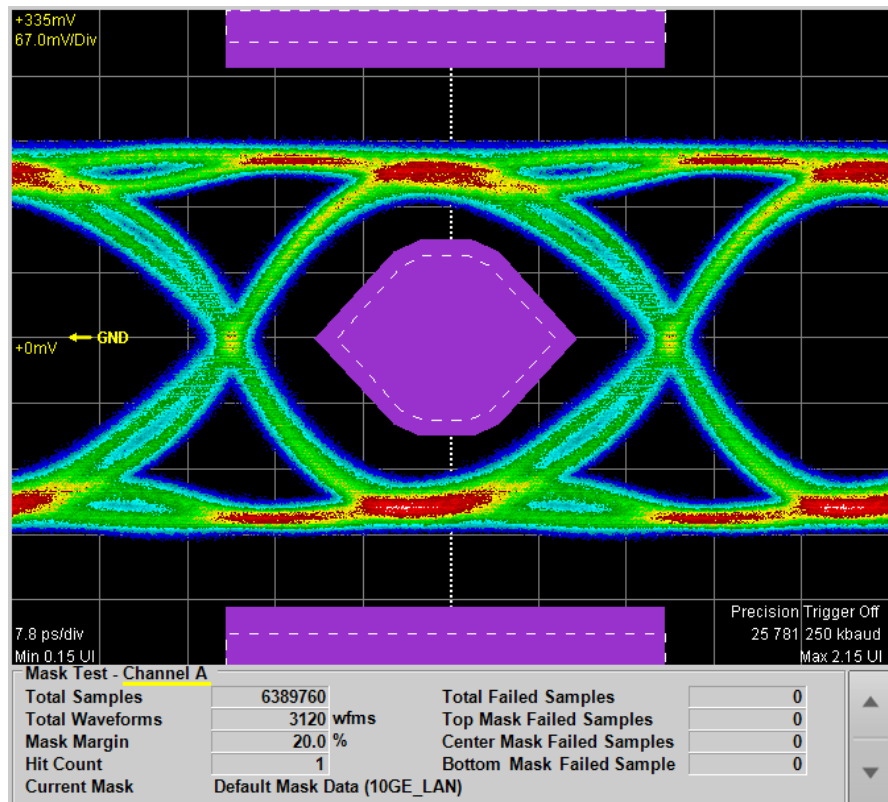

Figure 1.1-1   Mask Test Waveform

1.1.1 MP2110A BERTWave

MP2110A BERTWave (MP2110A) is a measuring instrument combining the BERT (Bit Error Rate Tester) and the sampling oscilloscope. It is used by connecting with the monitor, key board, and mouse as the same as PC. It is controlled remotely using Ethernet or GPIB (General Purpose Interface Bus).

Figure 1.1.1-1   MP2110A External View

MP2110A is a measuring instrument that evaluates the electronic devices such as 100G bit Ethernet (100GbE), OTU4, 32G Fiber Channel (32GFC). It performs the bit error rate test and waveform observation for the signals of bit rate "24.3 to 28.2 Gbit/s" used in the communication standards.

The bit error rate test and wave form observation for the signals of bit rate "10 Gbit/s" can be performed by adding the MP2110A-093 PPG/ED Bit Rate expansion.
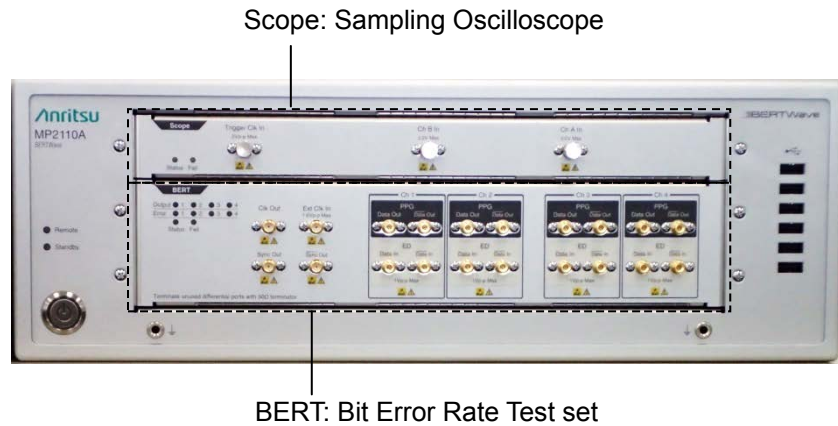
Scope: Sampling Oscilloscope

BERT: Bit Error Rate Test set

Figure 1.1.1-2   Front Panel of MP2110A

The input connectors of the sampling oscilloscope can be selected by specifying the option.

Table 1.1.1-1   Sampling Oscilloscope Input Connectors

Options	Channel A			Channel B		
	Electrical	Optical	Optical	Electrical	Optical	Optical
	K	MMF*1	SMF*2	K	MMF*1	SMF*2
MP2110A-021	✓			✓		
MP2110A-022, MP2110A-032		✓	✓		✓	✓
MP2110A-023, MP2110A-033	✓				✓	✓
MP2110A-025, MP2110A-035						✓
MP2110A-026, MP2110A-036					✓	

*1:   For a multi-mode fiber

*2:   For a single-mode fiber

Note:

MP2110A-022 to 026 and MP2110A-032 to 036 have different reference receiver properties (Bessel filter approximation property) of optical channel. MP2110A-032 to 036 are adjusted to have flat baseband properties.

BERT (Bit Error Rate Tester) uses PPG (Pulse Pattern Generator) and ED (Error Detector) together.
The number of BERT channels can be selected by specifying the option.

Table 1.1.1-2   Number of BERT Channels

Option	Number of Channels
MP2110A-011	1
MP2110A-012	2
MP2110A-014	4

By adding MP2110A-054 Clock Recovery (Electrical/Optical), it is possible to generate a trigger clock for the sampling oscilloscope from the input signal.

By adding MP2110A-095 PAM4 Analysis Software, PAM4 waveform can be analyzed.

In this document, multiple option names are collectively called as follows.

BERT option:　MP2110A-011, 012, and 014

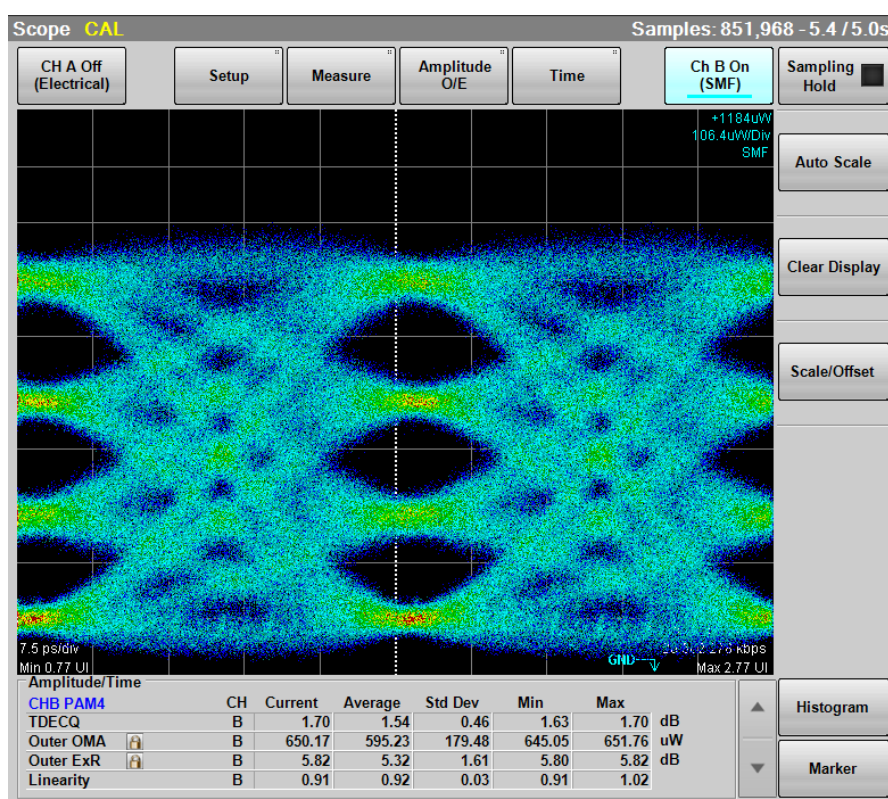Scope option:　MP2110A-021, 022, 023, 025, 026, 032, 033, 035, and 036

Figure 1.1.1-3　Example of PAM4 Waveform Analysis

By adding MP2110A-096 Jitter Analysis Software, jitter analysis result can be displayed.
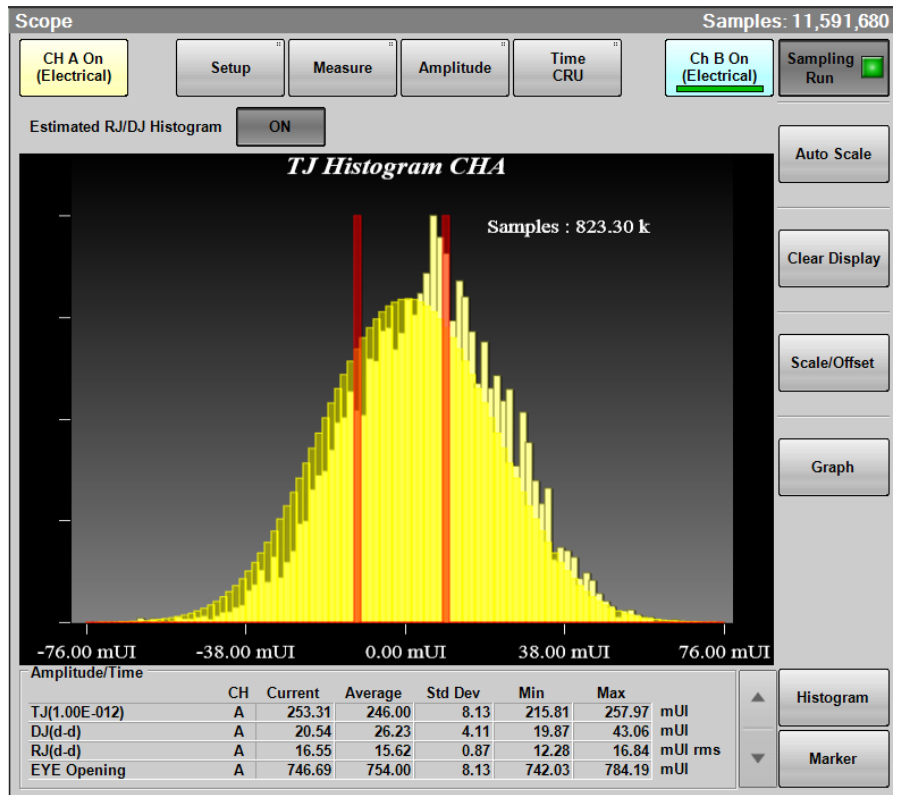
Figure 1.1.1-4   Example of Jitter Analysis

1.1.2 MP2100B BERTWave

MP2100B BERTWave supports the bit rate from STM-1 to 10GbE. It evaluates the 40 Gbps communication devices such as 40GbE using PPG and ED for 4 channels.
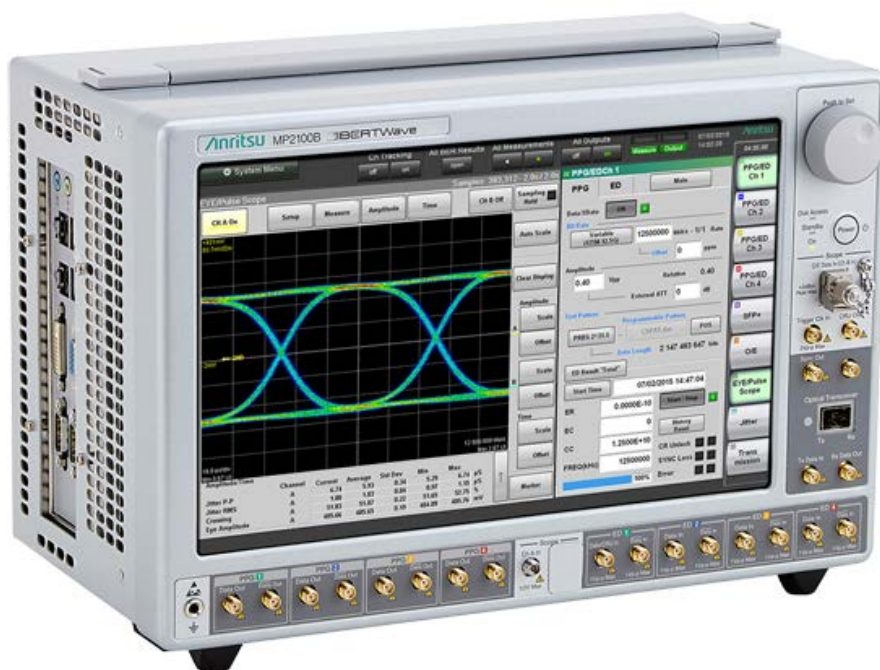
Figure 1.1.2-1　MP2100B External View

MP2100B BERTWave is a space-saving measuring instrument that can operate using the 12.1-inch touch panel. The SFP slot and O/E converter can be added as the option.

Refer to the following website for the MP2100B BERTWave information.
https://www.anritsu.com/en-us/test-measurement/products/mp2100b

1.2 Configuration

1.2.1 Standard Configuration

The following table lists the standard configuration of the MP2110A.

Table 1.2.1-1   Standard Configurations

| Item	Model/ Ordering No.	Product Name	Q'ty	Remarks
Main unit	MP2110A	BERTWave	1	
Accessories		POWER CORD	1	Contained in accessory box.
	J1627A	GND connection cable	1	
	Z1364A	MX210000A BERTWave Control Software CD-ROM	1	
	J0617B	Replaceable optical connector (FC-PC)	*1	
	J1632A	TERMINATOR	*1	
	J1341A	OPEN	*1	Coaxial connector cover
	J1763A	U Link Coaxial Cable (K)	1*2	
	J1764A	U Link Coaxial Cable (SMA)	1*2	
	Z0397A	FC Adaptor Cap	*1	

*1: Quantity depends on the options. Refer to Table 1.2.1-2 to Table 1.2.1-4.

*2: Only when MP2100A-054 is added

Table 1.2.1-2   Connection Destination and Quantity of J0617B and Z0397A

Option	Connection Destination	Q'ty
MP2110A-022, MP2110A-032	Ch A In SMF. Ch A In MMF, Ch B In SMF, Ch B In MMF	4
MP2110A-023, MP2110A-033	Ch B In SMF, Ch B In MMF	2
MP2110A-025, MP2110A-035	Ch B In SMF	1
MP2110A-026, MP2110A-036	Ch B In MMF	1

Table 1.2.1-3   Connection Destination and Quantity of J1632A

Option	Connection Destination	Q'ty
MP2110A-011	Data Out×1, $\overline{\text{Data}}$ Out×1, $\overline{\text{Sync}}$ Out×1	3
MP2110A-012	Data Out×2, $\overline{\text{Data}}$ Out×2, $\overline{\text{Sync}}$ Out×1	5
MP2110A-014	Data Out×4, $\overline{\text{Data}}$ Out×4, $\overline{\text{Sync}}$ Out×1	9
MP2110A-054	O/E Monitor Out ×1	1*

*:   When MP2110A-022, MP2110A-023, MP2110A-025, MP2110A-026, MP2110A-032, MP2110A-033, MP2110A-035, or MP2110A-036 is added.

**Table 1.2.1-4   Connection Destination and Quantity of J1341A**

Option	Connection Destination	Q'ty
MP2110A-011	Ext Clk In, Clk Out, Sync Out×1, Data In×1, $\overline{\text{Data}}$ In×1	5
MP2110A-012	Ext Clk In, Clk Out, Sync Out×1, Data In×2, $\overline{\text{Data}}$ In×2	7
MP2110A-014	Ext Clk In, Clk Out, Sync Out×1, Data In×4, $\overline{\text{Data}}$ In×4	11
MP2110A-021	Trigger Clk In, Ch A In, Ch B In	3
MP2110A-022, MP2110A-032	Trigger Clk In	1
MP2110A-023, MP2110A-033	Trigger Clk In, Ch A In	2
MP2110A-025, MP2110A-035	Trigger Clk In	1
MP2110A-026, MP2110A-036	Trigger Clk In	1
MP2110A-054	CRU In ×1, CRU Out ×1	2

1.2.2 Options

Option name format

The option number is indicated by three digits.

MP2110A- x x x

Number indicating function.

Anritsu management code.
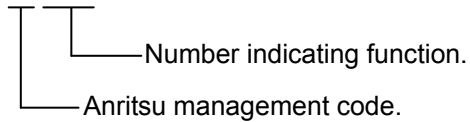
0: Installed at time of shipping

1: Retro-fitted option.
   Must be returned to Anritsu (Japan) when installing.

2: Retro-fitted option.
   Must be returned to an Anritsu Service and Sales office when installing.

3: Software option.
   License registration is required when installing.

The MP2110A options are shown below.

The numbers of the options added are indicated on the label on the rear panel.

For details of whether retro-fitted options or software options are included, please refer to the ordering information on the Anritsu website.

https://www.anritsu.com/en-us/test-measurement/products/mp2110a

1

Table 1.2.2-1   MP2110A Option List

Option Number	Name
MP2110A-011	1CH BERT*1,*2
MP2110A-012	2CH BERT*1,*2
MP2110A-014	4CH BERT*1,*2
MP2110A-021	Dual Electrical Scope*1,*3
MP2110A-022	Dual Optical Scope*1,*3
MP2110A-023	Optical and Single-ended Electrical Scope*1,*3
MP2110A-024	Precision Trigger*4
MP2110A-025	Optical Scope for Singlemode*1,*3
MP2110A-026	Optical Scope for Multimode*1,*3
MP2110A-032	Dual Optical Scope Baseband Flat*1,*3
MP2110A-033	Optical and Single-ended Electrical Scope Baseband Flat*1,*3
MP2110A-035	Optical Scope for Singlemode Baseband Flat*1,*3
MP2110A-036	Optical Scope for Multimode Baseband Flat*1,*3
MP2110A-054	Clock Recovery (Electrical/Optical)*4
MP2110A-093	PPG/ED Bit Rate Extension*5
MP2110A-095	PAM4 Analysis Software *4
MP2110A-096	Jitter Analysis Software *4

*1:   One or more these options are required.

*2:   Select one of the BERT options.

*3:   Select one of the Scope options.

*4:   Can be selected with the Scope option.

*5:   Can be selected with the BERT option.

1.2.3 Optional Accessories

Table 1.2.3-1 shows the optional accessories for MP2110A
Contact us to confirm the specifications of the optical switch and
programmable optical attenuator.

Table 1.2.3-1　Optional Accessories

Model/Order No.	Name
B0734A	Carrying Case
B0735A	Rack Mount Kit
G0307A	Clock Recovery Module (<2.667G)
G0342A	ESD Discharger
G0344F	Optical Switch (1x4, SM9, FC/UPC)
G0344S	Optical Switch (1x4, SM9, SC/UPC)
G0345F	Optical Switch (1x16, SM9, FC/UPC)
G0345S	Optical Switch (1x16, SM9, SC/UPC)
G0346F	Optical Switch (1x4, GI50, FC/UPC)
G0346S	Optical Switch (1x4, GI50, SC/UPC)
G0347F	Optical Switch (1x4, GI62.5, FC/UPC)
G0347S	Optical Switch (1x4, GI62.5, SC/UPC)
G0348F	Optical Switch (2x4, GI50, FC/UPC)
G0348S	Optical Switch (2x4, GI50, SC/UPC)
G0349F	Optical Switch (2x4, GI62.5, FC/UPC)
G0349S	Optical Switch (2x4, GI62.5, SC/UPC)
G0350F	Programmable Optical Attenuator (SM9, FC/UPC)
G0350S	Programmable Optical Attenuator (SM9, SC/UPC)
G0351F	Programmable Optical Attenuator (SM9, FC/UPC, Power Monitor)
G0351S	Programmable Optical Attenuator (SM9, SC/UPC, Power Monitor)
G0352F	Programmable Optical Attenuator (GI50, FC/UPC)
G0352S	Programmable Optical Attenuator (GI50, SC/UPC)
G0353F	Programmable Optical Attenuator (GI50, FC/UPC, Power Monitor)
G0353S	Programmable Optical Attenuator (GI50, SC/UPC, Power Monitor)
G0354F	Programmable Optical Attenuator (GI62.5, FC/UPC)
G0354S	Programmable Optical Attenuator (GI62.5, SC/UPC)
G0355F	Programmable Optical Attenuator (GI62.5, FC/UPC, Power Monitor)
G0355S	Programmable Optical Attenuator (GI62.5, SC/UPC, Power Monitor)
G0364A	100G LR4 1310 nm QSFP28
G0366A	100G SR4 850 nm QSFP28

Table 1.2.3-1   Optional Accessories (Cont'd)

Model/Order No.	Name
J0617B	Replaceable optical connector (FC-PC)
J0618D	Replaceable Optical Connector (ST)
J0618E	Replaceable Optical Connector (DIN)
J0619B	Replaceable Optical Connector (SC)
J0635A	FC・PC-FC・PC-1M-SM
J0660A	SC・PC-SC・PC-1M-SM
J0839A	SC・PC-SC・PC-1M-GI
J0893A	FC・PC-FC・PC-1M-GI
J1139A	FC・PC-LC・PC-1M-SM
J1341A	Open (Coaxial connector cover)
J1342A	Coaxial Cable 0.8 m
J1343A	Coaxial Cable 1.0 m
J1344A	LC・PC-LC・PC-1M-SM
J1345A	SC・PC-LC・PC-1M-SM
J1346A	LC・PC-LC・PC-1M-GI (62.5/125)
J1347A	FC・PC-LC・PC-1M-GI (62.5/125)
J1348A	SC・PC-LC・PC-1M-GI (62.5/125)
J1349A	Coaxial Cable 0.3 m
J1359A	Coaxial Adaptor (K-P.K-J,SMA)
J1439A	Coaxial cable (0.8m, K connector)
J1510A	Pick OFF Tee
J1519A	Optical Fiber Cord (MM, 12FIBER, MPO, 3M)
J1551A	Coaxial skew match cable (0.8m, K connector)
J1632A	Terminator
J1681A	MPO Loopback Cable
J1682A	MPO to FC convert cable
J1763A	U Link Coaxial Cable (K)
J1764A	U Link Coaxial Cable (SMA)
W3831AE	MP2110A BERTWave Operation Manual[1]
W3773AE	BERTWave Series Remote Control Operation Manual[1]
Z0306A	Wrist Strap
Z0541A	USB Mouse
Z0914A	Ferrule Cleaner
Z0915A	Replacement Reel for Ferrule Cleaner[2]
Z1944A	LCD Monitor
Z1952A	HDMI to VGA Adapter

*1: Printed version

*2: 6 rolls

1.3 Features

The MP2110A has the following features:

- Bit error rate measurement and waveform monitoring up to 28.2 Gbit/s
- Bit error rate measurement and waveform monitoring in one instrument
- Flexible selection of channel configuration according to evaluation target
- 4-channel simultaneous BER measurement, handy for CFP4 module and QSFP module testing (MP2110A-014)
- Accurate waveform monitoring using low residual jitter of 200 fs and rms (typical value) (MP2110A-024)
- For sampling oscilloscope:
  EYE analysis in short time using high-speed sampling
- Compatibility of remote commands with previous Anritsu measuring instruments
- MP2110A-054 Clock Recovery Unit (CRU) for Sampling Oscilloscope covering from 25.5 to 28.2 Gbaud
- MP2110A-095 for PAM4 (Pulse Amplitude Modulation) waveform analysis
- MP2110A-096 for jitter analysis from the waveform obtained by Sampling Oscilloscope

1.4 Intended Use

The MP2110A can be used for the following applications:

- Evaluating optical transceivers used in optical fiber communications
- Evaluating parts for digital communications

Evaluating optical transceivers used in optical fiber communications
Computer-based and public communications systems send and receive digital signals. These signals are converted to electrical or optical signals optimized for passage through the transmission path, which may be either coaxial cable or optical fiber. In the communication where the bit rate is around 100 Gbit/s, the optical transceiver based on the multisource agreement such as CFP4 and QSFP28 is used.

The optical transceiver includes the transmitters and receivers of which the bit rate is 25 Gbit/s for 4 circuits. The following figure shows a CFP4 block diagram for 100 Gbit/s.
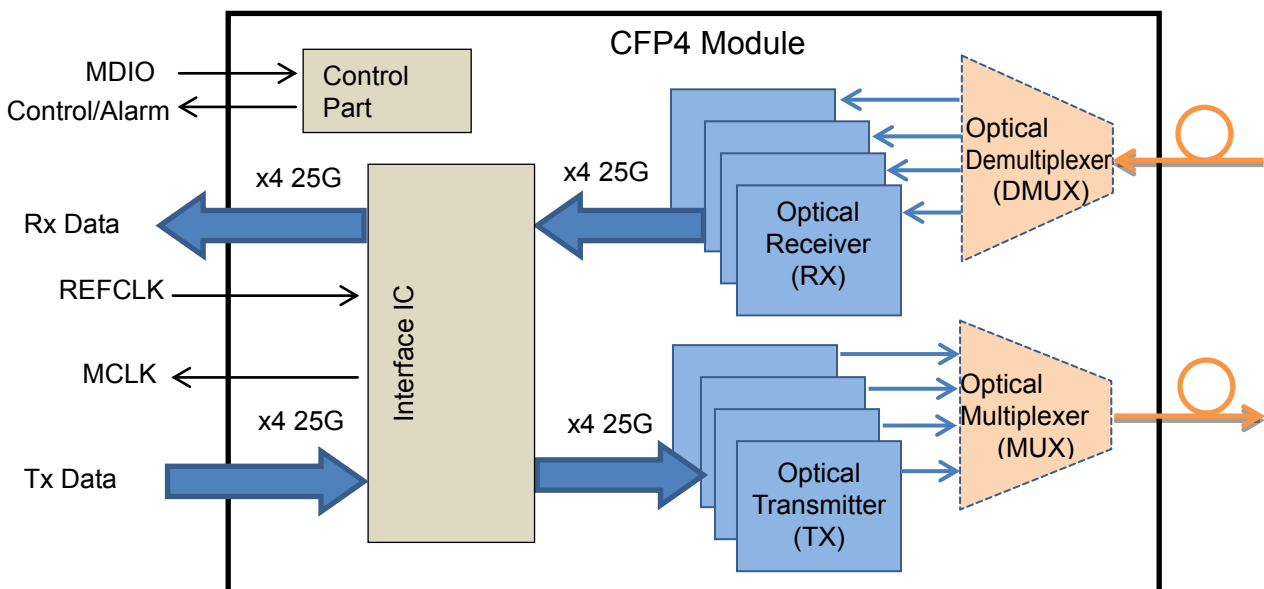

Figure 1.4-1   Functional Block Diagram of 100 Gbit/s CFP4

The receiver sensitivity which is one of the performances in the optical transceiver is calculated by measuring the bit error rate and optical power.

The following figure shows a connection example between the DUT and the measurement when the DUT is the CFP4 module.
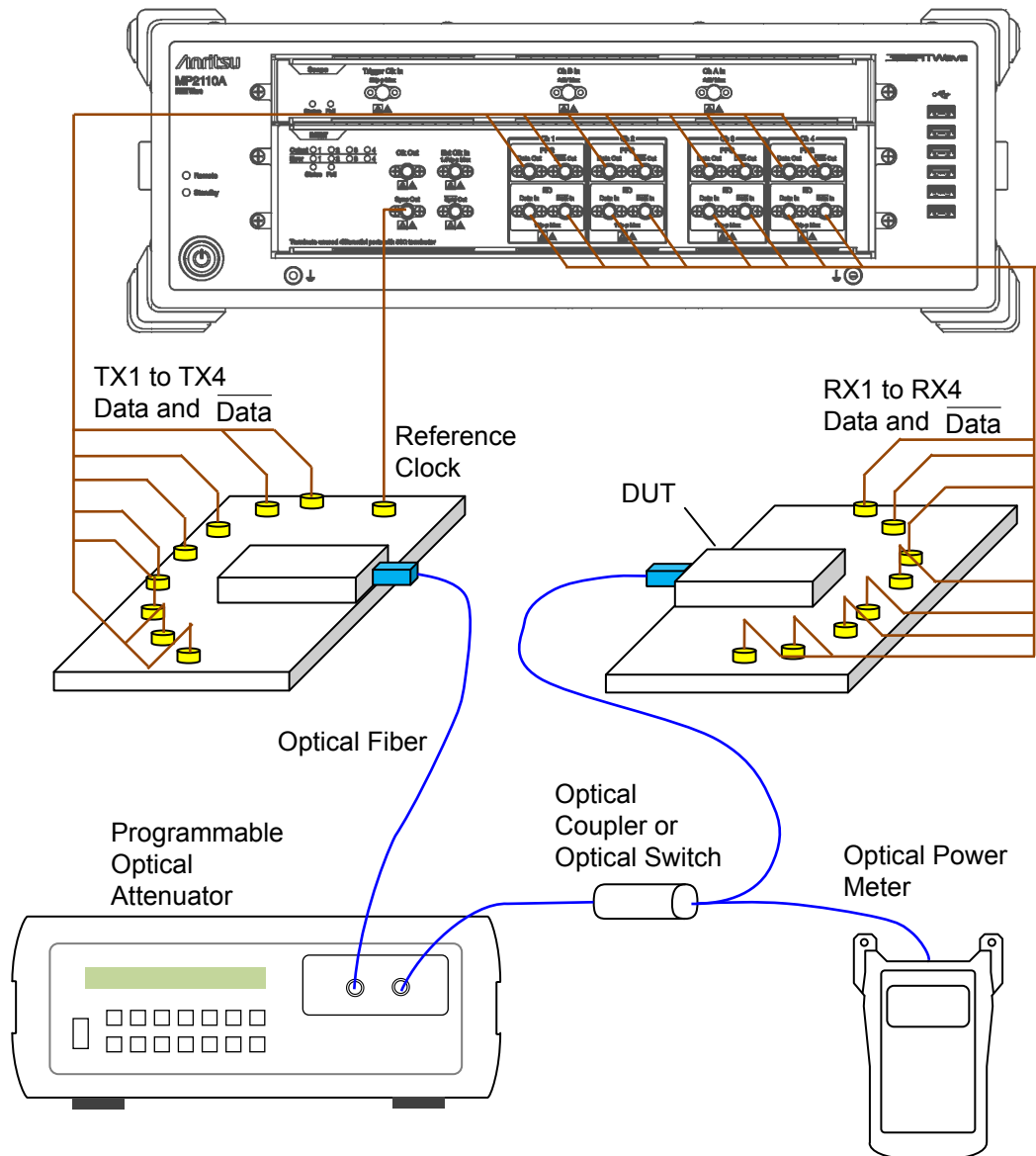

TX1 to TX4
Data and $\overline{\text{Data}}$

Reference Clock

RX1 to RX4
Data and $\overline{\text{Data}}$

DUT

Optical Fiber

Optical Coupler or Optical Switch

Programmable Optical Attenuator

Optical Power Meter

Figure 1.4-2   Connection Example of Receiver Sensitivity Measurement

The output waveform of the optical transceiver is evaluated using the pulse pattern generator and sampling oscilloscope. The output of optical transceiver is the wavelength multiplexed optic. Therefore, input only the optic of the wavelength to be measured using the optical demultiplexer or optical filter to MP2110A.

The following figure shows a connection example between the DUT and the measurement instruments when the DUT is the CFP4 module.
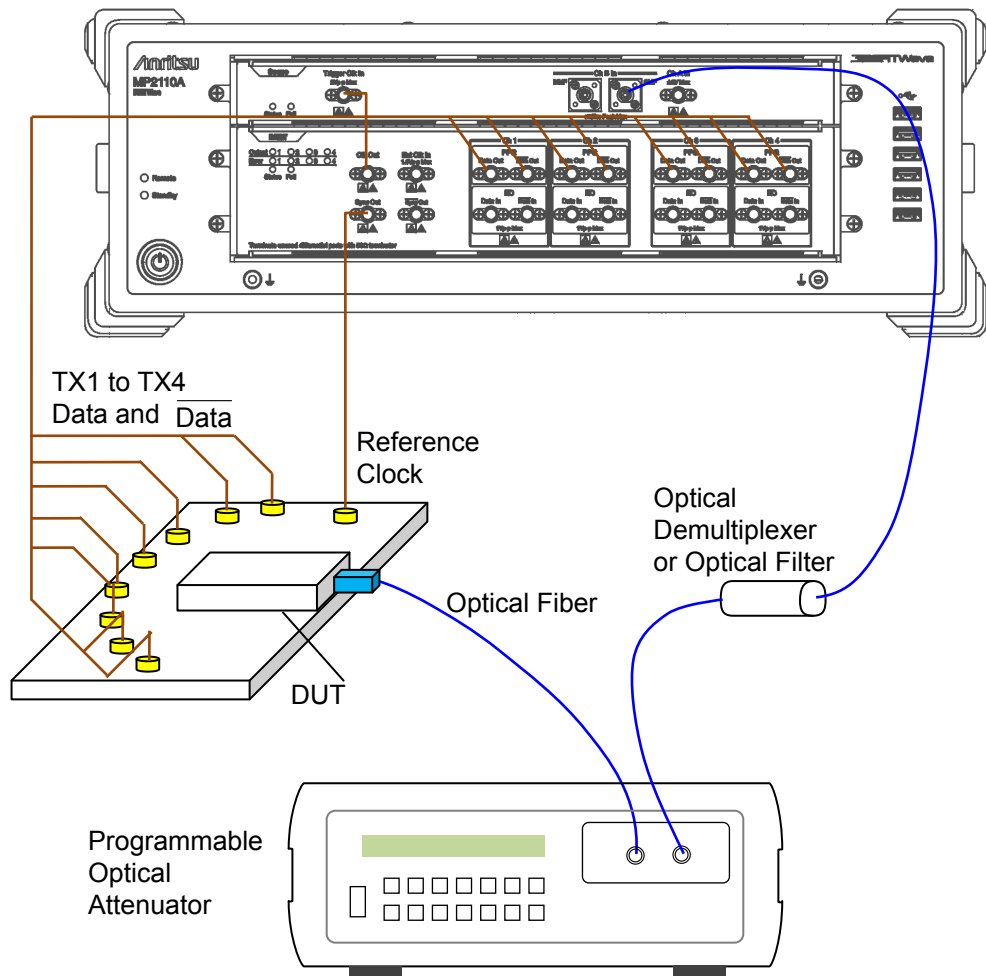
1

Outline

Figure 1.4-3   Connection Example of Waveform Measurement

1.5 Technical Terms

This section explains the technical terms used in this manual.

BER: Bit Error Rate

The Bite Error Rate is the ratio of the total received bits and error bits. It depends on the SNR (signal to noise ratio).
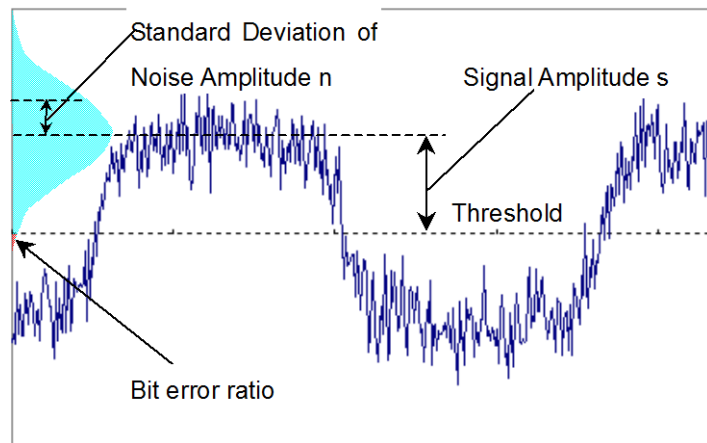

Figure 1.5-1   Bit Error Rate

When the distribution of the noise voltage amplitude is assumed to follow a normal distribution, the standard deviation is assumed to be n and the signal amplitude is s. Bit errors occur when the noise amplitude is larger than the signal amplitude. Consequently, the probability of amplitude occurring is the bit error ratio.

The bit error ratio, BER, is calculated by the following formula.

$$BER = \frac{1}{\sqrt{2\pi}} \int_{s/n}^{\infty} \exp(-\frac{x^2}{2})dx$$

When the SNR is large (greater than 4), the relationship between SNR and BER becomes linear when plotted on a semi-logarithmic graph.
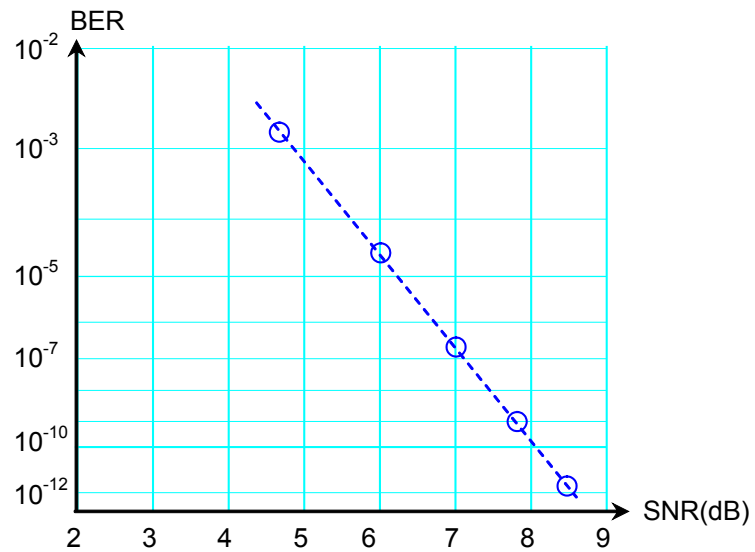
BER

10^{-2}

10^{-3}

10^{-5}

10^{-7}

10^{-10}

10^{-12}

SNR(dB)

2 3 4 5 6 7 8 9

Figure 1.5-2   Relationship between SNR and BER

Bit Rate

The Bit Rate is the speed at which the communications interface sends and receives data. It is expressed in its center per second as bit/s or bps.

Bathtub

As an evaluation method of eye pattern waveform, there is a graph that displays the measurement result with time as the horizontal axis and bit error rate as the vertical axis. The left and right edges of the graph are the positions of the cross points of the eye pattern waveform, and have large bit error rates. The center part of the graph is the center part of the eye pattern waveform, and has small bit error rate.   This graph is called a Bathtub graph or Bathtub curve line from the form of the graph. The Jitter analysis software displays the bathtub graph estimated from the histogram of total jitter.   The software displays the time with 99% jitter (J2) BER, 10^{-9} jitter (J9) specified in the communication standards, and the specified bit error rate such as 10^{-12} or less.
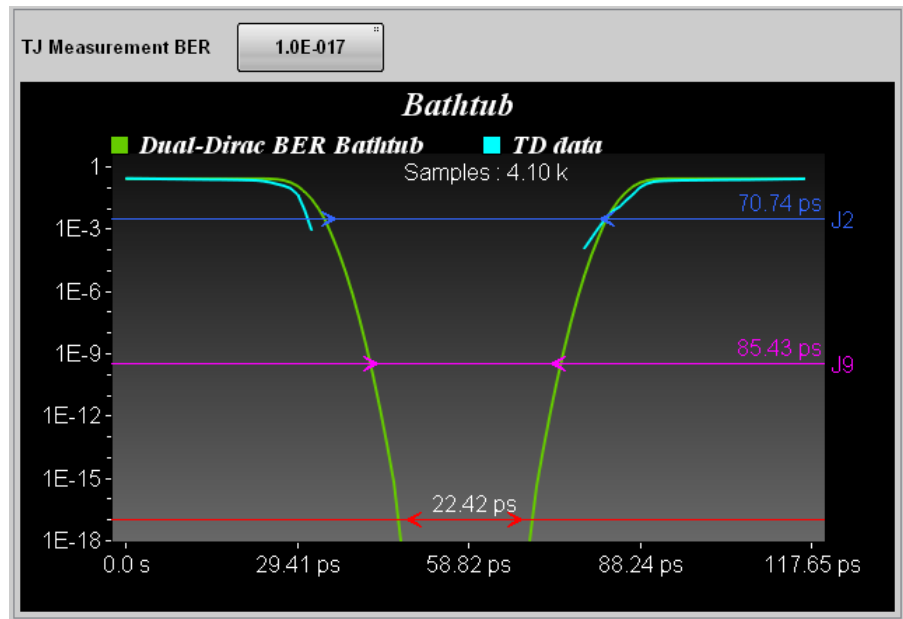
Figure 1.5-3   Example of Bathtub Curve

DCD: Duty Cycle Distortion

The duty cycle distortion (DCD) is found from the following equation:

$$DCD = (t_2 - t_1)/Bp \times 100 \qquad (\%)$$

Where,

t_1: Time at crossing point between 50% level of Eye Amplitude and rising waveform

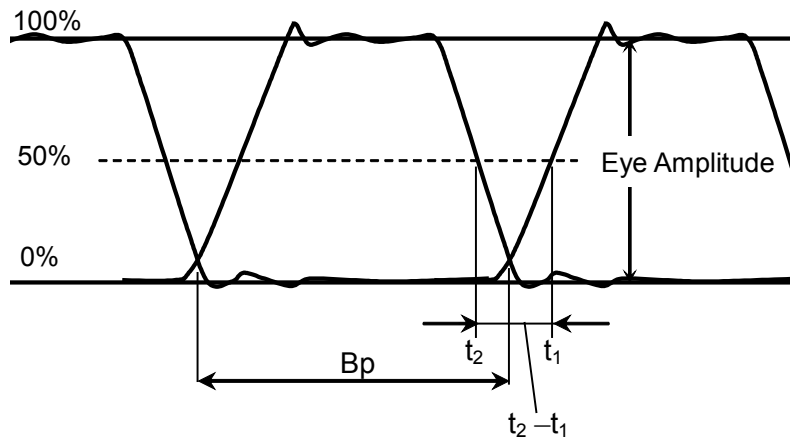t_2: Time at crossing point between 50% level of Eye Amplitude and falling waveform

Bp: Bit cycle

Figure 1.5-4   Duty Cycle Distortion

DDJ vs Bit

The amount of jitter, which is measured for each bit whose pattern changes, is displayed as a graph.

The time difference between the clock and the waveform at the cross point level is measured and the result is plotted on the pattern location.

When the waveform time is slower than the clock, the value is positive, and when the waveform is faster than the clock, the value is negative.
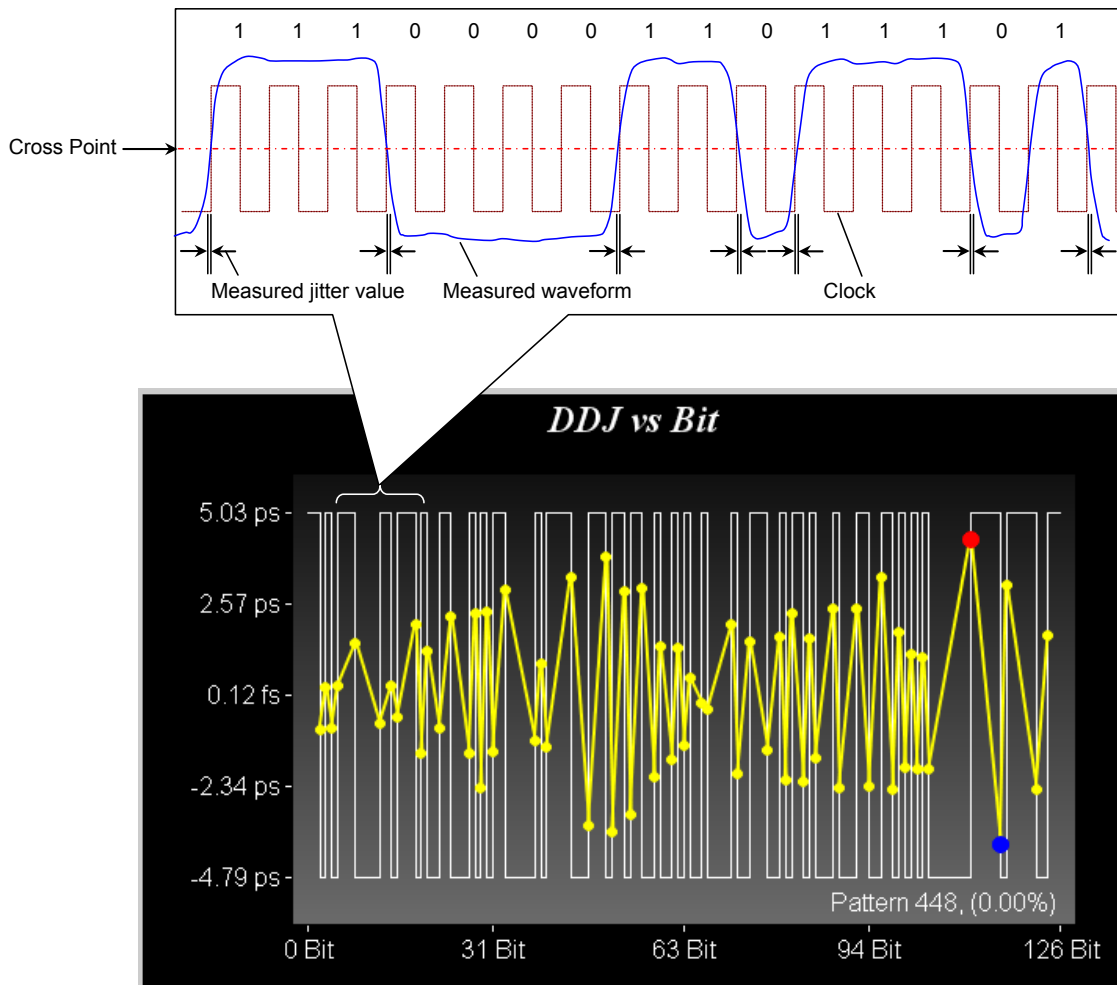

Figure 1.5-5   DDJ vs Bit Measurement Method

DDPWS (Data Dependent Pulse Width Shrinkage)

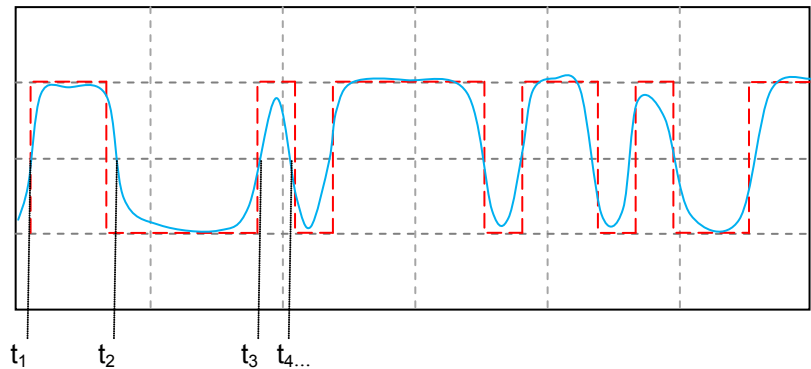DDPWS is the amount of pulse width shrinkage by data dependent jitter.

Figure 1.5-6   DDJ Measurement Method

In Figure 1.5-6, the red line is the ideal symbol waveform and the blue line is the measured waveform with jitter.   Let t_1, t_2, t_3 ... be the time of the blue line at the cross point, and let the time differences between the red line and the blue line be Δt_1, Δt_2, Δt_3 ....

DDJ and DDPWS are defined by the following formulas.

$$DDJ=\max(\Delta t_1, \Delta t_2, \Delta t_3..., \Delta t_n)-\min(\Delta t_1, \Delta t_2, \Delta t_3..., \Delta t_n)$$

$$DDPWS=T-\min(t_2-t_1, t_3-t_2, t_4-t_3, ...t_n-t_{n-1})$$

T: Symbol cycle

Dual Dirac Estimation

If the jitter elements include DJ, the histogram has multiple peaks at the waveform cross point. Dual Dirac Estimation is a method to estimate RJ and DJ using Dual Dirac function as the fitting curve of this histogram.
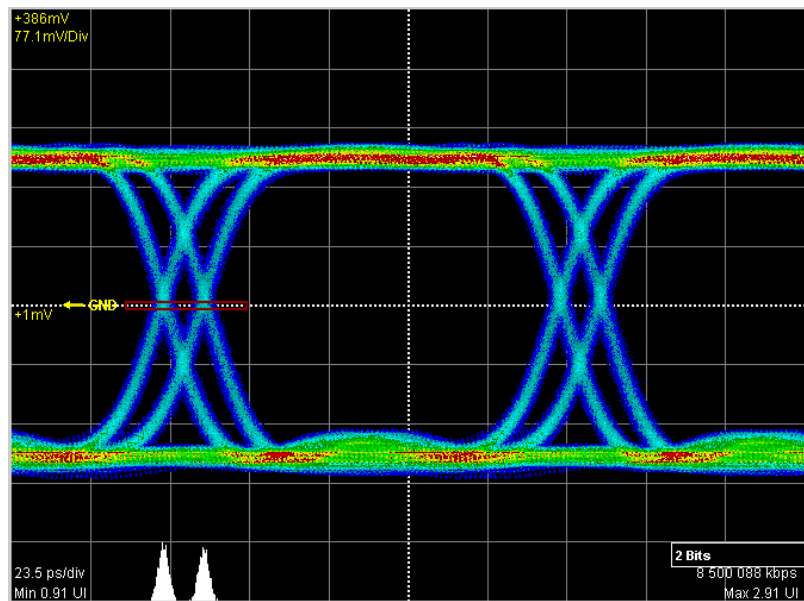

Figure 1.5-7   Histogram of Jitter with DJ

The Dual Dirac distribution is expressed as the combined formula of two normal distributions.

$$PDF(x) = \frac{1}{\sqrt{2\pi}\sigma}\left[\exp\left(-\frac{(x-\mu_L)^2}{2\sigma^2}\right) + \exp\left(-\frac{(x-\mu_R)^2}{2\sigma^2}\right)\right]$$
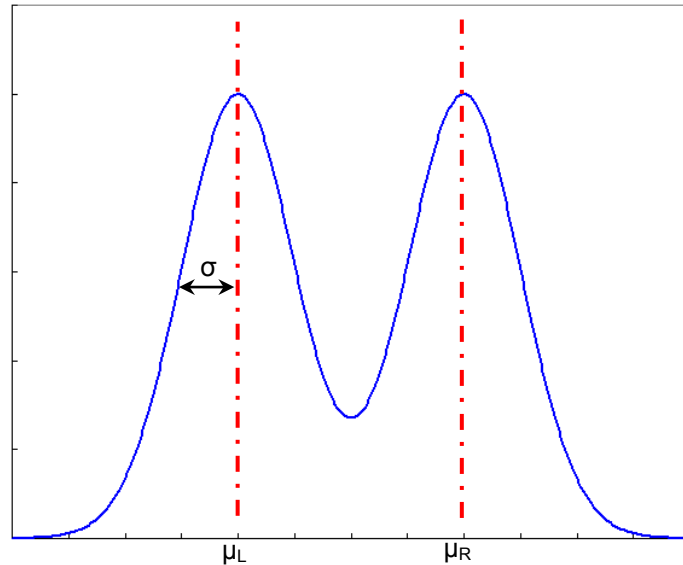

Figure 1.5-8   Dual Dirac Distribution

The Dual Dirac distribution assumes that RJ is the normal distribution and DJ is a constant value. The Jitter Analysis software displays σ and μ_R–μ_L of the Dual Dirac distribution approximated from the measured histogram to RJ (d-d) and DJ (d-d) respectively.

Extinction Ratio

The extinction ratio is the ratio of 1 Level and 0 Level; it is used for evaluating optical signal waveforms.
The extinction ratio is calculated by the following formula.

Extinction Ratio = $10\log_{10}\{(L_1 - L_D)/(L_0 - L_D)\}$ (dB)

L_1: 1 Level (mW)
L_0: 0 Level (mW)
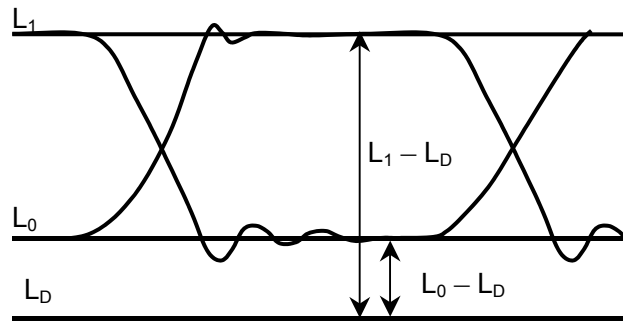L_D: Level without optical input (mW)

Figure 1.5-9   Extinction Ratio Measurement Level

For the extinction ratio of PAM4, refer to "Outer ExR (Outer Extinction Ratio)".

Eye Amplitude

For NRZ, eye amplitude is the difference between 1 Level and 0 Level. Refer to Figure 1.5-21.

In PAM4, eye amplitude is the difference between the levels. There are three of Upper, Middle, Lower. Refer to Figure 1.5-10.

Eye Crossing Percentage

Eye Crossing Percentage is the ratio of the Eye amplitude rising and falling waveforms. The calculation formula is as follows. Refer to Figure 1.5-21.

Crossing = (crossing point level–0 Level)/(1 Level–0 Level)

Eye Height

For NRZ, eye height can be calculated by the following formula. Refer to Figure 1.5-21.

Eye Height = (1 Level–3 σ_1) – (0 Level +3 σ_0)

σ_1: 1 Level Standard Deviation
σ_0: 0 Level Standard Deviation

For PAM4, eye height varies depending on eye definition method and sample method.

When Sample Timing is **Independent**, the maximum eye height is measured for each eye.
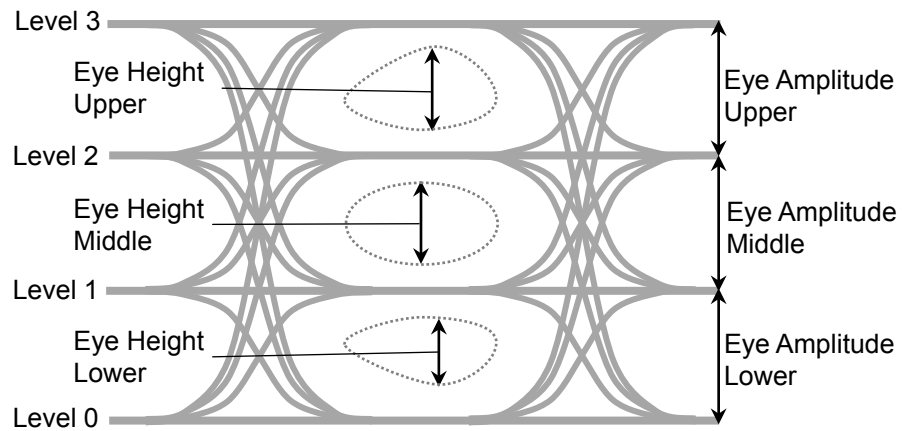
Figure 1.5-10   Eye Amplitudes and Eye Heights of PAM4 Waveform
(When Sample Timing is Independent)

When Sample Timing is **Track to Middle Eye Timing**, eye amplitude
Upper and eye amplitude Lower are measured at the center position of
Middle Eye.

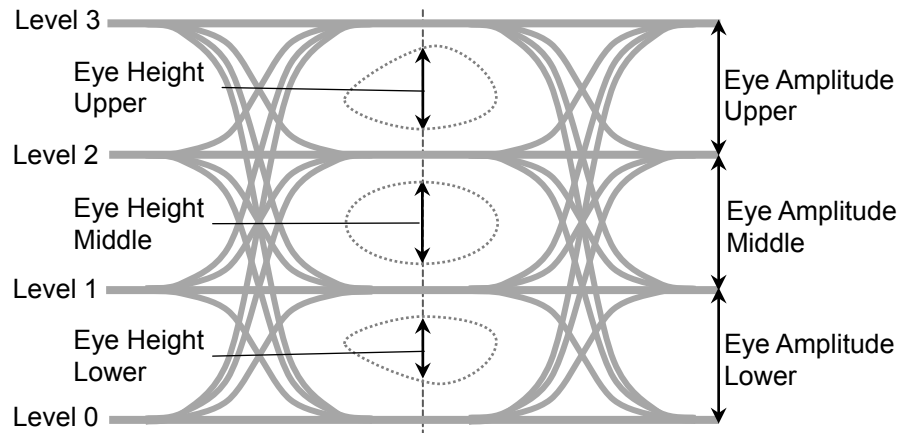**Figure 1.5-11   Eye Amplitudes and Eye Heights of PAM4 Waveform**
(When Sample Timing is Track to Middle Eye Timing)

Eye Levels, Eye Widths

Eye Widths Eye Widths are the eye widths of the PAM4 waveform.   They
depend on how the eyes are defined. Eye Levels are the levels to measure
eye widths.

Level 3

Eye Width Upper

Eye Level
Upper

Level 2

Eye Width Middle

Eye Level
Middle

Level 1

Eye Width Lower

Eye Level
Lower
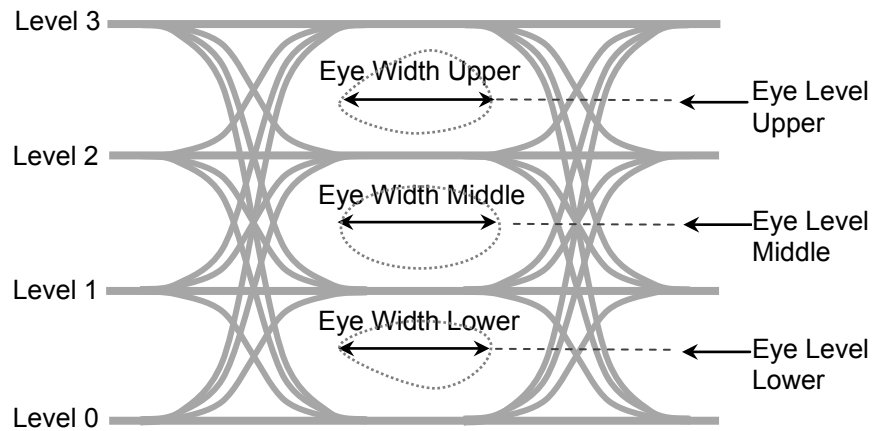
Level 0

Figure 1.5-12   Eye Level and Eye Width of PAM4 Waveform

Eye Mask

The Eye Mask is the boundary of the eye pattern waveform time and
amplitude. The value and waveform are specified by the communications
standards.

Maximum jitter

Maximum of 1 level

Minimum of 1 level

Maximum of 0 level

Minimum of 0 level

Figure 1.5-13   Example of Eye Mask

Eye Pattern

The Eye Pattern is the pattern created by superimposing the digital
waveforms sampled at the same timing.

1

Outline

First
measured
waveform

Second
measured
waveform

Third
measured
waveform

Fourth
measured
waveform

Super-
imposed
waveforms

Eye pattern

Figure 1.5-14   Eye Pattern Drawing Method

Eye Skews

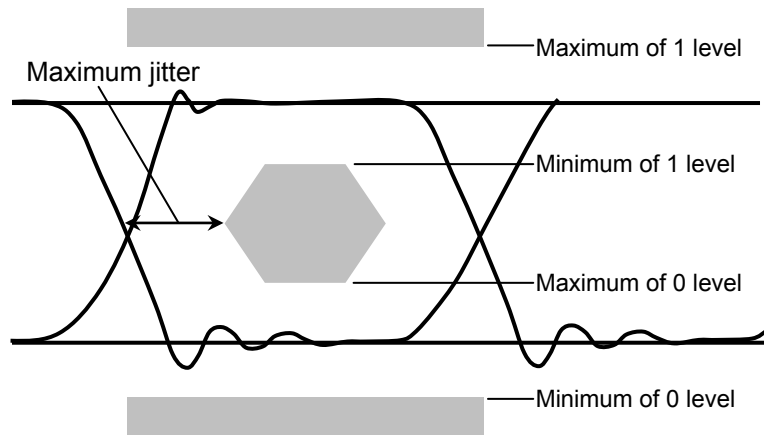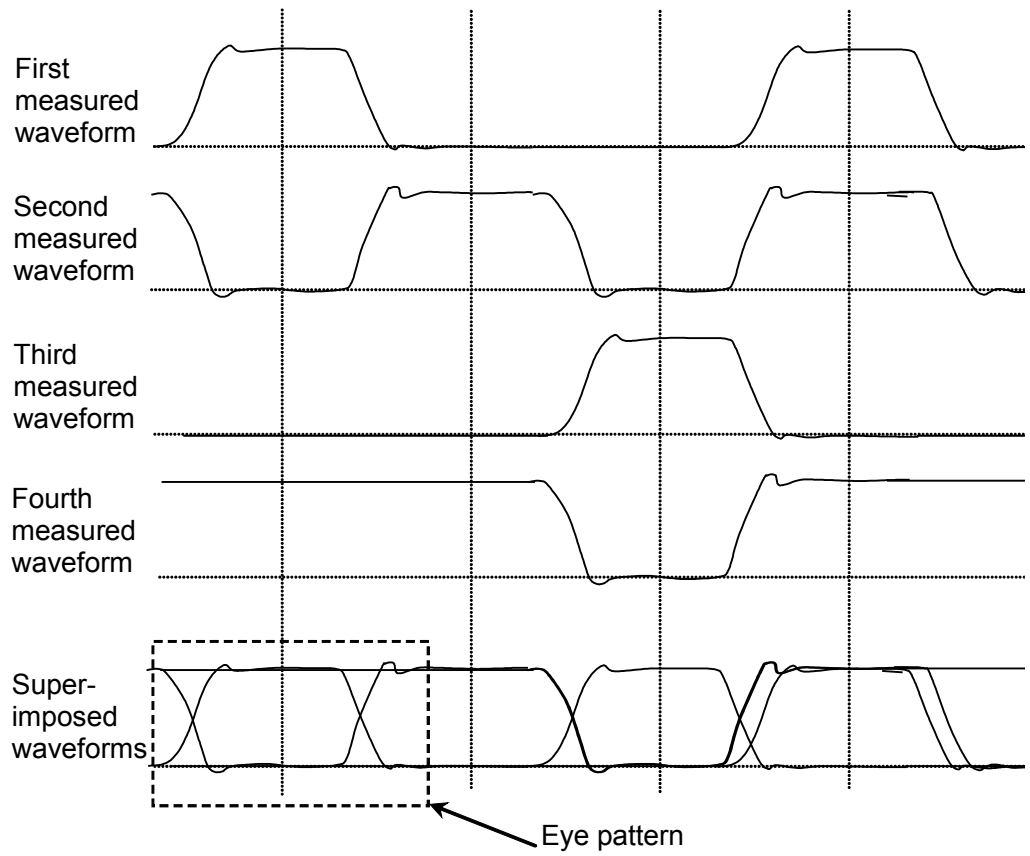When PAM4 waveform and Sample Timing is **Independent**, Eye Skews are phase differences between the average value of the center of each eye (Eye Center) and the centers of Upper Eye, Middle Eye and Lower Eye.
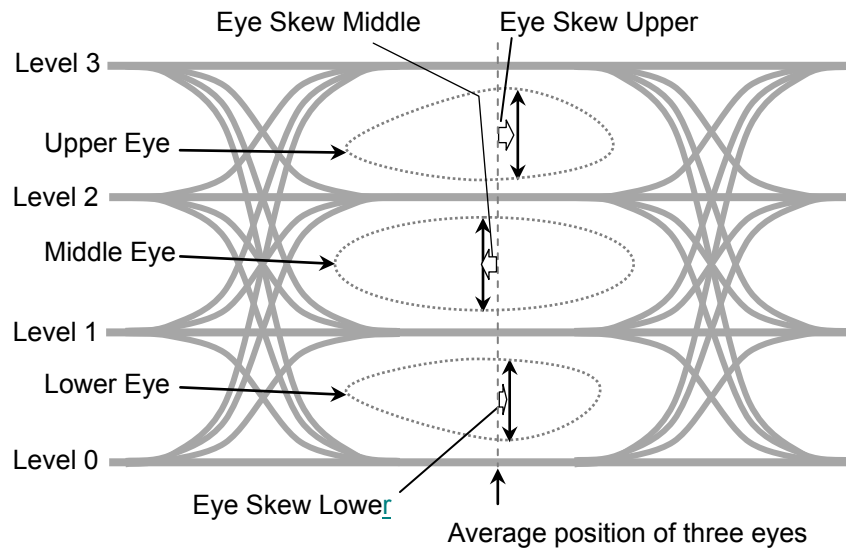
Figure 1.5-15   PAM4 Eye Skews (When Sample Timing is Independent)

When Sample Timing is **Track to Middle Eye Timing**, the eye skew is 0.

Eye Width

Eye Width is equivalent to Eye Height in the horizontal direction. For NRZ, it is calculated from a histogram of the two eye pattern crossing points in the time direction.

Eye Width = $(t_2 - 3\ \sigma_2) - (t_1 + 3\ \sigma_1)$

t_1: Average time of first crossing point
t_2: Average time of second crossing point
σ_1: Standard deviation of first crossing point
σ_2: Standard deviation of second crossing point
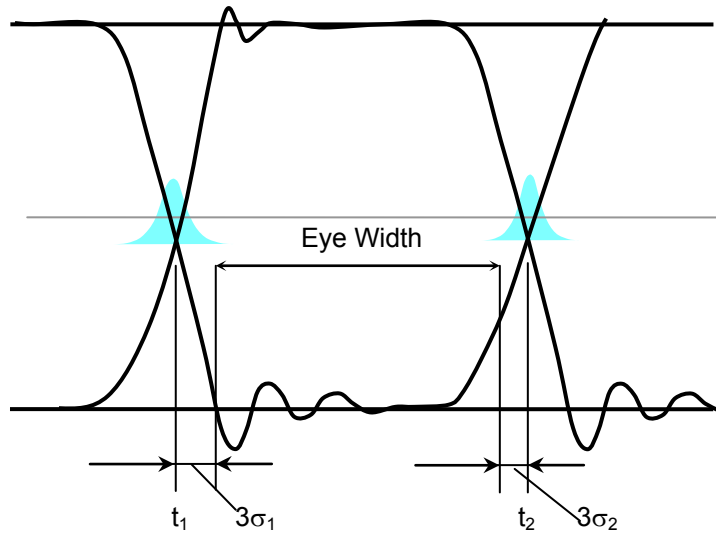
Figure 1.5-16   Eye Width

For PAM4, Eye Width is the width in time axis direction to be the defined bitrate or less. Refer to Figure 1.5-12.

Jitter

Jitter is the variation in the time of the crossover point between the Eye Diagram rising and falling parts of the waveform.

Jitter p-p (Jitter p-p):   Full width of histogram in time direction
Jitter RMS (Jitter RMS):   Standard deviation of histogram in time direction

Figure 1.5-17   Jitter p-p and Jitter RMS

The jitter measured with the sampling oscilloscope is the combined values of jitters with various occurrence factors. Actually occurred jitters consist of various jitter elements.

The types of jitter elements which compose actual signals are explained below.

Figure 1.5-18 Jitter Classification

Table 1.5-1 Jitter Type

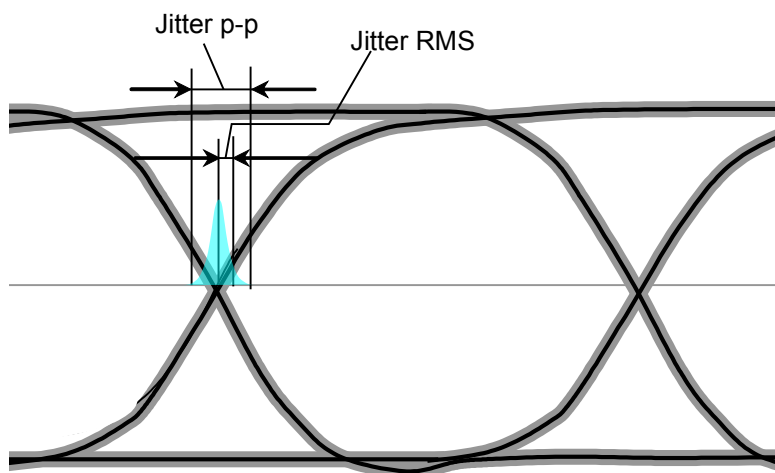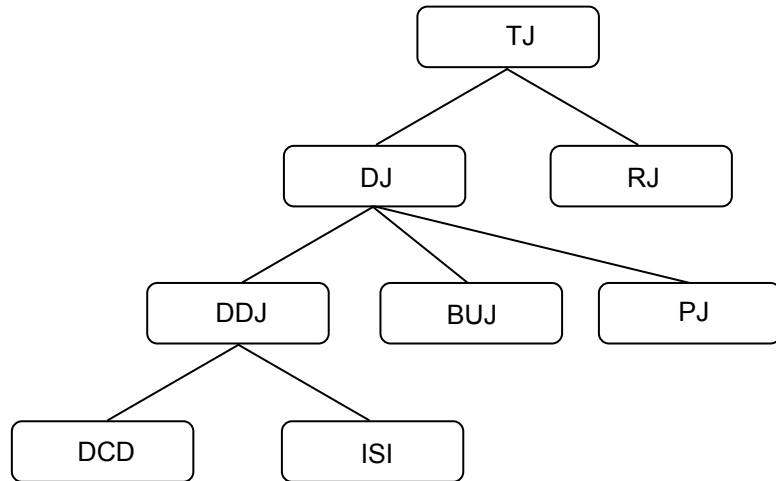| Abbrev.	Name	Description
TJ	Total Jitter	Jitter of combined RJ and DJ Not a simple sum of RJ and DJ
RJ	Random Jitter	Jitter which occurs with external factors such as thermal noise. It has a characteristic to spread unlimitedly which approaches Gaussian distribution. It is indicated with rms (root mean square) because it spreads unlimitedly.
DJ	Deterministic Jitter	Jitter with upper limit of amount relative to the Random Jitter
BUJ	Bounded Uncorrelated Jitter	Jitter which occurs with external factors such as cross talk effects from adjacent signal lines. It has a random nature like the Random Jitter; however, it is indicated with p-p (peak to peak) because its spreading is limited.
DDJ	Data Dependant Jitter	Jitter which is DJ and the occurrence amount depends on data.
DCD	Duty Cycle Distortion	Occurs with transmission/reception circuit offset distortion difference of High pulse width and Low pulse width.
ISI	Inter Symbol Interference	Occurs due to inadequate bandwidth and reflections caused by impedance mismatching, etc., in the transmission path. When components with no correlation to data are removed, it is defined either as the difference between the fastest and slowest rising edges, or as the difference between the fastest and slowest falling edges.
PJ	Period Jitter	Jitter which is DJ and occurs periodically.

With the communications standards such as IEEE 802.3-2015*, specifications for DDPWS (Data Dependent Pulse Width Shrinkage) have been decided as well as the jitters above.

*:   For the formal name, refer to Appendix E "Bibliography."

Levels p-p, Levels RMS, Level Skews

When measuring the histogram of each level with PAM4 waveform, the peak value of its width is Levels p-p and the standard deviation is Levels RMS.

If Sample Timing is **Independent**, Levels p-p, Levels and RMS are measured at the following positions.

Level 3	The center of Upper Eye
Level 2	Halfway between the center of Upper Eye and the center of Middle Eye.
Level 1	Halfway of the center of Middle Eye and the center of Lower Eye
Level 0	The center of Lower Eye

Level Skews are differences between the positions measured at each level and their averages.

When Sample Timing is **Track to Middle Eye Timing** , Levels p-p and Levels RMS are measured at the center of Center Eye. And Level Skews are 0.
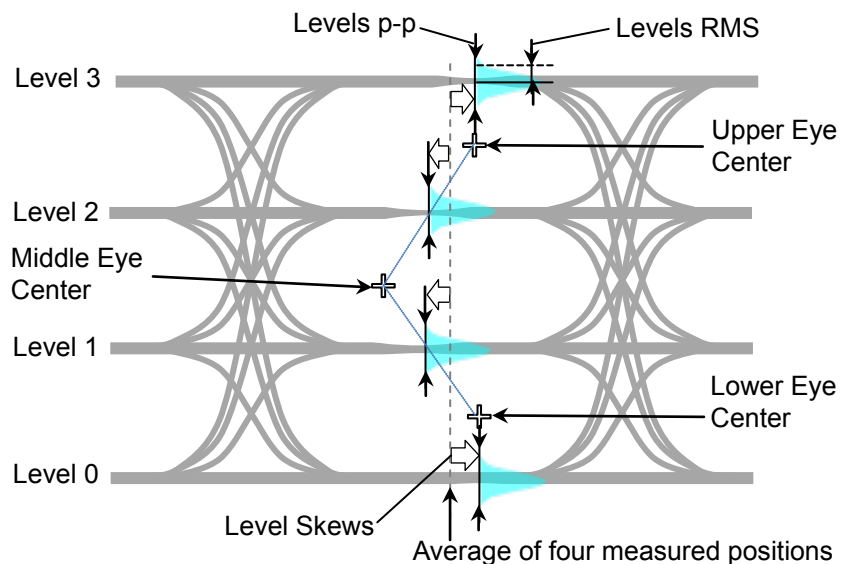
Figure 1.5-19   PAM4 Levels p-p and Levels RMS
(When Sample Timing is Independent)

Linearity

It indicates the degree that the three Eye Amplitudes of the PAM4 waveform deviate from one third of the difference between Level 0 and Level 3. If the three Eye Amplitudes are equal, the linearity is 1.

It is calculated with the smallest eye amplitude out of the three eye amplitudes.

Example:

Eye Amplitude Upper: 32%

Eye Amplitude Middle: 36%

Eye Amplitude Lower: 31%

The Linearity in this case is $\frac{31}{33.33}$=0.93

Mask Margin

This is margin of the masked waveform at the eye pattern mask test. The margin in the amplitude direction is the ratio to the interval from the edge of the eye mask to the 1 Level or the 0 Level.

The margin in the time direction is the ratio to the time from the edge of the eye mask to the cross point.
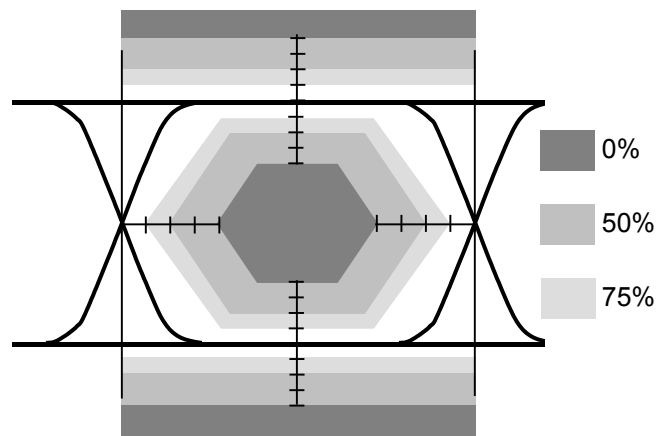
Figure 1.5-20   Mask Margin

Optical Modulation Amplitude (OMA)

This indicates a difference at 1 level and 0 levels of the NRZ waveform.

It is the same as Eye Amplitude.

For PAM4 waveform, refer to "Outer OMA".

One Level

At Eye pattern measurement, the maximum level at the center 20% of the bit interval is the average value of the high histogram.
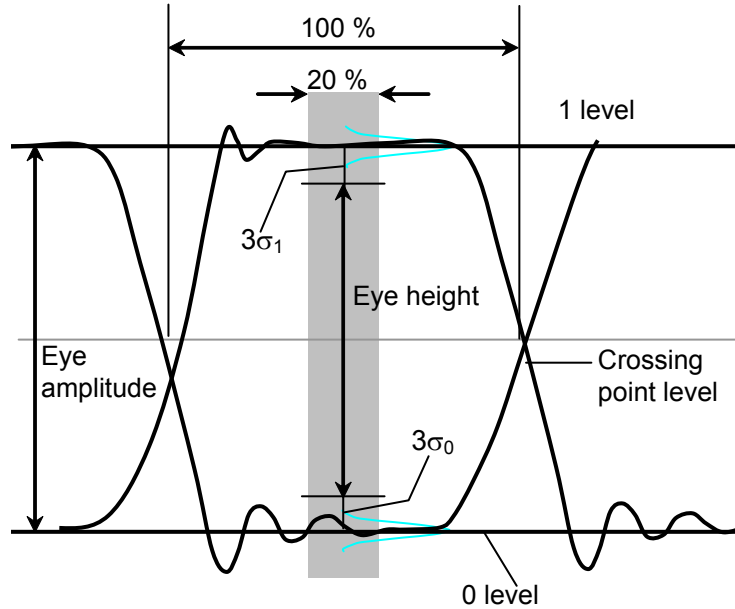
Figure 1.5-21   0 Level, 1 Level, Eye Amplitude and Eye Height

Outer ExR (Outer Extinction Ratio)

Outer Extinction Ratio is the ratio of Level 3 and Level 0 of the PAM4 waveform, and the calculation formula is as follows.

$$\text{Outer Extinction Ratio} = 10\log_{10}\{(L_3 - L_D)/(L_0 - L_D)\} \quad \text{(dB)}$$

L_3: Level 3 (mW)

L_0: Level 0 (mW)

L_D: Level when no light input (mW)

Figure 1.5-22   The level to measure Outer Extinction Ratio

Outer OMA

It is the optical modulation amplitude of PAM 4 waveform, and it is the difference between Level 3 and Level 0.

p-p (peak to peak)

Indicates difference between maximum and minimum values for signal amplitude and data distribution width

For example, Vp-p means the difference between the maximum and minimum values of the AC voltage.
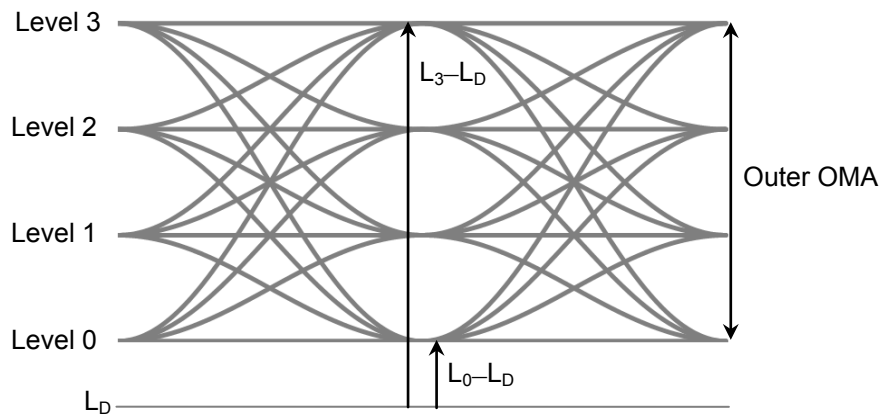
Jitter p-p means the difference between the maximum and minimum values of the jitter time distribution.

PRBS (Pseudo-Random Bit Sequence)

PRBS is the abbreviation for pseudorandom bit sequence. It is a bit string approximating actual communications data with a random distribution of "1" and "0". In a bit length of 2^n-1, n is called the number of the PRBS. Using the BERTWave, n can be set to 7, 9, 15, 23, and 31.

Table 1.5-2   PRBS Bit Length

n	2^n-1
7	127
9	511
15	32767
23	8388607
31	2147483647

The number of the PRBS used for measuring the Rx sensitivity is determined by the communications standard.

Rise/Fall Time

The Rise Time is time taken for the signal level to change to the next level.
- From 20% level of amplitude to 80%
- From 10% level of amplitude to 90%

The Fall Time is the time taken for the signal level to change to the next level.
- From 80% level of amplitude to 20%
- From 90% level of amplitude to 10%

For the BERTWave, the rise and fall time measurement level can be selected from either 10/90% or 20/80%.

"1" Level

*1 -

Eye amplitude

*2 -

"0" Level

Rise Time   Fall Time

*1: 90 or 80 %   *2: 10 or 20 %
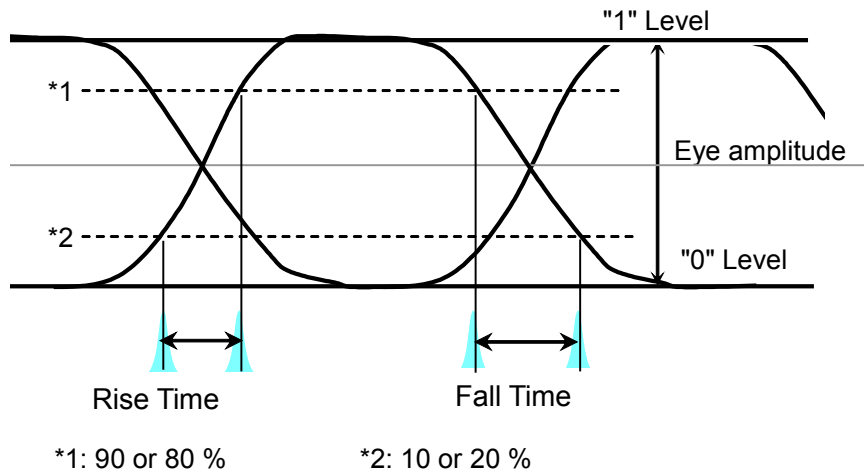
Figure 1.5-23   Rise and Fall Time

RMS (root mean square)

This is the DC voltage consuming the equal power the same as the consumed power when impressing AC voltage on a resistance.
In Voltage, RMS is DC voltage consuming the equal power when AC voltage is impressing on a resistance.

$$P_1 = \frac{1}{T}\int_0^T \frac{V^2(t)}{R}dt$$

$$P_2 = \frac{(V_1)^2}{R}$$
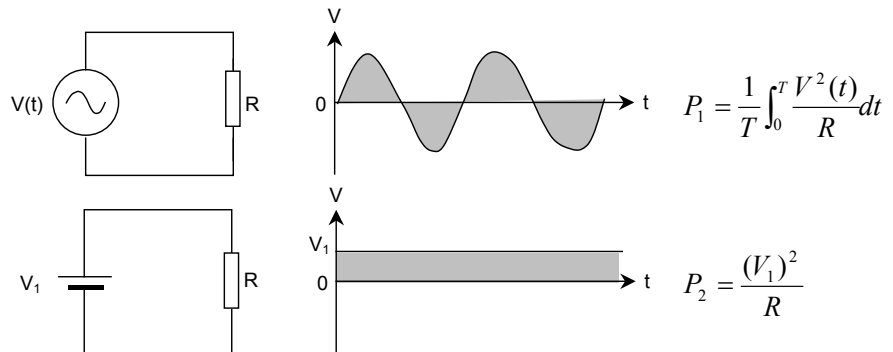
Figure 1.5-24   AC and DC Voltage Power Consumption

In the circuit in Figure 1.5-24, the voltage V_1 when the power P_1 and P_2 consumed by resistance R is equal is the effective AC voltage V(t). V_1 is the root mean square found using the following equation.

$$V_1 = \sqrt{\frac{1}{T}\int_0^T V^2(t)dt}$$

For a sine wave, the ratio of RMS and p-p is $2\sqrt{2}$.
Vrms means the effective voltage value.

Jitter rms is expressed as the standard deviation of the jitter time domain histogram.

Sampling Oscilloscope

The sampling oscilloscope is a function for monitoring the waveform of the input signal. It requires a clock input sampling and the waveform is drawn out of the clock timing. For a periodic signal like PRBS, the waveform data is obtained by slightly varying the sampling timing. This waveform data is drawn by superimposing the waveforms.
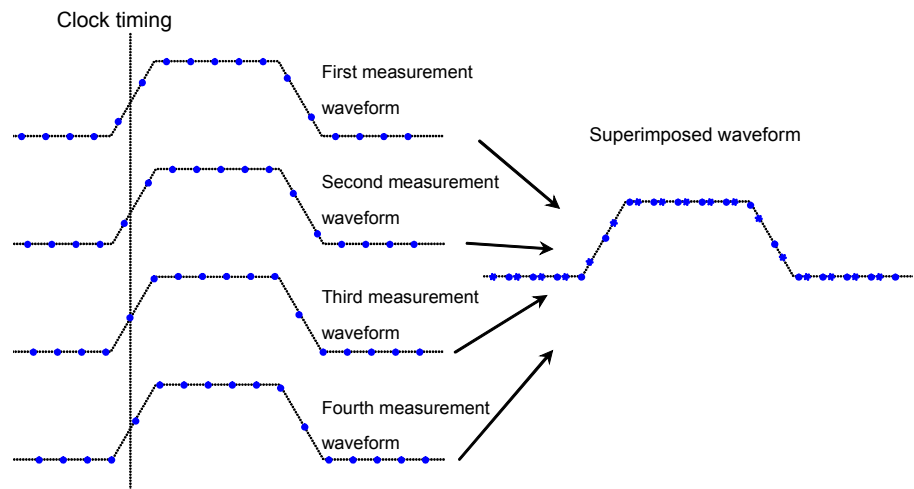
Figure 1.5-25   Drawing Method of Sampling Oscilloscope

SNR (Signal to Noise Ratio)

This is the ratio of the signal amplitude to the noise amplitude.
The sampling oscilloscope can be calculated by the following formula.

SNR= (1 Level–0 Level)/(σ_1+ σ_0)

σ_1: 1 Level Standard Deviation
σ_0: 0 Level Standard Deviation

Symbol Rate

Symbol rate is the modulation speed of the signal and the unit is baud. Since NRZ sends 1 bit of data with one modulation signal (symbol), the Symbol Rate and Bit Rate values are the same. Since PAM4 sends 2 bits of data with one modulation signal, the value of Bit Rate is twice the value of Symbol Rate.

TDECQ (Transmitter and Dispersion Eye Closure for PAM4)

TDECQ is the measured value of the eye opening of the PAM4 signal and is calculated by the following formula.

$$\text{TDECQ} = 10\log_{10}(\frac{\text{Outer OMA}}{6} \times \frac{1}{Q_t R}) \ \ (\text{dB})$$

Q_t: Coefficient for which SER (Symbol Error Rate) $=4.8 \times 10^{-4}$

   $Q_t = 3.414$ for Gray coded PAM4 waveform.

R: Additional noise necessary to make SER $= 4.8 \times 10^{-4}$
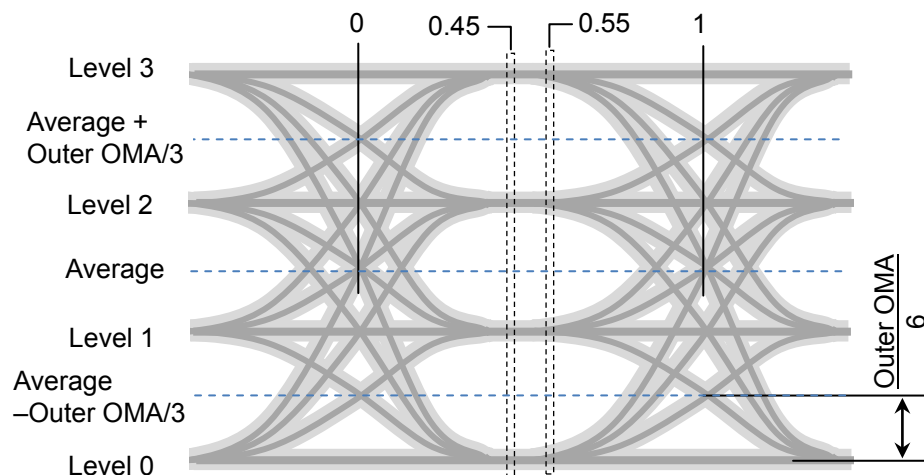
Figure 1.5-26   The position for TDECQ measurement

Total Error

There are two methods as follows for generating bit errors.
The following bit error count corresponding to the sum of Insertion Error and Omission Error is referred to as the Total Error.

- Signal "1" bits evaluated as "0" bits (Omission Error)
- Signal "0" bits evaluated as "1" bits (Insertion Error)

VECP (Vertical Eye Closure Penalty)

VECP is the ratio of eye amplitude to eye opening and is calculated by the following formula.

$$\text{VECP} = 10\log(\frac{\text{OMA}}{A_0}) \ \ (\text{dB})$$

OMA: Optical Modulation Amplitude

A_0:   Vertical Eye Opening

The histogram is measured at the center point between the cross points on the time axis. (OMA)

The upper and lower limits of the vertical eye opening is measured.(A_0)
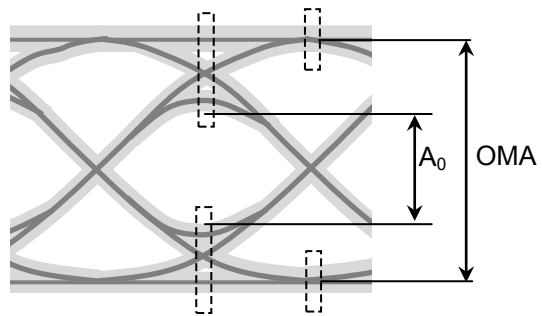
Figure 1.5-27   VECP Measurement

Zero Level

> At Eye pattern measurement, the maximum level at the center 20% of the bit interval is the average value of the low histogram.

1.6 Abbreviations

The abbreviations used in this manual are listed in Table 1.6-1.

Table 1.6-1　Abbreviation

Abbreviation	Description
100 GbE	100 Giga bit Ethernet
400GbE	400 Giga bit Ethernet
App	Application
ATT	Attenuator
Avg	Average
BER	Bit Error Rate
BERT	Bit Error Rate Tester
BERTS	Bit Error Rate Test Set
BIN	Binary
bps	bit per second
BW	Bandwidth
Cal	Calibration
CC	Clock Count
CFP	C Form factor Pluggable
Ch	Channel
CH	Channel
Clk	Clock
CPRI	Common Public Radio Interface
CRU	Clock Recovery Unit
DCD	Duty Cycle Distortion
DDJ	Data Dependent Jitter
DDPWS	Data Dependant Pulse Width Shrinkage
DJ	Deterministic Jitter
DM	Degrade Minutes
DMUX	De-multiplexer
DUT	Device Under Test
EC	Error Count
ED	Error Detector
EDR	Enhanced Data Rate
EI	Error Interval
ER	Error Rate
ER	Extinction Ratio
ES	Error Seconds
ESD	Electrostatic Discharge
ExR	Extinction Ratio
Ext	External
FC	Fiber Channel
FDR	Fourteen Data Rate
FEC	Forward Error Correction
Freq.	Frequency

Table 1.6-1   Abbreviation (Cont'd)

Abbreviation	Description
GND	Ground
GPIB	General Purpose Interface Bus
IEC	International Electrotechnical Commission
In	Input
INS	Insertion
INT	Internal
ISI	Inter Symbol Interference
ITU	International Telecommunication Union
LAN	Local Area Network
Max	Maximum
MDIO	Management Data Input/Output
MMF	Multi-mode fiber
MUX	Multiplexer
NA	Not Applied
NECL	Negative Emitter Coupled Logic
NEG	Negative
NRZ	Non Return Zero
O/E	Optical to Electrical
OMA	Optical Modulation Amplitude
OMI	Omission
OTU	Optical Transport Unit
Out	Output
PAM	Pulse Amplitude Modulation
PCML	Positive Current Mode Logic
PDF	Probability Density Function
PDJ	Pattern Dependant Jitter
PHY	Physical layer
PJ	Periodic Jitter
POS	Positive
p-p	Peak to peak
PPG	Pulse Pattern Generator
PRBS	Pseudorandom Bit Sequence
Pwr	Power
QSFP	Quad Small Form factor Pluggable
RJ	Random Jitter
RMS	Root Mean Square
rms	Root Mean Square
RX	Receiver
SCFL	Source-Coupled FET Logic
SES	Severely Error Second
SJ	Sinusoidal Jitter
SMF	Single-mode fiber
SNR	Signal to Noise Ratio

Table 1.6-1   Abbreviation (Cont'd)

Abbreviation	Description
SS	Sampling Scope
SSPRQ	Short Stress Pattern Random Quaternary
STM	Synchronous Transfer Mode
SYNC	Synchronize, Synchronization
TDECQ	Transmitter and Dispersion Eye Closure for PAM4
TJ	Total Jitter
Trig.	Trigger
TX	Transmitter
UI	Unit Interval
VECP	Vertical Eye Closure Penalty
WAN	Wide Area Network
XData	$\overline{\text{Data}}$

1

Outline

This chapter explains the following items:
- Procedures from unpacking through turning power-on
- Panel name and operation
- Control panel and peripheral devices settings
- Damage prevention measures

2

Before Use

2.1 Unpacking and Installation

2.1.1 Unpacking

At unpacking, check that all items are included. Contact an Anritsu Service and Sales office if any parts are missing or damaged. Keep the original packaging materials. They are required when transporting the BERTWave in future.

For repacking the MP2110A, refer to 8.8, "Transporting and Disposal".

The options listed in Table 1.2.2-1 are provided for the MP2110A. Verify that the options purchased are installed.

To install some options, the MP2110A might be returned to Anritsu factory. For the specifications, refer to Appendix A "Specifications".

2.1.2 Installation

Install the BERTWave horizontally as shown in Figure 2.1.2-1.
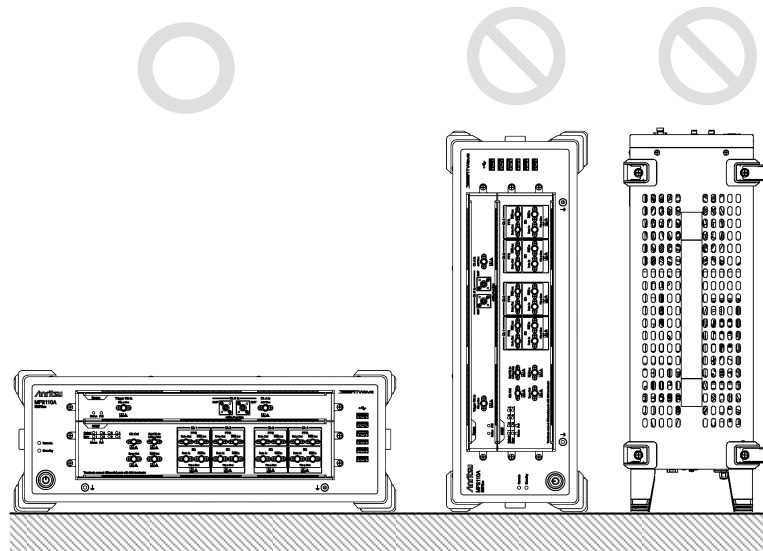
Figure 2.1.2-1   Installation Orientation

⚠ CAUTION

- **If the MP2110A is not installed in a "good" direction as above, a small shock may turn it over and harm the user.**

- **Do not stack three or more MP2110As on top of each other when using them. There is a risk of injury, because stacked MP2110As are unstable and can fall due to vibration or shock.**

The withstand load of the MP2110A top panel is 10 kg. Do not over 10 kg when putting the monitor, etc. on MP2110A. Fix the monitor, etc. on MP2110A to avoid falling it down from the top panel due to vibration or shock.

A fan is installed in the MP2110A to prevent the internal temperature from rising. Install the MP2110A in a location with the vents at least 10 cm away from walls, peripherals or other obstructions so as not to block the fan perimeter.
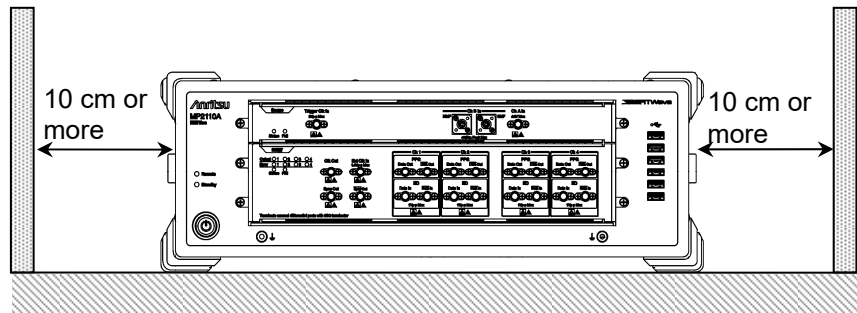
Figure 2.1.2-2   Distance from Surrounding Objects

The MP2110A takes in cooling air from the left side panel and exhausts it from the right side panel When using two or more the MP2110A units side-by-side, make sure that hot air exhausted from one unit is not taken into the adjacent unit, otherwise overheating may occur.

⚠ WARNING

Do not insert any metal object like, such as tweezers or a screwdriver, into vents on the side panels. Failure to do so can cause electric shock.

⚠ **CAUTION**

Although the MP2110A operates at an ambient temperature of 5 to 40°C, avoid using it in locations, such as the following, since it may cause failure.

- **In direct sunlight for extended periods**
- **Outdoors**
- **In excessively dusty locations**
- **In liquids, such as water, oil, organic solvents, and medical fluids, or places where these liquids may adhere**
- **In salty air or where chemically active gases (sulfur dioxide, hydrogen sulfide, chlorine, ammonia, nitrogen oxide, or hydrogen chloride etc.) are present**
- **Where toppling over may occur**
- **Where static electric charges or high electromagnetic fields are present**
- **Where abnormal power voltages (high or low) occur**
- **In the presence of lubricating oil mists**
- **Where condensation occurs**
- **In places at an altitude of more than 2,000 m**
- **In the presence of frequent vibration and mechanical shock, such as in cars, ships, and airplanes**

2.2 Part Names

2.2.1 Front Panel
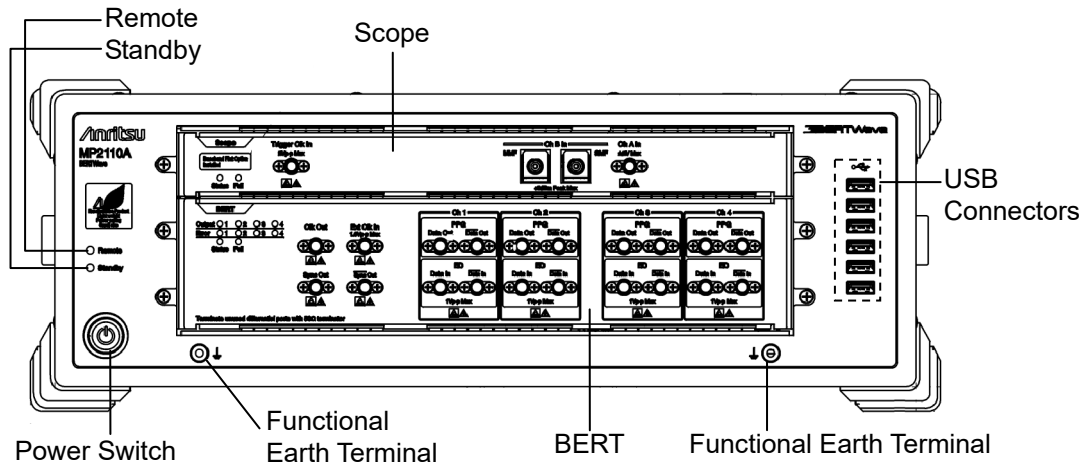
Figure 2.2.1-1   Front Panel

Table 2.2.1-1   Front Panel Description

Name	Description
Scope	The panel of the sampling oscilloscope When the scope option is not installed, a blank panel is mounted.
BERT	The panel of Bit Error Rate Tester When the BERT option is not installed, a blank panel is mounted.
Remote	Lit green while MP2110A under remote control.
Standby	Lit orange while power supplied to MP2110A.
Power Switch	Lit green while MP2110A powered-on; flashes during shutdown.
Functional Earth Terminal	Ground terminal For connecting wrist strap, ESD Discharger, or DUT.
USB Connector	USB 2.0 connectors for connecting peripheral accessories, such as mouse, keyboard, etc.
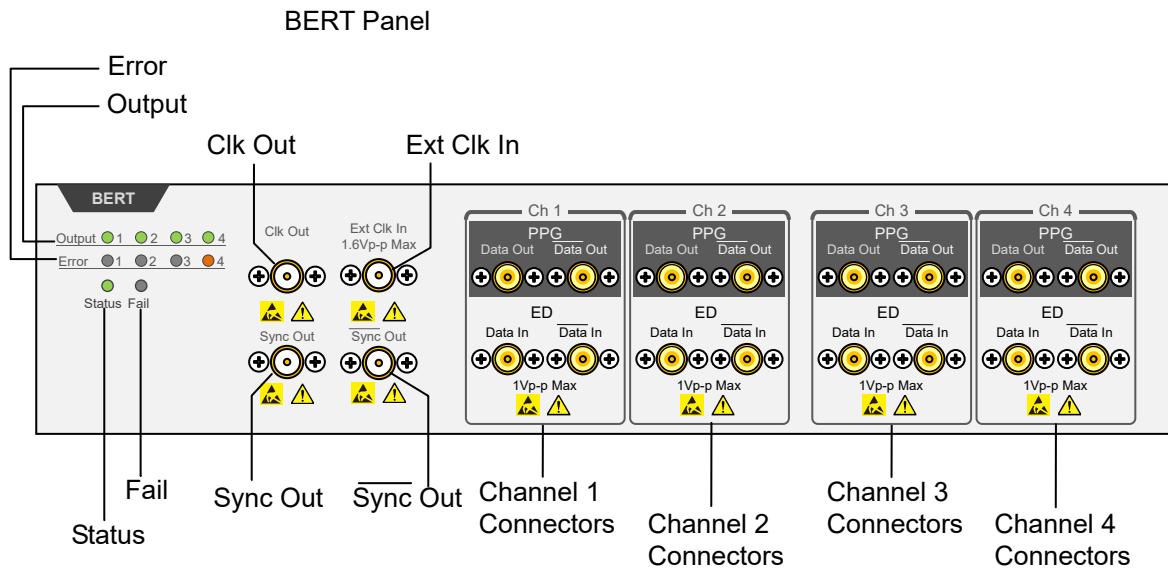
BERT Panel

Figure 2.2.1-2   BERT Panel Names (MP2110A-014)

The following tables describe the panel.

Table 2.2.1-2   Lamp List

Name	Description
Output	Lit green during signal output from PPG connector.
Error	Lit orange at following condition at ED: - Unable to synchronize pattern (Sync Loss). - Bit error detected.
Status	Lit green during normal operation while able to receive remote commands.
Fail	Lit red when hardware fault detected. This may light briefly at power-on, but there is no abnormality.

Table 2.2.1-3   Terminal List

Connector Name	Description	Level Range
Clk Out	Outputs divided clock.	0.3 to 0.5 Vp-p
Ext Clk In	For input of external clock.	0.2 to 1.6 Vp-p
Sync Out	Outputs the clock synchronized to PPG pattern.	V_{OH}: −0.2 to 0.05 V
$\overline{\text{Sync}}$ Out	Outputs the inverted clock synchronized to PPG pattern.	V_{OL}: −1.2 to −0.7 V
Data Out	Outputs the PPG data.	0.1 to 0.8 Vp-p
$\overline{\text{Data}}$ Out	Outputs the PPG inverted data.	(Variable)*
Data In	ED data input.	0.05 to 0.8 Vp-p*
$\overline{\text{Data}}$ In	ED inverted data input.	

*:   Same for Ch1 to Ch4.

Scope Panel

Figure 2.2.1-3   Scope Panel Names (MP2110A-021)
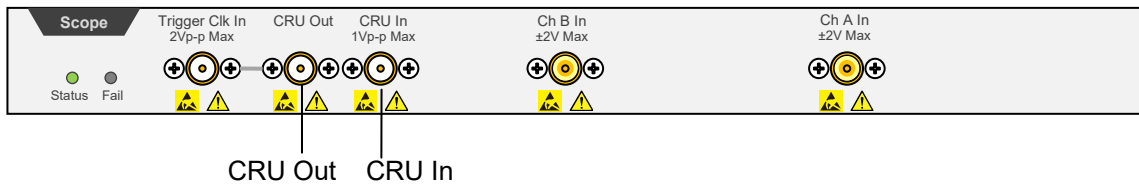
Figure 2.2.1-4   Scope Panel Names (with MP2110A-021 and MP2110A-054)
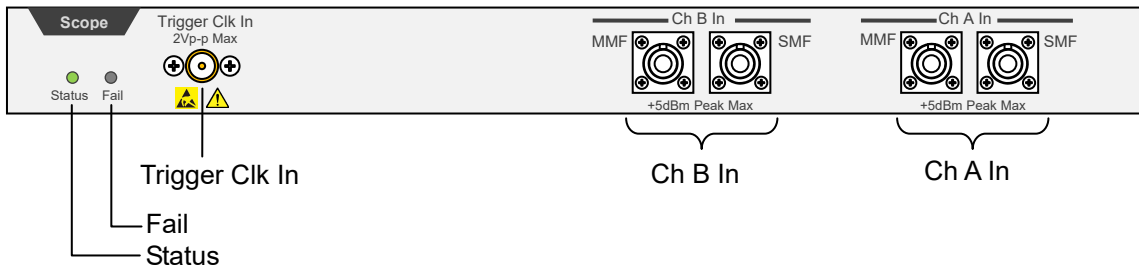
Figure 2.2.1-5   Scope Panel Names (MP2110A-022)

The following label is on the panel of MP2110A-032, MP2110A-033, MP2110A-035, and MP2110A-036.
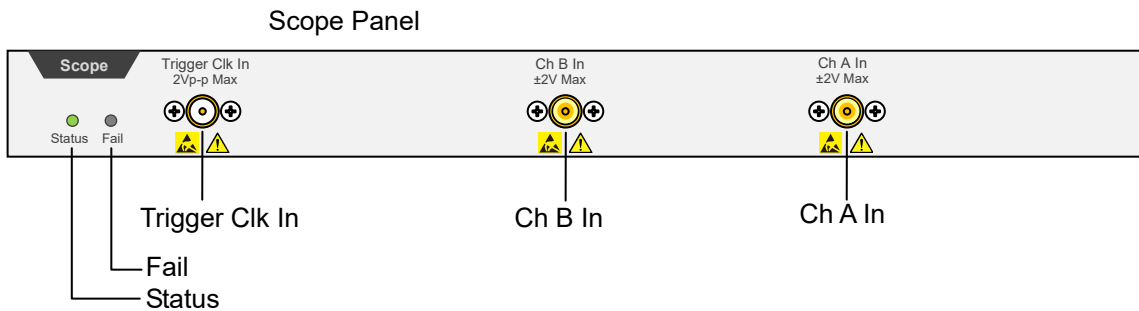
Baseband Flat
Option Installed
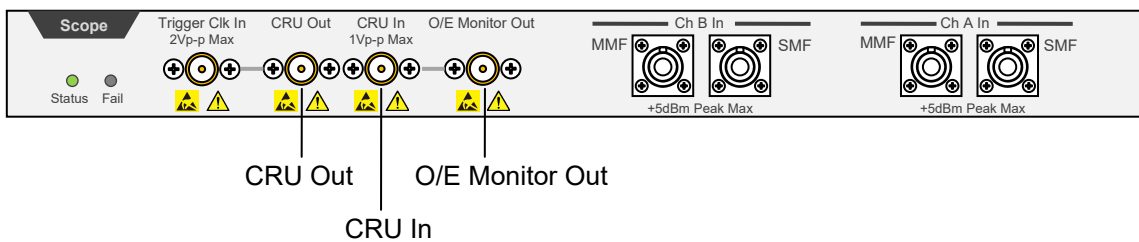
Figure 2.2.1-6   Scope Panel Names (with MP2110A-022 and MP2110A-054)

The following tables describe the panel.

Table 2.2.1-4   Lamp List

Name	Description
Status	Lit during normal operation when remote commands can be received; color indicates trigger clock input status.
	Green: The trigger clock detected.
	Red: The trigger clock not detected; check signal input to trigger clock input terminal.
	Orange: Detected trigger clock signal input frequency out of range.*
Fail	Lit red when hardware fault detected at startup.
	This may be lit in short time when the power is turned on and off, but it is not abnormal.

*:   Check the following items when the Status lamp is lit in orange. Refer to Section 6.2.5, " Time, CRU Dialog Box", for the operation method.

- Specify the input trigger clock in the range from 0.1 to 15.0 GHz. (When ON is specified at Precision Trigger, specify 2.4 GHz or more.)
- When Off is specified at Tracking in Time dialog box, match the Clock Rate setting value and the actual trigger clock frequency by one of the following methods.
  - Change the Clock Rate setting value to the actual trigger clock frequency.
  - Execute Acquire Clock Rate.
- When **PPG** is specified at Tracking in Time dialog box, specify the trigger clock frequency within the range defined by PPG's Bit Rate and Divide Ratio.
- When **CRU** is specified at Tracking in Time dialog box, check CRU In input signal and CRU setting in Time dialog box to turn Lock Status green.

Table 2.2.1-5   Terminal List

Connector Name	Description	Maximum Input Level
Trigger Clk In	For trigger clock input to the sampling oscilloscope.	2 Vp-p
Ch A In	Data input SMF: 860 to 1650 nm MMF: 800 to 860 nm	Coaxial connector: ±2 V SMF optical connector: +8 dBm peak MMF optical connector: +10 dBm peak
Ch B In	Data input SMF: 860 to 1650 nm MMF: 800 to 860 nm	Coaxial connector: ±2 V SMF optical connector: +8 dBm peak MMF optical connector: +10 dBm peak
O/E Monitor Out[*1,*2]	O/E monitor output	
CRU In[*1]	Clock recovery unit input	1 Vp-p
CRU Out[*1]	Clock recovery unit output	

[*1]: When MP2110A-054 is installed.

[*2]: When MP2110A-022, 023, 025, 026, 032, 033, 035, or 036 is installed.

2

2.2.2 Rear Panel
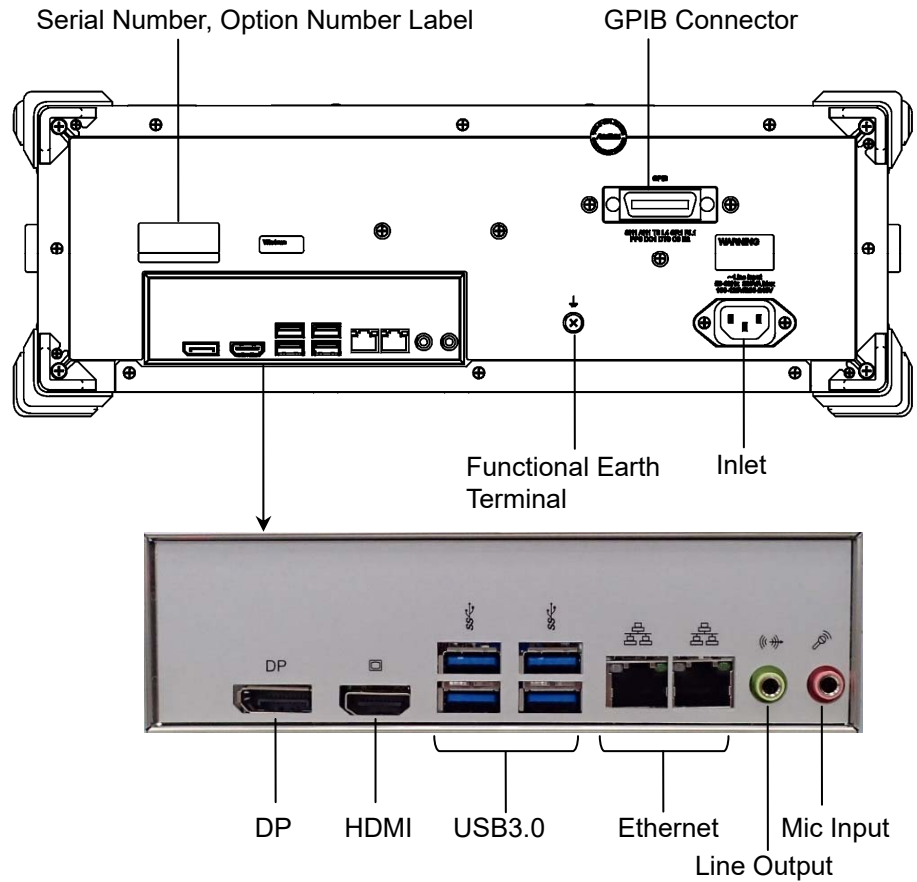
Figure 2.2.2-1   Rear Panel

The following table describes the terminals.

Table 2.2.2-1   Terminal List

Name	Description
GPIB	For connection to PC to remote control MP2110A.
DP	For connecting external monitor supporting DisplayPort specification.
HDMI	For connecting external monitor supporting HDMI specification. Refer to 2.4 "Connecting Peripheral Devices".
USB3.0	For connecting accessories such as keyboard, mouse.
Ethernet	For connecting PC or network to control MP2110A remotely.
Line Output	This terminal is not used.
Mic Input	This terminal is not used.
Functional Earth Terminal	Ground terminal For connecting wrist strap or DUT.
Inlet	Connects to the accessory power cord.

2.3 Power Connection

2.3.1 Power Requirements

For normal operation of the MP2110A, use the power voltage range described below.

Table 2.3.1-1   Power Requirements

Power source	Voltage range	Frequency
100 Vac system	100 to 120 V	50 to 60 Hz
200 Vac system	200 to 240 V	50 to 60 Hz

Operating voltage: within the range of +10% to –15% from the rated voltage (Max. AC 250 V).
Switching between 100 and 200 V systems is automatic.

⚠ CAUTION

Supplying power exceeding the above range may result in electrical shock, fire, failure, or malfunction.

2

Before Use

2.3.2 Connecting Power Cord

Insert the power plug into an outlet, and connect the other end to the power inlet on the rear panel. To ensure that the MP2110A is properly grounded, always use the supplied 3-pin power cord.

⚠ WARNING

Always connect the MP2110A to a properly grounded outlet. Do not use the instrument with an extension cord or transformer that does not have a ground wire.

If the MP2110A is connected to an ungrounded outlet, there is a risk of receiving a fatal electric shock. In addition, the peripheral devices connected to the MP2110A may be damaged.

Unless otherwise specified, the signal-connector ground terminal, like an external conductor of the coaxial connector, of the MP2110A is properly grounded when connecting the power cord to a grounded outlet. Connect the ground terminal of DUT to a ground having the same potential before connecting with the MP2110A. Failure to do so may result in an electric shock, fire, failure, or malfunction.

⚠ CAUTION

If an emergency arises causing the MP2110A to fail or malfunction, disconnect the MP2110A from the power supply by disconnecting either end of the power cord.

2.4 Connecting Peripheral Devices

USB devices

USB devices such as mouse, keyboard, storage, etc., can be connected to the left side panel USB connector.

No panel operations are required before removing USB devices from the BERTWave. USB devices can be removed at any time as long as no files are being written to or read from the USB device.

External Monitor

Connect an external monitor to the DP or HDMI connector on the rear-side panel.

Available monitor is:

- Connection via either HDMI or Display Port
  When connecting to an external monitor with the VGA connector, use the HDMI to VGA conversion adapter.
- Resolution 1280×800 or greater
  If the resolution of the display is less than 1280 × 800, the entire application window will not be displayed. If the resolution is 1280 x 800, you can prevent the application window from disappearing by fixing the operation screen to the upper left with **Dock / Undock** on the System Menu.   (Refer to 2.9.3 "Setting External Monitor").

2

Before Use

2.5 Connecting Remote Control Devices

Refer to Section 4.3.10, "Remote Control" for details of how to set the remote control interface.

Ethernet

Connect an Ethernet cable that is CAT 5 cable or newer to the Ethernet connector on the rear panel.

GPIB

Connect the cable to the rear-panel GPIB connector.
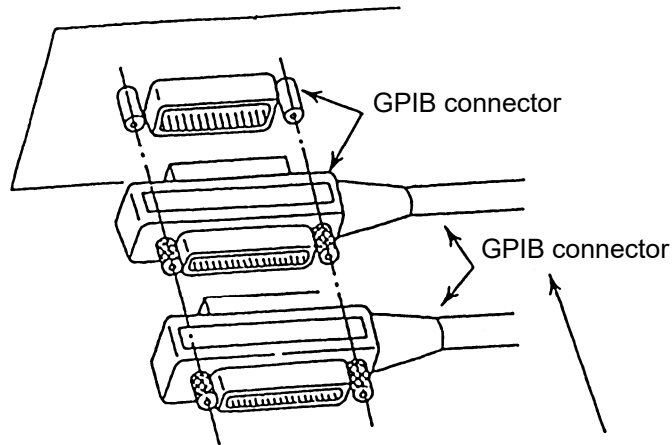
Total cable length:	Up to 20 m
Cable length between devices:	Up to 4 m
Number of devices that can be connected:	Up to 15

Figure 2.5-1   GPIB Cable Connection 1

Connect cables without forming loops.
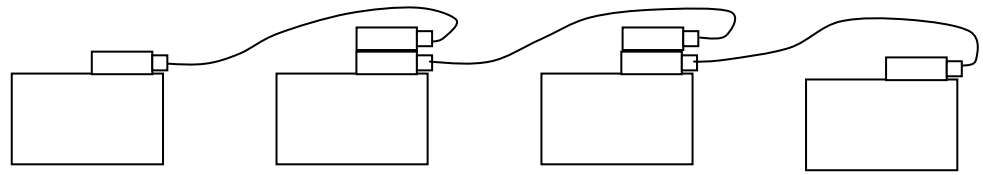
(a) Daisy Chain
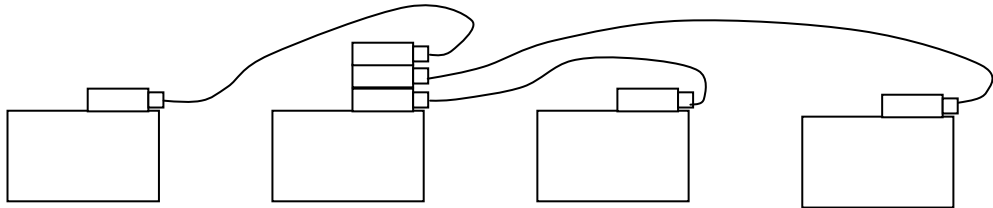
(b) Star
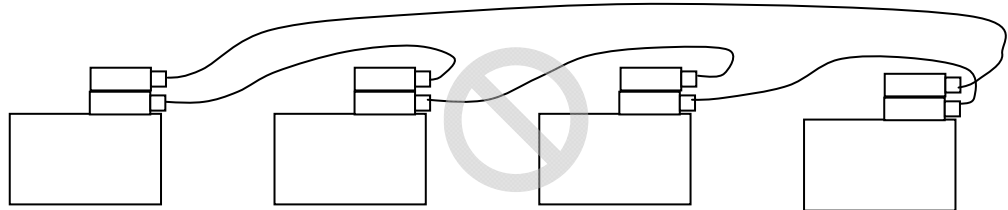
(c) Loop

Figure 2.5-2   GPIB Cable Connection 2

2

Before Use

2.6 Cautions on Handling Optical Fiber Cables

Optical fiber cables may degrade in performance or be damaged if handled improperly.

Note the following points when handling them.
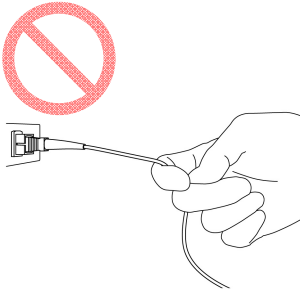
⚠ CAUTION

Do not pull the cable when removing the connector.

Doing so may break the optical fiber inside the cable, or remove the cable sheath from the optical connector.
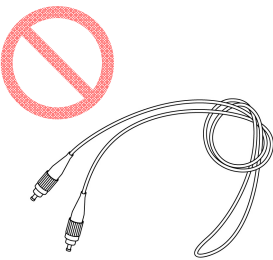
⚠ CAUTION

Do not excessively bend, fold, or pinch an optical fiber cable.

Doing so may break the optical fiber inside the cable.
Keep the bend radius of an optical fiber cable at 30 mm or more. If the radius is less, optical fiber cable loss will increase.
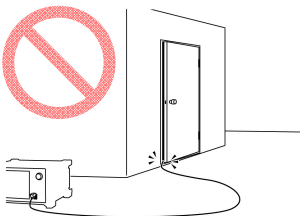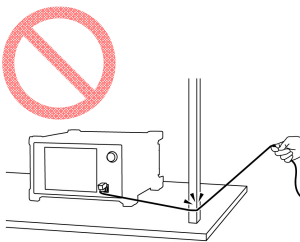
⚠ CAUTION

Do not excessively pull on or twist an optical fiber cable.

Also, do not hang anything by using a cable. Doing so may break the optical fiber inside the cable.
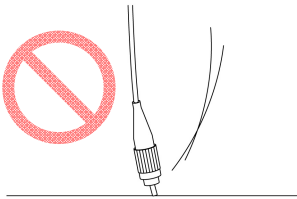
⚠ CAUTION

Be careful not to hit the end of an optical connector against anything hard such as the floor or a desk by dropping the optical fiber cable.

Doing so may damage the connector end and increase connection loss.
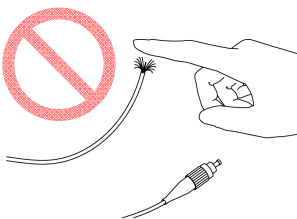
⚠ WARNING

Do not Click the end of a broken optical fiber cable.

The broken optical fiber may pierce the skin, causing injury.

⚠ CAUTION

Do not disassemble optical connectors.

Doing so may cause part to break or the performance to degrade.

2

Before Use

2.7 Connecting Coaxial Cable

Connect the coaxial cable to the MP2110A coaxial connector. Refer to 2.10 "Precautions for Preventing Damage".

2.7.1 Notes on Coaxial Cable Connection

⚠ WARNING

When signals are input to the MP2110A, avoid excessive voltage beyond the rating. Otherwise, the circuit may be damaged.

- When output is used at the 50 Ω/GND terminator, never feed any current or input signals to the output.
- Use the correct coaxial cable for connecting to the coaxial connectors of the MP2110A, which are either SMA or K connectors. If the wrong coaxial cable for the connector is used, there is a risk of damage to the connector.
- Tighten coaxial connectors to the correct torque (0.9 Nm). If the coaxial connector is over tightened, there is a risk of damage to the connector, which may prevent disconnection. If the connector is not sufficiently tightened, correct measurement may be impossible.
- When operating the MP2110A with other equipment, arrange so that the co-axial cables are not accidentally pulled; if they are pulled accidentally, the MP2110A may be dragged off the bench top and damaged.
- Always use a coaxial cable with sufficiently low loss matching the signal to be measured. Correct measurement may be impossible if the cable loss is too large.
- Use a coaxial cable with an impedance of 50 Ω. Correct measurement may be impossible if the impedance is incorrect.
- Keep the protective caps fitted to unused coaxial connector.

2.7.2 How to Discharge the Electrostatic Charges of the Coaxial Cable

There is a risk of damaging MP2110A if the coaxial cable you connect to MP2110A is charged electrostatically.

To prevent MP2110A from being damaged by ESD, discharge the electrostatic charges of the coaxial cable by using the ESD Discharger, which is an optional accessary of MP2110A, before cabling the connectors. The ESD Discharger can be used with one of SMA connector, K connector, and V connector (and its compatible connector).
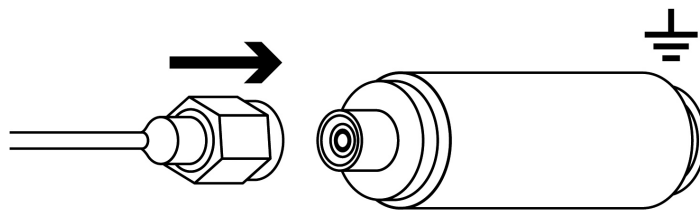
Figure 2.7.2-1   How to Use the ESD Discharger

2.8 Turning Power On/Off

2.8.1 Power-on

1. Before turning power on, connect an external monitor, a keyboard and a mouse to MP2110A. Refer to 2.4 "Connecting Peripheral Devices".

2. Turn on the external monitor.

3. Connect the power cord plug, referring to Section 2.3 "Power Connection". The MP2110A enters the standby state and the Standby lights orange.

4. Press the power switch.
    The power lamp lights green and the Windows start-up begins.

5. In 30 seconds, the application window is displayed. If the application window is not displayed, refer to 2.9.3 "Setting External Monitor".
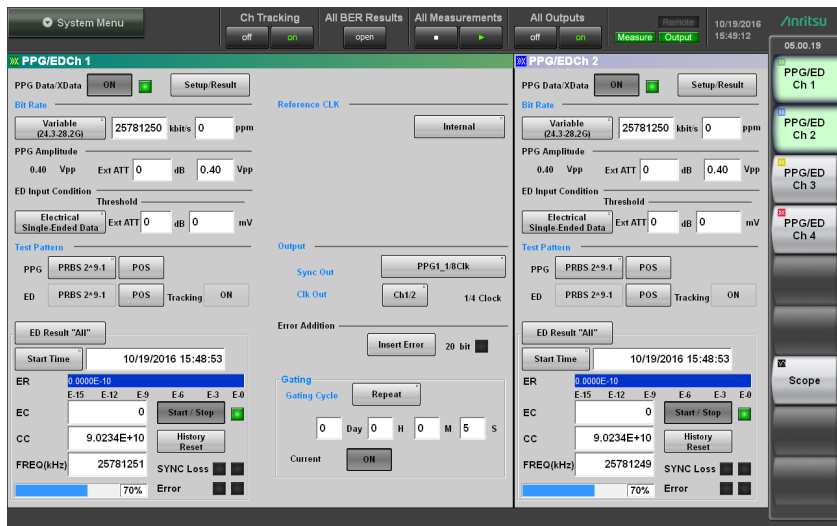
Figure 2.8.1-1   Application Window

Note:

>   The power of MP2110A can also be turned on by supplying the AC power even if the power button on the panel is not pressed. To perform this operation, select the **On follows AC power** check box in the dialog box displayed by clicking Start Menu - Program - MX210000A - Power Configuration.
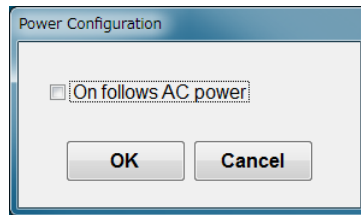
Figure 2.8.1-2   Power Configuration Dialog Box

2.8.2 Power-off

1.   Click **System Menu** in the application window.

2.   Click **Exit**.

3.   Click **Yes**.

4.   Press the Power switch.
The Power switch blinks in green. After the power-off process has completed, the power switch lamp goes off, and the Standby lights orange.

Notes:

- If the power plug is removed while the panel access lamp is lit, the data may not be saved correctly. Depending on the type of data that was not saved correctly, sometimes the equipment may not start correctly at the next power-on. Remove the power plug after cutting the power.

- The power may not turn on correctly if the power is turned off and then turned on again immediately after the Standby illuminates orange.
Wait at least 5 seconds after turning off the power before turning on again.

2.9 Setting Control Panel

The MP2110A is set to the factory defaults for optimal measurement. Changing the Windows settings is outside the scope of operation warranty. In addition, the performance may drop or functions may not operate correctly if the Windows settings are changed. Read the general notes in this section carefully when changes to the Windows settings are required.

⚠ CAUTION

Anritsu guarantees the MP2110A to work properly only when the factory settings for Windows have not been changed.

MP2110A operations are not guaranteed if program installation or update, including Windows Update, is performed.

Changing registries may cause abnormal operations.

2.9.1 Displaying Windows Desktop

The Windows desktop can be displayed as described below.
To display the MP2110A application again, click **MX210000A** on the Windows taskbar.

When using Click panel and mouse:
1.   Click **System Menu** on the left upper side of the application window.
2.   Click **Minimize**.

When using keyboard:
Press the Windows + **D**. All windows will be minimized to display the Windows desktop.

2.9.2 Setting Control Panel

The system time, external display settings and Click panel settings are set at the Windows Control Panel. Do not change any settings other than those listed in Table 2.9.2-1.

Table 2.9.2-1   Description of Control Panel

Icon	Description
	<u>Date and Time</u> • Change the date, time and time zone as necessary. • Internet Time is set to off at factory shipment. Operation may be affected if this setting is changed.
	<u>Display</u> <u>Intel® HD Graphics</u> • Change this setting when connecting an external monitor to Display Port or HDMI connector. For details, refer to 2.9.3 "Setting External Monitor" for details. • Changing the screen resolution, refresh rate or power management, or enabling the screen saver may cause abnormal BERTWave operation.

2.9.3 Setting External Monitor

The external monitor resolution is changed using the following method.

1. Connect the external monitor to the monitor connector on the rear panel of the MP2110A.

2. Set the MP2110A and monitor power to On.

3. Click **System Menu**.

4. Click **Minimize**.

5. Right click on desk top.

6. Click **Screen Resolution**.
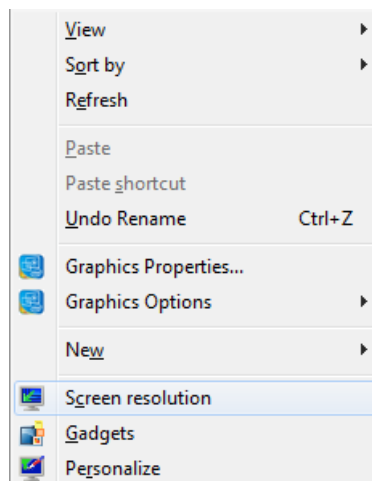
7. Change the external monitor resolution.
   Specify **1280 × 800** or greater at Resolution to display the
   application window in full screen.
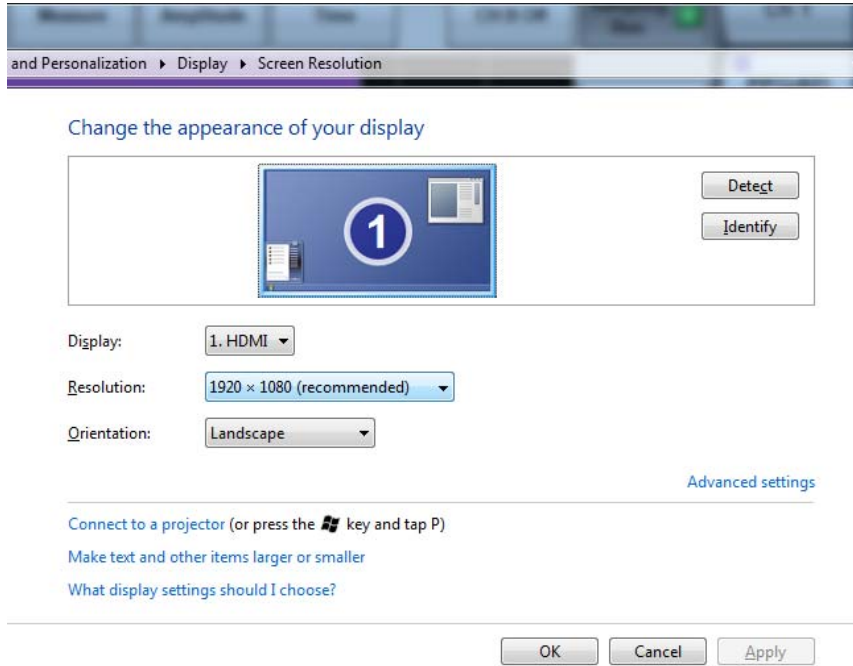
8. Click **OK**.

9. The dialog box confirming changes of the desktop appears.
   Click **Keep changes**.
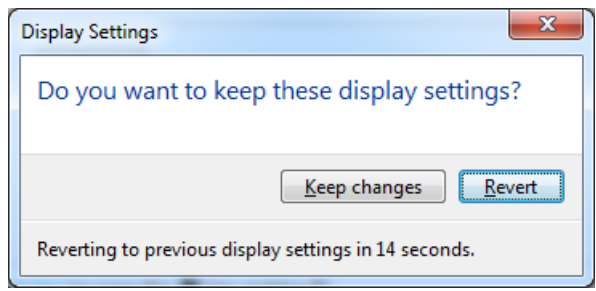
10. Click [icon] on the task bar.

11. When the external monitor resolution is set to **1280 × 800**, click
    System Menu - Dock/Undock to fix the application window at top left
    of the screen (refer to 4.3.9 "Dock/Undock").

Note:

      Do not set the Control Panel - Display setting to anything other
      than [Smaller - 100% (default)].

2.10 Precautions for Preventing Damage

⚠ CAUTION

● **Always use the supplied 3-pin power cord to ground both the MP2110A and DUT (included in test circuit). After confirming that both the MP2110A and DUT are grounded, use coaxial cables to connect them.**
NEVER connect the MP2110A and DUT without grounding, otherwise electrostatic discharge may damage the MP2110A.

● **Do not touch the core conductor of the connector or bring it into contact with metal. Doing so may damage the input circuit of the MP2110A.**
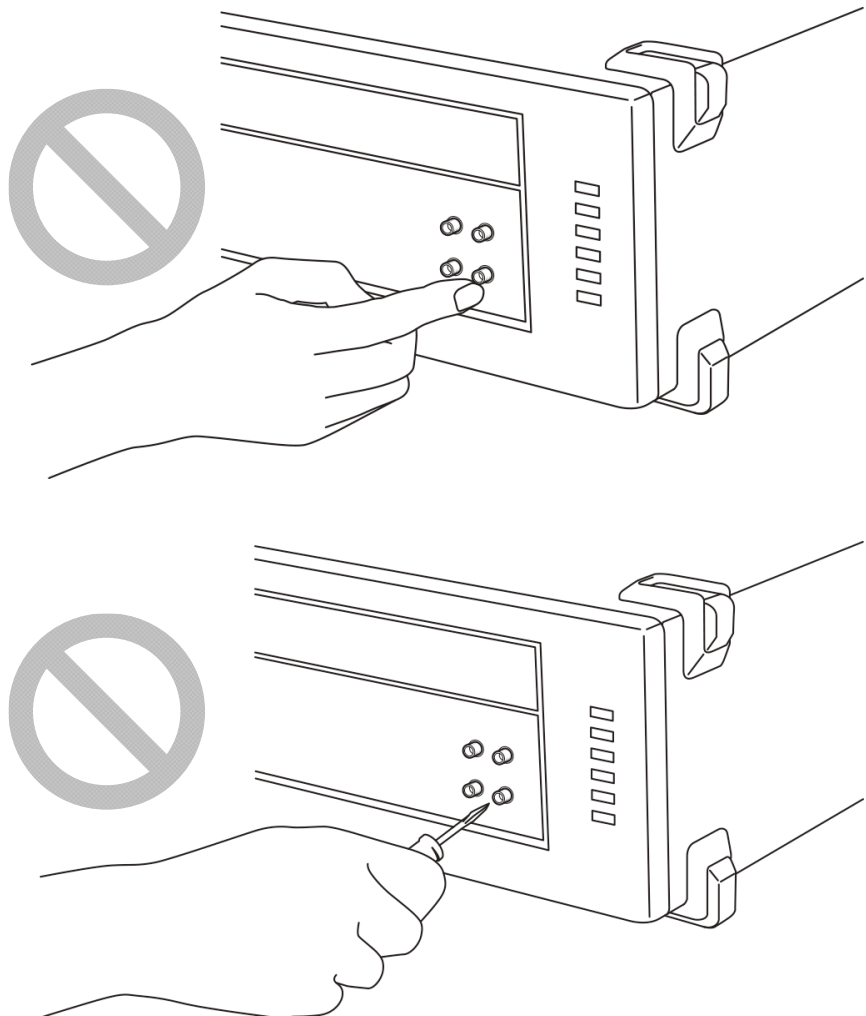
⚠ CAUTION

Do not touch the core conductor of the coaxial cable connected to the input connector or bring it into contact with metal.

Doing so may damage the input circuit of the MP2110A.
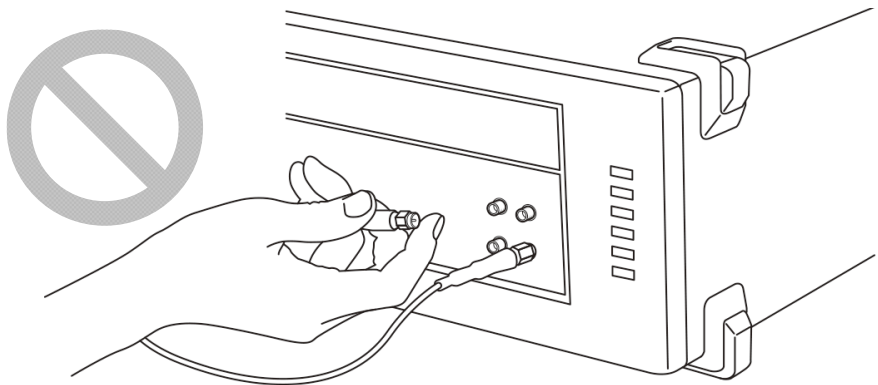
⚠ CAUTION

Do not touch the core conductor to the metal when connecting the coaxial cable to the connector.

Doing so may damage the input circuit of the MP2110A.
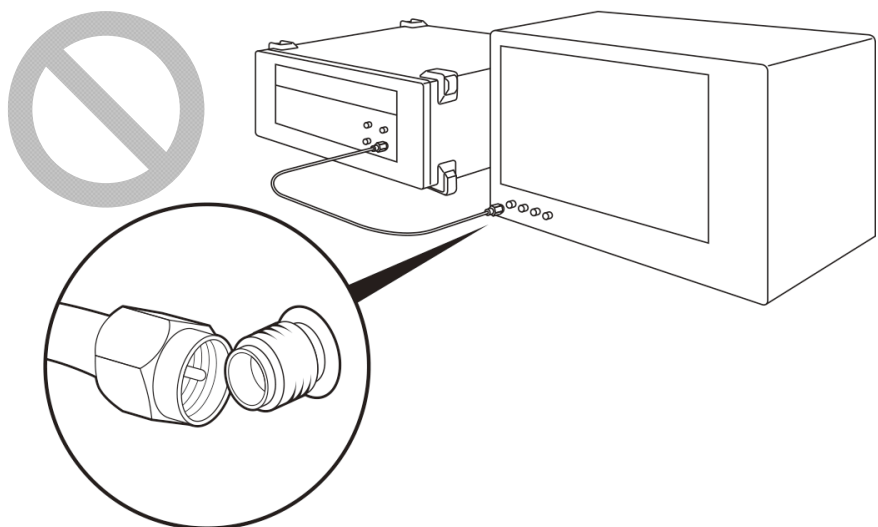
2.10.1   Precautions on Electrostatic Discharge and Electrical Overstress

2

Before Use

<div align="center">

⚠ CAUTION

</div>

- When signals are input to the MP2110A, avoid excessive voltage beyond the rating. Otherwise, the circuit may be damaged.

- Never feed any current or input signals to the output connector.

- As a countermeasure against static electricity, connect the ground structures (for example, frame ground) of external devices, including experimental circuits, to the ground terminal of the MP2110A by using ground wires before connecting the IO connector.
  Shorten ground wires as much as possible.

- To the input terminal of the MP2110A, connect an attenuator that can protect the MP2110A without affecting measurement results. An attenuator with a bandwidth of 40 GHz or more is recommended.

- The outer conductor and core of the coaxial cable may become charged as a capacitor. Use any metal to discharge the outer conductor and core before use.

- The MP2110A has many important circuits and parts including hybrid ICs.
  These parts are extremely sensitive to static electric charges, so never open the case of the MP2110A.

- To prevent the risk of damage to the MP2110A from static electric charges, always use an antistatic mat on the workbench and ensure that the operator wears a grounded wrist strap.
  Always ground the wrist strap to the workbench antistatic mat or the frame ground of the MP2110A.

⚠ **CAUTION**

- **Always use 3-pin power cords when connecting external devices, including experimental circuits, to AC outlets.**
  Connect the ground wires of external devices and MP2110A to a common ground.

- **Turn on the external devices, including experimental circuits, before connecting them to the MP2110A. Use coaxial cables when connecting.**
  On the contrary, disconnect the coaxial cables between external devices and the MP2110A before turning off the external devices.
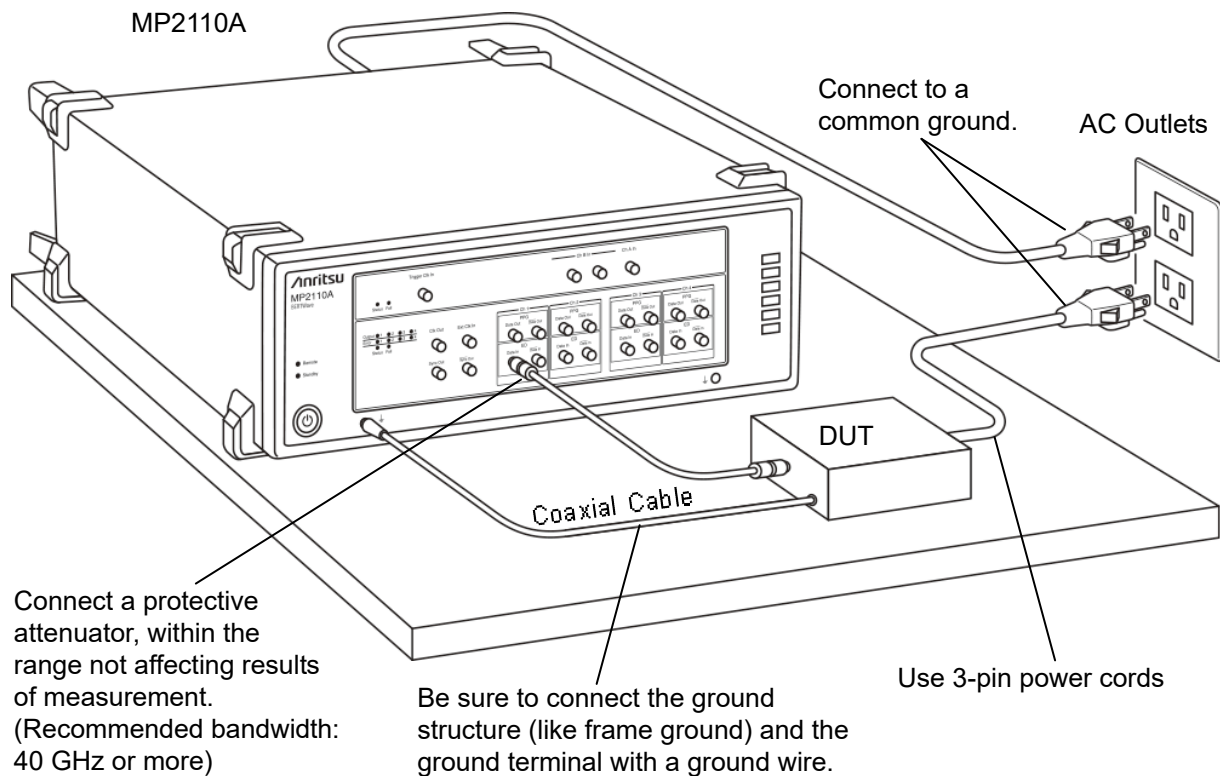
Figure 2.10.1-1   Example of Connection with DUT

Follow the procedure below to check for electrical overstress to the MP2110A before connecting DUT (Device Under Test).

Checking the ground connection using a tester

1. Connect DUT and the ground terminal of the MP2110A with a ground wire.

2. Turn on the power to DUT and MP2110A without connecting DUT to the I/O terminal of MP2110A.

3. Measure the voltage between DUT's ground structure and ground terminal of MP2110A with a tester in AC mode, and confirm the voltage is 0 V.

If the voltage measured in step 3 is not 0 V, there is a possibility that MP2110A and DUT may not be connected to a common ground. In this condition, do not connect the I/O terminal of MP2110A and DUT. Failure to do so may cause damage to MP2110A due to a voltage exceeding a rated value.

Review the ground wiring by, for example, changing the location of the DUT's ground wire connected to MP2110A so that the voltage measured in step 3 to be 0 V.

Notes:

> If it is impossible to connect a ground wire to DUT, follow the instructions below so that the voltage to be measured in step 3 becomes 0 V.
>
> - Check that the 3-pin power cords described in 2.3.2 "Connecting Power Cord" are used for the MP2110A and DUT.
>
> When the 3-pin power cords are used, take the following actions:
> - There may be a disconnection in the ground terminal of the used power cord. Replace it with a different 3-pin power cord.
> - There is a possibility that the ground terminal inside the AC outlets to which the 3-pin power cords of MP2110A and DUT are connected is not connected to ground. Connect the 3-pin power cords to different AC outlets.

2

Before Use

Checking the output waveform with an oscilloscope

1. Connect the DUT and the oscilloscope using a cable with an impedance of 50 Ω.

2. Set the input impedance of the oscilloscope to 50 Ω.

3. Observe the waveform with the oscilloscope, and perform the following operations to check the observed waveform for surge voltage exceeding the rated voltage*.

   There is a risk of damage if a voltage exceeding the rated voltage* is generated.

   - Turning On/Off the DUT power
   - Outputting a pulse from DUT
   - Connecting and disconnecting the cable between DUT and the BERTWave

*:   The rated voltages for MP2110A are shown in the table below.

Table 2.10.1-1   Rated Voltages of Input Connector

Connector		Rated Voltage
ED	Data In, $\overline{\text{Data}}$ In	1 Vp-p
Scope	Ch A, Ch B electrical	±2 V
	Trigger Clk In	2 Vp-p
	CRU In	1 Vp-p

2.10.2 Precautions When Using Bias-T

When connecting an external device such as a Bias-T to the output connectors of the MP2110A, if the output signal includes any DC voltage, variations in the output of the DC power supply or load may change the level of the output signal, risking damage to the internal circuits.

⚠ CAUTION

- **Do not connect or disconnect any external devices while DC voltage is impressed.**

- **Only switch DC power sources ON and OFF when all equipment connections have been completed.**
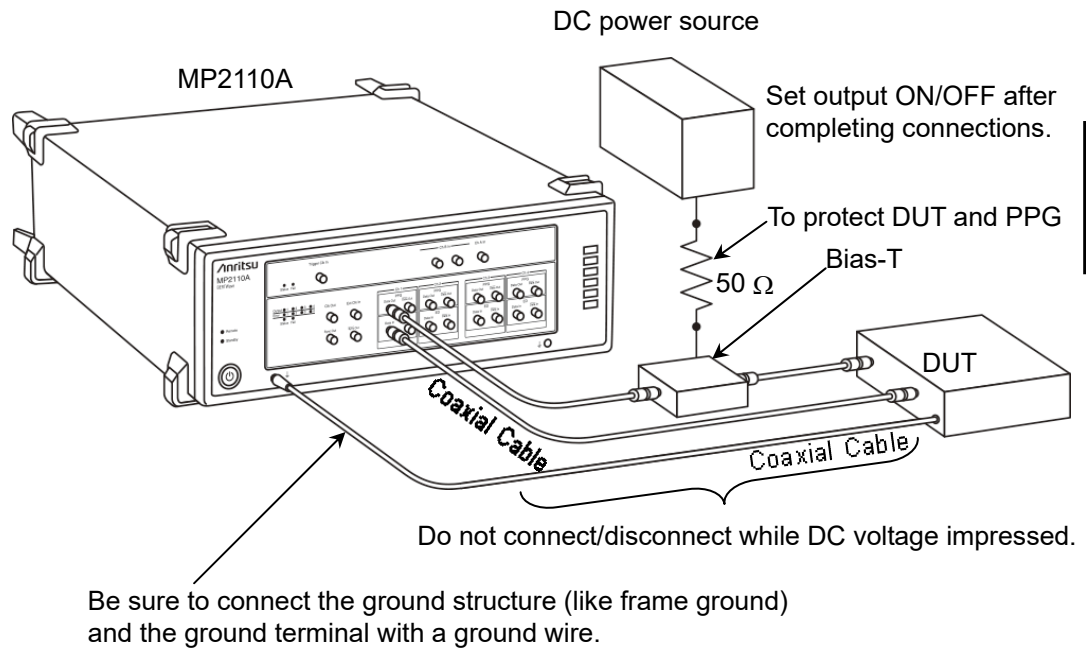
Figure 2.10.2-1   Bias-T Connection Example

<Recommended procedures>

Measurement Preparation 1:

1.   Connect the MP2110A and all equipment.

2.   Set the DC power supply output to ON.

3.   Set the MP2110A output to ON, and start measurement.

Measurement Preparation 2:

1.   Set the MP2110A output to OFF.

2.   Set the DC power supply output to OFF.

3.   Disconnect the MP2110A and all equipment, or change the DUT connections.

Since even unforeseen fluctuations in DC voltage and load (open or short circuits at the MP2110A output side and changes caused by using a high-frequency probe, etc.) can damage the DUT and the MP2110A, we recommend connecting a 50 Ω resistance in series with the DC terminal of the Bias-T to prevent risk of damage.

2.11 Windows Security Measures

MP2110A uses Windows Embedded Standard 7 (WES7) 64bit version. When connecting MP2110A to a network, in addition to connecting to secure and virus-protected networks, the following procedures are recommended in order to add protection against malware (malicious software) and viruses.

- Activating firewall
- Installing Windows important update programs
- Using antivirus software

The security measure settings condition of this product can be confirmed from the Control Panel of Windows.

1. Click **Start → Control Panel** from the Windows menu bar hidden in the lower part of the screen.

2. Click **System and Security → Action Center**.

3. Click **Security**, and confirm security measures settings condition.

Note:

Security warnings are not displayed by factory default.

⚠ CAUTION

When connecting MP2110A to the Internet or to an external network, there is a possibility an unpredictable problem or damage may occur. Anritsu Corporation does not recompense for any damage caused by connecting MP2110A to a network.

2.11.1 Activating Firewall

It is recommended to turn On the Windows firewall on MP2110A.

Windows firewall On/Off setting:

1. Click **Start → Control Panel** from the Windows menu bar hidden in the lower part of the screen.

2. Click **System and Security →Windows Firewall** to show Windows Firewall window.

Note:

Depending on when MP2110A was released, factory default setting of Windows firewall might be set to Off.

3. Click **Turn Windows Firewall on or off** found in left side of Windows Firewall window.
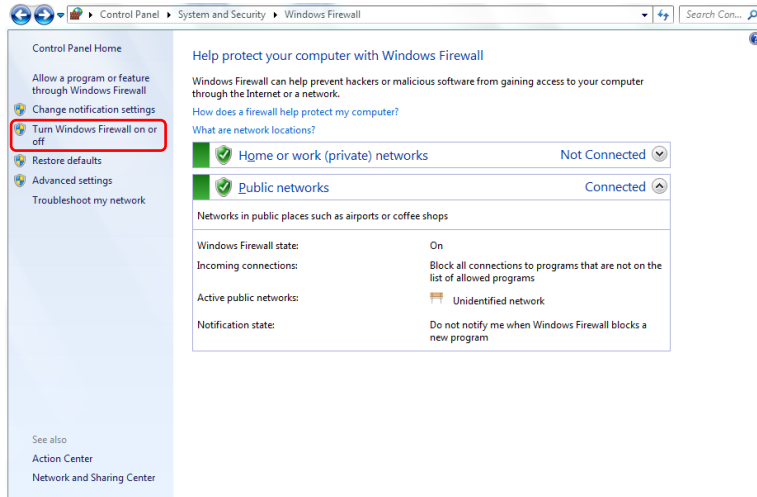
Figure 2.11.1-1 Windows Firewall Window

4. Customize Settings display will be shown where Windows firewall On/Off settings can be changed.
Use MP2110A with the following checkboxes Off (unchecked).

- **Block all incoming connections, including those in the list of allowed programs**

- **Notify me when Windows Firewall blocks a new program**
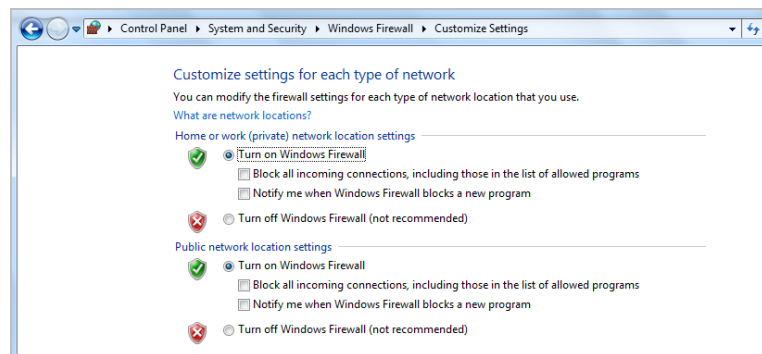
Figure 2.11.1-2 Customize Settings Window

Confirmation and setting of allowed programs through Windows firewall:
Even if Windows firewall is On, in order for this product to operate properly, it is necessary to set as allowed programs those that enable external communication from MP2110A.

Note:

Depending on when MP2110A was released, factory default setting for allowed programs might not be set beforehand.

2

Before Use

1. Use the mouse to click **Allow a program or feature through Windows Firewall** found in left side of Windows Firewall window.
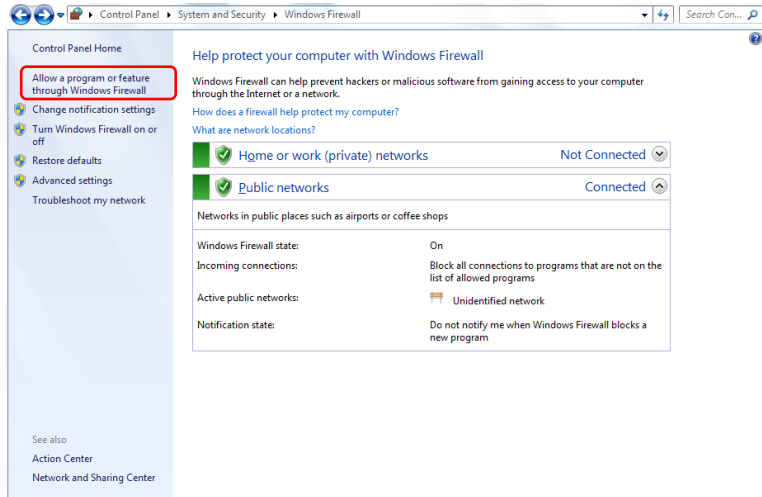
Figure 2.11.1-3   Windows Firewall Window

2. Allowed Programs window will be shown where programs allowed through Windows firewall can be confirmed.

    Confirm if **MX210000A** is found and set to On (checked) under Allowed programs and features.

    When no such information is displayed, it is necessary to add **MX210000A**.
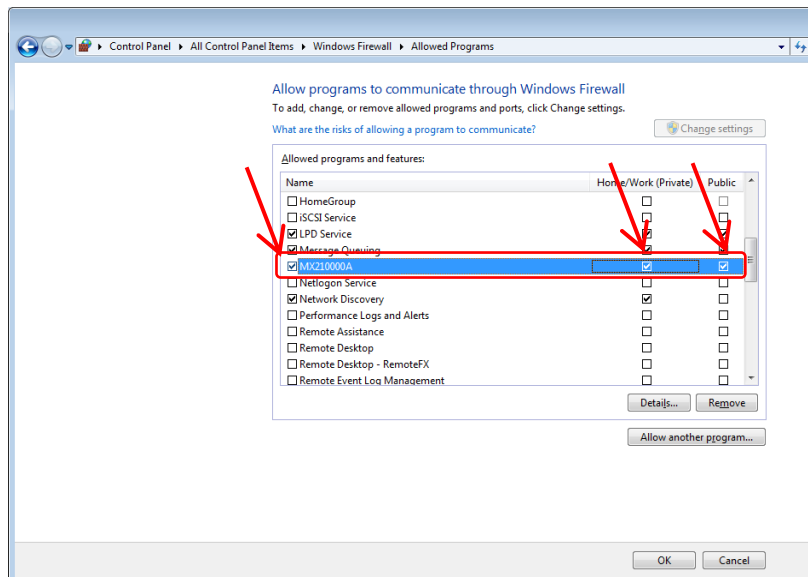
Figure 2.11.1-4   Allowed Programs Window

Procedure to add [MX210000A] when it is not registered:

1.   Use the mouse to click **Allow another program...** found in Allowed Programs window.
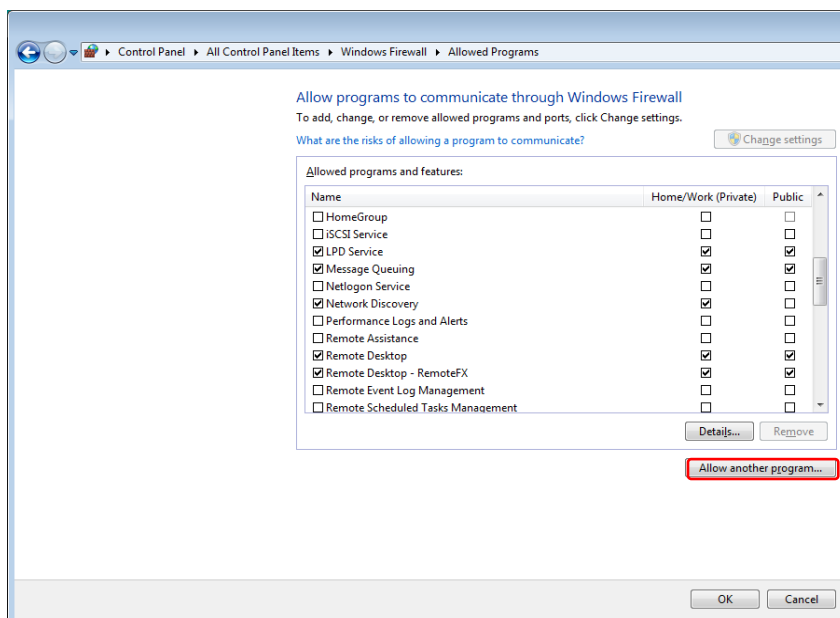
Figure 2.11.1-5   Allowed Programs Window

2.   In Add a Program window, select **MX210000A**, and click **Add**.
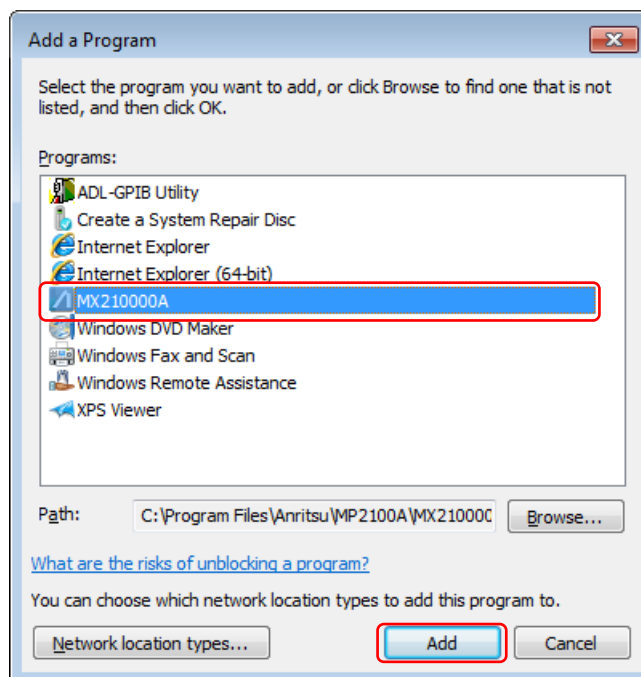
Figure 2.11.1-6   Add a Program Window

3.   **MX210000A** is added to Allowed programs and features.
Confirm if **MX210000A** is found and set to On (checked).
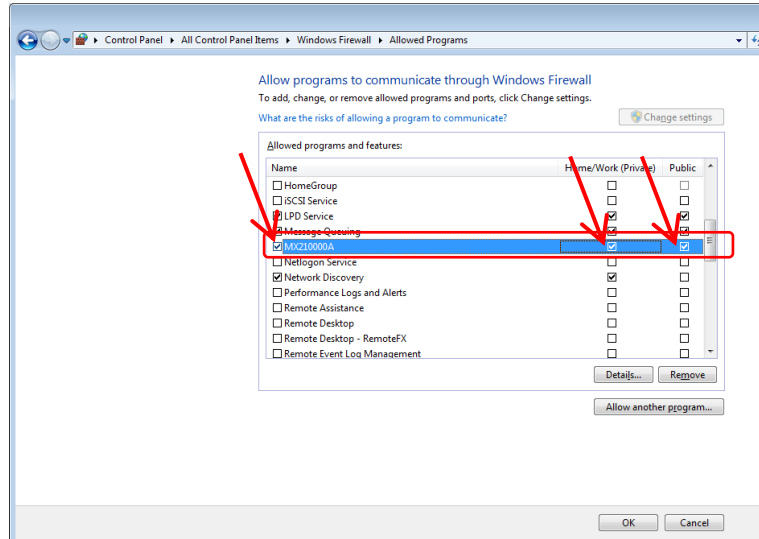
Fogure 2.11.1-7   Browse display of Add a Program

2.11.2 Installing Windows Important Update Programs (Windows Update)

It is necessary to regularly check for important Windows update programs and keep them up-to-date. However, since executing update program downloads and installations will decrease the performance of MP2110A, deactivate automatic updates for Windows Update. Instead, it is recommended to check for new updates, execute downloads and installations periodically when MP2110A is not in use for measurement.

Windows Update setting and execution:

1.   Click **Start** → **Control Panel** from the Windows menu bar hidden in the lower part of the screen.

2.   Click **System and Security** → **Windows Update** to show Windows Update window.

3.   To deactivate automatic updates, click **Change settings** found in left side of Windows Update window.

Figure 2.11.2-1   Windows Update Window

4.   Select **Never check for updates (not recommended)** in Important
updates, then click **OK**.
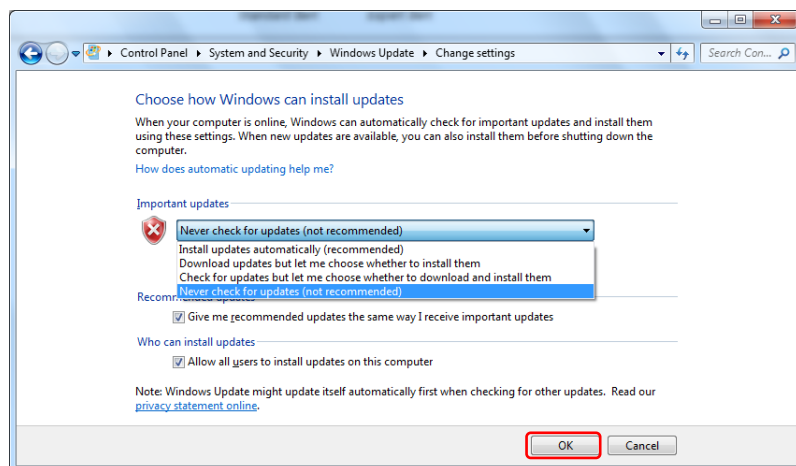
Figure 2.11.2-2   Change settings Window

Before Use

2

5. To check for newly available update programs (manual update), click **Check for updates** in Windows Update window.
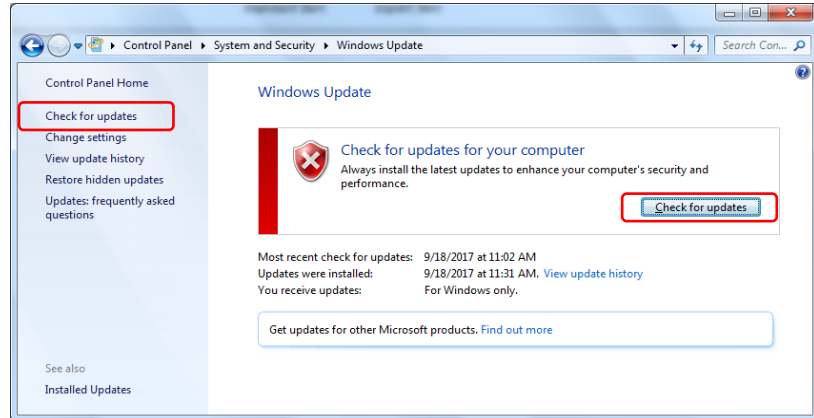
Figure 2.11.2-3   Windows Update Window (manual update)

6. When a new update program is found, download and install following the displayed instructions.

2.11.3 Using Antivirus Software

It is recommended to install antivirus software on MP2110A. However, since the automatic updates for virus data library and the full scans run in the background by the antivirus software will decrease the performance of MP2110A, do not execute them. Instead, it is recommended to run them periodically when MP2110A is not in use for measurement.
The antivirus software that checked operation in MP2110A is shown below.

● Trend Micro Virus Buster Corporate Edition XG

Note:

Refer to the antivirus software operation manual for its installation and operation procedures. Although it is confirmed that no negative effects in the general usage of MP2110A are caused by using the software mentioned above, there is no guarantee for different software even if containing similar functions.

Chapter 3 Measurement Examples

This chapter explains examples of how to connect the MP2110A and the DUT and their measurement procedures.
When changing the optical level input to the DUT such as the receiver sensibility measurement, connect other measurement instruments such as optical attenuator.

3

Measurement Examples

3.1 Measuring Bit Error Rate

When the DUT input/output signal is electrical:

1. Connect the DUT input terminal to PPG1 $\overline{\text{Data}}$ Out and Data Out connectors using the coaxial cable.
    If the DUT has only one input connector, connect it to the Data Output connector of PPG1. Also, connect the coaxial terminator, which is attached to the BERTWave standard configuration, to the $\overline{\text{Data}}$ Out connector.

2. Connect the DUT output terminator to ED1 $\overline{\text{Data}}$ In and Data In connectors using the coaxial cable.
    If the DUT has only one output connector, connect it to the Data In connector of ED1. Also, connect the coaxial terminator, which is attached to the BERTWave standard configuration, to the $\overline{\text{Data}}$ In connector.
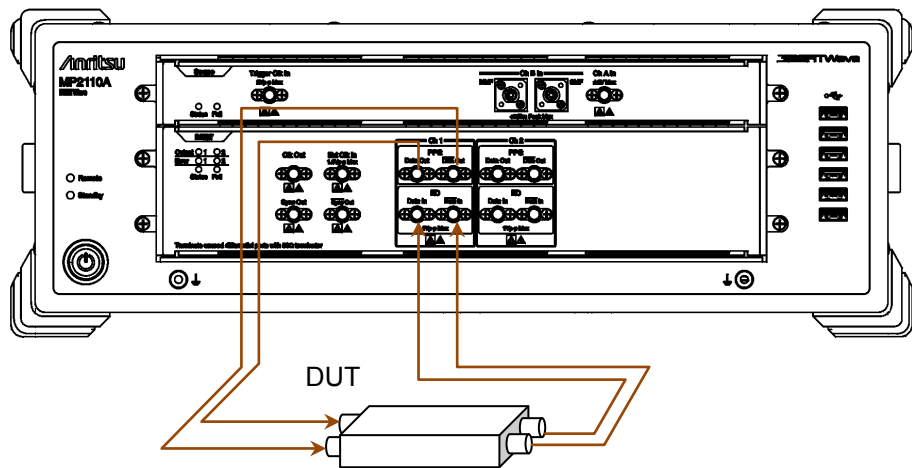
Figure 3.1-1   Making Connections Using Electrical Signal

3. Click **PPG/ED Ch1** in the application window.

4. Set Bit Rate, PPG Amplitude, ED Input Condition, and Test Pattern. Refer to Chapter 5, "How to Operate BERT", for details of the operation method.

5. Click the PPG Data XData button and set the display to **ON**. Check the following items.
    *   The Output lamp 1 on the BERT panel is lit. (Refer to Figure 2.2.1-2.)
    *   SYNC Loss and Error are not lit in the Application window.

6. Set Gating.

7. Click **Start/Stop**. When the time set at Gating elapses, the measurement values are displayed at ER, EC, CC, and FREQ (kHz).
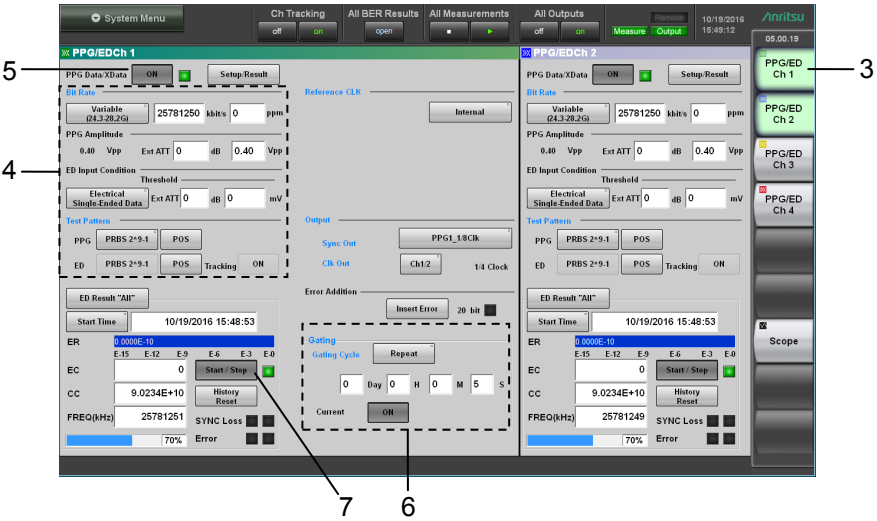
Figure 3.1-2   Operating Bit Error Rate Measurement

Measurement Examples

3

3.2 Measuring Waveform

When the DUT input/output signal is electrical:

Input the output of the PPG in the MP2110A to the DUT, and then measure the DUT output using the sampling oscilloscope.

1.   Connect the DUT input terminal to PPG1 $\overline{\text{Data}}$ Out/Data Out using a coaxial cable.
     If only one DUT input connector is conveniently available, connect to the PPG1 Data Out. Also, connect the coaxial terminator included as a standard accessory to the $\overline{\text{Data}}$ Out.

2.   Connect the Clk Out (or Sync Out) on BERT to Trigger Clk In on Scope using a coaxial cable.
     When the Sync Out is connected, connect the accessory coaxial terminator to $\overline{\text{Sync}}$ Out.

3.   Connect the DUT output terminals to Ch A In and Ch B In on the sampling oscilloscope using a coaxial cable.
     When the amplitude of the input signal is more than 400 mVp-p, connect the attenuators to Ch A In and Ch B In to perform the measurement more accurately.
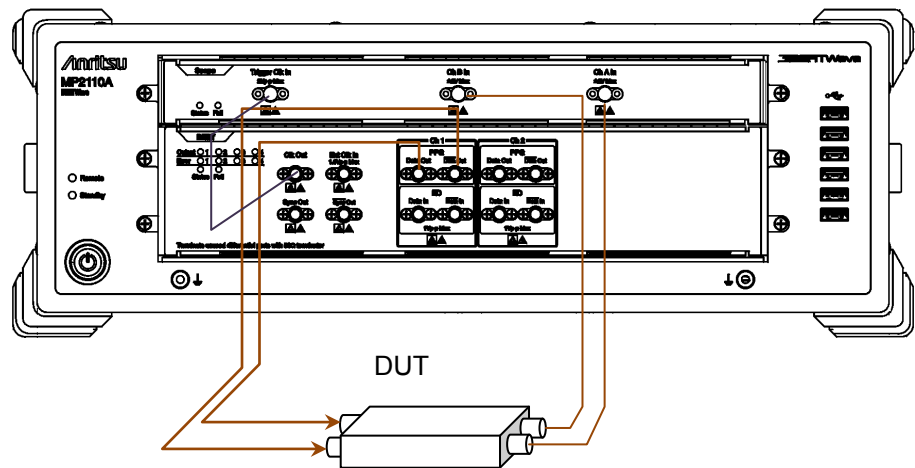
Figure 3.2-1   Electrical Signal Used for DUT Input/Output (MP2110A-012, 021)

4.   Click **PPG/ED Ch1** in the application window.

5.   Set Clk Out, Bit Rate, PPG Amplitude, and Test Pattern. Refer to Chapter 5, "How to Operate BERT", for details of the operation method.

6.   Click the PPG Data XData button and set the display to **ON**. Check the following items.
     •   The Output lamp 1 on the BERT panel is lit. (Refer to Figure 2.2.1-2.)

- SYNC Loss and Error are not lit in the Application window.
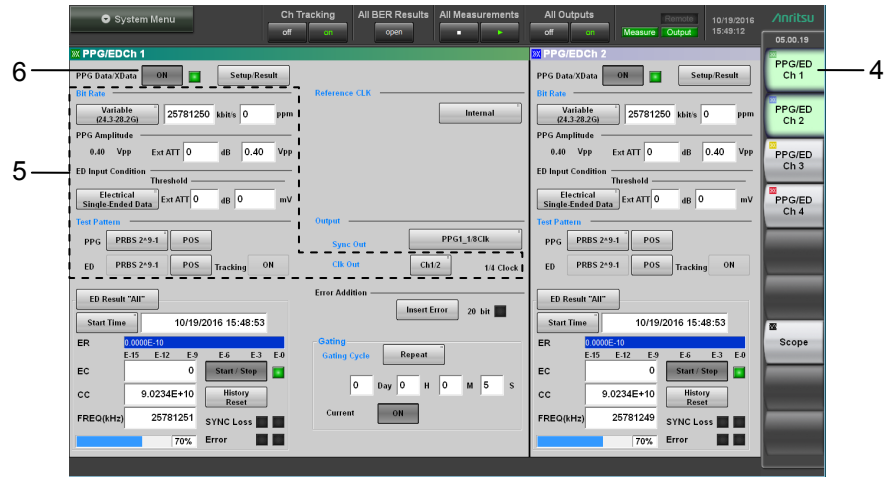
Figure 3.2-2   PPG Operation

7. Click **Scope**.

8. Click **Time**.

9. Click **Rate** and set Tracking. Refer to Chapter 6, "How to Operate Sampling Scope" for details of the operation method.

10. Click **CHA Off** and **CHB Off**. The display is changed to **CHA On** and **CHB On**.

11. When the waveform is displayed, click **Auto Scale**.
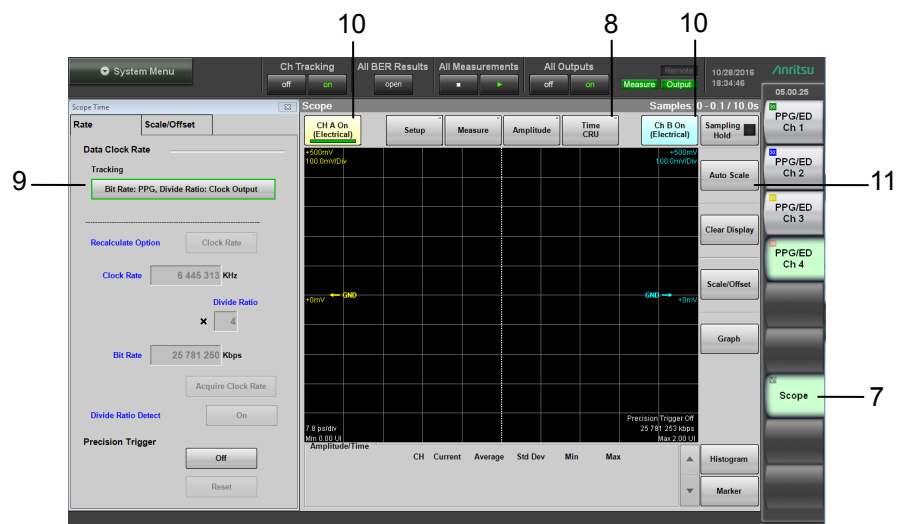
Figure 3.2-3   Scope Operation

When the DUT is an optical transceiver:

When the Option 022, 023, 025, 026, 032, 033, 035, or 036 is selected, the output waveform of the optical transceiver can be measured using the O/E converter.

Input the output of the PPG in the MP2110A to the DUT, and then connect the DUT optical output to the SMF or MMF.

1. Connect the DUT input terminal to PPG1 $\overline{\text{Data}}$ Out/Data Out using a coaxial cable.
    If only one DUT input connect is conveniently available, connect to the PPG1 Data Out. Also, connect the coaxial terminator included as a standard accessory to the $\overline{\text{Data}}$ Out.

2. Connect the DUT optical output connector to Ch B In using an optical fiber. When the DUT wavelength is 850 nm, connect it to MMF. When the DUT wavelength is 1310 nm or 1550 nm, connect it to SMF.

3. Connect the Clk Out (or Sync Out) to Trigger Clk Input using a coaxial cable.
    When the Sync Out is connected, connect the accessory coaxial terminator to $\overline{\text{Sync}}$ Out.

⚠ CAUTION

Check that the DUT optical output level does not exceed the rated optical input level for Ch B In.

There is a risk of damaging the built-in O/E module if the optical power exceeding the rated optical input level is applied to the Ch B In connector.
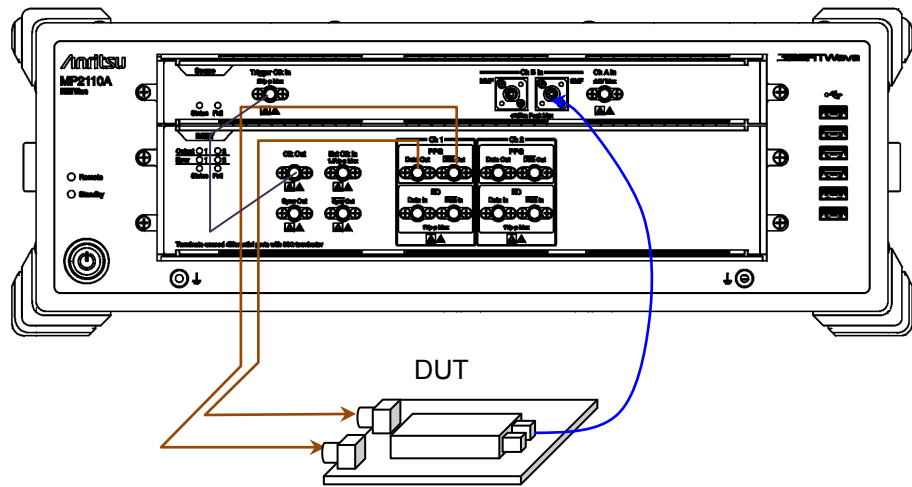
Figure 3.2-4   Optical Transceiver Used as DUT (Option 012, 023)

4.   Click **PPG/ED Ch1** in the application window.

5.   Set Clk Out, Bit Rate, PPG Amplitude, and Test Pattern. Refer to Chapter 5, "How to Operate BERT", for details of the operation method.

6.   Click the PPG Data XData button and set the display to **ON**. Check the following items.
   - The Output lamp 1 on the BERT panel is lit. (Refer to Figure 2.2.1-2.)
   - SYNC Loss and Error are not lit in the Application window.
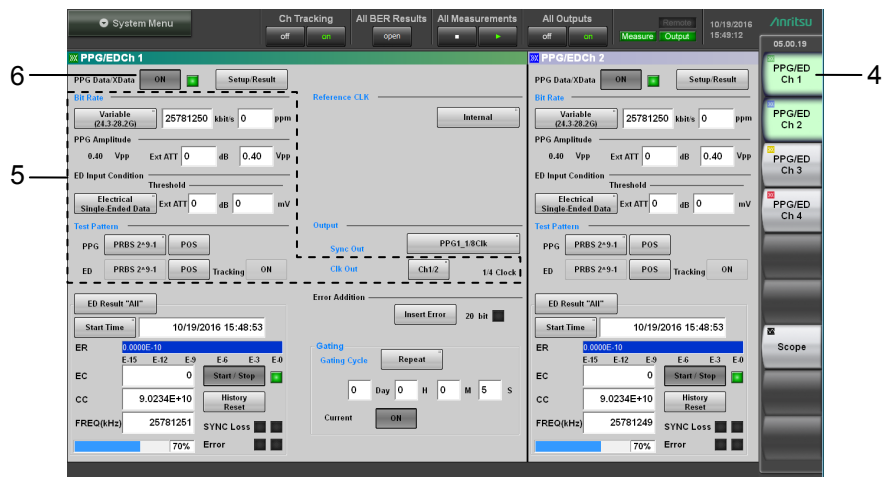
Figure 3.2-5   PPG Operation

7.   Click **Scope**. Refer to Chapter 6, "How to Operate Sampling Scope", for details of the operation method.

8.   Click **Time**.

9.   Click **Rate** and set Tracking.

10. Click **Amplitude**.

11. Click **O/E** and set Input Connector (Wavelength).

12. Click **CHB Off**. The display is changed to **CHB On**.

13. When the waveform is displayed, click **Auto Scale**.
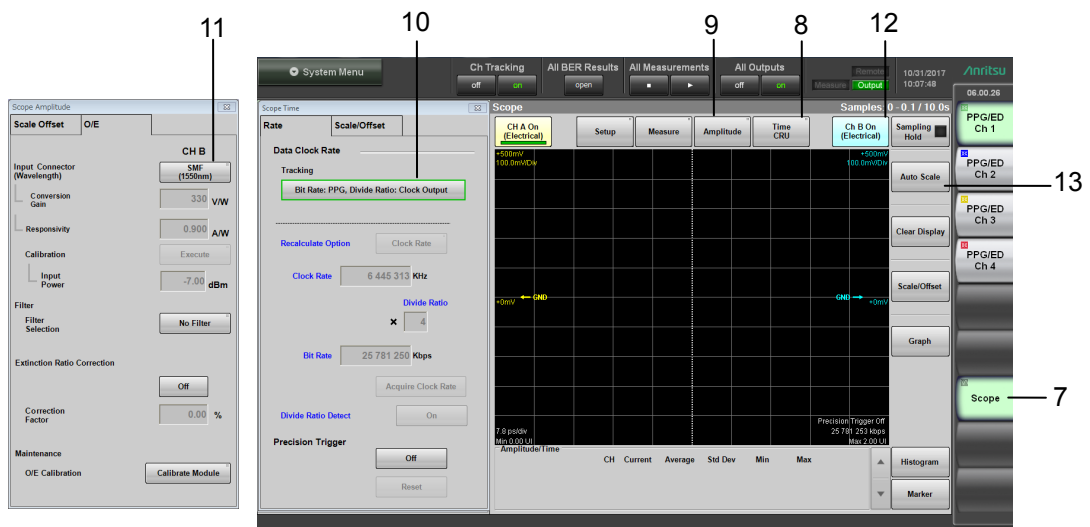
Figure 3.2-6   Scope Operation

3.3 Measuring Multichannel Optical Module Bit Error Rate

This section explains the CFP4 module measurement method as an example of multichannel optical module.

The CFP4 module contains four pairs of transmitters and receivers. With the MP2110A-014, the CFP4 Module bit error rate can be measured for four channels simultaneously.

If using a separate CFP4 for transmission in addition to the DUT CFP4, connect as follows. Use coaxial cables of the same length as for between Data Out and $\overline{\text{Data}}$ Out to connect the BERTWave and CFP4. Bit error rate cannot be measured correctly if different length coaxial cables are used.

1. Connect the PPG1-PPG4 Data Out and Input connector on the transmission CFP4 using a coaxial cable.

2. Connect the PPG1-PPG4 $\overline{\text{Data}}$ Out and Input connector on the transmission CFP4 using a coaxial cable.

3. Connect Reference Clock and Sync Out of CFP4 using a coaxial cable to use the optional Reference Clock.

4. Connect the DUT CFP4 output connector and ED1-ED4 Data In using a coaxial cable.

5. Connect the DUT CFP4 output connector and ED1-ED4 $\overline{\text{Data}}$ In using a coaxial cable.

6. Connect the optical output connector of the transmission CFP4 to the input connector of the optical attenuator using an optical fiber.

7. Connect the output connector of the optical attenuator to the optical coupler.

8. Connect one end of the optical coupler to the input connector of the DUT CFP4.

9. Connect the other end of the optical coupler to the optical power meter.

An optical switch can be used in place of the optical coupler.

3

Measurement Examples
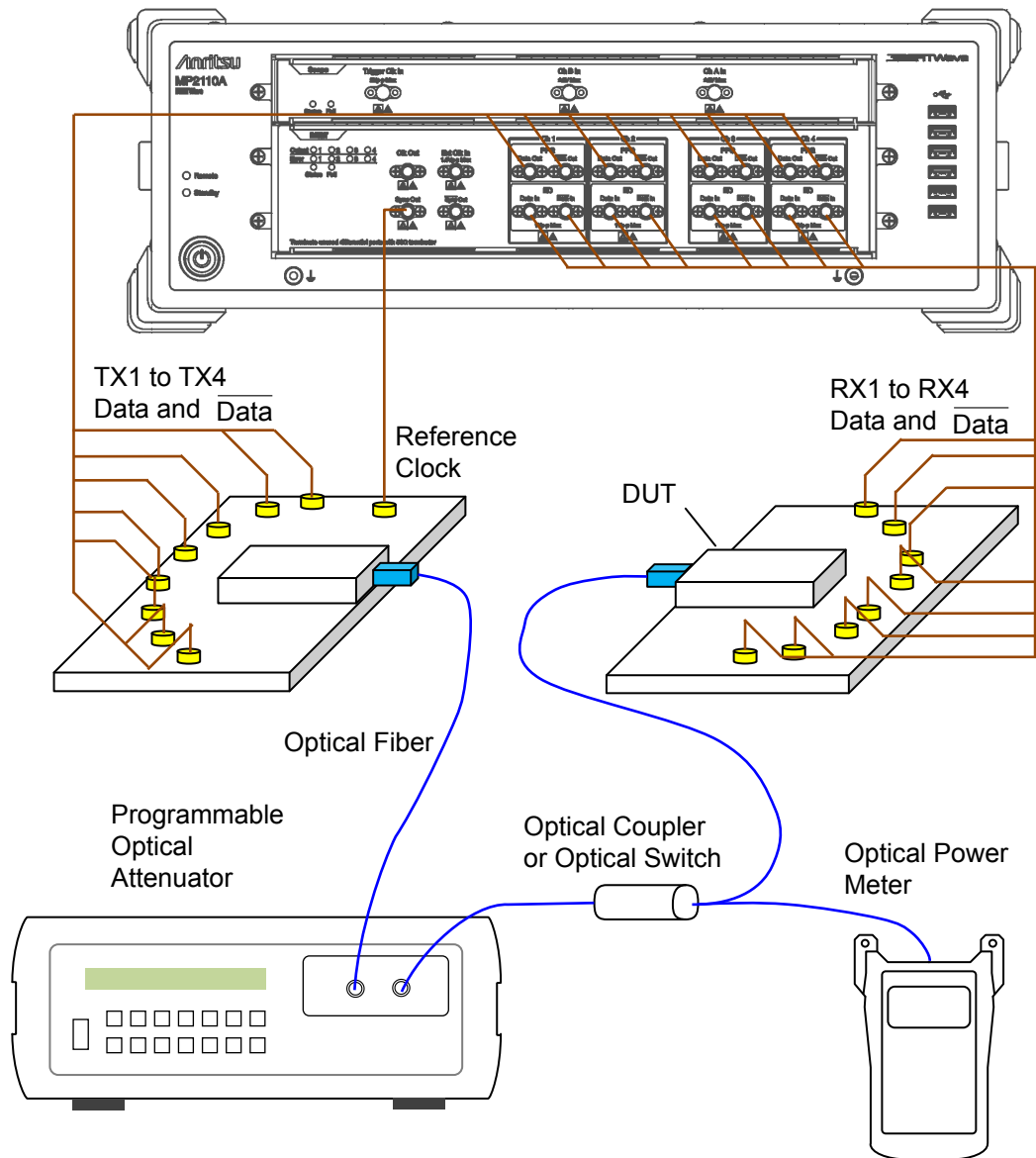
**Figure 3.3-1   Simultaneously Measuring Bit Error Rate for 4 Channels
(MP2110A-014)**

⚠ CAUTION

**Check that the optical output level input to the CFP4 under
the test does not exceed the rated optical input level.**

**There is a risk of damaging the CFP4 module if the optical
power exceeding the rated optical input level is applied.**

10. Click **PPG/ED Ch1** in the application window.

11. Set Bit Rate, PPG Amplitude, ED Input Condition, and Test Pattern. Refer to Chapter 5, "How to Operate BERT", for details of the operation method.

12. Set Gating.

13. Change the color of the characters on the button to green by clicking **on** at Ch Tracking.
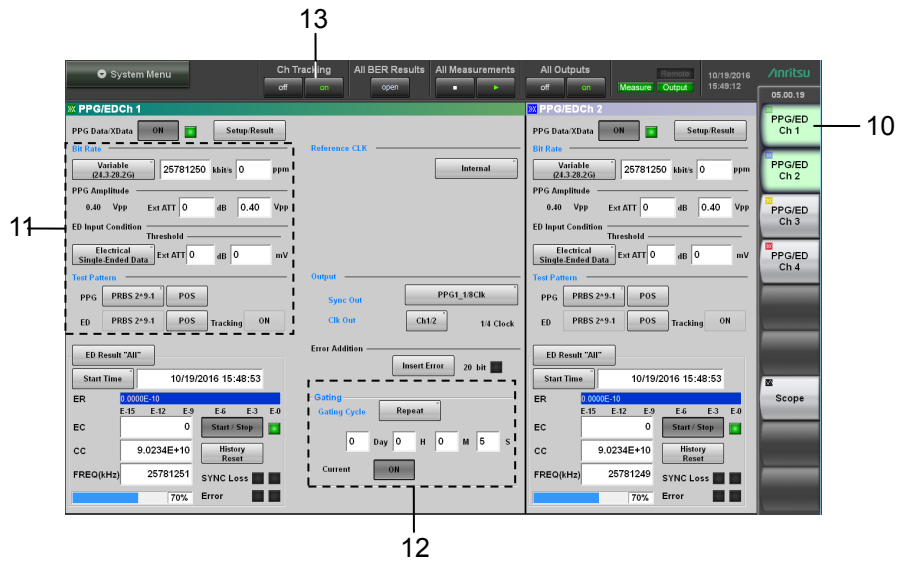
Figure 3.3-2   PPG/ED Settings

14. Click **open** at All BER Results.

15. Change the color of the characters on the button to green by clicking **on** at All Output. Check the following items.
    - The Output lamp 1 on the BERT panel is lit. (Refer to Figure 2.2.1-2.)
   - SYNC Loss and Error are not lit in the Application window.

16. Change the color of the characters on the button to green by clicking ▶ at All Measurement. When the time set at Gating elapses, the measurement values are displayed at ER, EC, CC, and FREQ (kHz).
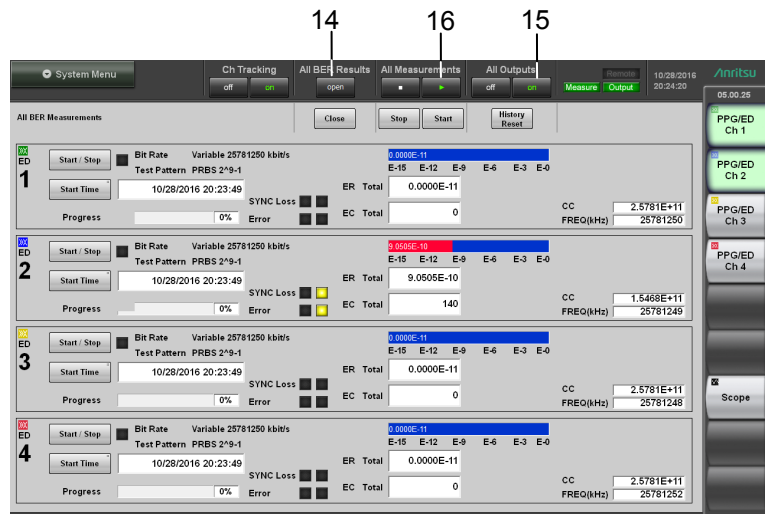
Figure 3.3-3   Bit Error Rate Measurement Operation

This chapter explains the window name and common operating method of the MP2110A.

4

Screen Operation

4.1 Window Configuration

The element names in the Application window are shown in Figure 4.1-1.
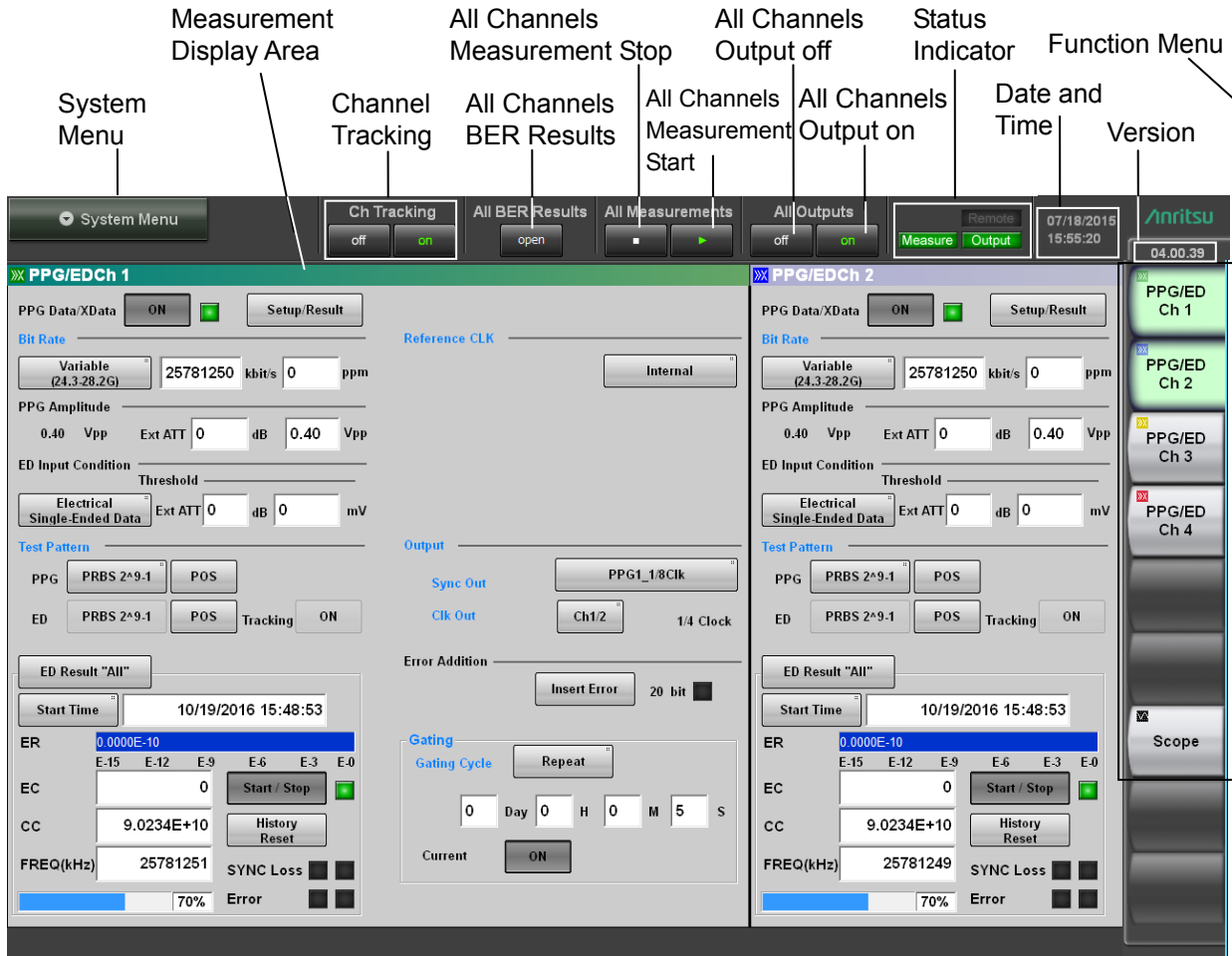
Figure 4.1-1 Names of Application Window Elements

Table 4.1-1   Application Screen Elements

Name	Description
All BER Results	Displays the BER measurement results for multiple channels.
All Measurements	Starts and stops up to four channels of error rate measurement (Options 011, 012, 014) and two channels of waveform data (Options 021, 023) sampling at the same time.
All Outputs	Sets all PPG (Options 011, 012, 014) channels output to On/Off at the same time.
Ch Tracking	Sets the bit rate, test pattern, PPG/ED tracking function, and gating for all channels to match the setting for channel 1.
System Menu	The following setting button can be displayed: • Saving measurement conditions and measurement results • Reading measurement conditions • Saving window image • Initializing device settings • Remote control settings • The application window display position (Dock/Undock) • Setting panel lock • Enabling panel lock and remote display • Minimizing screen display • Terminating application
Function menu	Selects the measurement device to be operated. The displayed measurement device varies depending on the options.
Status display	The following four kinds of the status are displayed: Remote: Remotely controlled Measure: Measuring bit error rate and obtaining waveform data of sampling oscilloscope Output: Signal output from one of the PPG channels
Measurement display area	Displays the measurement screen selected at the function menu.
Date and Time	Displays date and time set in the MP2110A.
Version display	Displays software version. Displayed in red if the version has not been updated.

4

Screen Operation

The buttons available on the function menu will vary depending on the installed options and software. The following table shows the relation between available buttons and installed options and software.

Table 4.1-2   Buttons Displayed on Function Menu

Function menu Button	Option			
	011	012	014	021, 022, 023, 025, 026, 032, 033, 035, 036
PPG/ED Ch1	✓	✓	✓	–
PPG/ED Ch2	–	✓	✓	–
PPG/ED Ch3	–	–	✓	–
PPG/ED Ch4	–	–	✓	–
Scope	–	–	–	✓

Clicking a Function Menu button displays the child window for displaying the measurement conditions and results.
Refer to the following chapters for the child window operations.

    PPG/ED: Chapter 5
    Scope: Chapter 6

4.2 Data Input Method

The measurement setting item selection, numeric data, and character data are input from the panel displayed on the screen.
The displayed panel varies depending on the input data types.

Arrow Key Entry Panel

Click the numeric data area when entering the numeric data of the bit rate or power voltage.
The arrow key entry panel as shown in Figure 4.2-1 is displayed.
Click the right and left arrow keys and select the line to change the value.
Click the up and down arrow keys or turn the rotary knob to change the value.
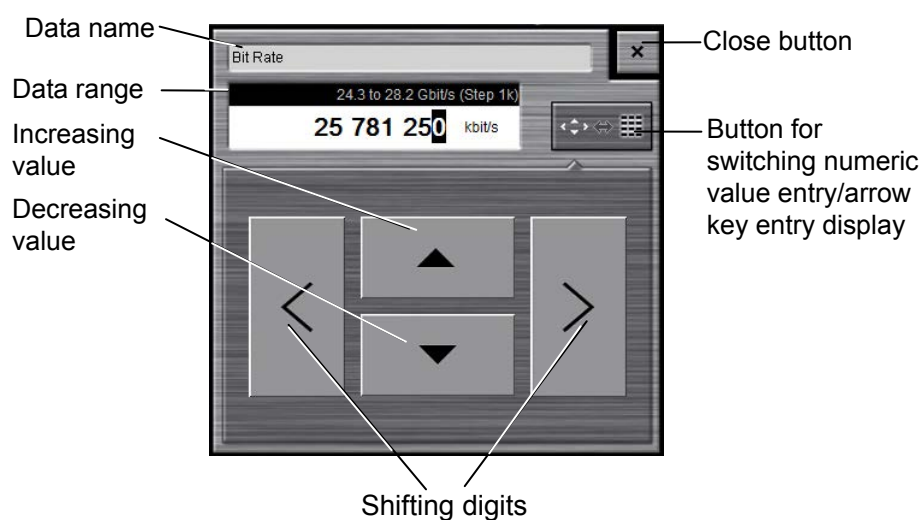
Figure 4.2-1   Arrow Key Entry Panel

Table 4.2-1 lists the key and mouse operations corresponding to the buttons on the arrow key entry panel.

Table 4.2-1   Correspondence between Mouse Operation and Keyboard

Panel Button	Keyboard	Mouse
▲	↑	Turn the mouse wheel up.
▼	↓	Turn the mouse wheel down.
〈	←	
〉	→	

Numeric value entry panel

Click the button for switching the display of the numeric value entry/ arrow key entry panel as shown in Figure 4.2-1, and then the numeric value entry panel as shown in Figure 4.2-2 is displayed. The key type, unit and input range displayed on the panel vary depending on the data.

Click the arrow key entry panel display button, and then the arrow key entry panel as shown in Figure 4.2-1 is displayed.
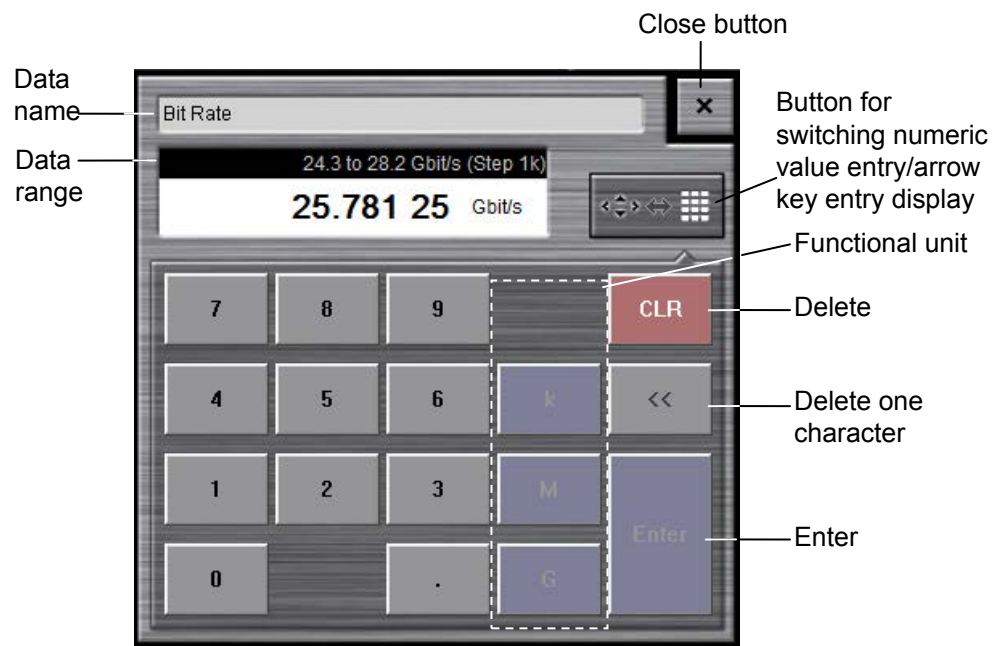
Figure 4.2-2   Numeric Value Entry Panel

Table 4.2-2 lists the keys on the keyboard corresponding to buttons on the numeric value entry panel.

Table 4.2-2   Correspondence between Panel Keys and Keyboard

Panel Key	Keyboard	Panel Key	Keyboard
0	0	.	.
1	1	+/–	–
2	2	CLR	ESC
3	3	<<	BS
4	4	Enter	Enter
5	5		
6	6		
7	7		
8	8		
9	9		

Software Keyboard

When entering character string data such as file name, click the **Screen Keyboard**. The keyboard as shown in Figure 4.2-3 is displayed, and then click the key and enter the character. If you click **Shift** or **Caps** once, all keys are locked. To unlock them, click **Shift** or **Caps** again.

Deleting one character

Shifting cursor   Cancel
Determined
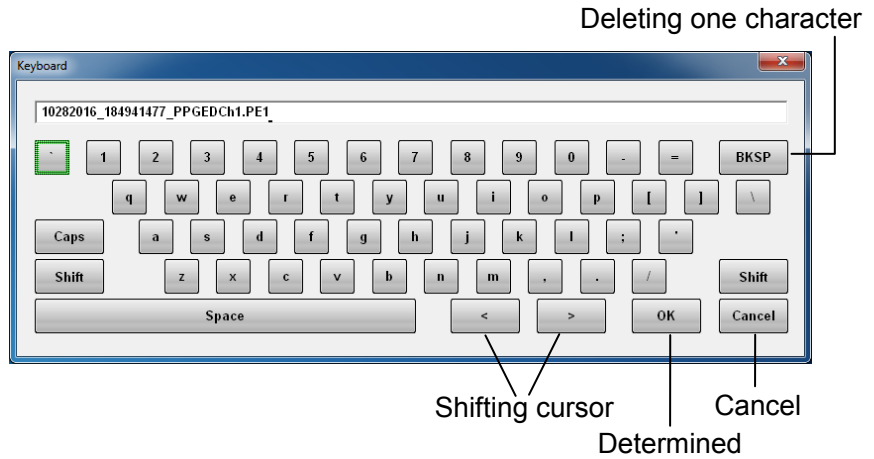
Figure 4.2-3   Software Keyboard
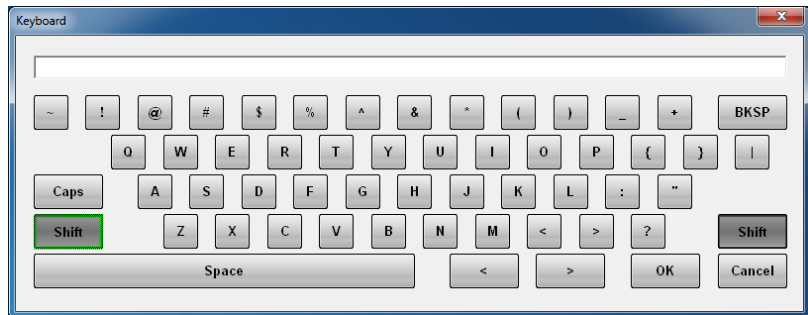
Figure 4.2-4   Software Keyboard (Shift Locked)
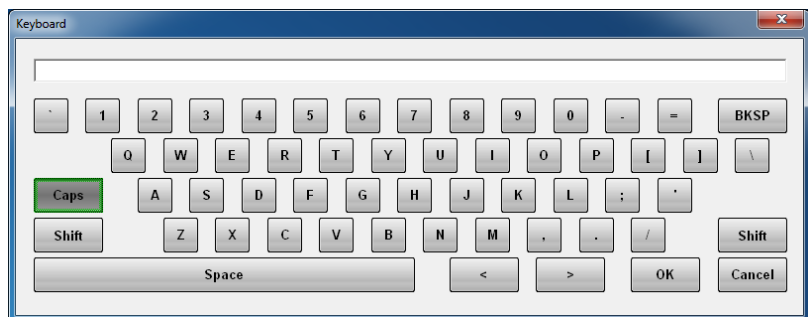
Figure 4.2-5   Software Keyboard (Caps Key Locked)

4

Screen Operation

4.3 Setting System Menu

The following items can be set and confirmed at the system menu.

- Saving measurement conditions and measurement results
- Loading measurement conditions
- Saving window image
- Setting window display mode
- Initializing device settings
- Setting panel lock
- Enabling panel lock and remote display
- Minimizing screen display
- Setting the application window display position
- Setting remote control
- Displaying system information
- Terminating application

To set the system menu, click **System Menu** as shown in Figure 4.1-1.
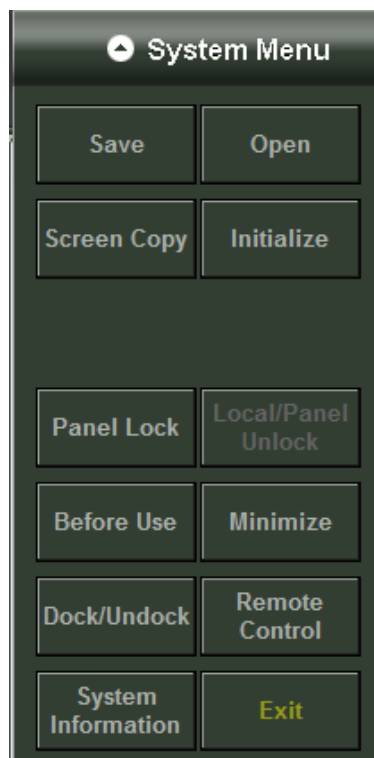
Figure 4.3-1   System Menu

4.3.1 Save

Saving measurement conditions and measurement results

1.   Click **Save** to display the Save panel.

2.   Select the save data from the following:
     All Setup, **PPG/ED Ch1**, **PPG/ED Ch2**, **PPG/ED Ch3**, **PPG/ED Ch4**,
     Scope
     The displayed module varies with the options.

3.   When **PPG/ED Ch1**, **PPG/ED Ch2**, **PPG/ED Ch3**, **PPG/ED Ch4**, or
     Scope is saved, select the data type from the following:
     Setting: Measurement condition
     Result: Measurement result

4.   The file name is displayed. When changing the displayed file name,
     click the keyboard display button.

Close button

Software keyboard display button
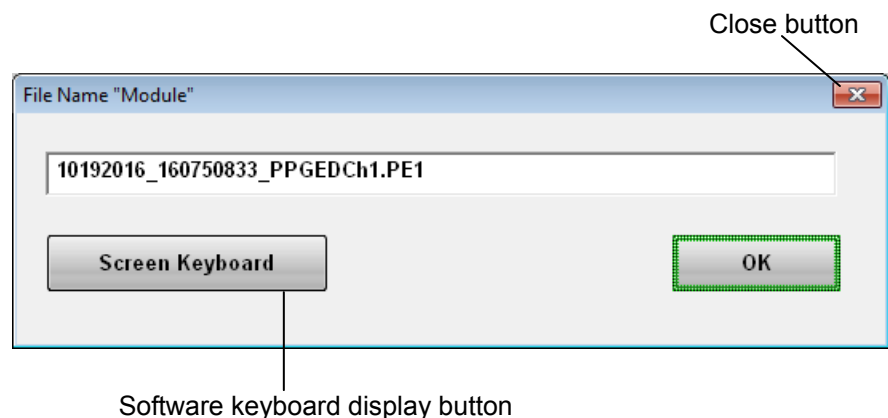
5.   Enter the file name using the software keyboard.

6.   When saving the file name, click **OK**. Also, when canceling the
     saving procedure, click the close button.

The measurement condition file is saved in the following folder.
C:\Users\Public\Documents\Anritsu\MX210000A\UserData\Setting

The measurement result file is saved in the following folder.
C:\Users\Public\Documents\Anritsu\MX210000A\UserData\Result\CSV
C:\Users\Public\Documents\Anritsu\MX210000A\UserData\Result\TXT

The CSV file cannot be read in the spreadsheet software.
You can confirm the test file details on the test editor.

4

Screen Operation

4.3.2 Open

Reading measurement conditions from file

1. Click **Open** to display the Open panel.

2. Select the target module form the following:
    All, **PPG/ED Ch1**, **PPG/ED Ch2**, **PPG/ED Ch3**, **PPG/ED Ch4**, **Scope**
    The displayed module varies with the model name and options.

3. The file selection screen is displayed.
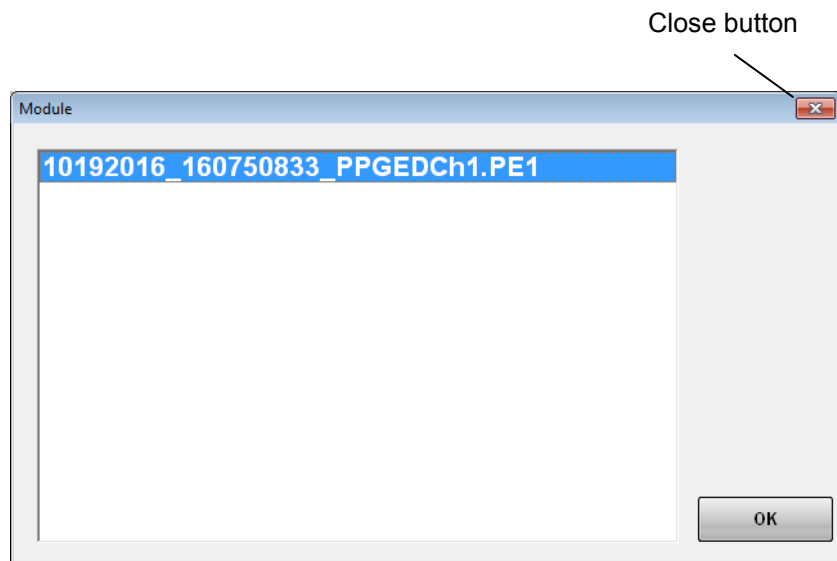
Close button

4. Click the file to be read.

5. When reading the file, click **OK**. On the other hand, when canceling
    the procedure, click the close button.

4.3.3 Screen Copy

Saving a screen to the image file

1. Click **Screen Copy** .

    The file selection screen is displayed.
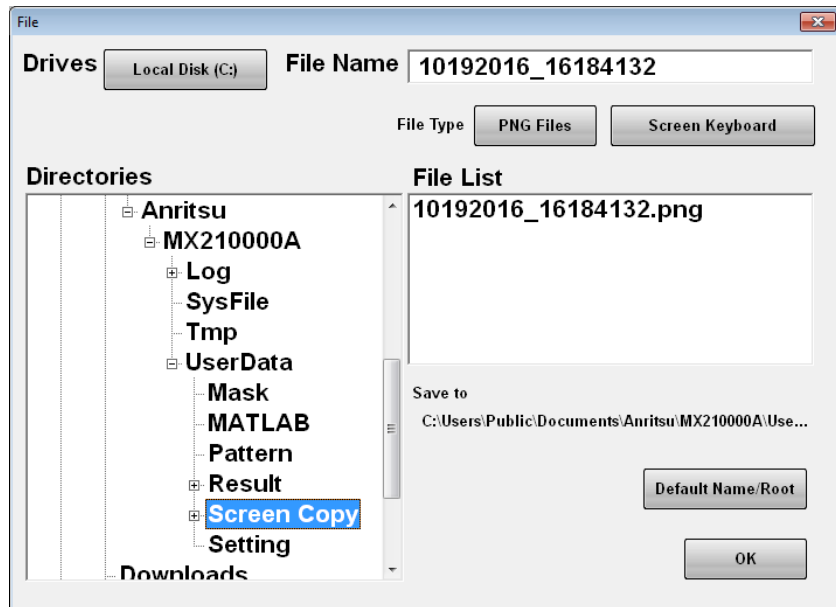
2. Click the Drives button and the Directories display to set the saving destination folder. The file name is displayed in the Save to.

3. The file format to be saved is displayed in the right button of the file type. Clicking the button can set the file format.

4. When inputting the file name, click **Screen Keyboard** to set the file name.

5. When overwriting the existence file, click the file name displayed in the File List.

6. Click **OK** to save the screen file.

    When overwriting the screen file, the confirmation message is displayed.

When clicking **Default Name/Root**, the folder and file names are set to the initial values.
The initial value of the folder is as follows.
C:\Users\Public\Documents\Anritsu\MX210000A\UserData\Screen Copy
The initial value of the file name is configured as date and time.
For example, file 523 saved at 12:05:55 on 17 January 2017 will have the following file names:
For **JPEG Files**:   01172017_120555523.jpg
For **PNG Files**:   01172017_120555523.png

4

Screen Operation

4.3.4 Initialize

Initializing measurement conditions

1. Click **Initialize**. Then, the dialog box indicating the initialization process is displayed.

2. Click **OK** to initialize the measurement condition and click **Cancel** to stop the initialization.

4.3.5 Panel Lock

Panel locking

Preventing screen operations at menus other than the System Menu is called panel locking.

1. Click **Panel Lock** to lock the panel.

2. The screens other than the system menu, status display, and date/time display are shaded and displayed.

Even though the panel is locked, the system menu and power switch are enabled.

If the panel is locked, the **Local/Panel Unlock** button at the system menu can be operated.

When the BERTWave performs the measurement via a remote control, the panel is locked.

4.3.6 Local/Panel Unlock

Unlocking the panel

1. Click **Local/Panel Unlock**.

2. The Remote lamp at the status display goes off.

4.3.7 Before Use

Playing back the video of countermeasure against static electricity

Click **Before Use**.

Other window is displayed and the video of countermeasure against static electricity is played back in the window.

The playback time is about 1 minute 40 seconds.
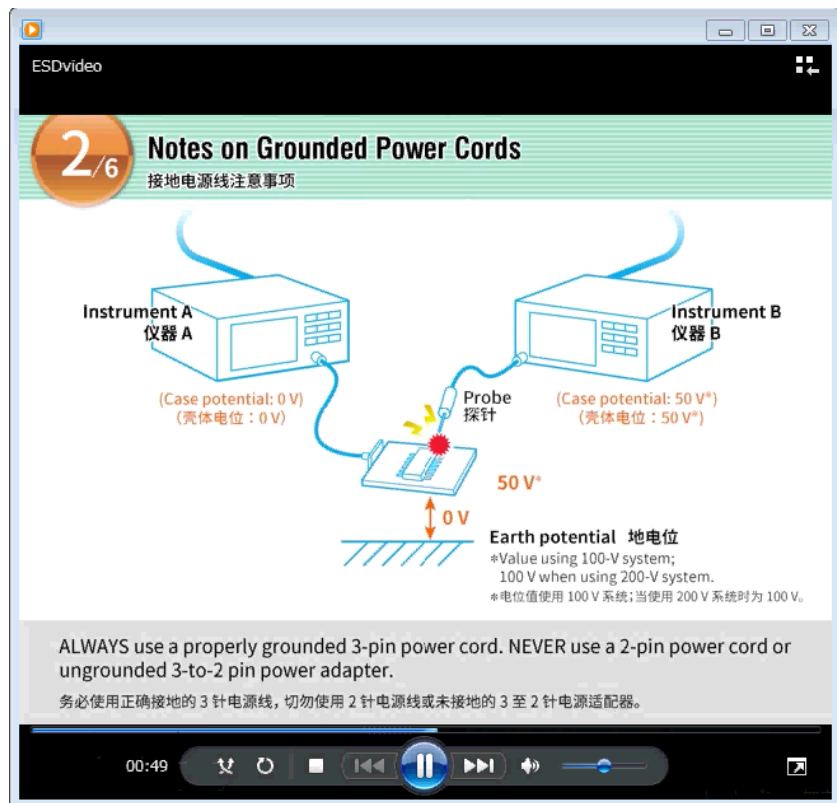
Figure 4.3.7-1   Display Window for Video of Countermeasure Against Static Electricity

4.3.8 Minimize

Minimizing the screen display

1. Click **Minimize** to display the desk top.
    MX210000A is displayed on the task bar.

2. To display the screen, click **MX210000A** on the task bar.

4.3.9 Dock/Undock

Changing the window display method

Click **Dock/Undock** .

At Dock, the window is fixed at the upper left of the screen, and the window cannot be moved. This setting allows the application window to display in full screen when the monitor resolution is 1280×800. Refer to 2.9.3 "Setting External Monitor".

At Undock, the window can be moved.

4.3.10　Remote Control

Clicking **Remote Control** displays the following dialog box.

Figure 4.3.10-1　Remote Control Dialog Box

To set GPIB

1.　Click the GPIB Address text box. A dialog box for inputting the address is displayed.

2.　Enter the GPIB address from 0 to 30.

3.　Clicking the **OK** completes the settings.
　　Clicking the **Cancel** deletes the settings made at steps 2.

To set Ethernet

1.　Click the Port Number text box of Raw Socket. A dialog box for inputting the port number is displayed.

2.　Set the number in the following range:
　　Port Number:　　1024 to 5001

3. Click **Change Network Connection** to change the IP address, subnet mask, and gateway address of MP2110A. The Network Connection dialog box of Windows is displayed.
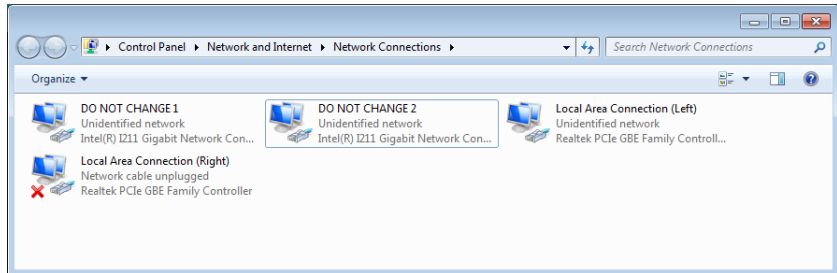
4. Right-click the icon of Local Area Connection (Left) or Local Area Connection (Right), and click Properties.

5. Click Internal Protocol Version 4 (TCP/Ipv4), and click **Properties**.

6. Set the items in the Internal Protocol Version 4 (TCP/IPv4) Properties dialog box.
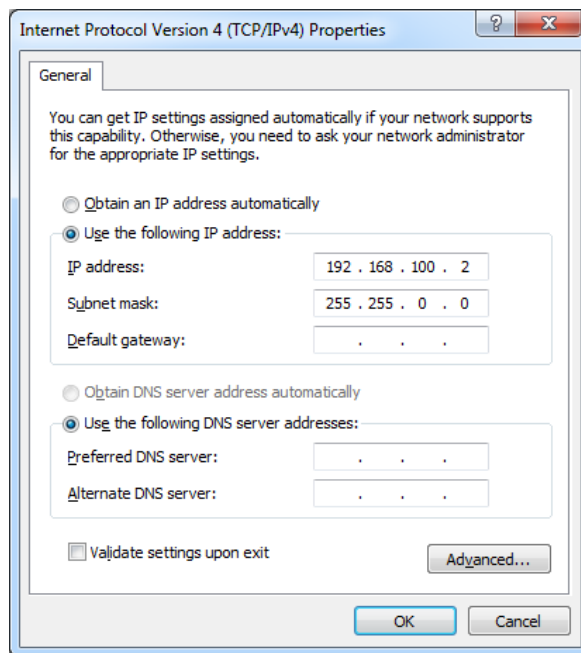
Click **Obtain an IP address automatically** to automatically obtain an IP address of Local Area Connection using DHCP.

7. Click **OK** to complete the settings.
   Click **Cancel** to cancel the settings.

Note:

Do not change the setting of Intel(R) Gigabit Network Controller in the Network Connection dialog box explained at step 3. Otherwise, the application is not started correctly. When this setting is changed, select [Obtain an IP address automatically] at step 6.

4.3.11   System Information

Displaying the system information

Click **System Information**. System Information dialog box appears.

Software Version
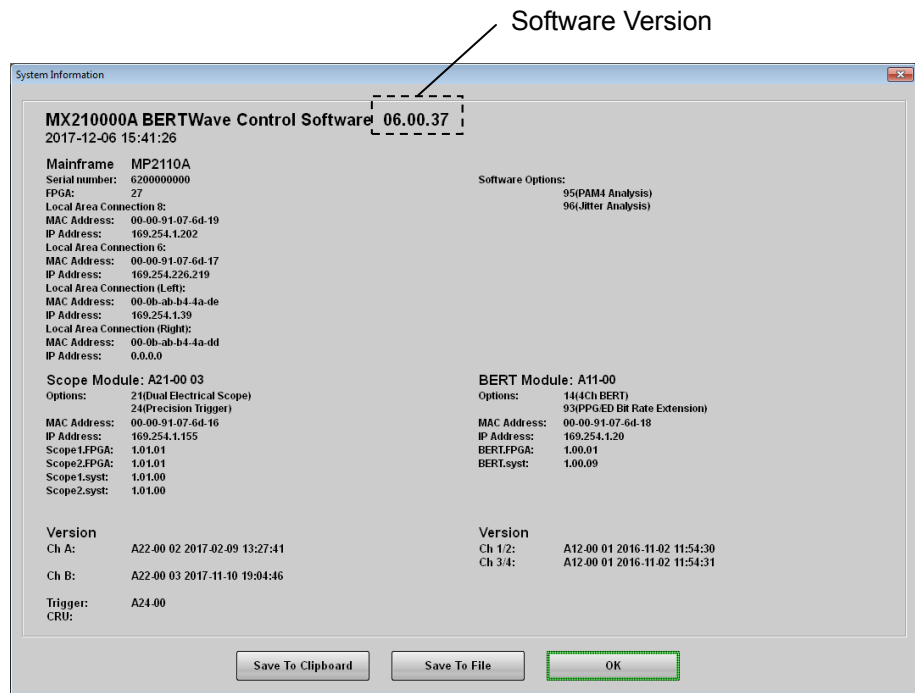
Figure 4.3.11-1   System Information Dialog Box

Click **Save To Clipboard** to copy the system information to the clipboard of Windows.

Click **Save To File** to display the Save dialog box. Enter the file name and click **OK** to save the system information in the file.
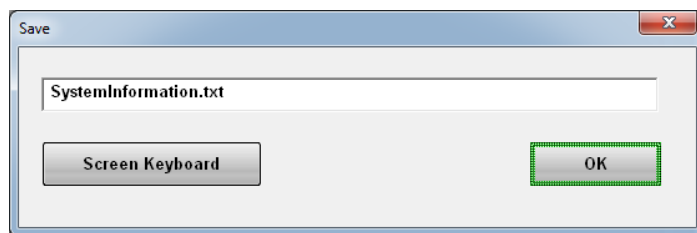
Click **Exit** to close the System Information dialog box.

4.3.12 Exit

Terminating applications

1.   Click **Exit**. The dialog box is displayed to confirm the application termination.

2.   When terminating the applications, click **Yes**. On the other hand, when canceling the application termination, click **No**.

Click **All Programs** → **Anritsu** → **MX210000A** from the start menu of Windows to restart the application.

4.4 Multi-channel Signal Output

The MP2110A can set PPG channels 1 to 4 to On/Off at the same time.

To output signal of PPG:

1.   Click **on** as shown in Figure 4.4-1.

2.   The characters of **on** are changed to green and then the Output lamp for the status display is turned on.
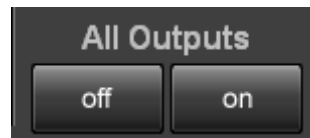
Figure 4.4-1   All Outputs Button

The signals of all the PPG channels are output.

To stop the signal output from the PPG:

1.   Click **off** as shown in Figure 4.4-1.

2.   The characters of **on** are changed to white and then the Output lamp for the status display is turned off.

The data signal output is stopped for all the PPG channels 1 to 4.

Note:

All Output button is set to **off** after starting the Main Application at the Selector screen.

4

Screen Operation

4.5 Simultaneous Measurement Start and Stop at Multi-channels

MP2110A can measure error rates for up to four channels and sample waveform data for up to two channels simultaneously.

To start simultaneous measurement, click the ▶ key shown in Figure 4.5-1 while the Measure lamp is lit.

To stop simultaneous measurement, click the ■ key shown in Figure 4.5-1 while the Measure lamp is lit off.
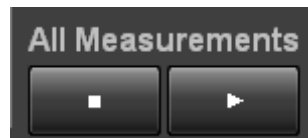
Figure 4.5-1   All Measurements Button

4.6 Linking Measurement Settings for Multiple Channels

Ch Tracking is displayed for the MP2110A-014.

Clicking **on** sets the PPG and ED settings for Ch1 to the PPG and ED settings for other channels. In this state, altering settings for Ch1 also alters the settings for other channels.
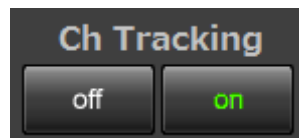
Figure 4.6-1   Ch Tracking

The following settings are linked:

    Programmable Pattern
    Data Length
    ED Tracking*
    ED Gating Cycle (Repeat/Single/Untimed)
    ED Gating Period

*:   Setting Ch Tracking to On sets ED Tracking to On. However, setting Ch Tracking to Off does not set ED Tracking to Off.

4

Screen Operation

4.7 Displaying BER Measurement Results for Multiple Channels

All BER Results is displayed for the MP2110A-014.

Clicking **Open** displays the BER measurement results for all channels.
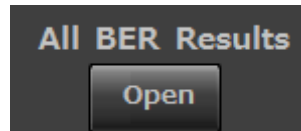
Figure 4.7-1   All BER Results

Figure 4.7-2   All BER Results Display

Table 4.7-1   All BER Results Screen Settings

Name	Description
Start	Starts BER measurement for all channels. The sampling oscilloscope measurement is not started.
Stop	Stops BER measurement for all channels. The sampling oscilloscope measurement is not stopped.
History Reset	Resets the History lamp for all channels.
Close	Exits the All BER Results display.

Clicking the function button of the top menu closes the All BER Results display.

4.8 Displaying Date/Time and Status

To display date and time

Date and time is displayed on the upper right side of the screen.

Date and time can be changed from the Windows control panel.

To display status

The following three kinds of indicators indicate the status.

Table 4.8-1   Indicator Status

Indicator	Status
Remote	Remote Control
Measure	Measuring bit error rate or acquiring waveform data of sampling oscilloscope
Output	A signal is output from one of the PPG channels or from the optical transceiver.
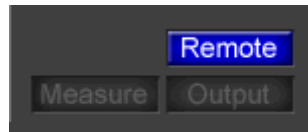
Figure 4.8-1   Remote Control
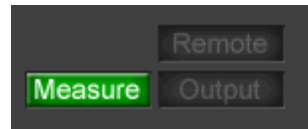
Figure 4.8-2   Displays at Bit Error Rate Measurement and Waveform Data Capture
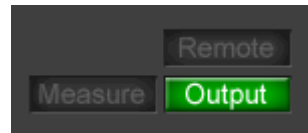
Figure 4.8-3   Display when PPG Signal is Output

Chapter 5 How to Operate BERT

This chapter explains the BERT module setting items and how to measure the bit error.

5

How to Operate BERT

5.1 Procedure for Generating Pulse Signal

The basic procedure is as shown in the following figure.
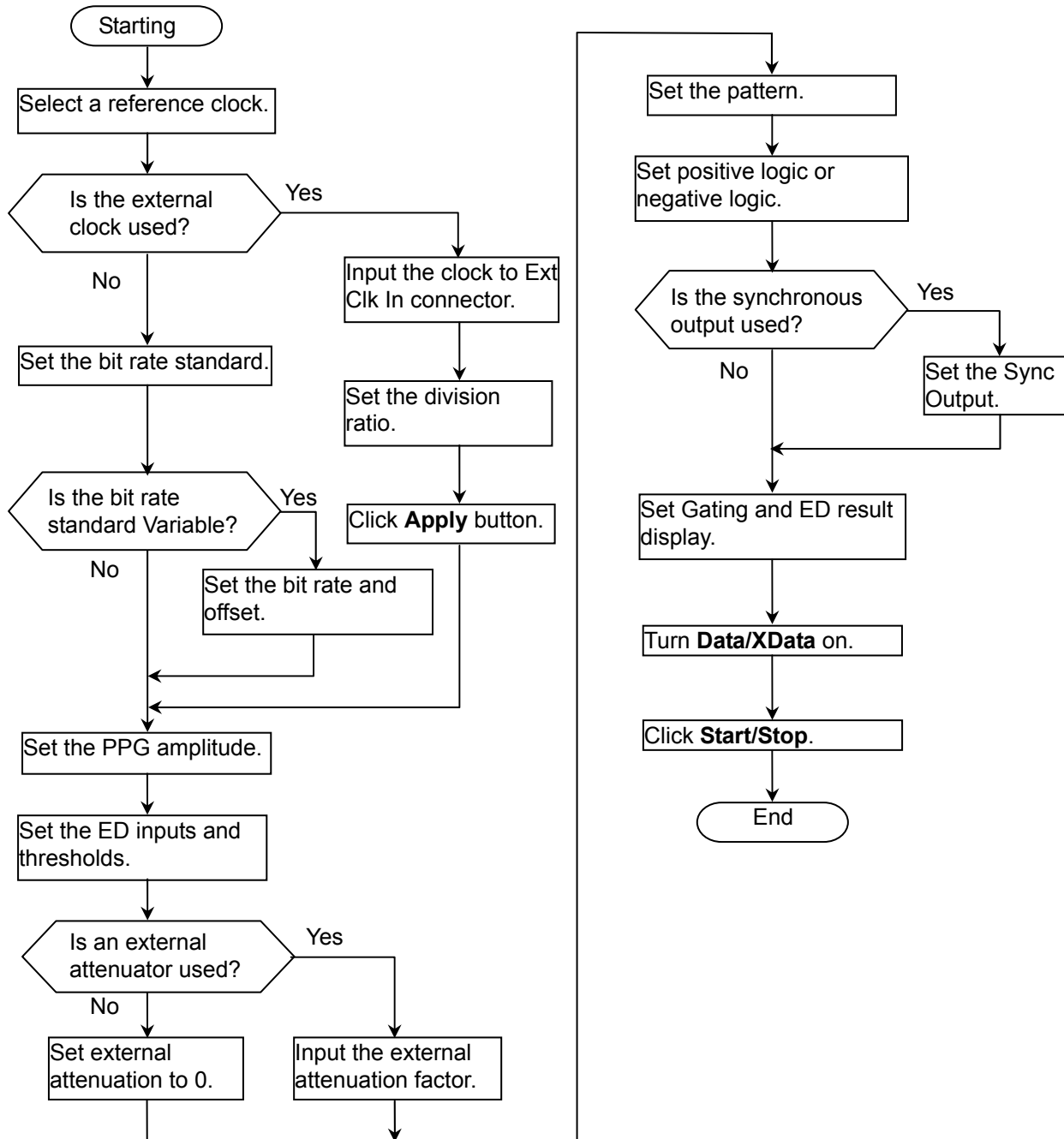
Figure 5.1-1   Basic Procedure of Generating Pulse Signal

5.2 PPG/ED Panel

Clicking **PPG/ED Ch1** of the function key displays the following panel. The items that are set as common in the channels other than Ch 1 are displayed by the light blue characters.
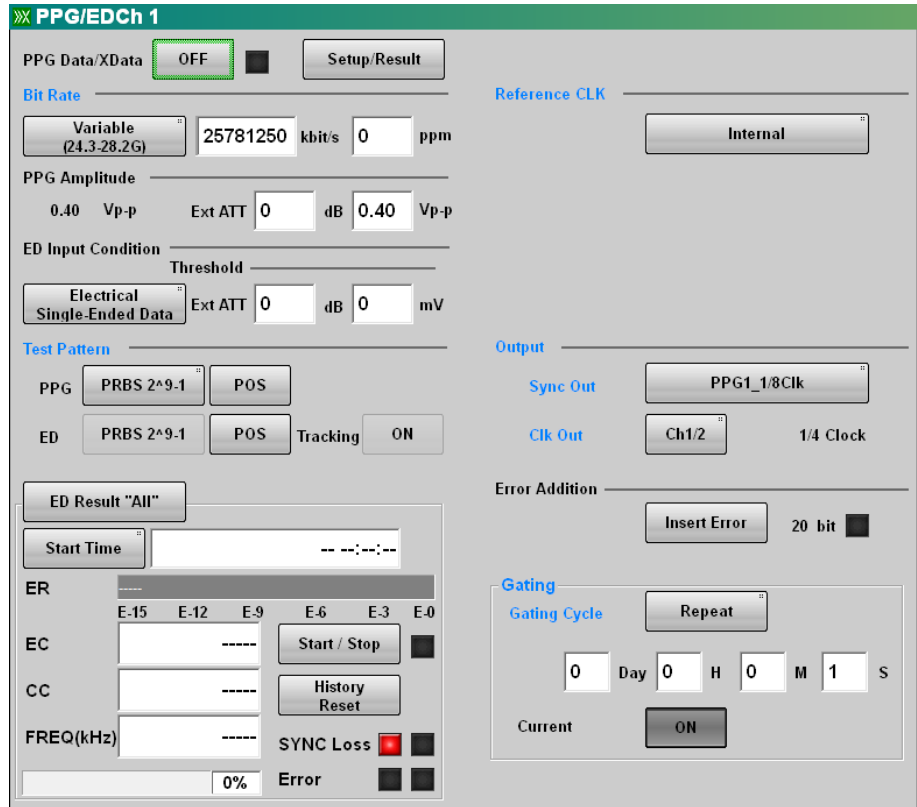
Figure 5.2-1   PPG/ED Settings Panel

Figure 5.2-2 shows the bit rate display when setting Ext Clk In at Reference Clock.
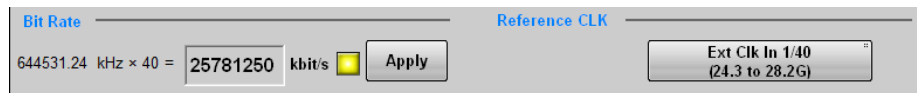
Figure 5.2-2   Bit Rate Display When Setting Ext Clk In

How to Operate BERT

5

When **Setup/Result** is clicked, the panel display is changed to the panel shown in Figure 5.2-3. And when **Setup/Result** is clicked again, the panel display is changed to the panel shown in Figure 5.2-1.
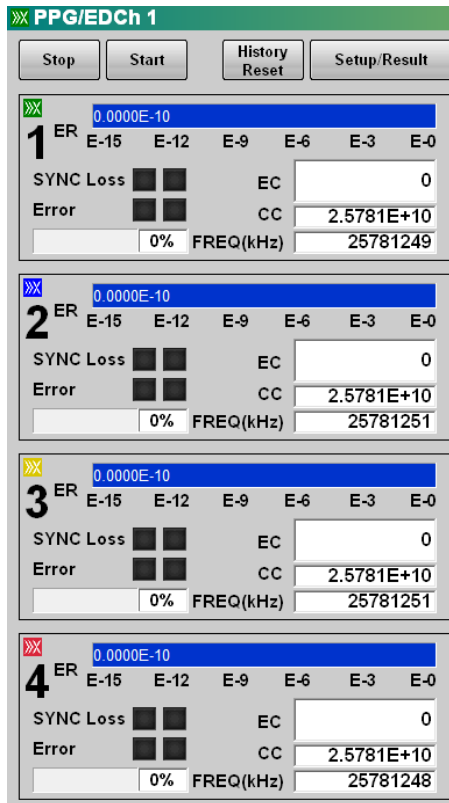
Figure 5.2-3 PPG/ED Results Panel (In case of MP2110A-014)

The following table describes the panel.

Table 5.2-1   Setting Items of PPG/ED

Item	Description
Setup/Result	Switches the PPG/ED panel display.
PPG Data/XData	Sets the PPG data signal output On/Off. XData means $\overline{\text{Data}}$ on the front panel. The right side of the button is lit in green while the data is outputting to the connector.
Bit Rate*1	When Reference CLK is **Internal**: 　Select the communication standards by clicking the button. 　Set the bit rate when Variable is selected. 　Set the offset in the range from –100 to 100 ppm for the set bit rate. When Reference CLK is **Ext Clk In**: 　Input the external clock and check that the indicator of the Reference CLK status display is changed to yellow, then click **Apply**. 　When the internal pattern generation circuit is synchronized with the external clock, the external clock frequency and bit rate are displayed.
Reference CLK Status Display	Displays the reference clock synchronization status. Red:　　　　Reference clock cannot be detected. Yellow:　　Reference clock was detected, but is not synchronized with pattern data. Green:　　Reference clock is synchronized with pattern data.
PPG Amplitude	Sets the amplitude voltage of the signal output to the **Data Out** connector and $\overline{\text{Data}}$ **Out** connector at the text box on the right. When the attenuators are connected to the **Data Out** connector and $\overline{\text{Data}}$ **Out** connector, set the attenuation at Ext ATT. The amplitude voltage of the signal output from the attenuator is displayed. ***Note:*** 　Connect the attenuators that are the same attenuation to the **Data Out** connector and $\overline{\text{Data}}$ **Out** connector.
ED Input Condition	Selects the input method of ED by clicking the button. Set the threshold voltage of the **Data In** connector and $\overline{\text{Data}}$ **In** connector at the text box on the right. When the attenuators are connected to the **Data In** connector and $\overline{\text{Data}}$ **In** connector, set the attenuation at Ext ATT. ***Note:*** 　Connect the attenuators that are the same attenuation to the **Data In** connector and $\overline{\text{Data}}$ **In** connector.

*1:　This is set to the following channels as common:
　　　In MP2110A-012: Ch 1 and Ch 2
　　　In MP2110A-014: Ch 1 to Ch 4

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Table 5.2-1   Setting Items of PPG/ED (Cont'd)

Item	Description

Test Pattern*2	Selects the test pattern by clicking the button.
	The polarity of test pattern can be changed by clicking POS or NEG.
	   The polarity when the test pattern is "1" is shown below:
	   POS: The voltage of Data connector is higher than the voltage of $\overline{Data}$ connector.
	   NEG: The voltage of $\overline{Data}$ connector is higher than the voltage of Data connector.
	Set **ON** at Tracking to set the same test pattern to PPG and ED.

ED Result	Sets the method for displaying the bit error measurement results.
Start/Stop	Stops/starts bit error rate measurement.
History Reset	Deletes the history displays of Sync Loss and Error.

Reference CLK*1	Selects the clock to be used from the following items:
	Internal:
	   Use the internal clock based on the internal 10 MHz oscillator
	Ext Clk In:
	   Use the external clock input from the Ext Clk In connector

Sync Out*1	Selects the clock source and division ratio for the signal output to the Sync Out and $\overline{Sync}$ Out connector
Clk Out*1	Selects the clock source for the signal output to the Clk Out connector.
Error Addition	When **Insert Error** is clicked, bit errors are inserted in the test pattern, and the indicator on the right is lit in red for one second.
Gating Cycle*2	Selects the bit error measurement method by clicking the button. Set the time of single bit error measurement.
Current	Setting **On** updates the results display while BER measurement is in progress.

*2: This is set as common in Ch 1 to Ch 4 when Ch Tracking is **on** in MP2110A-014.

5.2.1 Setting Reference Clock

BERT uses the reference clock to generate the data and detect an error.

The reference clock can be selected from the following supply sources:

- Internal clock generated inside the MP2110A
- External clock input from the Ext Clk In connector

The internal clock accuracy is ±10 ppm after power is applied for 1 hour.

The external clock is used under the following conditions:

- When synchronizing other equipment with clock
- When using clock with higher accuracy than internal clock

Table 5.2.1-1   Reference CLK Settings

Reference CLK	Description	Frequency of Clock Input to Ext Clk In (MHz)
Internal	Use the internal clock based on the internal 10 MHz oscillator	
Ext Clk 1/16*	Use the external clock input from the Ext Clk In connector When the bitrate is within 9.5 to 14.2 Gbit/s The division ratio of external clock frequency and bit rate is 16.	593.75 to 887.5
Ext Clk 1/40	Use the external clock input from the Ext Clk In connector When the bitrate is within 24.3 to 28.2 Gbit/s The division ratio of external clock frequency and bit rate is 40.	607.5 to 705.0

*:   This is displayed when MP2110A-093 is added.

Note:

Click **Apply** when the Reference CLK status display is lit in yellow while the external clock is used.

The Ext Clk In connector is an AC coupling.

Input the signal of the sine wave or square wave where the amplitude is 0.2 to 1.6 Vp-p.

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5.2.2 Setting Bit Rate

Set the bit rate when Reference CLK has been set to **Internal**.
The bit rate is set as common in PPG/ED Ch 1 to Ch 4. For example, when the bit rate is changed in the PPG/ED Ch1 panel, the bit rates of PPG/ED Ch2 to PPG/ED Ch4 are also changed.

1. Click the Bit Rate button.
   The window is opened to select the standards.
   The number of displayed buttons varies depending on whether MP2110A-093 is added or not.
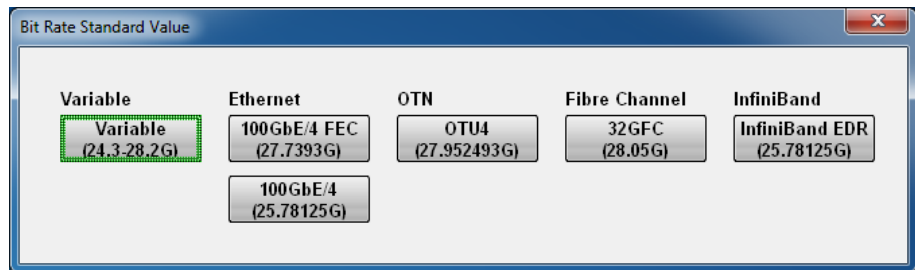
Figure 5.2.2-1   Bit Rate Standard Value Dialog Box (Without MP2110A-093)
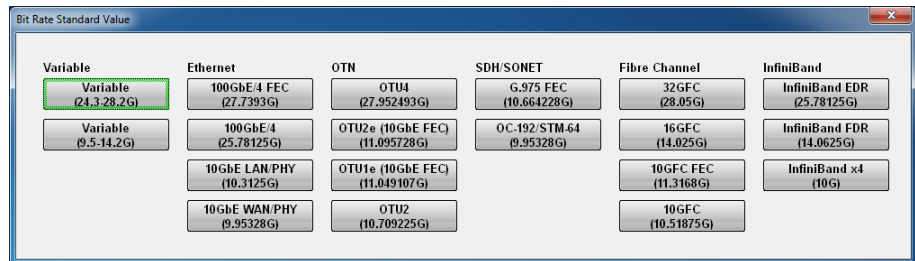
Figure 5.2.2-2   Bit Rate Standard Value Dialog Box (With MP2110A-093)

2. Click the bit rate standards button.
   The number displayed in the button is the specified bit rate (bit/s).
   When indicating 28.05G, this means 28.05 Gbit/s.

3. When selecting **Variable**, click the bit rate and offset text boxes and input the value. The bit rate can be set in the range 24.3 to 28.2 GHz, and the offset can be set in the range –100 to 100 ppm.

   When MP2110A-093 is added, the offset can also be set in the range 9.5 to 14.2 GHz.

Setting Amplitude

1.   Click the Amplitude text box and set the amplitude voltage.

2.   When the attenuators are inserted between the **Data Out** connector
     and $\overline{\text{Data}}$ **Out** connector of MP2110A and the DUTs, click the
     External Attenuation text box and input the attenuation. The
     amplitude voltage after passing through the attenuator is displayed.

⚠ CAUTION

**When inserting attenuator at both the Data Out connector
and $\overline{\text{Data}}$ Out connector, use an attenuator with the same
amount of attenuation.**

**If the attenuation amounts are different, the displayed
amplitude and the amplitude output at the connector will
be different.**

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How to Operate BERT

5.2.3 Setting Patterns

The following three test patterns can be selected.
- PRBS
- 1/2 Clock Pattern
- 1/16 Clock Pattern

PRBS

PRBS is the pattern generated at the hardware.
The generated pattern length, maximum length of contiguous 1s, and maximum length of contiguous 0s differ depending on the hardware configuration.

The following block diagram indicates the hardware generating PRBS 2^7-1.
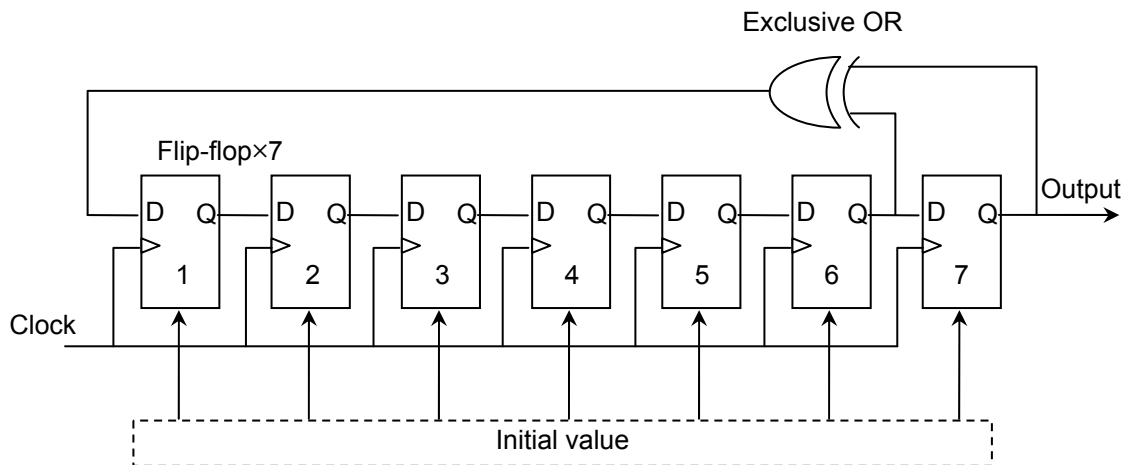
Figure 5.2.3-1   Block Diagram for PRBS Generating Circuit

This block diagram is composed of a shift register composed of a seven-stage flip-flop and an Exclusive OR circuit. A signal of the sixth and seventh stages of the shift register are input to the Exclusive OR and the output of the Exclusive OR is input to the shift register. This type of configuration is described by the following pattern generation polynomial.

$1 + X^6 + X^7$

When inputting the default value of 7 bits and impressing the clock, a pattern with a bit length of $2^7-1 = 127$ is repeatedly generated. The default value of seven bits includes 1 or more "1" bits.
The following shows the pattern length, maximum number of contiguous 1s, and maximum number of contiguous 0s using the PRBS generation formula of the MP2110A.

PRBS	Pattern Generation Polynomial	Pattern Length	Maximum number of contiguous 1s	Maximum number of contiguous 0
2^7–1	$1+X^6+X^7$	127	7	6
2^9–1	$1+X^5+X^9$	511	9	8
2^15–1	$1+X^{14}+X^{15}$	32767	15	14
2^23–1	$1+X^{18}+X^{23}$	8388607	23	22
2^31–1	$1+X^{28}+X^{31}$	214748647	31	30

The ratio of 1s to the PRBS pattern length is 50%.

1/2 Clock Pattern

"1/2 Clock Pattern" means the repeating pattern of "1" and "0".
The pattern of which the clock frequency is divided in half is output from the **Data Out** connector and $\overline{\textbf{Data}}$ **Out** connector.
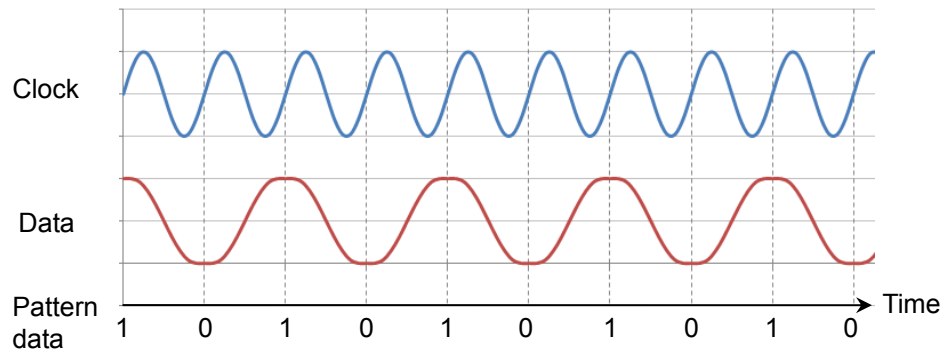
Figure 5.2.3-2   Relationship between 1/2 Clock Pattern and Clock

1/16 Clock Pattern

"1/16 Clock Pattern" means the repeating pattern of "11111111" and "00000000".
The pattern of which the clock frequency is divided in one-sixteen is output from the **Data Out** connector and $\overline{\textbf{Data}}$ **Out** connector.
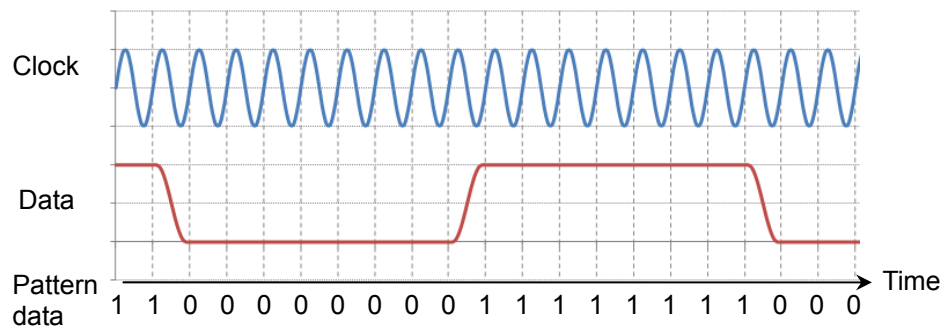
Figure 5.2.3-3   Relationship between 1/16 Clock Pattern and Clock

Pattern Logic

There are two types of logic; Positive Logic (POS) and Negative Logic (NEG).

With positive logic, the voltage at the Data connector goes High when the data is "1".

With negative logic, the voltage at the Data connector goes Low when the data is "1".

Pattern data   0   1   0   0   1   1   0   1   0   1

Data connector voltage if POS is set

Data connector voltage if NEG is set
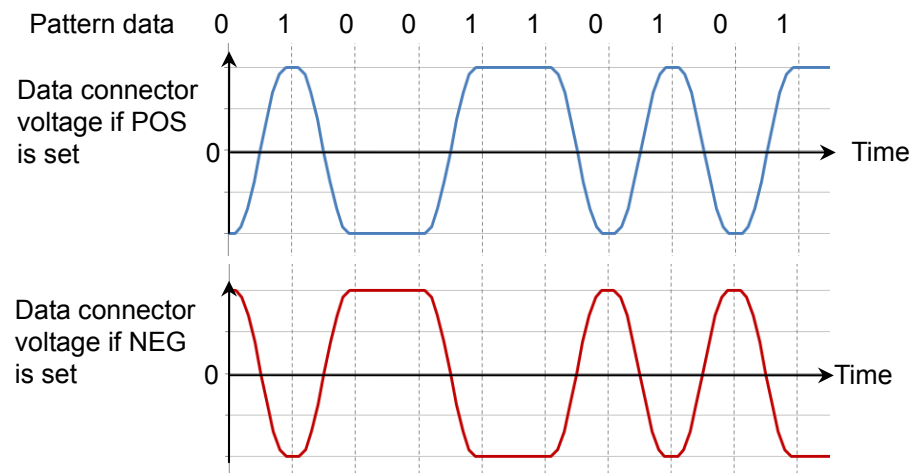
Figure 5.2.3-4   Relationship between Logic Setting and Output Voltage Waveform at Connector

Set the pattern using the following procedure.

1.   Click the button for Test Pattern, and you will see the Test Pattern dialog box.

Test Pattern

PRBS 2^7-1	PRBS 2^9-1
PRBS 2^15-1	PRBS 2^23-1
PRBS 2^31-1	1/2 Clock Pattern
1/16 Clock Pattern	
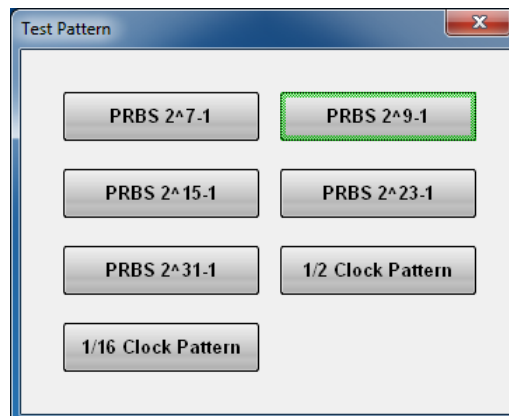
2.   Click the button for the pattern you want to set.

5.2.4 Setting Output Waveform

The PPG Data connector and $\overline{\text{Data}}$ connector are AC coupling.
When it is necessary to impose DC voltage on an output waveform, connect a bias-T.

⚠ CAUTION

- The impedance of the Data Out and $\overline{\text{Data}}$ Out connectors is 50 Ω. Measurement may not be performed correctly if a coaxial cable with another impedance is used or if the impedance of the DUT is not 50 Ω.

- The amplitude of signal output to the Data Out and $\overline{\text{Data}}$ Out connectors is 0.1 to 0.8 Vp-p. Check that the output voltage amplitude does not exceed the DUT maximum input specifications. If it does, connect an attenuator to the output connector.

Set the bit rate and amplitude of the waveform output to the $\overline{\text{Data}}$ and **Data** connectors.
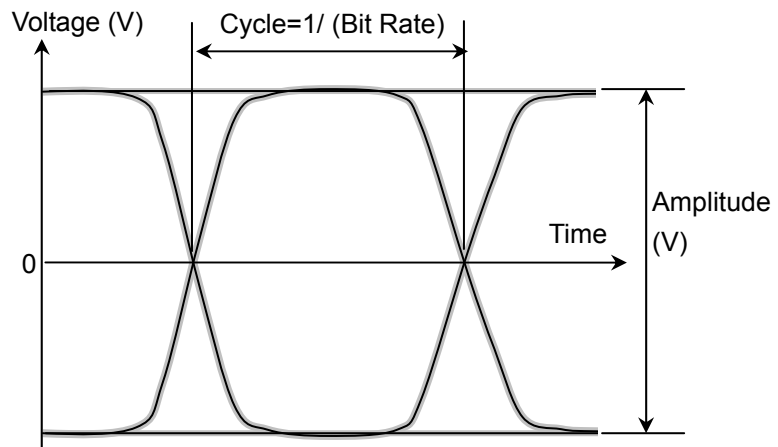
Figure 5.2.4-1   Waveform Setting Item

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5.2.5 Setting Sync Out

Set the signal type output from the front-panel Sync Out connector. Sync Output connector outputs a clock synchronized to the data generated by the PPG. The **Sync Out** Connector is a DC coupling.

To monitor the waveform pattern of the pulse pattern generator, set **Pattern Sync** at Sync Out and connect the **Sync Out** connector and the **Trigger Clk In** connector of the sampling oscilloscope using a coaxial cable.
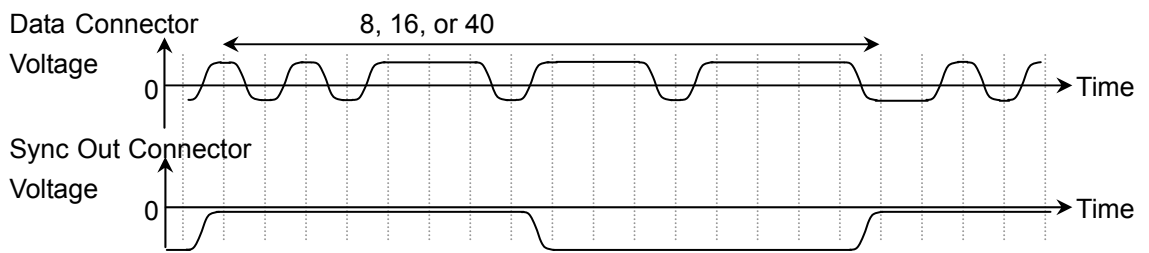
Figure 5.2.5-1   Correspondence between Sync Output Setting and Output Voltage Waveform at Connector using PPG Rate Division
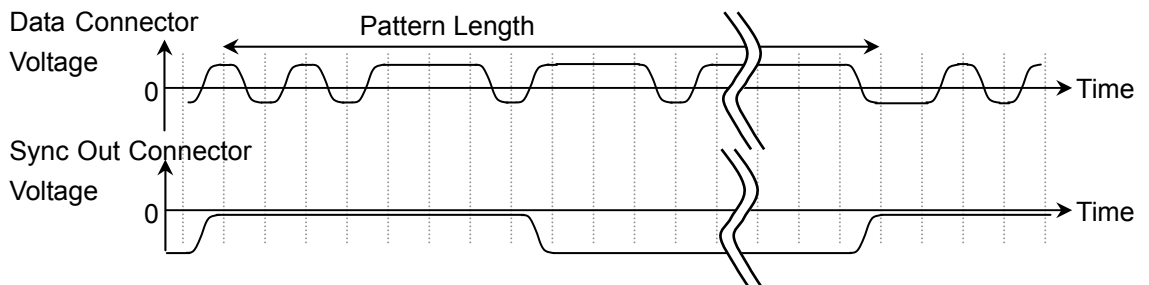
Figure 5.2.5-2   Voltage Waveform Output to Connector Corresponding to Sync Output Setting for Pattern Sync

The Sync Output amplitude cannot be set.

The time interval outputting the pulse varies depending on the pattern length and bit rate when Sync Output is Pattern Sync .

Select the pattern for the measurement referring to Table 5.2.5-1.

Table 5.2.5-1   Cycle of Sync Output (Pattern Sync)

Pattern Name	Bit Rate (kbit/s)			
	10 000 000	14 025 000	25 781 250	28 050 000
PRBS 2^7–1	12.7 ns	9.1 ns	4.9 ns	4.5 ns
PRBS 2^9–1	51.1 ns	36.4 ns	19.8 ns	18.2 ns
PRBS 2^15–1	3.28 µs	2.34 µs	1.27 µs	1.17 µs
PRBS 2^23–1	838.9 µs	598.1 µs	325.4 µs	299.1 µs
PRBS 2^31–1	214.7 ms	153.1 ms	83.3 ms	76.6 ms

⚠ **CAUTION**

- **The impedance of the Sync Out connector is 50 Ω. Measurement may not be performed correctly if a coaxial cable with another impedance is used or if the impedance of the DUT is not 50 Ω.**

- **The output voltage of the Sync Out connector is –1.2 to 0 V. Check that the output voltage does not exceed the DUT maximum input specifications. If it does, connect an attenuator to the Sync Out connector.**

Note:

PPG Pattern Sync cannot be set for the following Scope setting.

Time dialog box
Data Clock Rate: Tracking On

Procedure

1.   Click **Sync Out**.

2.   Select the type of signal output to Sync Output.

5.2.6 Setting Clk Out

Set a signal output from the **Clk Out** connector on the front panel.
Clk Out is a function to output the clock synchronized to the data
generated from the pulse pattern generator to the **Clk Out** connector on
the front panel. The **Clk Out** connector is AC-coupled.

To measure the eye waveform using the sampling oscilloscope, connect the
Clk Out connector and the **Trigger Clk In** connector of the sampling
oscilloscope using a coaxial cable.

For MP2110A-093, the clock output division rate is automatically changed
according to the bit rate.
24.3 to 28.2 Gbit/s: 1/4 Clock
  9.5 to 14.2 Gbit/s: 1/2 Clock
For MP2110A-014, the clock source of clock output is selected from Ch1/2
or Ch3/4.
The jitter is reduced by matching the channel used for the measurement
and the channel at Clk Out as shown in Figure 5.2.6-1. Refer to the
descriptions at Jitter in Section A.2.2, "Pulse Pattern Generator", for
details of the jitter.

To perform the measurement using PPG/ED Ch1 and PPG/ED Ch2, set
Ch1/2.
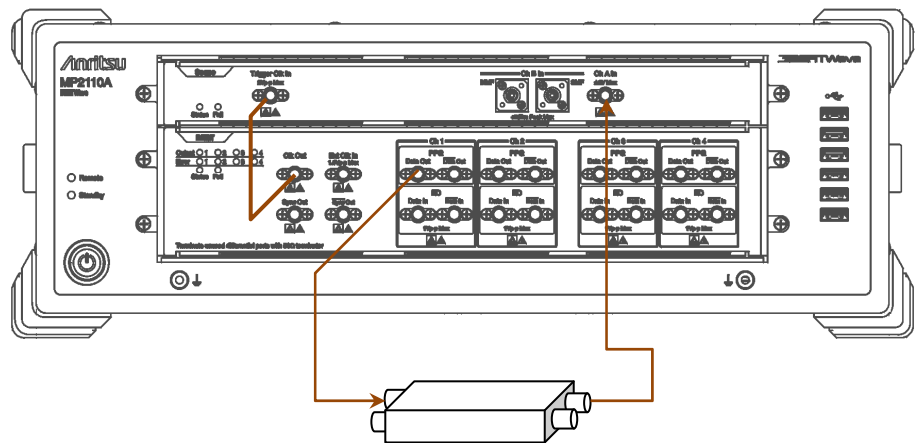
Figure 5.2.6-1   Connection Example When Setting Ch1/2 at Clk Out

To perform the measurement using PPG/ED Ch3 and PPG/ED Ch4, set
Ch3/4.
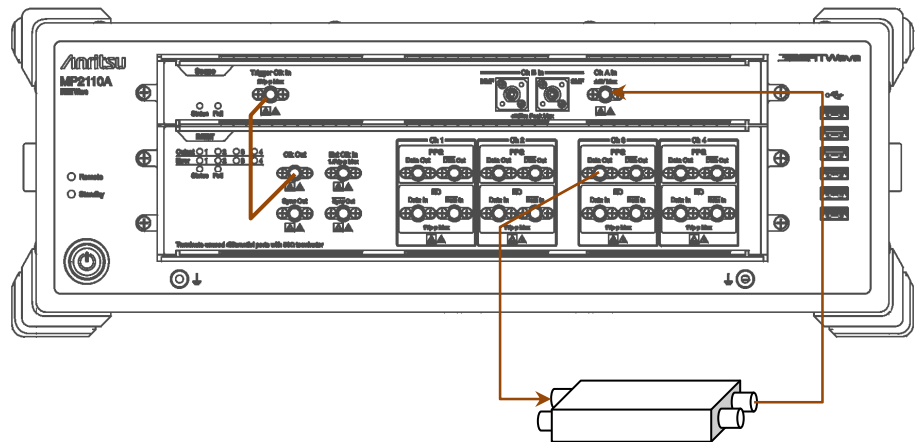
Figure 5.2.6-2   Connection Example When Setting Ch3/4 at Clk Out

5.2.7 Inserting Bit Error

Insert a bit error when confirming whether to detect the bit error at the ED. The number of bit errors to be inserted at one time is determined according to the bit rate.

24.3 to 28.2 Gbit/s ：   20 bit
9.5 to 14.2 Gbit/s ：   8 bit

Inserting bit errors one bit at a time using screen operation
Click **Insert Error**.
When inserting the bit error, the indicator on the right side of **Insert Error** lights green.

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5.2.8 Setting Error Detection Method

Set the conditions for detecting a bit error.

Signal input terminal

The block diagram for **Data In** and $\overline{\textbf{Data}}$ **In** connectors on BERT panel is as shown below.

Data In

$\overline{\text{Data}}$ In

Threshold voltage
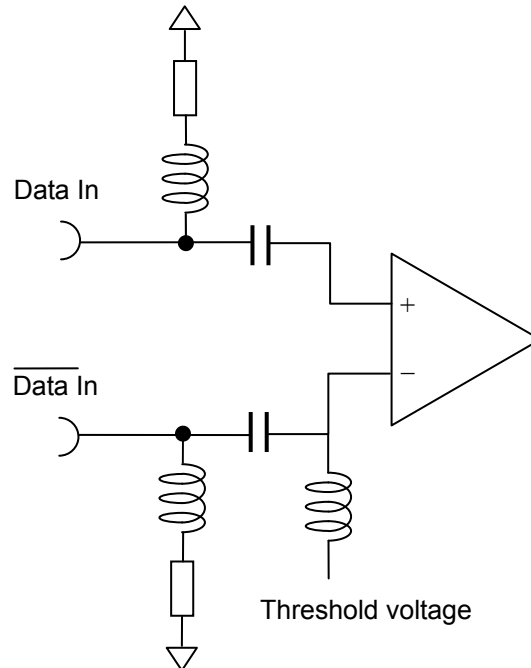
Figure 5.2.8-1   Input Terminal Block Diagram

⚠ CAUTION

● **The impedance of the electrical input connector is 50 Ω. Measurement may not be performed correctly if a coaxial cable with another impedance is used.**

● **Do not apply a DC voltage of more than 1 V to the $\overline{\text{Data}}$ In connectors. Otherwise, the internal circuits may be damaged.**

Select the signal input terminal depending on the Data Input Condition

Differential 50 Ohm: Signal input terminal for both **Data In** and **Data In** connectors. The differential voltage of each signal input to two connectors is the input voltage.

Electrical Single-Ended Data:
Signal input terminal for **Data In** connector

Electrical Single-Ended XData:
Signal input terminal for **Data In** connector

Attenuator Factor (External Attenuation)

When installing the fixed attenuator in the Data In and **Data In** connectors of the BERTWave, input the attenuation (dB) of the fixed attenuator.

The threshold voltage calculated to the input voltage of the attenuator is displayed.

The calculation formula is as follows:

Calculated Threshold Voltage = Threshold Voltage × 10^(attenuation/20))

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⚠ CAUTION

- When inserting the attenuators at both Data In connector and **Data In** connector, use the attenuators with the same amount of attenuation. When the attenuators with the different amounts of attenuations are used, the displayed threshold voltage and the actual threshold voltage are different.

- When the voltage input to the attenuator is more than 5V or less than –5V, check that the voltage consumed in the attenuator does not exceed the rated power of the attenuator.

- Check that the voltage of the signal attenuated in the attenuator does not exceed the voltages displayed at the Data In connector and **Data In** connector.

Threshold Level

Voltage level for evaluating "1" and "0".

The input terminals are AC coupled, so set a voltage corresponding to the signal waveform excluding the DC components.

The waveform excepting the waveform input to the connector and the DC component when inputting the 1.2V LVCMOS signal to the **Data In** connector and $\overline{\textbf{Data}}$ **In** connector is shown below.

Set the threshold level to the waveform excepting the DC component.
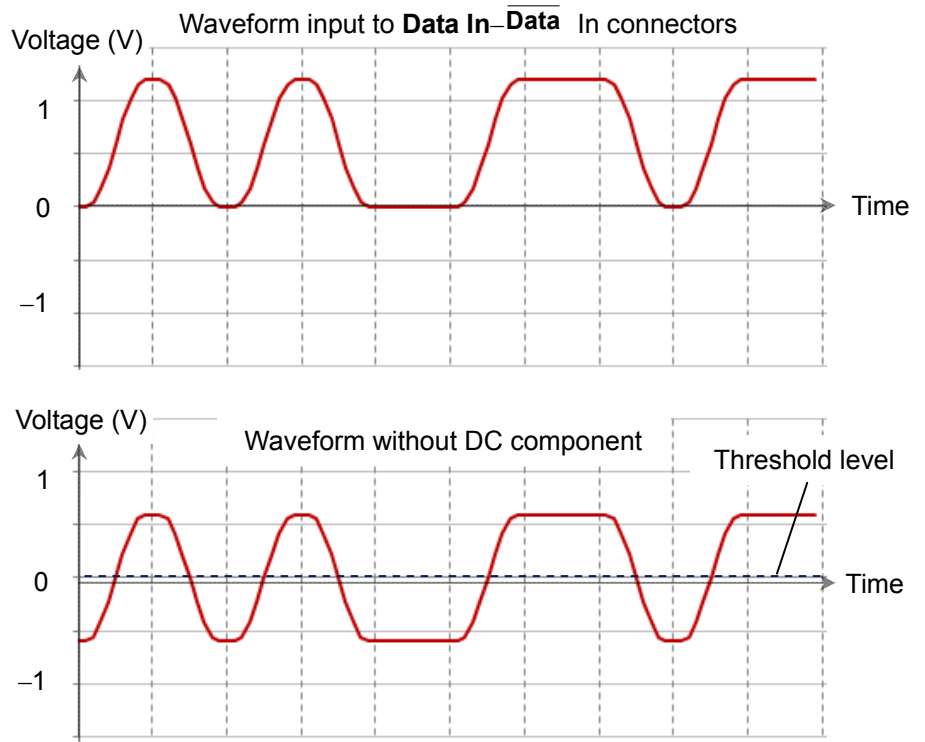
Figure 5.2.8-2   Waveform That Threshold Level Can be Set

Logic

Select the positive logic (POS) or negative logic (NEG).
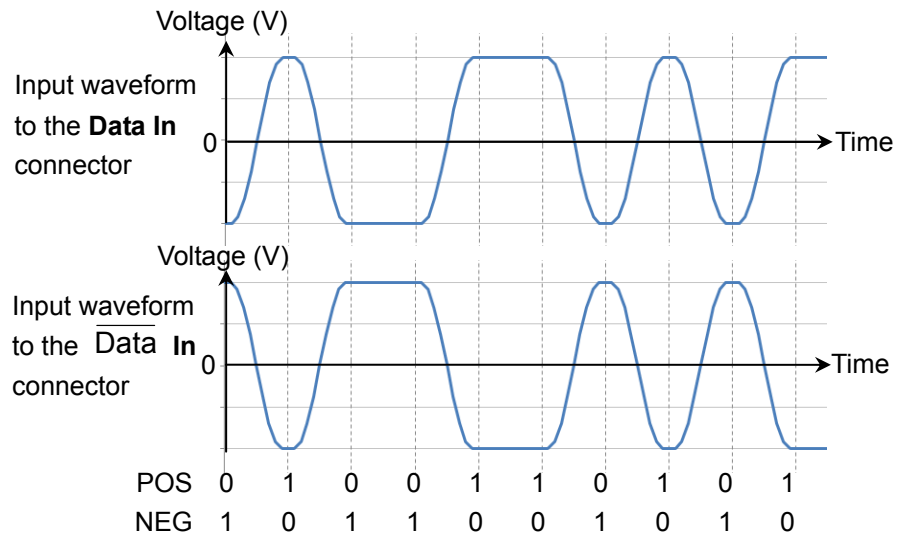
Figure 5.2.8-3   Values Defined as Input Waveform

Pattern

The ED compares the received bit string and the internally generated bit stream bit-by-bit and evaluates it differences as it errors.
As a result, set the same pattern at the PPG and ED.

The setting procedure of the error detection conditions is as follows:

1. When changing the bit rate and pattern of the PPG and applying the changing settings to the ED click the Tracking button and set to **On**.
    When setting to **On**, go to the step 6.
    When setting to **Off**, go to the step 2.

2. Click the Bit Rate button and select the standard.

3. Click the Test Pattern button and select the pattern.
    Set the same pattern of the PPG.

4. Set Logic to **POS** or **NEG**.

5. Click the ED Input Condition button.

6. Select the connector receiving the signal from the followings:

    Differential 50 Ohm: **Data In** and $\overline{\textbf{Data}}$ **In** connectors
    Electrical Single-Ended Data: **Data In** connector
    Electrical Single-Ended XData: $\overline{\textbf{Data In}}$ connector

7. Click the Ext ATT text box.

8. When inserting the fixed attenuator to the $\overline{\textbf{Data}}$ **In** and **Data In** connectors, enter the attenuation (dB). When not inserting the attenuator, enter 0.

9. Click the Threshold text box.

10. Enter the threshold voltage.

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5.2.9 Setting ED Measurement Condition

To set how to measure bit error:

Set Gating Cycle at Gating.

Single: Performs measurement until the time set at the measurement period is exceeded.

Repeat: Performs measurement until ER Result button display becomes **Stop**.
The bit error rate returns to 0 at each measurement period.

Untimed: Performs measurement until ER Result button display becomes **Stop**. The bit errors are accumulated.

The following figure shows the relationship between the Gating Cycle setting and the change in the displayed bit error count.
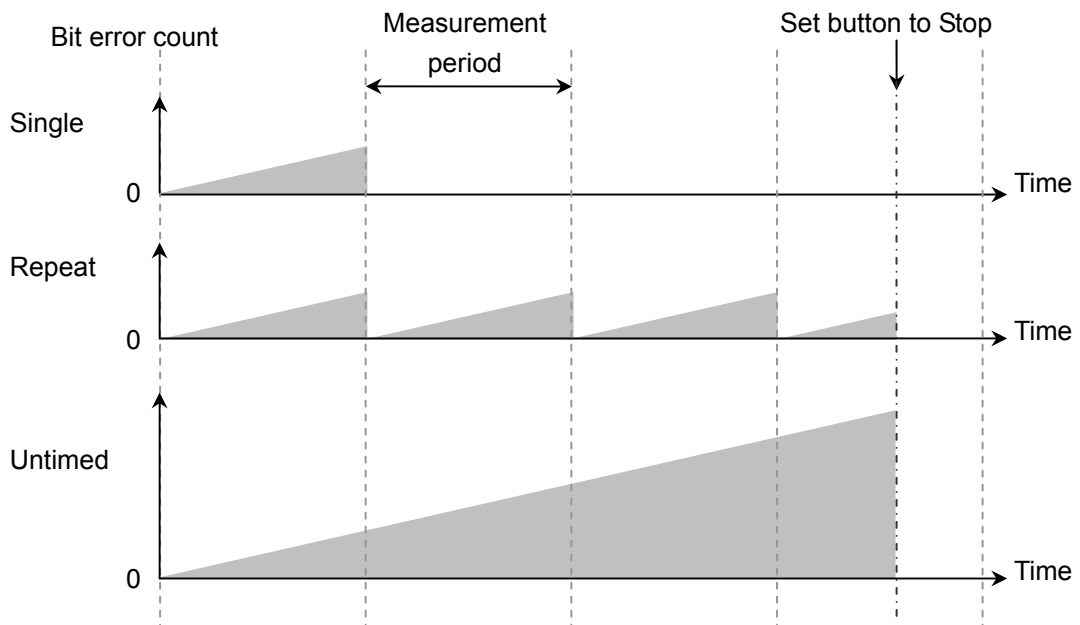
Figure 5.2.9-1   Gating Cycle Settings and Bit Error Count

Bit error measurement Period

The Gating Period can be set when Gating Cycle is Single or Repeat. The time can be set from 1 second to 9 days 23 hours 59 minutes 59 seconds.

Measurement method

The ED Result display can be refreshed either in real time (approx. 0.1 s intervals) or when the progress bar reaches 100%. The display method is set at Current of Gating.

On: Updates measurement results in real time.

Off: Updates measurement results when progress reaches 100% for either Single or Repeat Gating Cycle.

Updates measurement results when measurement stops for Untimed Gating Cycle.

The setting procedure of the measurement conditions is as follows:

1. Click the Gating Cycle button and select the measurement method as follows:
   Repeat
   Single
   Untimed

2. When Gating Cycle is Repeat or Single, click the text box under the Gating Cycle and enter the numeric value.
   The measurement cycle can be set from 1 second to 9 days 23 hours 59 minutes 59 seconds.

3. Click **Current** to set the timing for the measurement result.
   On: Updates measurement results per 100 ms.
   Off: Displays measurement results per measurement results or when measurement stops

4. Click the measurement start/stop button, and set the display to **Start**.
   The right indicator of the button is changed to green.
   Measure is displayed at the status display.
   The measurement processing rate is displayed.

When pattern synchronization is obtained, the SYNC Loss display is erased.

When Gating Cycle is set to **Untimed**, the measurement cycle progress is displayed every 5 seconds.

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When SYNC Loss is displayed in red

Pattern synchronization has not been obtained; check the following:

- The Test Pattern generated by the DUT matches the Test Pattern for the error detector.
- The Logic POS and NEG settings are correct.
- A suitable threshold voltage has been set for the signal input to the **Data In** connector and the $\overline{\textbf{Data}}$ **In** connector.
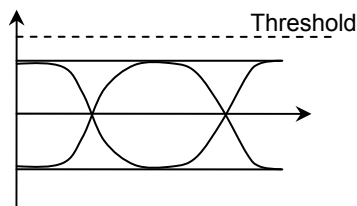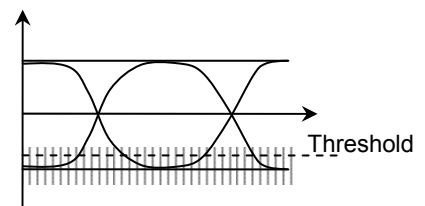
Figure 5.2.9-2　Examples of Improper Thresholds

5.2.10 Measurement Result

The following measurement result is displayed in the ED Result.

Start Time：   Time when bit error measurement started

Elapsed Time: Time elapsed from start of bit error rate measurement
When Gating Cycle is Single or Repeat, when time exceeds
the Time setting at Gating, the time is reset back to 0.

Remaining Time： Bit error measurement elapsed time subtracted from
time set at Gating Time setting.

ER: The bit error rate is displayed from 0.0001E–18 to 1.0000E–0.
Mantissa is 0.0000 when the bit error does not occur.
At this time, the numeric part varies depending on the clock number.
Example: 0.0000E–3   Clock count 1000 or more, 9999 or less
0.0000E–4   Clock count 10000 or more, 99999 or less

EC: The occurred bit errors are displayed from 0 to 9999999 or from
1.0000E07 to 9.9999E17.

CC: The received bit count is displayed from 0 to 9999999 or from
1.0000E07 to 9.9999E17.

FREQ (kHz)：   Clock frequency calculated by the received bit count.
It is the same as the transmission speed (kbit/s) of the received data.

Alarm Indicator

Error: Displays red when detecting bit error.

SYNC Loss: Displays red when pattern not synchronized.

When the alarm indicator goes red once, the History Indicator goes yellow
when the cause of the alarm is removed, indicating that an alarm
occurred.
When the **History Reset** button is pressed when the History Indicator is
yellow, the yellow display disappears.

The threshold of SYNC loss (error rate where the pattern synchronization
cannot be performed) varies depending on the bit rate, and the threshold
is calculated using the following formula.

$$\text{Threshold value} = \frac{65565000}{\text{Bit rate (bit/s)}}$$

Example: When the bit rate is 28.2 Gbit/s, the threshold is 2.32E–3.

$$\frac{65565000}{28.2 \times 10^9} = 2.325 \times 10^{-3}$$

5.2.11   Saving Measurement Results

The measurement result of the saved bit error is as follows:

Bit Error Measurement Result

CC (Clock Count)

EC (Error Count)

ER (Error Rate)

Frequency

Start Time

Stop Time

Test Pattern

```
Anritsu;MP2110A  ;01.00;TXT--------------------------------
Pattern PRBS2^9-1
Option 12,21,24,93
Start  2017/03/27 15:46:16   End  2017/03/27 15:46:26


       | Total
-------+---------------------------------------------------------
ER     | 0.0000E-11
EC     |        0

Frequency      Clock Count
---------------------------------------------------------------------
 25781250kHz     2.5781E+11
```

Figure 5.2.11-1   Text File Example

```
Anritsu;MP2110A;01.00;CSV
Pattern,PRBS 2^9-1
Option 12,21,24,93
Start  2017/03/27 15:46:16   End  2017/03/27 15:46:26

,Total
ER,0.0000E-11
EC,0

Frequency,Clock Count
25781250kHz,2.5781E+11
```

Figure 5.2.11-2   CSV File Example

Procedure

1. Click **System Menu**.

2. Click **Save**.

3. Select from **All, PPG/ED Ch1**, **PPG/ED Ch2**, **PPG/ED Ch3**, or
   PPG/ED Ch4.

   Selecting **All** saves the measurement results for PPG/ED Ch1 to 4.

4. Click **Result**.
   The file name input dialog box is displayed.

5 When saving the file as the displayed file name, click **OK**.

6 Click the right button of the text box when editing the file name. The
  software keyboard is displayed.

7 Input the file name.

8 When changing the file name, click **OK**, and when canceling the
  procedure, click **Cancel** and go back to the step 4.

The measurement result file is saved in the following folder.
C:\Users\Public\Documents\Anritsu\MX210000A\UserData\Result\CSV
C:\Users\Public\Documents\Anritsu\MX210000A\UserData\Result\TXT

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How to Operate BERT

5.3 Setting Restrictions

The setting items of the PPG have the following restrictions.

When Test Pattern is not PRBS (Test Pattern is 1/2 Clock or 1/16 Clock) in MP2110A, the Pattern Sync is disabled due to the hardware restrictions. The setting item can be selected, but "PPG 1/8 Clock" is output under this condition.

When the following conditions are met, no signal is output from Clk Out.
- The bit rate operates in the range from 24.3 to 28.2 Gbit/s.
- "1/2 Clock Pattern" is set at PPG Test Pattern in one of the channels specified at the Clk Out Source Channel setting (Ch1/2 or Ch3/4).

Chapter 6 How to Operate Sampling Scope

This chapter explains the Sampling Scope setting items and how to measure the waveform.

Note:

This chapter (Eighth Edition) explains how to operate MP2110A with the software version 6.00.00 or later.

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How to Operate Sampling Scope

6.1 Measurement Procedure

The following figure shows the basic measurement procedure.

```
                Start
                  │
          ┌───────┴───────┐   Yes
          │  Calibration  ├──────────┐
          │   required?   │          ▼
          └───────┬───────┘   ┌──────────────────┐
               No │           │Perform calibration.│
                  │◄──────────┴──────────────────┘
                  ▼
          ┌───────────────┐   Yes
          │ Track the clock├──────────────────────────┐
          │  rate to BERT? │                           │
          └───────┬───────┘                            │
               No │                                     │
                  ▼                                      │
          ┌───────────────┐   Yes                       │
          │ Use CRU clock  ├──────────┐                 │
          │     rate?      │          │                 │
          └───────┬───────┘          │                 │
               No │                   │                 │
                  ▼                   ▼                 │
        ┌──────────────────┐ ┌──────────────────┐       │
        │Input clock signal │ │Connect Trigger Clk│      │
        │  to Trigger Clk In│ │In connector to CRU│      │
        │    connector.     │ │  Out connector.   │      │
        └─────────┬────────┘ └─────────┬────────┘       │
                  ▼                    ▼                 │
        ┌──────────────────┐ ┌──────────────────┐       │
        │  Set Symbol Rate. │ │     Set CRU.     │       │
        └─────────┬────────┘ └─────────┬────────┘       │
                  ▼                    │                 │
        ┌──────────────────┐          │                 │
        │Set Clock Frequency│          │                 │
        │or Clock Divide    │          │                 │
        │ratio.             │          │                 │
        └─────────┬────────┘          │                 │
                  │◄──────────────────┘                 │
                  ▼                                      │
        ┌──────────────────┐                             │
        │Set to Sampling    │                             │
        │mode.              │                             │
        └─────────┬────────┘                             │
                  ▼                                      │
        ┌──────────────────┐                             │
        │Sets data acquired │                             │
        │method.            │                             │
        └─────────┬────────┘                             │
                  └─────────────────────────────────────┘
```

```
          ┌───────────────┐   Yes
          │  Pulse mode?   ├──────────┐
          └───────┬───────┘          ▼
               No │          ┌──────────────────┐
                  │          │Set pattern length.│
                  │◄─────────┴──────────────────┘
                  ▼
        ┌──────────────────┐
        │Input measurement  │
        │signal to either   │
        │Ch A or Ch B In.   │
        └─────────┬────────┘
                  ▼
        ┌──────────────────┐
        │Set Ch A or Ch B   │
        │display to On.     │
        └─────────┬────────┘
                  ▼
        ┌──────────────────┐
        │  Start sampling.  │
        └─────────┬────────┘
                  ▼
        ┌──────────────────┐
        │   Adjust scale.   │
        └─────────┬────────┘
                  ▼
        ┌──────────────────┐
        │Measure a waveform.│
        └─────────┬────────┘
                  ▼
        ┌──────────────────┐
        │  Stop sampling.   │
        └─────────┬────────┘
                  ▼
        ┌──────────────────┐
        │Save measurement   │
        │result.            │
        └─────────┬────────┘
                  ▼
                 End
```

Figure 6.1-1   Basic Measurement Procedures

6.2 Explanation of Windows

6.2.1 Result Window

In the function menu, click **Scope**, and then the Scope result window is displayed.
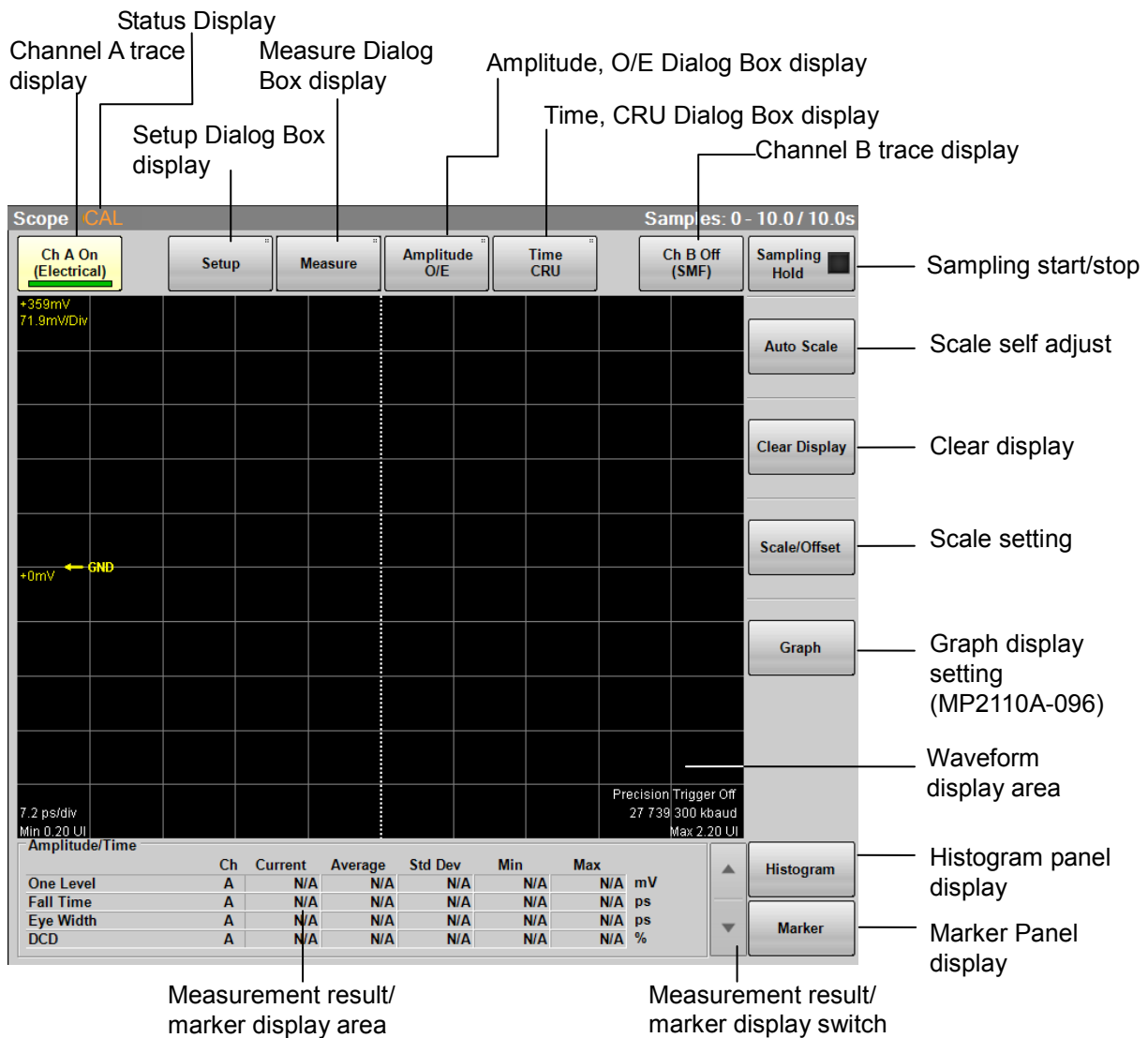
Figure 6.2.1-1   Result Window

Clicking **Setup**, **Measure**, **Amplitude O/E**, and **Time CPU** displays the dialog box.

MP2110A-021 Dual Electrical Scope does not display **Amplitude O/E** but **Amplitude**.

How to Operate Sampling Scope

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When MP2110A-054 Clock Recovery (Electrical/Optical) is not added, not **Time/CRU** but **Time** is displayed.

When Channel Math in Amplitude O/E dialog box is **On**, **Scale/Offset** cannot be operated.

Channel A Top level   Channel B Top level

Channel A ——— +500mV   +2995uW ——— Channel B
Level scale   100.0mV/Div   599.0uW/Div   Level scale
                                                                  SMF

Channel A ———   ——— Channel B
Optical   Optical
connector type   connector type

Channel A——— +0mV   GND   GND   +0uW
Level offset   ——— Channel B
                                                                  Level offset

Channel A ———   ——— Channel B
GND level   GND level

                                                          ——— Precision
                                                                  trigger status
Time scale ——— 7.8 ps/div   Precision Trigger Off ——— Symbol rate
                   Min 0.00 UI   25 781 250 kbaud
                                      Max 2.00 UI

        Time offset   Time at right edge of display area

Figure 6.2.1-2   Waveform display area

Note:

The arrows that indicate the GND levels appear differently according to the options installed.

■ Arrows when MP2110A-021, 022, 023, 025, or 026 is installed.

ChA: ← GND   ChB: GND →

■ Arrows when MP2110A-032, 033, 035, or 036 is installed.

ChA: ← GND   ChB: GND →

The graph size changes depending on the number of measurement results displayed on Result Window.
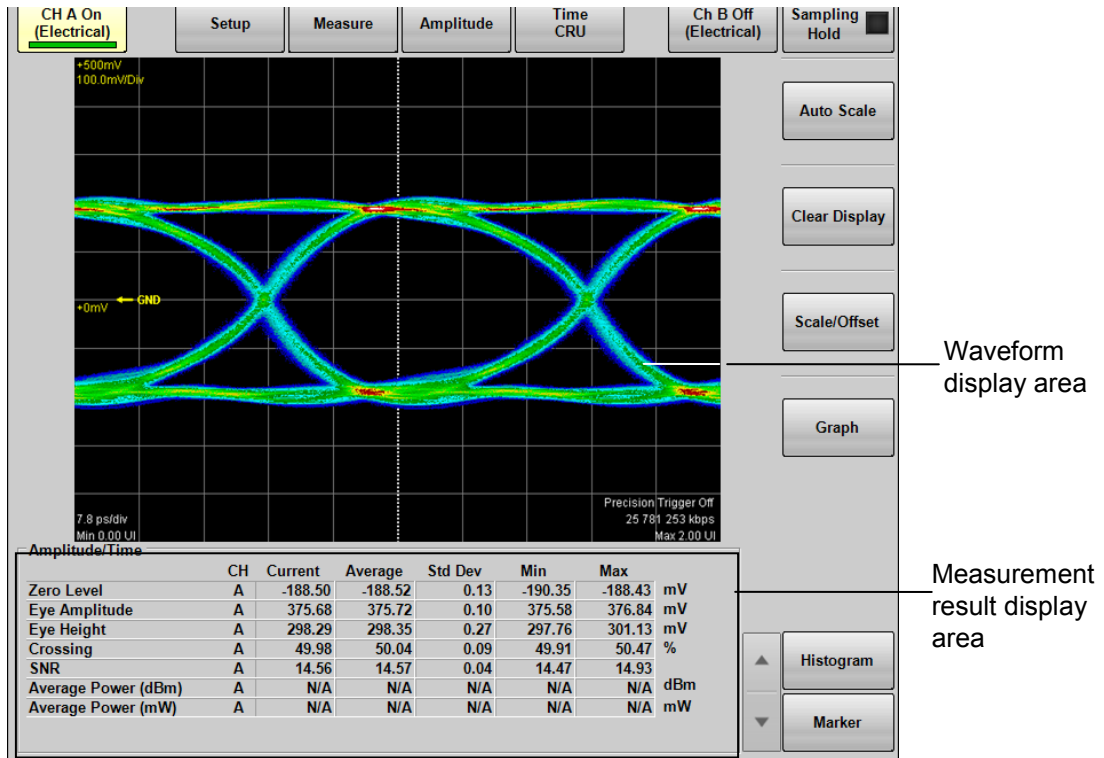
Figure 6.2.1-3   Result Window (Number of measurement items is from five to eight)
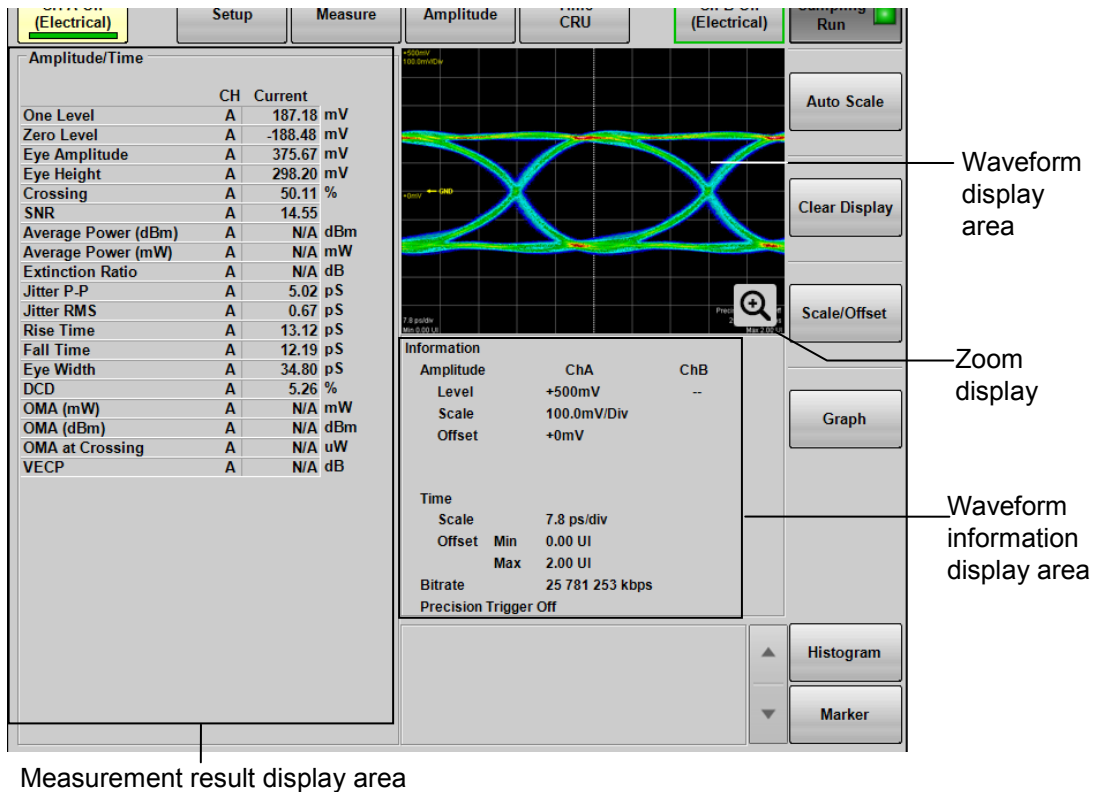
Figure 6.2.1-4   Result Window (Number of measurement items is nine or more)

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How to Operate Sampling Scope

When the number of measurement items is nine or more, Zoom display icon (⊕) is shown. Clicking this icon displays Scope Result dialog box and the waveform is displayed larger.
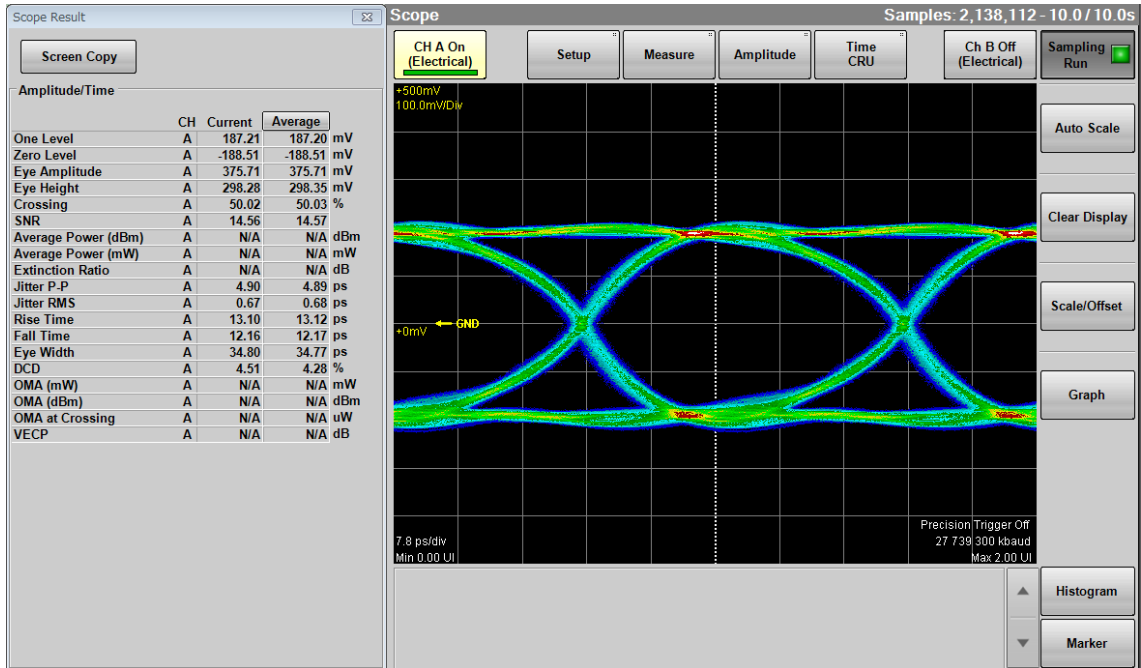
**Figure 6.2.1-5   Enlarging Display of Result Window
(Number of measurement items is nine or more)**

Click **Screen Copy** in the Scope Result dialog box to save the images of the Result window and Scope Result dialog box to a file.

For the method of saving files and the destination folder, refer to 4.3.3 "Screen Copy".

When clicking a measurement item, the letter turns blue, and the measurement area is displayed with a yellow dotted line in the window. When clicking the measurement item again, the display of the measurement area disappears.
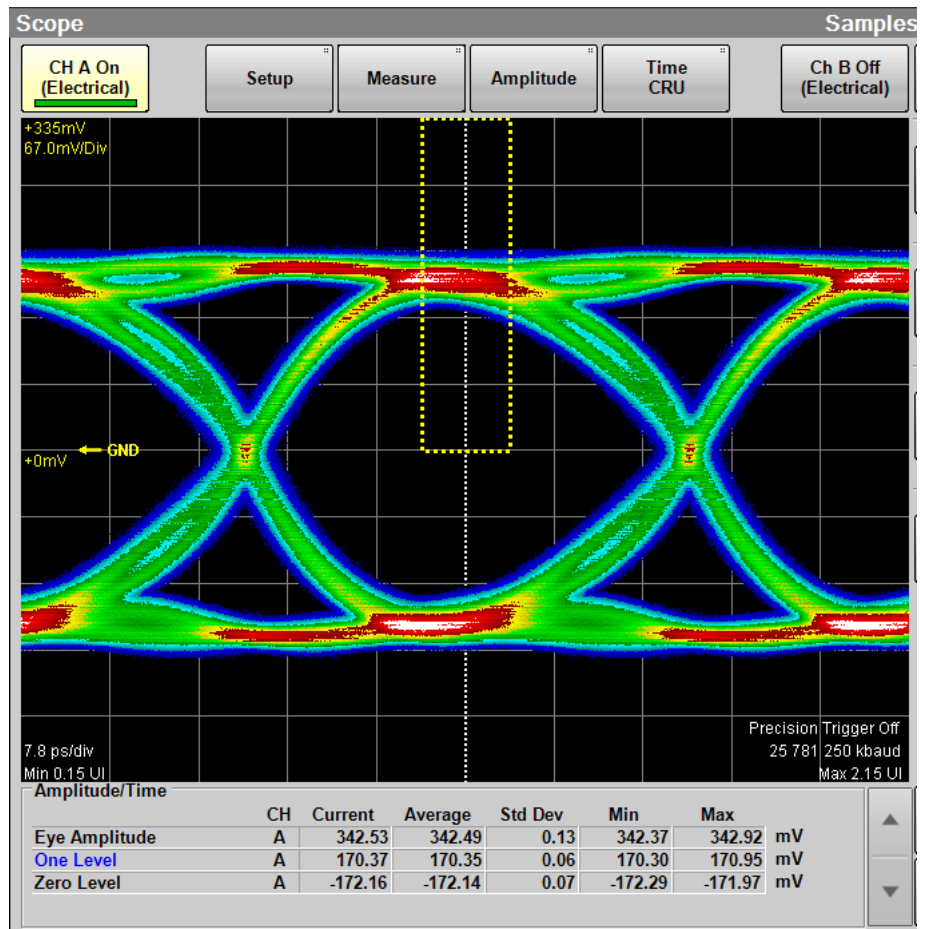
Figure 6.2.1-6   Example of Measurement Area Display

Status Display

The following statuses of the sampling scope are displayed.

Table 6.2.1-1   Status Display Items

Item	Color	Description
CAL	Orange	The correction value of O/E is not appropriate. Calibrate the O/E module.
CAL	Yellow	There is a difference of ± 2.5 °C or more from the calibration temperature.
CAL	Red	There is a difference of ± 5.0 °C or more from the calibration temperature.
CRU Unlock	Orange	The clock recovery unit is not synchronized with the input signal.
Free Running	Red	The trigger clock cannot be detected.
Trigger setting wrong	Orange	The trigger clock can be detected, but its frequency does not match the clock frequency setting value

When MP2110A - 096 is added, **Graph** is displayed in the Result window. Click **Graph** to display the scroll bar.

Note:

> **Graph**] cannot be operated when Sampling Mode is set to **Pulse** or **Coherent Eye**.
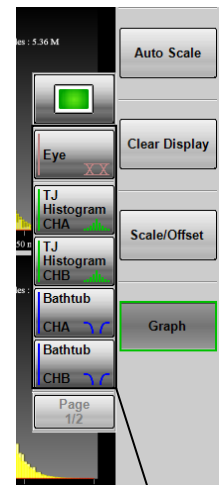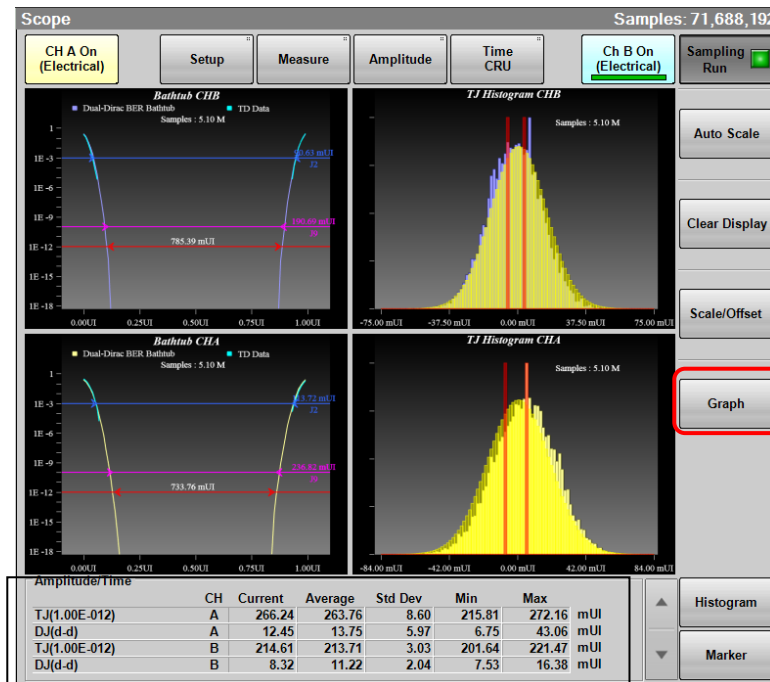
Jitter analysis result

Graph selection button

Figure 6.2.1-7   Result Window (Graph Display)

Advanced Jitter is set to Sampling Mode in the Setup dialog box, the following buttons in the Result window cannot be operated.

Auto Scale, **Clear Display**, **Scale/Offset**, **Histogram**, **Marker**

When the Correction Factor of Figure 6.2.3-7 Jitter Measure Dialog Box (Advanced Tab) is **ON**, the corrected value is displayed in brown in the measurement result display area.

Displaying Graphs

When **Graph** in the Result window is clicked, a scroll bar appears and the graph to display can be selected.

Graph selection button

Advanced Jitter

Eye
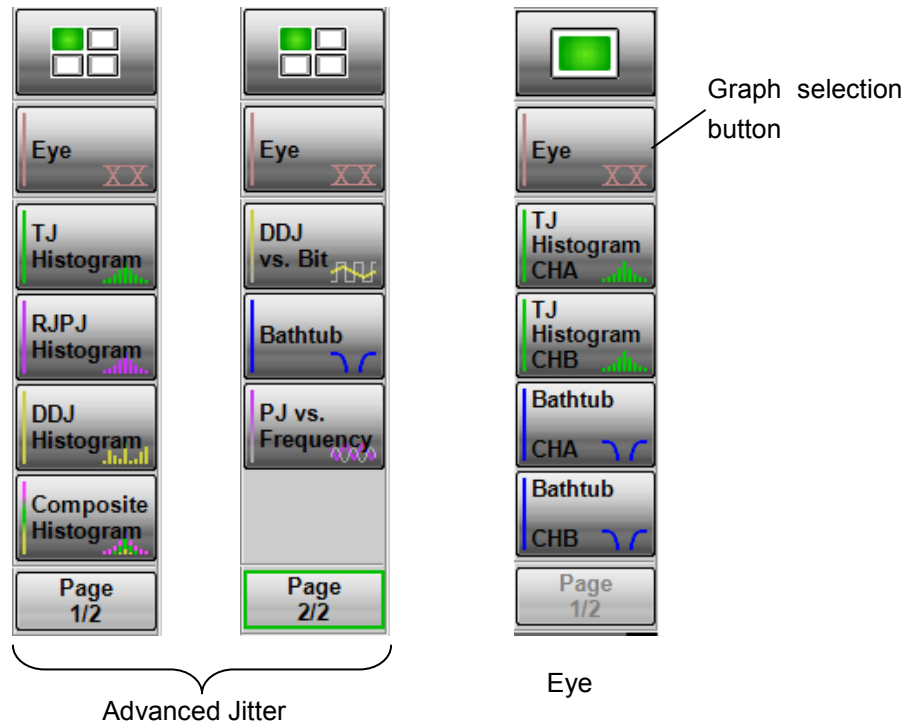
Figure 6.2.1-8   Examples of Scroll Bars

The graph can be switched between enlarged display and reduced (4 screens) display.

To switch the display size of the graph, click or .
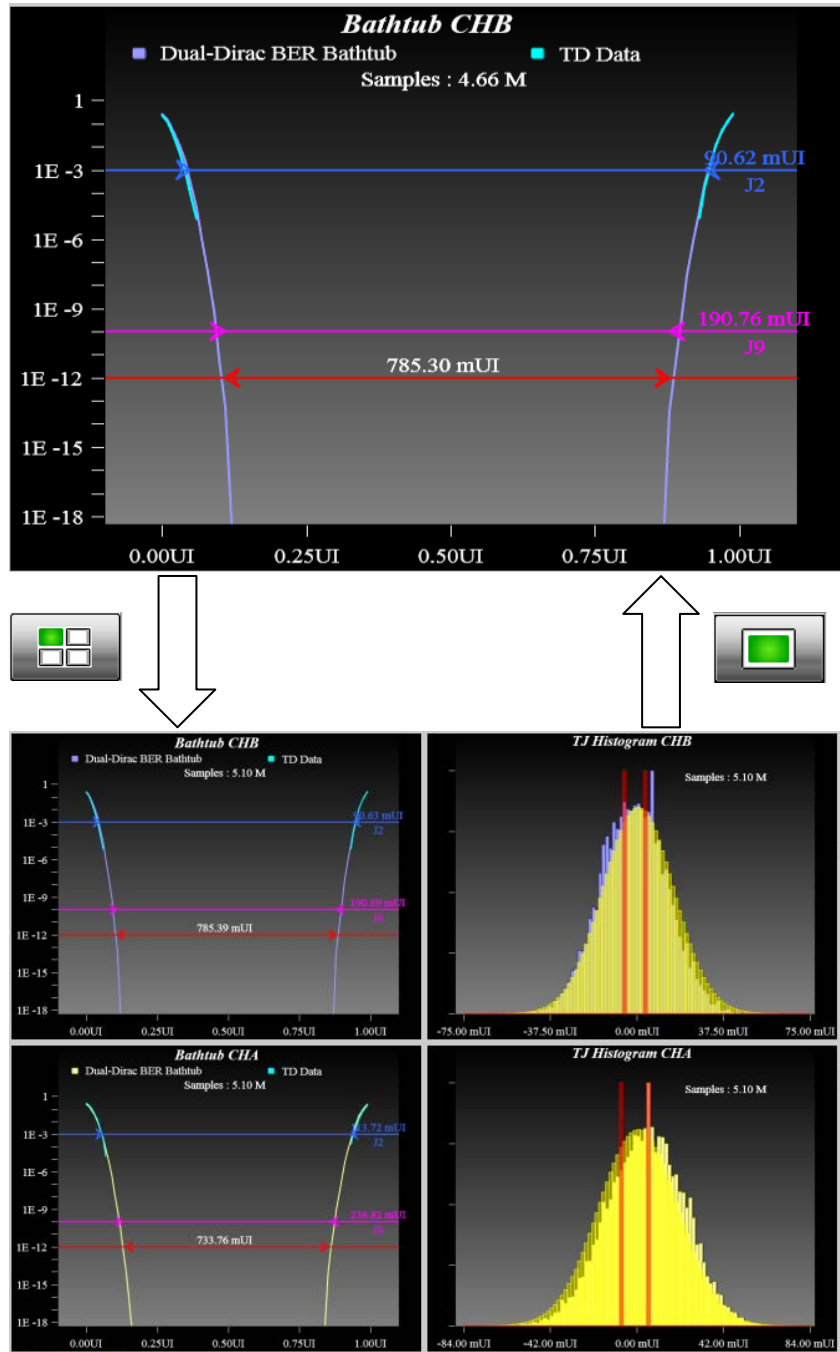
Figure 6.2.1-9 Switching Graph Display

Display of Eye Measurement

TJ Histogram

When clicking **TJ Histogram CHA** or **TJ Histogram CHB** on the scroll bar, histograms of channel A and channel B are displayed on separate screens.
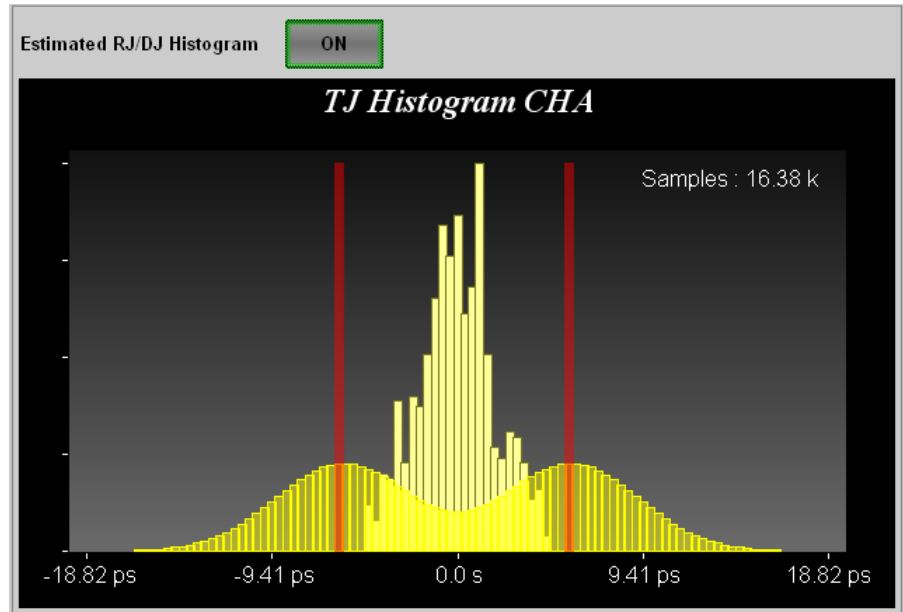
Figure 6.2.1-10   TJ Histogram CHA

Table 6.2.1-2   TJ Histogram CHA/CHB Item

Name	Description
Estimate RJ/DJ Histogram	Appears when Sampling Mode is set to **Eye**. Switches the histogram display for RJ and DJ estimated with dual dirac function. DJ amplitude is displayed with red lines.
Samples	The number of samples for the histogram

Bathtub

When clicking **Bathtub CHA** or **Bathtub CHB** on the scroll bar, the channel A and channel B bathtubs are displayed on separate screens.
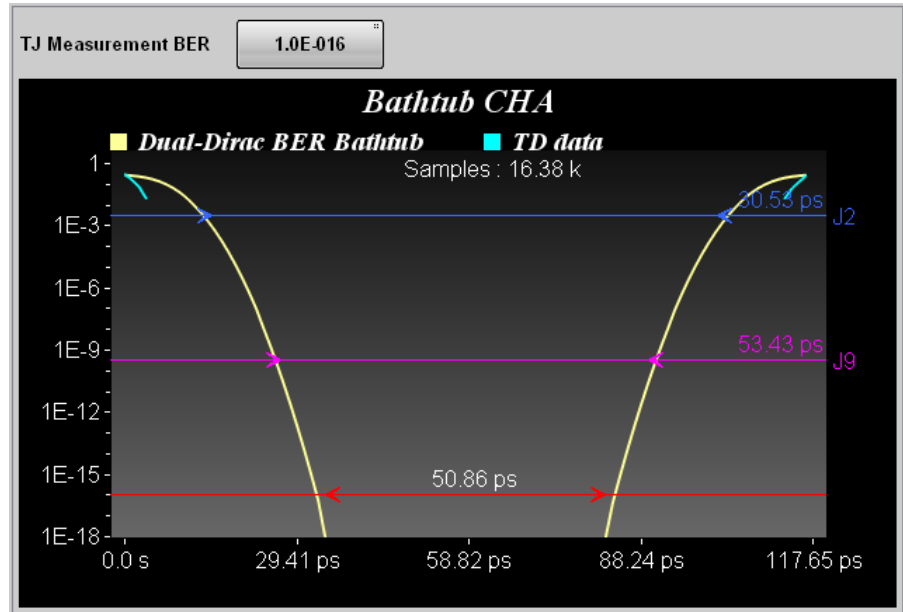
Figure 6.2.1-11   Bathtub CHA

Table 6.2.1-3   Bathtub CHA/CHB Item

Name	Description
TJ Measurement BER	Sets the BER to measure the TJ and eye opening. The red line and eye opening are displayed at the location of specified BER. The eye opening is displayed at the measurement result area.
TD data	BER curve line measured with　Scope
Dual-Dirac BER Bathtub	BER curve line approximated with the dual dirac function from TD data
J2	The location of 2.5×10^{-3} BER and TJ are displayed.
J9	The location of 2.5×10^{-10} BER and TJ are displayed.
Samples	The number of samples for the histogram

Graphs of Jitter Analysis (Advanced Jitter)

For jitter analysis (Advanced Jitter), except for the DDJ Histogram graph, the type of measurement edge (All, Fall or Rise) is displayed in the graph name. The measurement edge type is set on the Algorithm tab of the Jitter Measure dialog box.

TJ Histogram

Click **TJ Histogram** on the scroll bar to display TJ's histogram.
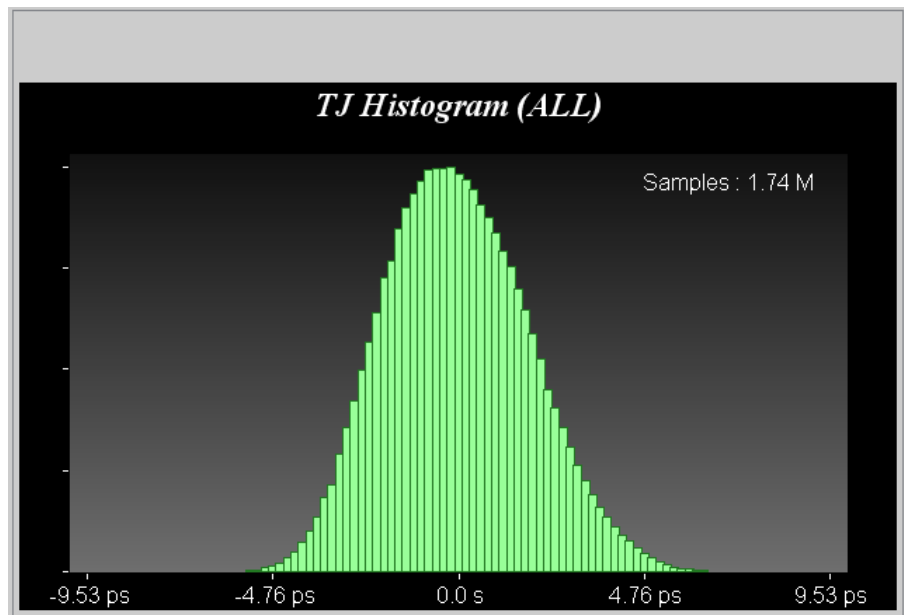
Figure 6.2.1-12   TJ Histogram

Table 6.2.1-4   TJ Histogram Item

Name	Description
Samples	The number of samples for the histogram

Bathtub

When clicking **Bathtub** on the scroll bar, the following graph is displayed.
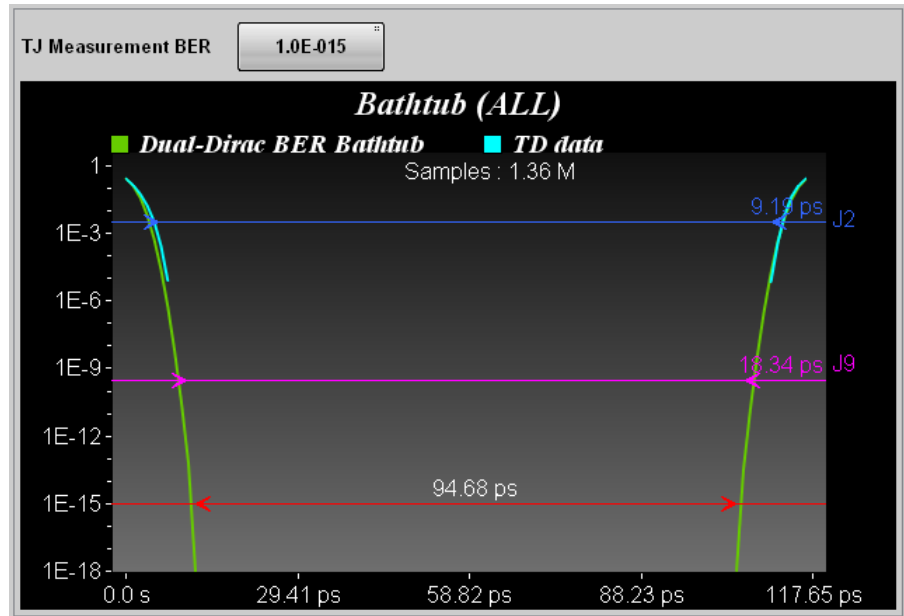
Figure 6.2.1-13   Bathtub

Table 6.2.1-5   Bathtub Item

Name	Description
TJ Measurement BER	Sets the BER to measure the TJ and eye opening. The red line and eye opening are displayed at the location of specified BER. The eye opening is displayed at the measurement result area.
TD data	BER curve line measured with EYE/Pulse Scope
Dual-Dirac BER Bathtub	BER curve line approximated with the dual dirac function from TD data
J2	The location of 2.5×10^{-3} BER and TJ are displayed.
J9	The location of 2.5×10^{-10} BER and TJ are displayed.
Samples	The number of samples for the histogram

RJ/PJ Histogram

Clicking **PJ/RJ Histogram** on the scroll bar, a histogram that is the sum of PJ and RJ is displayed.

When Estimate RJ / PJ Histogram is set to **ON**, histogram of RJ approximated by dual Dirac function is displayed in yellow and amplitude of PJ is displayed in red line.
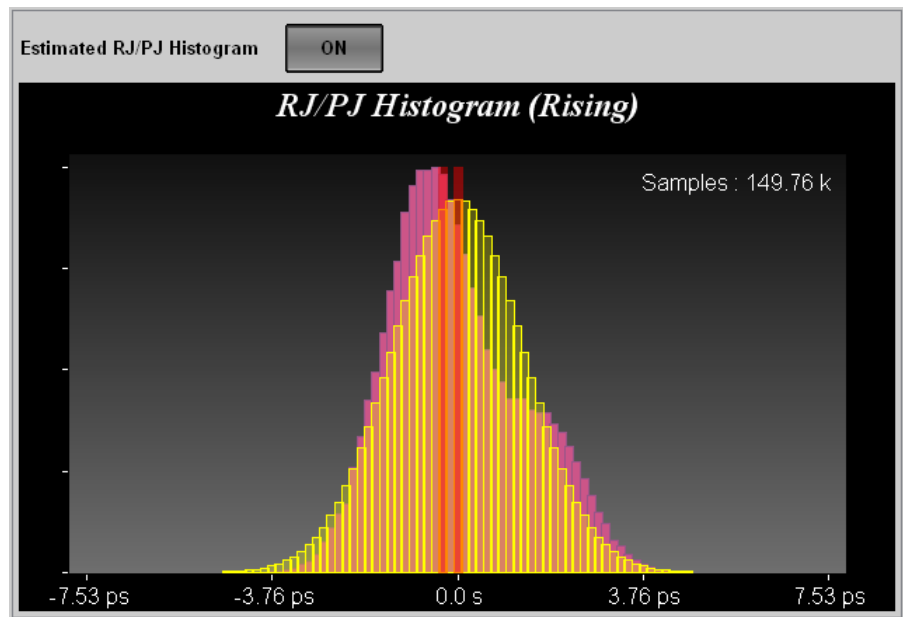
Figure 6.2.1-14   PJ/RJ Histogram

Table 6.2.1-6   PJ/RJ Histogram Item

Name	Description
Estimate RJ/PJ Histogram	Switches the histogram display for RJ and PJ estimated with dual dirac function. PJ amplitude is displayed with red lines.
Samples	The number of samples for the histogram

Composite Histogram

Click **Composite Histogram** on the scroll bar, TJ, RJ/PJ, and DDJ histograms are displayed.
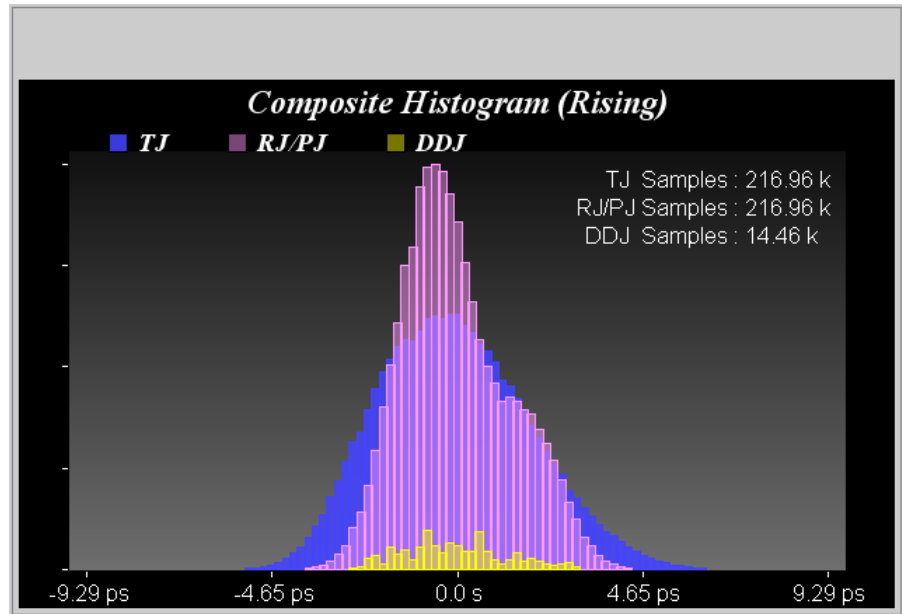
Figure 6.2.1-15   Composite Histogram

Table 6.2.1-7   Composite Histogram Item

Name	Description
TJ Samples RJ/PJ Samples DDJ Samples	The number of samples for the histogram

DDJ Histogram

Click **DDJ Histogram** on the scroll bar, the histogram of DDJ is displayed by edge.
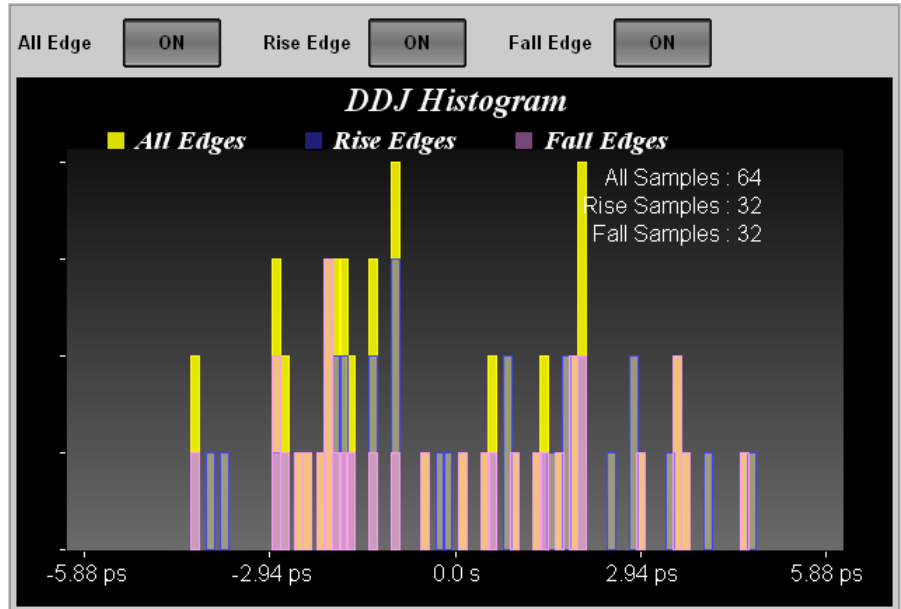
Figure 6.2.1-16   DDJ Histogram

Table 6.2.1-8   DDJ Histogram Item

Name	Description
All Edge	When the button display is **ON**, the histogram is displayed.
Rise Edge	
Fall Edge	
All Samples	The number of samples for the both edges histogram
Rise Samples	The number of samples for the rising edge histogram
Fall Samples	The number of samples for the falling edge histogram

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How to Operate Sampling Scope

PJ vs Frequency

When clicking **PJ vs Frequency** on the scroll bar, spectrum of jitter is displayed.
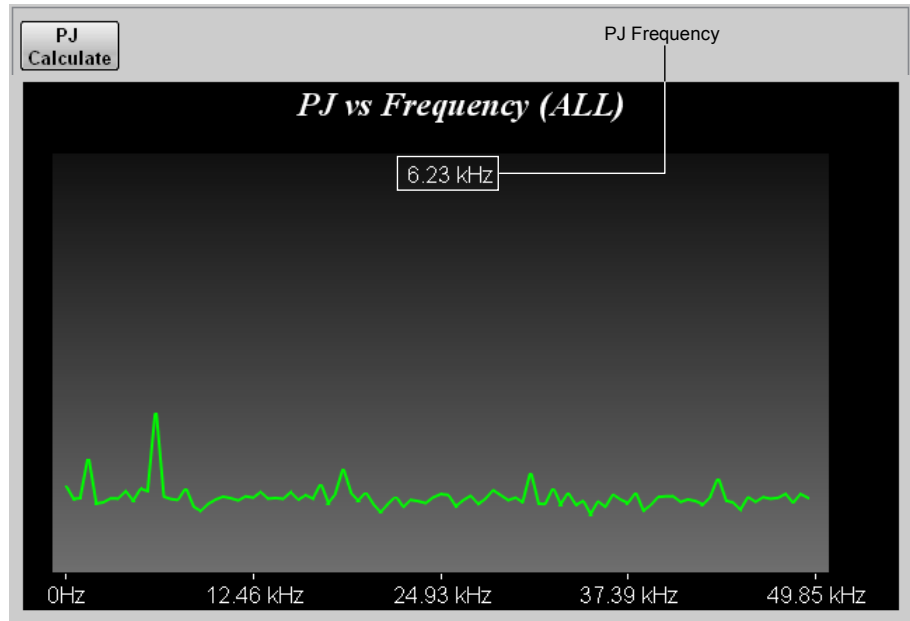
Figure 6.2.1-17   PJ vs Frequency

Table 6.2.1-9   PJ vs Frequency Item

Name	Description
PJ Calculate	Calculates the jitter peak spectrum frequency. Operatable when [Start] is displayed.
(PJ Frequency)	Spectrum peak frequency

DDJ vs Bit

When clicking **DDJ vs Bit** on the scroll bar, Pattern, and DDJ graph are displayed.

Notes:

- If PDJ measurement is **ON**, **DDJ vs Bit** changes to **PDJ vs Bit**.

- When the display range on the horizontal axis is 193 bits or more, the pattern graph (white line) is not displayed.

A red circle is displayed at the maximum position of the DDJ, and a blue circle marker is displayed at the position where the DDJ is at the minimum position.
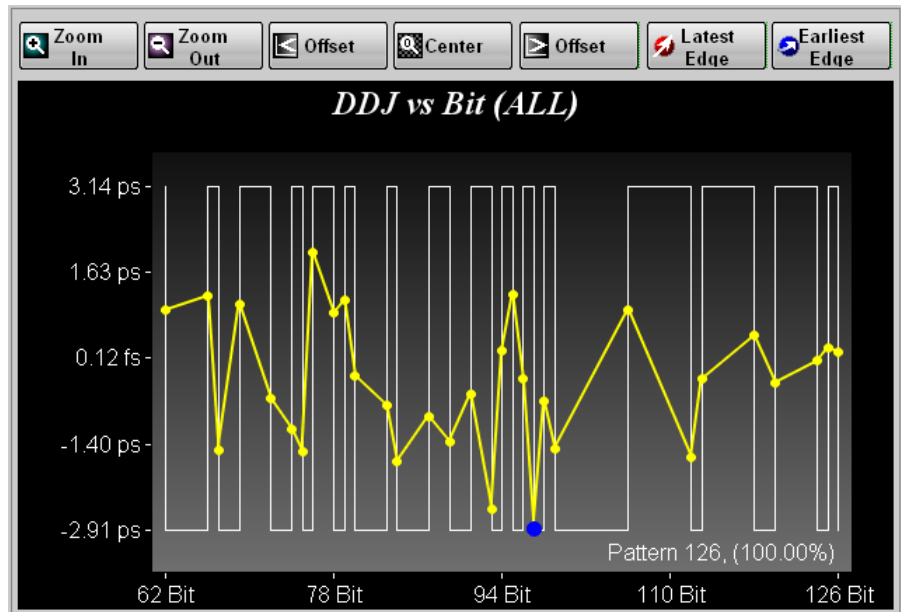
Figure 6.2.1-18   DDJ vs Bit

Table 6.2.1-10   DDJ vs Bit Item

Name	Description
Zoom In	Makes the display range of the graph half.
Zoom Out	Doubles the display range of the graph.
< Offset	Moves the display area of the graph to the left.
Center	Displays the entire range of the graph.
Offset >	Moves the display area of the graph to the right.
Latest Edge	Zooms in the location with the maximum jitter amount
Earliest Edge	Zooms in the location with the minimum jitter amount
Pattern	Displays the number of measured patterns and acquisition rate.

6.2.2 Setup Dialog Box

Click **Setup** shown in Figure 6.2.1-1, to display the Setup dialog box shown in Figure 6.2.2-1.
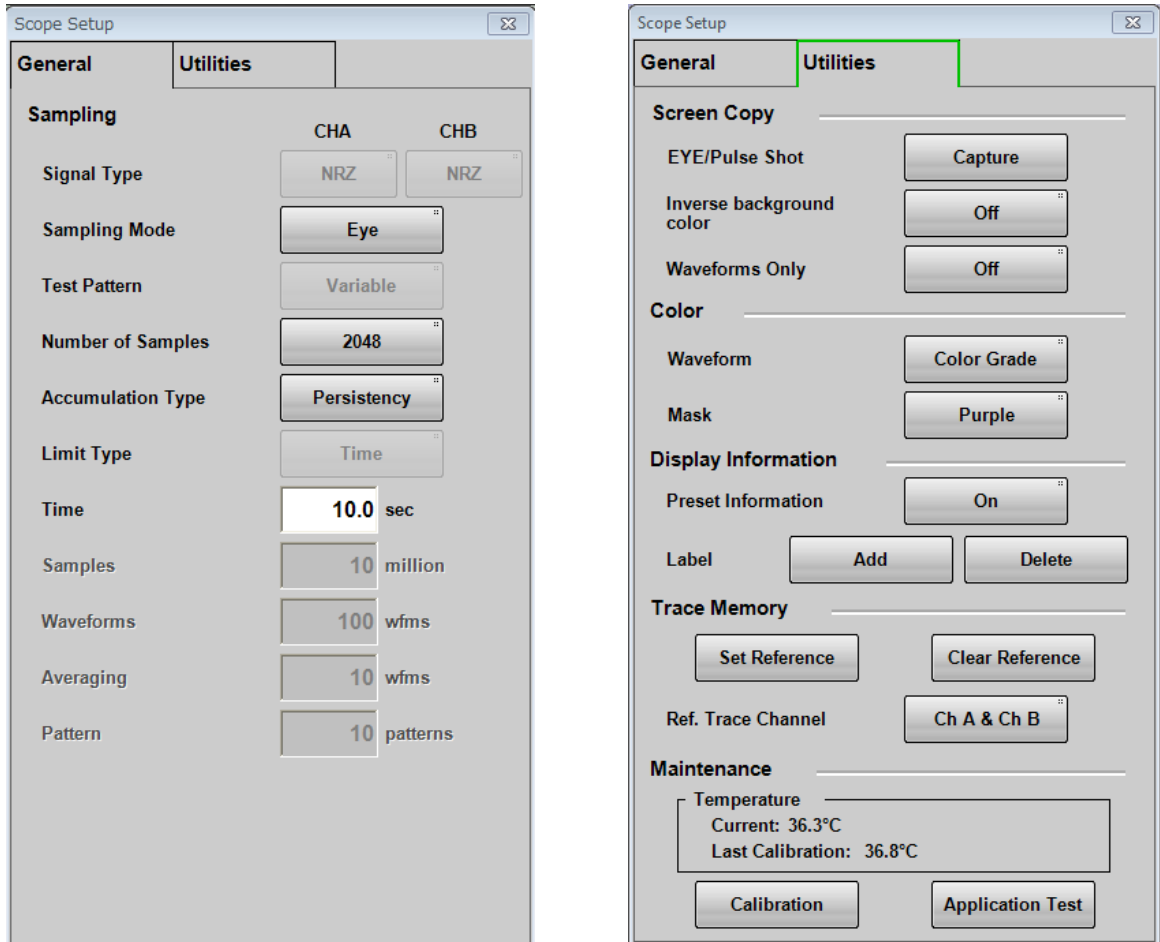
Figure 6.2.2-1   Setup Dialog Box

Table 6.2.2-1   Items of Setup Dialog Box

Tab	Item	Description
General	Signal Type	When MP2110A-095 is added, select the type of signal (NRZ or PAM4). To measure jitter, select **NRZ**.
	Sampling Mode*1	Select sampling mode from **Eye**, **Pulse**, **Coherent Eye**, **Advanced Jitter**. **Pulse**, **Coherent Eye** can not measure jitter. For the jitter graph, see Table 6.2.2-2 Sampling Mode settings and graphs.
	Test Pattern	When Signal Type is set to **PAM 4**, select the pattern from **Variable**, **PRBS 7**, **PRBS 9**, **PRBS 13**, **PRBS 15**, **SSPRQ**. When Sampling Mode is **Eye**, it is set to **Variable**.
	Number of Samples	Sets the number of samples. When Sampling Mode is set to **Advanced Jitter**, the number of samples is 8128.
	Accumulation Type	Sets the accumulation method of the sampling data.
	Limit Type	Select the sampling end condition from **Time**, **Samples**, **Waveforms**, or **Patterns**. **Patterns** can be selected when the sampling mode is **Advanced Jitter**.
	Time	Sets the sampling time.
	Samples	Sets the number of samples.
	Waveforms	Sets the waveforms. The number of samples is the product of Waveforms and Number of Samples. When Sampling Mode is set to **Advanced Jitter**, it is the number of waveform sweeps
	Averaging	When measuring the pulse mode, set the averaging process count.
	Pattern	Set the number of patterns. The number of samples is automatically set by the product of the pattern length and the number of patterns.

*1:   When MP2110A-096 is added, **Advanced Jitter** is added to Sampling
Mode.

Table 6.2.2-1   Items of Setup Dialog Box (Cont`d)

Tab	Item	Description
Utilities	EYE/Pulse Shot	Clicking **Capture** saves the screen file in the result window.
	Inverse background color	Sets the color of the save screen at EYE/Pulse Shot.
	Waveforms Only	**On**: Saves only the waveform displayed in the Result window to a file. The jitter graph is not saved. **Off**: Saves the whole Result window to a file. The jitter graph is not saved.
	Waveform Color	Selects the color of waveform from **Color Grade** or **Gray Scale**. It does not apply to jitter graphs.
	Mask Color	Selects the color of mask from **Purple** or **Gray**.
	Preset Information	**On**: Displays the setting information (vertical axis/horizontal axis scale, offset, symbol rate, status of precision trigger (On/Off)) in the waveform display area. **Off**: Hides the setting information other than GND.
	Label Add*2	Adds a new label.
	Label Delete*2	Deletes the displayed label.
	Set Reference*2	Saves the displayed waveform as the reference trace.
	Clear Reference*2	Deletes the reference trace.
	Ref.Trace Channel	Sets the channel saved in the reference trace.
	Temperature	Displays current temperature of the sampling oscilloscope and the temperature when the level is calibrated.
	Calibration*3	Calibrates the amplitude level of the sampling oscilloscope.
	Application Test*3	Runs the self test for the sampling oscilloscope.

*2: If Sampling Mode is set to **Advanced Jitter**, the setting is not reflected.

*3: Operation is not possible when Sampling Mode is set to **Advanced Jitter**.

Table 6.2.2-2   Sampling Mode Setting and Graph

Sampling Mode	Eye	Advanced Jitter
Graph to display	Bathtub (CHA) TJ Histogram (CHA) Bathtub (CHB) TJ Histogram (CHB)	Bathtub DDJ Histogram Composite Histogram DDJ vs Bit PJ vs Frequency RJ/PJ Histogram TJ Histogram

6.2.3 Measure Dialog Box

When clicking **Measure** in the Figure 6.2.1-1 Result Window, the Measure dialog box shown in Figure 6.2.3-1 is displayed.

If both Signal Type of Ch A and Ch B are set to **PAM 4** in the Setup dialog box, Mask Test tab cannot be operated.

NRZ   PAM4
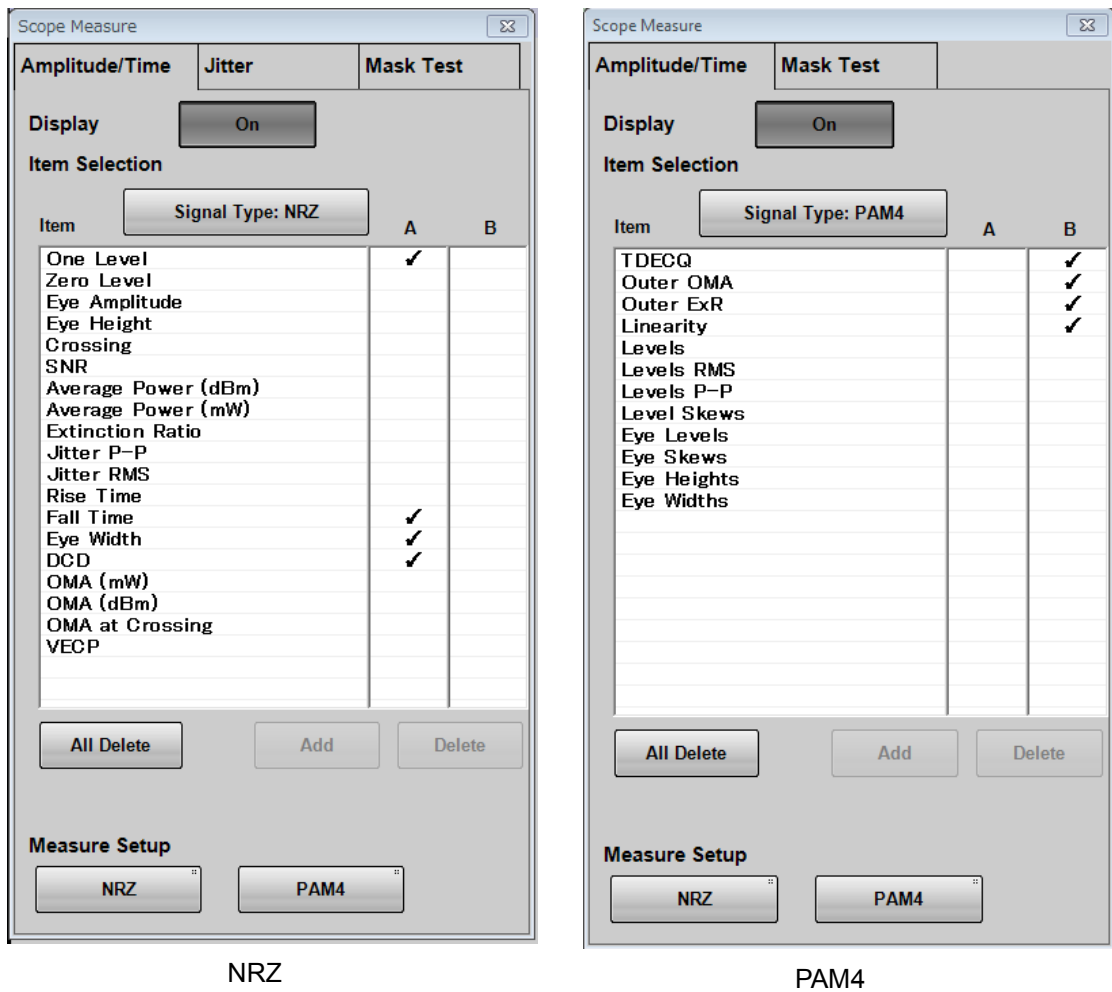
Figure 6.2.3-1   Measure Dialog Box - Amplitude/Time   tab

Table 6.2.3-1   Items of Amplitude/Time Tab

Item	Description
Display	**On**: The measurement results of Amplitude/Time are displayed in the Result window. **Off**: The Amplitude/Time measurement results are not displayed in the Result window.
Item Selection	Select measurement items. When MP2110A-095 is added, a button to switch the display of measurement items is displayed.
Item	Click column A or column B and select the item to add a display to the Result window. Click on the selected item to deselect it. Multiple cells can be selected by dragging the mouse.
All Delete	Deletes all the display of measurement items listed in Item from the Result window.
Add	Selects items in the Item list to display in the Result window.
Delete	Selects items in the Item list to remove from the Result window.
Measure Setup	Click the button to display the dialog box for setting the measurement condition. **PAM 4** is displayed when MP2110 A-095 is added.

Depending on options, the settings are restricted as follows:

Option 021

At Amplitude/Time in the Measurement dialog box, the following measurement results are invalid values.

Signal Type	NRZ	PAM4
Measurement Item	Average Power (dBm), Average Power (mW), Extinction Ratio, OMA (mW), OMA (dBm), VECP, OMA at Crossing	TDECQ, Outer OMA, Outer ExR
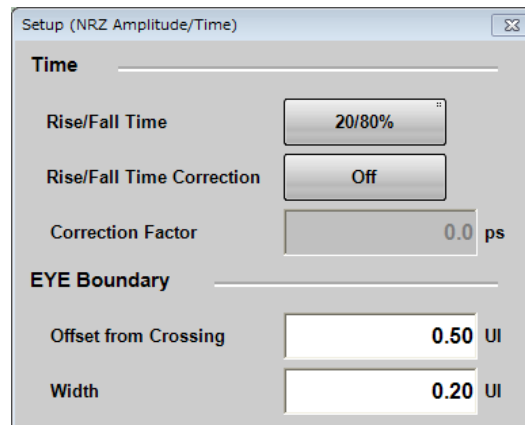
Figure 6.2.3-2   Setup (NRZ Amplitude/Time) Dialog Box

Table 6.2.3-2   Items of Setup (NRZ Amplitude/Time) Dialog Box

Item	Description
Rise/Fall Time	Sets the position to measure Rise Time and Fall Time.
Rise/Fall Time Correction	When setting to **On**, the Rise Time and Fall Time are corrected. * "Corrected" is displayed in the measured values of Rise Time and Fall Time.
Correction Factor	Sets the correction factor for Rise Time and Fall Time.
Offset from Crossing*	Sets the center position to measure One Level and Zero Level.
Width*	Sets the width for measuring One Level and Zero Level.

*:   Refer to "Figure 6.9.1.1-2   Setting Item of EYE Boundary".
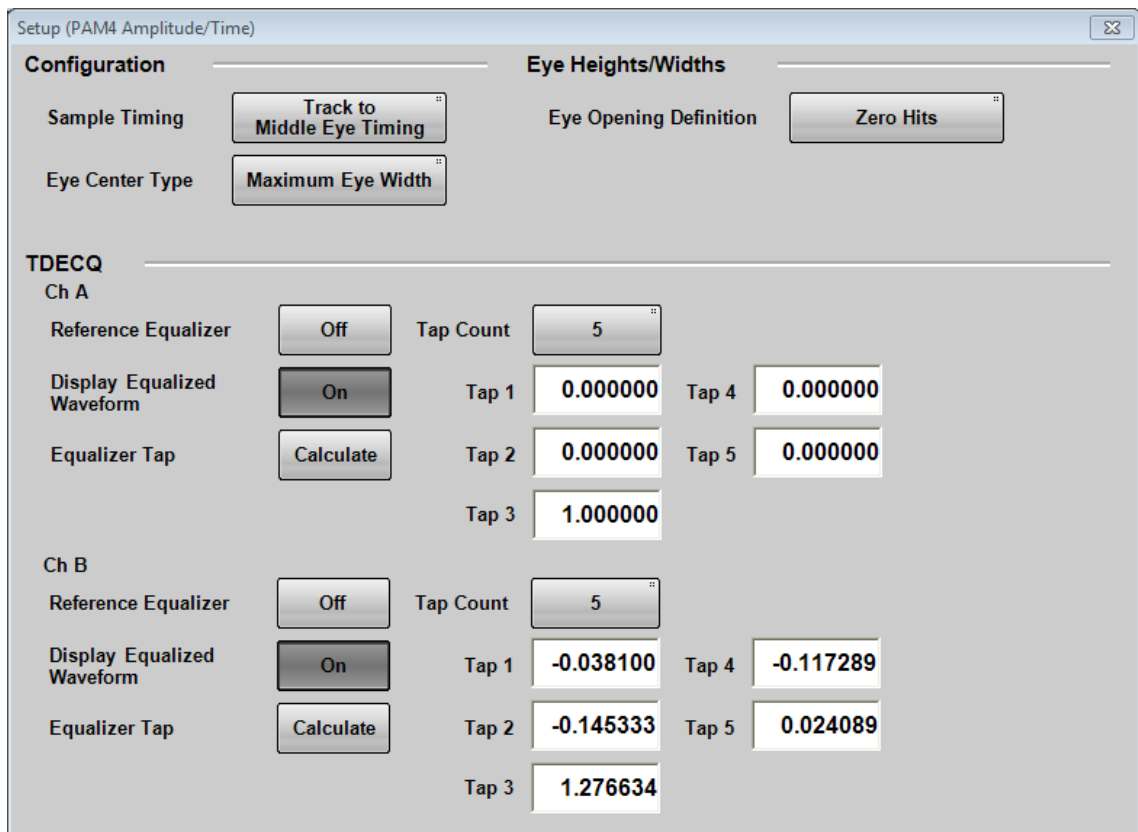
Figure 6.2.3-3   Setup (PAM4 Amplitude/Time) Dialog Box (MP2110A-022 or MP2110A-032)

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How to Operate Sampling Scope

Table 6.2.3-3   Items of Setup (PAM4 Amplitude/Time) Dialog Box

Item		Description
Configuration		
	Sampling Timing	Set the reference position of the upper eye and the lower eye. **Track to Middle Eye Timing**: Adjust to the center eye position. Refer to Figure 1.5-11. **Independent**: The reference positions of the three eyes can be set separately. Refer to Figure 1.5-10.
	Eye Center Type	Select the method to set the center position of the eye. **Width**: Based on the position where the Eye Width becomes maximum **Height**:Based on the position where the eye height becomes maximum.
Eye Heights/Widths		
	Eye Opening Definition	Defines the eye opening. **Zero Hits**:The area where sampling does not occur. **E_1** to **E_6**:The area that bit error is equal to or less than the specified value. E_1 means 10^{-1}
TDECQ*1,*2		
	Reference Equalizer	Sets whether to use the Reference Equalizer when measuring TDECQ (Transmitter and dispersion eye closure for PAM-4).
	Display Equalized Waveform	**Off**: Displays waveforms not applying Reference Equalizer. **On**: Displays waveforms applying Reference Equalizer.
	Equalizer Tap	**Calculate**:Calculate the Tap coefficient of Reference Equalizer automatically. The result of automatic calculation is displayed as Pass (success) or Fail (failure).
	Tap Count	Select the number of Tap from 5, 7, or 9.
	Tap 0 to Tap 9*3	Set the coefficient of each Tap within the range of -2.000000 to 2.000000.

*1: It is displayed for optical channel.

*2: The setting is valid when both of the following conditions are satisfied.

Sampling Mode is **Coherent Eye**

Test Patterns other than **Variable**

*3: The number displayed depends on the setting of Tap Count.
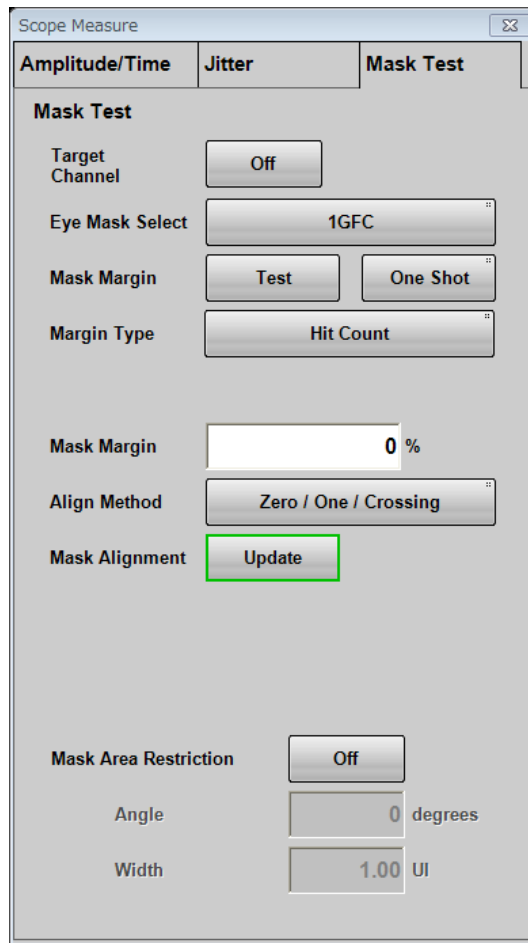
Figure 6.2.3-4   Mask Test   tab in Measure Dialog Box

Table 6.2.3-4   Items of Mask Test Tab

Item	Description
Target Channel	Selects the channel for the mask test.
Eye Mask Select	Select the Mask type. Refer to "Table 6.9.2-1 Mask List".
Mask Margin	Click **Test** to make mask tests continuously. Click **One Shot** and sampling will be stopped after mask test.
Margin Type	**Hit Count**:Judges Pass or Fail by the number of hits in the mask area. **Margin**:Judge Pass or Fail with mask margin.
Hit Count	If the number of hits measured is equal to or less than this value, it is judged as Pass.
Mask Margin	If the measured mask margin is equal to or greater than this value, it is judged as Pass.
Align Method	Set the method of mask position setting. **Zero/One/Crossing**:Determines the position of the mask with reference to the 0 level, 1 level and cross point position. **User Defined**:The user sets the position of the mask.
Alignment Marker	It is displayed when Align Method is **User Defined**. **Display Off**, **Display On**:Switches marker display. **Center**:Moves the mask to the center of the waveform display area.
X1, ΔX,, Y1, ΔY	Set mask position and width. Refer to "Figure 6.9.2-3 Example of Adjusting Mask Position Manually".
Mask Alignment	It is displayed when Align Method is [Zero / One / Crossing]. Click **Update** to update the mask position.
Mask Area Restriction	When setting to **On**, Angle and Width can be set and the mask area can be restricted. Refer to "Figure 6.9.2-4 Example of Limiting Mask Area".

When setting Sampling Mode to **Eye** or **Advanced Jitter** in the Setup dialog box, the Jitter tab will be displayed in the Measure dialog box.

When setting Sampling Mode to **Advanced Jitter** in the Setup dialog box, Mask Test tab cannot be operated.
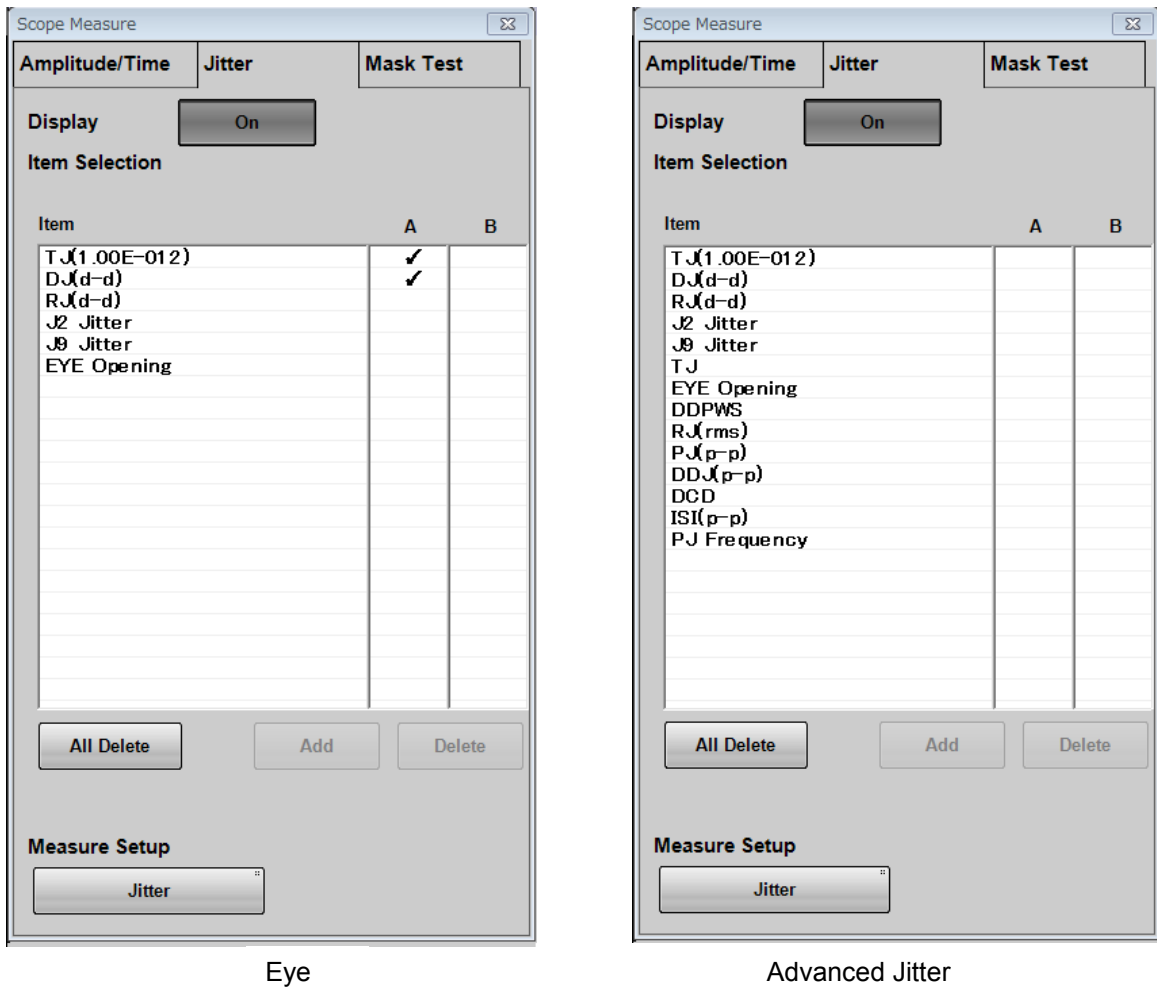
Eye   Advanced Jitter

Figure 6.2.3-5   Jitter   Tab in Measure Dialog Box

Table 6.2.3-5   Items of Measure Dialog Box

Item	Description
Display	**On**: Displays Amplitude/Time and Jitter measurement results in the Result window. **Off**: Does not display Amplitude / Time and Jitter measurement results in the Result window.
Item Selection	Select measurement items. Selects measurement items.
Item	Click column A or column B and select the item to add a display to the Result window. Click on the selected item to deselect it.
All Delete	Delete all the items of measurement items displayed in Item from the Result window.
Add	Items selected in the Item list are displayed in the Result window.
Delete	Delete the item selected in the Item list from the Result window.
Measure Setup	Click the button to display the dialog box for setting the measurement condition.

Jitter Measure Dialog Box

When clicking **Jitter** in Figure 6.2.3-5, the Jitter Measure dialog box   is displayed.

If Sampling in the Setup dialog box is **Advanced Jitter**, the **Algorithm** tab and **Advanced** tab are displayed in the Jitter Measure dialog box.
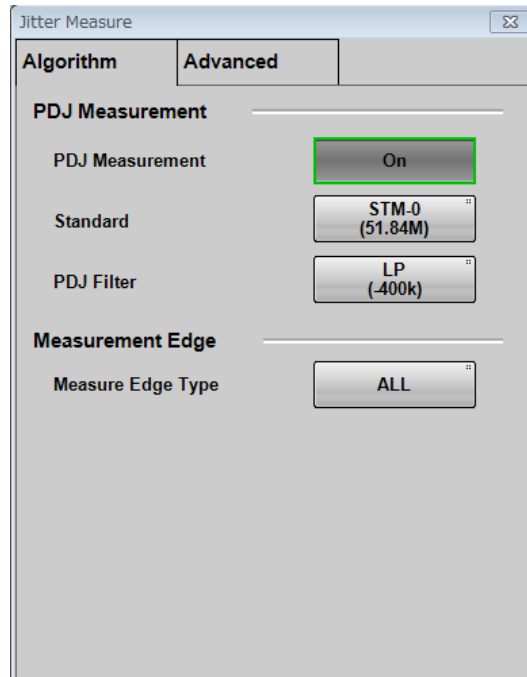
Figure 6.2.3-6   Jitter Measure Dialog Box (Algorithm Tab)

Table 6.2.3-6   Items of Jitter Measure Dialog Box (Algorithm Tab)

Item	Description
PDJ Measurement	Sets execution of PDJ measurement. PDJ (Pattern Dependent Jitter) is jitter measured by applying a band-pass filter to DDJ. **ON**: Displays PDJ vs Bit graph, **OFF**: Displays DDJ vs Bit graph,
Standard	Specify the standard used for PDJ measurement from the following. STM-0, STM-1, STM-4, STM-16, STM-64, STM-256
PDJ Filter	Set the combination of filters to be used for PDJ measurement from the following. LP, HP0+LP, HP1+LP, HP1'+LP, HP2+LP, HP+LP, HP'+LP, LP', HP0+LP' Table 6.2.3-7 shows the filter name and frequency range.
Measurement Edge Type	Set edge detection method of pattern data from All, Falling or Rising. The name you set will be displayed in the graph.

Table 6.2.3-7   Settable Standards for PDJ measurement and Filter Sets (Unit Hz)

Standard	HP0	HP1	HP1'	HP2	HP'	HP	LP	LP'
	PDJ Filter							
STM-0	10	100	–	20 k	–	12 k	400 k	–
STM-1	10	500	–	65 k	–	12 k	1.3 M	500
STM-4	10	1 k	–	250 k	–	12 k	5 M	1 k
STM-16	10	5 k	–	1 M	–	12 k	20 M	5 k
STM-64	10	20 k	10 k	4 M	50 k	12 k	80 M	20 k
STM-256	–	80 k	20 k	16 M	–	–	320 M	–

The jitter specification values specified in ITU-T G.825/Amd.1 Table 1 are shown in the following table.

Table 6.2.3-8   Maximum permissible jitter at network interfaces

Interface	Measurement bandwidth, –3dB frequencies (Hz)	Peak-to peak amplitude (UIpp)
STM-1e (Notes 1, 2)	500 to 1.3 M	1.5
	65 k to 1.3 M	0.075
STM-1 (Note 3)	500 to 1.3 M	1.5
	65 k to 1.3 M	0.15
STM-4 (Note 3)	1 k to 5 M	1.5
	250 k to 5 M	0.15
STM-16 (Note 3)	5 k to 20 M	1.5
	1 M to 20 M	0.15
STM-64 (Note 3)	20 k to 80 M	1.5
	4 M to 80 M	0.15
STM-256 (Note 3)	80 k to 320 M	1.5
	16 M to 320 M	0.18

NOTE 1 – Electrical format CMI-encoded, according to G.703.
NOTE 2 – For networks deployed with G.813 Option II clocks or G.812 Type II, III or IV clocks, STM-1 requirements apply to STM-1e.
NOTE 3 – STM-1   1 UI = 6.43 ns
STM-4   1 UI = 1.61 ns
STM-16   1 UI = 0.402 ns
STM-64   1 UI = 0.100 ns
STM-256 1 UI = 0.025 ns

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How to Operate Sampling Scope

When the Sampling Mode of the Setup dialog box is **Advanced Jitter**, the Advanced tab   is displayed in the Jitter Measure dialog box.
When the Sampling Mode of the Setup dialog box is **Eye**, the tabs for channel A (Ch A) and channel B (Ch B) are displayed, and the items on the Advanced tab for each channel can be set.

	Jitter Measure
Algorithm	**Advanced**
TJ Measurement BER	1.00E-012
Fixed RJ	
Fixed RJ	Off
RJ Value	1.00 ps rms
Correction Factor	
Correction Factor	Off
DJ(Scale)	1.00
RJ(Scale)	1.00
RJ(rms)	1.00 ps rms
Threshold Level	
Define Threshold	Auto
Manual Crossing	50 %

Advanced Jitter

	Jitter Measure
Ch A	**Ch B**
TJ Measurement BER	1.00E-012
Fixed RJ	
Fixed RJ	Off
RJ Value	1.00 ps rms
Correction Factor	
Correction Factor	Off
DJ(Scale)	1.00
RJ(Scale)	1.00
RJ(rms)	1.00 ps rms
Threshold Level	
Define Threshold	Auto
Manual Crossing	50 %

Eye

Figure 6.2.3-7   Jitter Measure Dialog Box (Advanced Tab)

Table 6.2.3-9   Items of Jitter Measure Dialog Box

Item	Description
TJ Measurement BER	Sets the bit error rate to measure the eye opening in the Bathtub graph.
Fixed RJ	Set **OFF** to display the graph using RJ calculated from the measured waveform. Set **ON** to display TJ graph by setting RJ an arbitrary value. It is used to simulate the change of TJ by changing RJ value.
RJ Value	TJ is calculated with the use of the value entered here when Fixed RJ is set to **ON**.
Correction Factor	Can be operated while [Sampling] lamp is lit. (Refer to "Figure 6.2.1-7 Result Window".) When setting the display to **ON**, DJ (Scale), the correction coefficients of RJ (Scale) and RJ (rms) can be entered. And the jitter values corrected by these correction coefficients are displayed in brown in the measurement result display area.
DJ (Scale)	It is the correction coefficient of DJ. The value calculated from the waveform multiplied by this number is displayed in the measurement result. Set to 1.00 for no correction.
RJ (Scale)	It is the correction coefficient of RJ. The value calculated from the waveform multiplied by this number is displayed in the measurement result. Set to 1.00 for no correction.
RJ (rms)	RJ (d-d), RJ (rms) correction coefficient. RJ is corrected with the following formula. $$RJ = \sqrt{\sigma_m{}^2 - \sigma_r{}^2}$$ σ_m: Standard deviation of measured RJ σ_r: Correction Coefficient RJ: RJ(d-d), RJ(rms) after correction. When not correcting, set Correction Factor to **OFF**.
Define Threshold	Sets the position detection method of the cross point relative to the amplitude of the eye pattern. Set it to **Auto** for automatic detection and [Manual] to specify the position.
Manual Crossing	When Define Threshold is **Manual**, set the cross point position within the range of 30 to 70% of the amplitude.

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How to Operate Sampling Scope

6.2.4 Amplitude, O/E Dialog Box

When clicking **Amplitude O/E** in Figure 6.2.1-1 "Result Window", to display the Amplitude dialog box shown in Figure 6.2.4-1. O/E tab appears if the optical input connector has equipped.
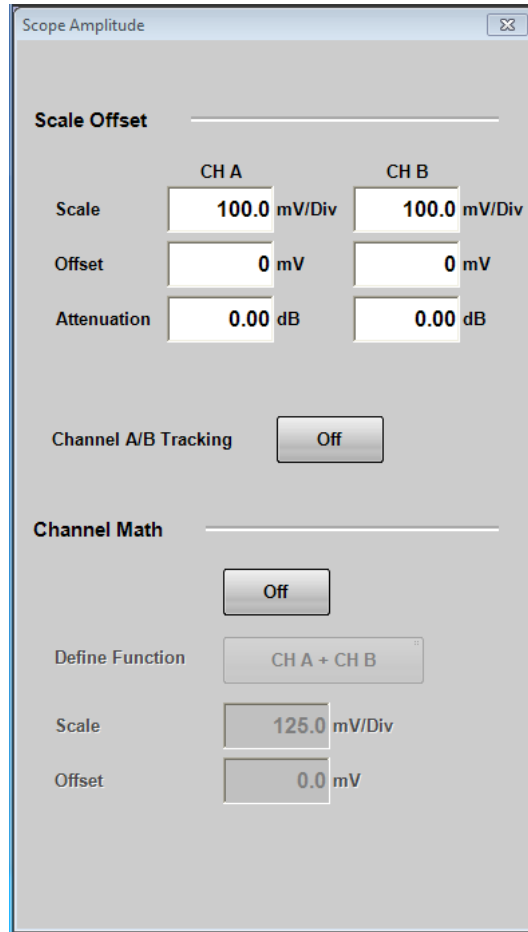
Figure 6.2.4-1   Amplitude Dialog Box (When MP2110A-021)
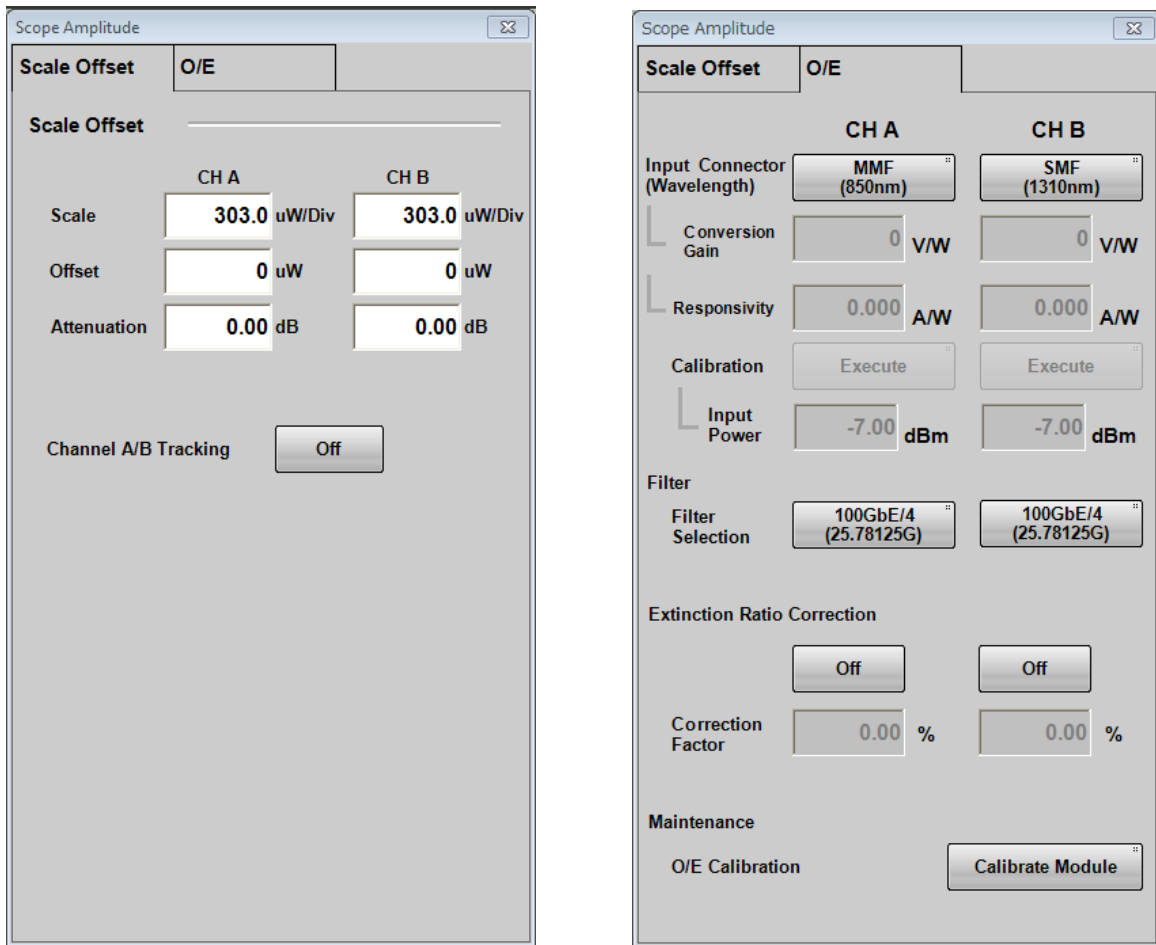
Figure 6.2.4-2   Amplitude Dialog Box (When MP2110A-022, 032)
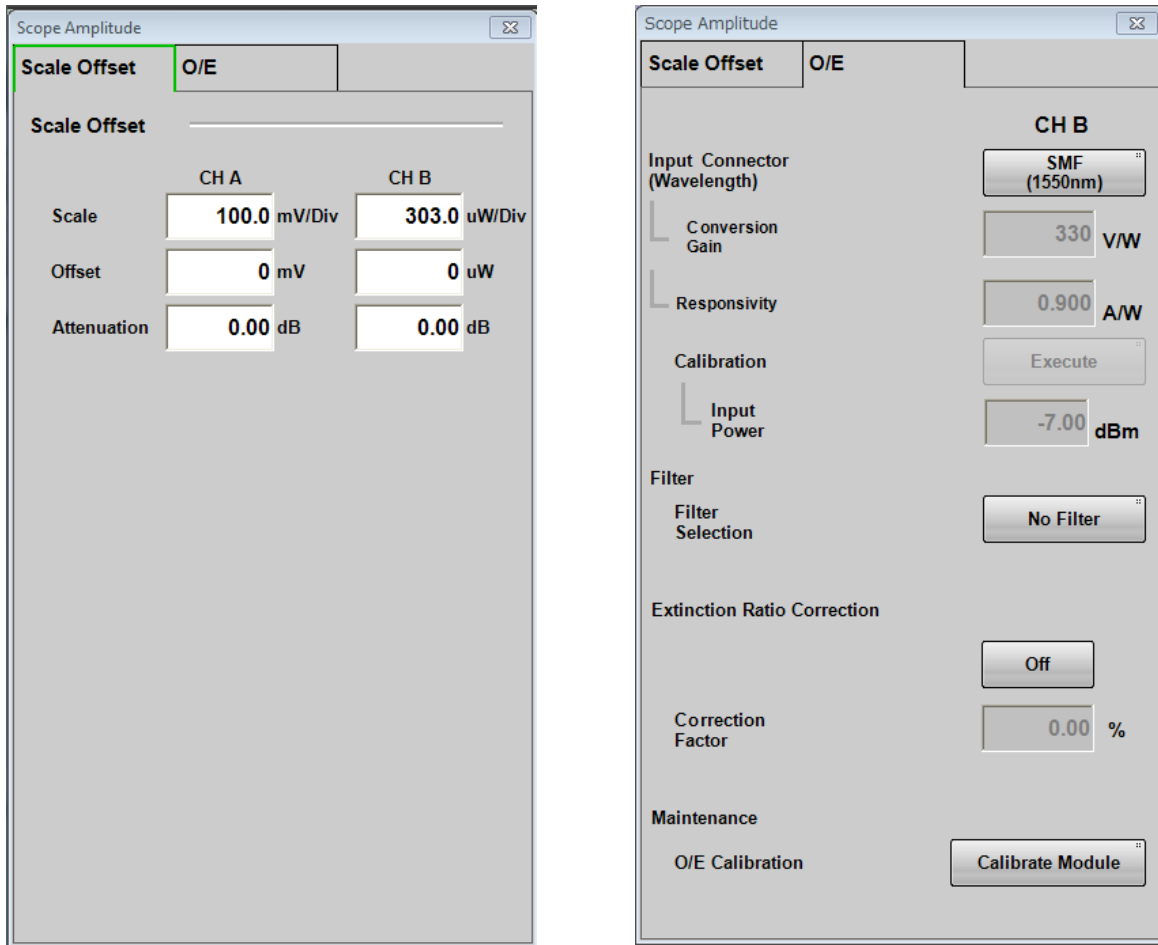
Figure 6.2.4-3   Amplitude Dialog Box (When MP2110A-023, 033)

Table 6.2.4-1   Items of Amplitude Dialog Box

Tab	Item	Description
Scale Offset	Scale Offset	Sets the level scale for Channel A and B.
	Scale	Sets vertical scale.
	Offset	Sets vertical offset.
	Attenuation	Sets attenuation amount for external attenuation.
	Channel A/B Tracking	Off: Sets scales for Channel A and B separately. On: Sets scales for Channel A and B as the same value.
	Channel Math*1	Off: Displays waveforms for Channel A and B separately. On: Calculates waveforms for Channel A and B, and then that calculated result is displayed as Channel A.
	Define Function*1	Sets calculation method between channels.
	Scale	Sets vertical scale for calculation result between channels.
	Offset	Sets vertical offset for calculation result between channels.
O/E	Input Connector (Wavelength)	Select the wavelength of input light from the following: MMF connector: 850 nm, User SMF connector: 1310 nm, 1550 nm, User
	Conversion Gain*1, *2	Indicates the conversion ratio of the O/E. The setting range is from 1 to 9999 (V/W).
	Responsivity*2	Rate at which photodiode converts optical power to current The setting range is from 0.001 to 65.535
	Calibration*2	Automatically adjusts the values of Conversion Gain and Responsivity when Wavelength is **User**.
	Input Power*2	Setting used when performing calibration of Conversion Gain and Responsivity.
	Filter Selection*1	When MP2110A-095 is added, **400GbE_8_SMF**, **400GbE_8_MMF** and **400GbE_8** are added. Since these filters use digital signal processing, they can be used under the following conditions. • Sampling Mode is set to **Coherent Eye** • Test Pattern is set to other than **Variable**
	Extinction Ratio Correction	Sets whether to correct the Extinction Ratio measurement. This correction is applied to the results of Extinction Ratio and Outer ExR
	Correction Factor	Indicates the correction factor of Extinction Ratio The setting range is from –9.99 to 9.99%.
	O/E Calibration	Starts module calibration.

*1:   When Sampling Mode is set to **Advanced Jitter**, it can be operated while stopping measurement.

*2: When 850 nm, 1310 nm, or 1550 nm is selected at Wavelength, the values calibrated before factory shipment are set at **Conversion Gain** and **Responsivity**.

To measure an optical signal at the other wavelength than 850 nm, 1310 nm, or 1550 nm by selecting **User** at **Wavelength**, change the setting values of **Conversion Gain** and **Responsivity** according to the changed wavelength. For the way to change the setting values, refer to 6.3.3, "Adjusting values for changing the wavelength bands".

Depending on options, the settings are restricted as follows:
Option 023, 025, 026, 033, 035, 036
Channel A/B Tracking and Channel Math are not displayed in the Amplitude dialog box.

6.2.5 Time, CRU Dialog Box

When clicking **Time** in Figure 6.2.1-1 "Result Window", Time dialog box shown in Figure 6.2.5-1 is displayed..
If MP2110A-054 is added, CRU tab is displayed.
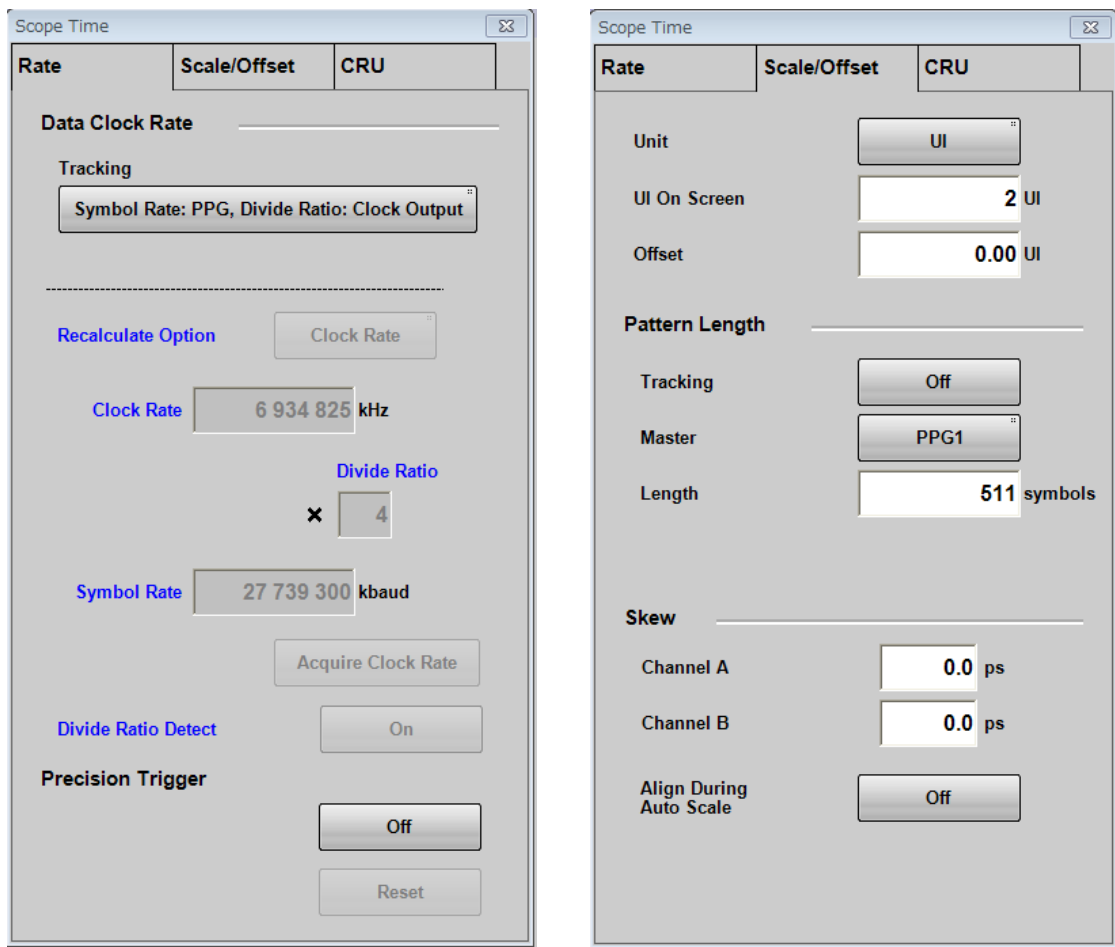
Figure 6.2.5-1 Time Dialog Box (Rate Tab, Scale/Offset Tab)
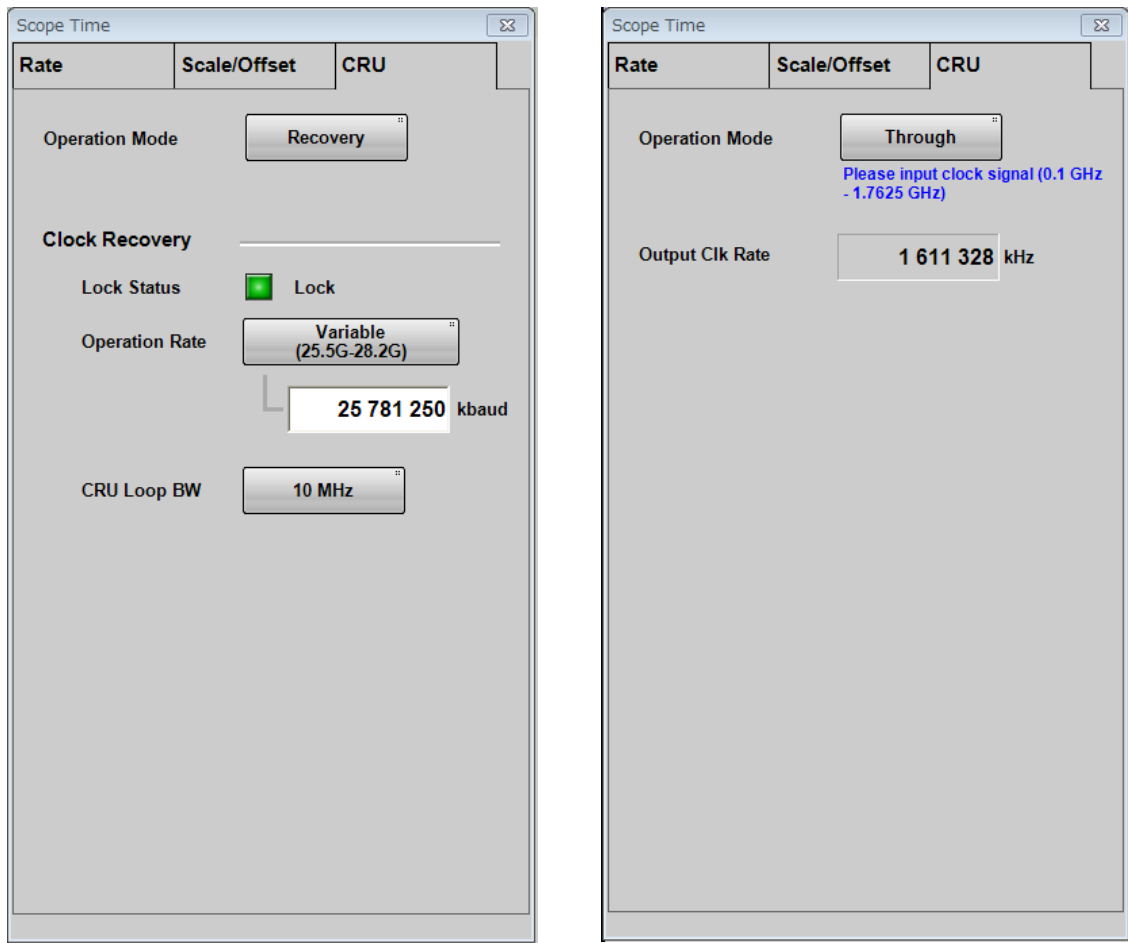
Figure 6.2.5-2 Time Dialog Box (CRU Tab)

Table 6.2.5-1 Items of Time Dialog Box

Tab	Item	Description
Rate	Data Clock Rate	Sets input data speed, clock frequency, and frequency dividing rate.
	Tracking*1	Specifies Symbol Rate whether to follow the Bit Rate of PPG/ED Ch1. **Off**: Symbol Rate does not follow PPG Bit Rate. **Symbol Rate: PPG, Divide Ratio:Clock Out**: 　　Symbol Rate follows PPG Bit Rate. 　　Divide Ratio follows PPG Clock Out. **Symbol Rate: PPG, Divide Ratio:Sync Out**: 　　Symbol Rate follows PPG Bit Rate. 　　Divide Ratio follows PPG Sync Out. **Symbol Rate: PPG, Divide Ratio:User**: 　　Symbol Rate follows PPG Bit Rate. **Symbol Rate: CRU, Divide Ratio: 2***2: 　　Symbol Rate follows CRU Rate. 　　Divide Ratio is 2.
	Recalculate option	Clock Rate: Calculates Clock Rate from Symbol Rate and Divide Rate Symbol Rate: Calculates Symbol Rate from Clock Rate and Divide Rate.
	Clock Rate	Sets clock frequency input to **Trigger Clk In** connector.
	Divide Ratio	Sets frequency dividing rate (Symbol Rate/Clock Rate).
	Symbol Rate	When Tracking is **Off**, Sets signal symbol rate to be measured.
	Acquire Clock Rate	Measures clock frequency input to **Trigger Clk In** connector.
	Divide Ratio Detect	Sets whether to detect frequency dividing ratio of clock signal input to **Trigger Clk In** connector. The automatic detection of the dividing ratio and the Divide Ratio resetting are preformed when this item is set to On or Auto Scale is executed.
	Precision Trigger*3	
	On, Off	Enables or disables the precision trigger.
	Reset	Resynchronizes the trigger when the precision trigger is set to On.

*1: An error message is displayed because the Tracking operation is not performed when one or both of the following conditions is/are met.

- When Reference Clock of PPG is set to **External**, Tracking is set to other than **Off**.
- When Clock Out of PPG is set to **Off**, Tracking is set to **Clock Out**.

*2: If MP2110A-054 is added

*3: If MP2110A-024 is added

Table 6.2.5-1   Items of Time Dialog Box (Cont'd)

Tab	Item	Description
Scale/Offset	Unit	Sets units of horizontal axis on screen.
	UI on Screen	Sets the scale on the horizontal axis of the screen as the number of unit intervals.
	Offset	Sets time on left side of screen.
	Pattern Length	Sets input data pattern length.
	Tracking	**Off**: Allows you to directly set the pattern length in the **Length** box. **On**: Sets pattern length selected at Master to Length.
	Master	Selects the item that reflects the pattern length.
	Length	Sets the pattern symbol length. If the Test Pattern of the General tab in the Setup dialog box is **Variable**, specify the symbol length.
	Skew	Sets time offset. Setting positive values moves the waveform to the right. Setting negative values moves the waveform to the left.
	Align During Auto Scale	**On**: Automatically adjusts the Skew setting value to display the waveforms of both Channel A and Channel B in the center when executing Auto Scale.
CRU	Operation Mode	Selects the operation of the clock recovery unit. **OFF**: Clock is not output from the **CRU Out** connector. **Recovery**: The clock recovered from the data signal input to the **CRU In** connector is output to the **CRU Out** connector. **Through**: The data signal input to the **CRU In** connector is output to the **CRU Out** connector as it is.
	Clock Recovery	Sets the clock recovery unit when Operation Mode is **Recovery**.
	Lock Status	Whether or not the clock recovery unit is synchronized with the input signal is indicated. Green: The clock output from **CRU Out** is synchronized with the input data signal. Red: The clock output from **CRU Out** is NOT synchronized with the input data signal. Off: Operation Mode is **OFF** or **Through**.
	Operation Rate	Selects the operating frequency of the clock recovery unit. Specifies the symbol rate (kbaud) if the Operation Rate is **Variable**.
	CRU Loop BW	Selects the loop bandwidth of the clock recovery unit.
	Operation Clk Rate	When Operation Mode is **Through**, the frequency of the clock input to the **CRU In** connector is displayed.

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Depending on options, the settings are restricted as follows:

Scope Option

There are the following restrictions when Option 011, 012, or 014 is not added.
● Tracking cannot be set to On at Data Clock Rate in the Time dialog box.
● Tracking cannot be set to On at Pattern Length in the Time dialog box.

6.3 Calibration and Adjustment

6.3.1 Calibrating Level

The amplitude accuracy of the sampling oscilloscope is guaranteed after performing calibration.

When the calibration is required, the error message "Calibration is required" is displayed in the Setup dialog box in red.

Perform the calibration, when using the MP2110A for the first time or the message is displayed.

The calibration procedures are as follows:

1.   Check that no signals are input to the front-panel **Ch A In**, **Ch B In**, or **Trigger Clk In** connectors.

2.   Click **Setup** to open the Setup dialog box.

3.   Click the **Utilities** tab.

4.   Click **Calibration**, and then the message is displayed to confirm that the signal is not input to the connector.
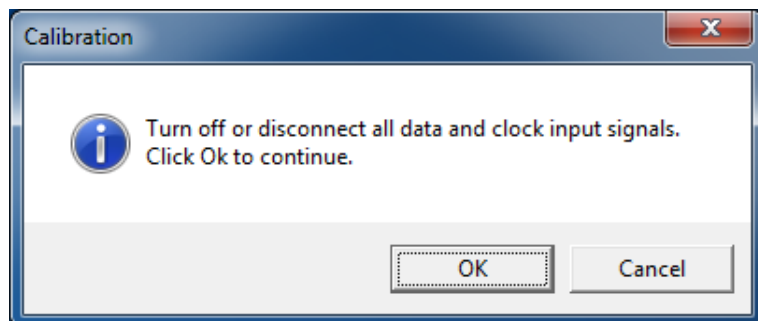
5.   Click **OK**.

Upon completion of the calibration, a dialog box appears and gives you the calibration result.
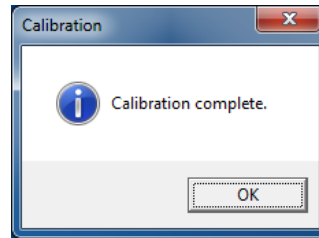
Figure 6.3.1-1   Calibration Result Display
(When Calibration Is Successful)
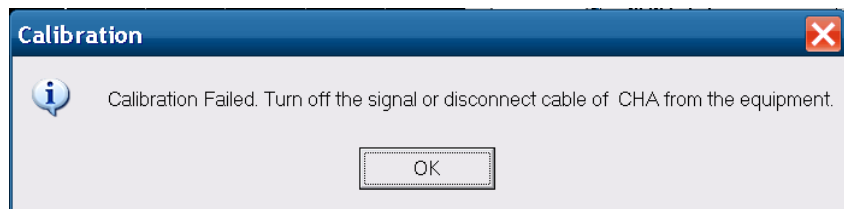
When the Calibration of CHA Fails
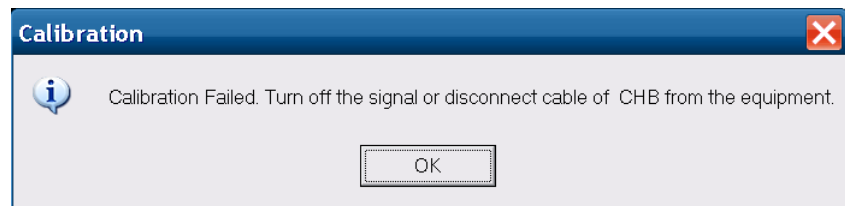
When the Calibration of CHB Fails
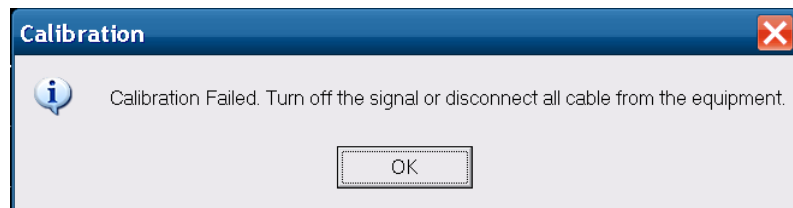
When the Calibration of CHA and CHB Fails

Figure 6.3.1-2   Calibration Result Display (When Calibration Fails)

If the calibration fails, follow the instruction that applies to your situation, and then retry from step 2.

● Check that the coaxial cable is not connected to any of the **Ch A In**, **Ch B In** and **Trigger Clk In** connectors on the front panel.
● If it is required to keep the coaxial cables connected to the **Ch A In**, **Ch B In** and **Trigger Clk In** connectors on the front panel, check that the connectors do not receive any incoming signal.

6.3.2 Adjusting Dark Current

When light is not input to the Optical connector, the O/E module output voltage is adjusted.
The output voltage of the O/E module used changes depending on the ambient temperature.
Calibrate the MP2110A before using the optical connector.

1.   Confirm that no light has been input to the optical connector (SMF or MMF).

2.   Click **Calibrate Module**.

3.   The window confirming that the light is not input is displayed. Click **OK**.

4.   In about 5 seconds from step 3, the dialog box appears indicating that the calibration is complete. Click **OK**.

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6.3.3 Adjusting values for changing the wavelength bands

To measure an optical signal at the other wavelength band than 850 nm, 1310 nm or 1550 nm, adjust the values of Conversion Gain and Responsivity.

Warm up the O/E module at least one hour because the output voltage varies depending on the ambient temperature. Additionally, be sure to calibrate the sampling oscilloscope before performing adjustment.

<Adjusting Manually>

Adjustment method of Conversion Gain

1. Adjust the wavelength of the optical power meter to the optical signal.
2. Measure unmodulated optical signal power with the optical power meter.
3. Input the optical signal to the optical input connector.
4. Measure the average of the optical signal power by using the Histogram function of the sampling oscilloscope.
5. Click **Amplitude**.
6. Click the **O/E** tab.
7. Select **User** for the connector of the optical signal input at Input Connector (Wavelength).
8. Adjust the Conversion Gain value so that the average of the optical signal power measured by the Histogram function of the sampling oscilloscope becomes equal to the value measured by the power meter. The System Conversion Gain value is automatically set by setting the Conversion Gain value.

Adjustment method of Responsivity

1. Adjust the wavelength of the optical power meter to the optical signal.
2. Measure unmodulated optical signal power with the optical power meter.
3. Input the optical signal to the optical input connector.
4. Measure the Average Power (mW) or Average Power (dBm) of the optical signal by using the Amplitude/Time function of the sampling oscilloscope.
5. Click **Amplitude**.
6. Click the **O/E** tab.
7. Select **User** for the connector of the optical signal input at Input Connector (Wavelength).
8. Adjust the Responsivity value so that the Average Power value of the optical signal measured by the Amplitude/Time function of the

sampling oscilloscope becomes equal to the value measured by the optical power meter.

<Adjusting Automatically by Auto Correction>

1. Adjust the wavelength of the optical power meter to that of the optical signal.

2. Measure unmodulated optical signal power with the optical power meter.

3. Input the optical signal to the optical input connector.

4. Click **Amplitude**.

5. Click the **O/E** tab.

6. Select **User** for the connector of the optical signal input at Input Connector (Wavelength).

7. Set the Input Power to the value of the optical signal power measured by Step 2.

8. Click **Execute** to calibrate automatically.

9 When Auto Correction is completed, the values of Conversion Gain, and Responsivity are adjusted so that they become equal to the values measured by the optical power meter.

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6.3.4 Performing Self Test

Perform the self test in the following cases:

- When the error message is displayed after level calibration referring to 6.3.1 "Calibrating Level"
- When the noise voltage is over the specified value shown in Appendix A when the signal is not input
- When the waveform is not displayed, the displayed waveform amplitude and bit cycle is different from the expected value, and the MP2110A operation and measurement results are abnormal.

The application self test runs following items.

- Power

If the test result is normal, "passed" is displayed, on the other hand, if the test result is abnormal, "failed" is displayed.

The self test procedures are as follows.

1. Check that no signals are input to the front-panel **Ch A In**, **Ch B In**, **Trigger Clk In** connectors.
2. Click **Setup** to open the Setup dialog box.
3. Click the **Utilities** tab.
4. Click **Application Test**. The self test dialog box is displayed while the self test is running.
5. After the self test is completed, the result is displayed.

When the power supply test result is failed:
1. When the power voltage is displayed, record the value.
2. If the power supply test result shows "failed", contact an Anritsu Service and Sales office.

When the frequency test result is failed:
1. Check that no signals are input to the **Trigger Clk In** connector.
2. Perform the self test again.
3. If the frequency test result shows "failed", calibrate the sampling oscilloscope again. And then, perform the self test again. Nonetheless, in cases where the test result fails, contact an Anritsu Service and Sales office.
4. Perform the self test again.

5. Nonetheless, in cases where the test result fails, contact an Anritsu Service and Sales office.

When the amplitude test result is failed:

1. Check that no signals are input to the **Ch A In**, **Ch B In** connectors.

2. Perform the self test again.

3. If the amplitude test result shows "failed", calibrate the sampling oscilloscope again.

4. Perform the self test again.

5. Nonetheless, in cases where the test result fails, contact an Anritsu Service and Sales office.

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6.4 Setting CRU

The clock recovery unit (CRU) generates a clock signal from the signal input to **CRU In** connector.

The waveform can be observed by using the generated clock signal.

The clock recovery unit sets the following.

- Operation Rate
- CRU Loop BW

Operation Rate sets frequency range.

CRU Loop BW is a loop filter bandwidth that is used in the frequency control circuit of the clock recovery unit.
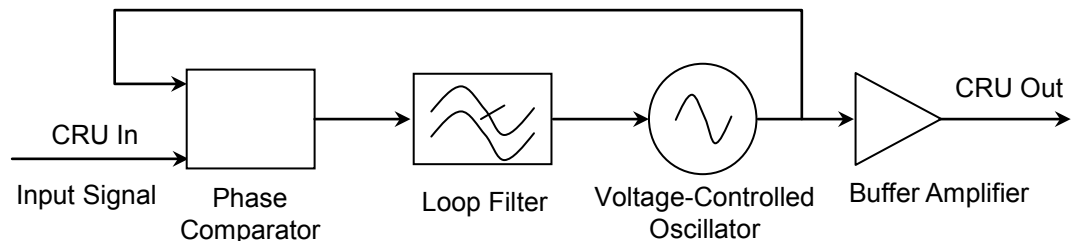
Figure 6.4-1   Block Diagram of Clock Recovery Unit

A wider frequency bandwidth can absorb more frequency fluctuations that occur momentarily. The loop filter bands for the Jitter measurement are defined in the communication standards.

⚠ CAUTION

- **The impedance of the CRU In and CRU Out connectors is 50 Ω. If you use a coaxial cable with impedance other than 50 Ω, or connect a device with impedance other than 50 Ω, the measurement may not be performed properly.**

- **The CRU Out connector output voltage is 0.4 to 0.8 Vp-p. Make sure that the voltage output to the connectors does not exceed the input voltage range of a device to be connected. The voltage amplitude to be output to the CRU Out connector exceeds the input voltage range of a device to be connected, install an attenuator to the CRU Out connector.**

- **The amplitude of the signal input to the CRU In connector is 0.8 Vp-p max. This is equivalent to +2 dBm for a sine-wave signal. Inputting a signal with a larger voltage risks damaging the internal circuits.**

Procedure

1. Connect the **CRU Out** and **Trigger Clk In** connectors with a supplied U-link coaxial cable (SMA).

U Link Coaxial Cable (SMA)
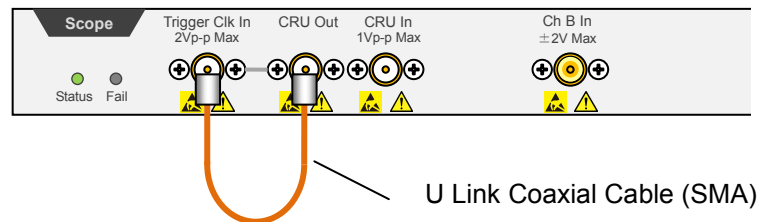
If the Scope module is equipped with **O/E Monitor Out** connector, Clock Recovery can be executed from Channel B optical signal input by connecting the **O/E Monitor Out** and **CRU In** connectors with a U-link coaxial cable (K). If the **O/E Monitor Out** and **CRU In** connectors are not connected, make sure to install a coaxial terminator to the **O/E Monitor Out** connector.

U Link Coaxial Cable (SMA)   U Link Coaxial Cable (K)
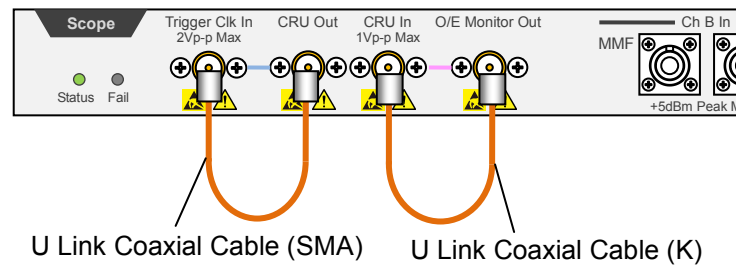
2. Input the signal to the **CRU In** connector.

3. Click **Time CRU**.

4. Click **CRU** tab.

5. Click the Operation Mode button and set the display to **Recovery**. When synchronized with the input signal to **CRU In**, the Lock Status lamp is lit green.

    If the Lock Status lamp is not lit, "CRU Unlock" is displayed in the Result window.
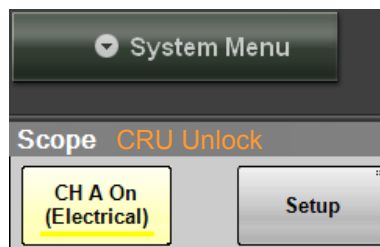
6. Click the Operation Rate button and set the symbol rate.

7. Click the CRU Loop BW button and select the loop bandwidth from the following.

    [4 MHz], [10 MHz], [Bitrate/1667]

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8. Click **Rate** tab.

9. Click the Tracking button and set the display to **CRU**.

Notes:

*   When the clock recovery unit is not used, set Clock Recovery to **OFF** on the CRU tab.

*   If the frequency of the input signal to the clock recovery unit is outside the frequency band set for Operation Rate, the clock recovery unit may not recover the clock. At that time, "CRU Unlocked" is displayed in the Result window.

*   When the clock recovery unit is used, the symbol rate displayed at the bottom right in the waveform area may not be a desired value. At that time, check the signal waveform, frequency, and amplitude to input to the clock recovery unit. Click **Acquire Clock Rate** on the **Rate** tab after the Lock Status lamp is lit green and the CRU is synchronized.

6.5 Setting Rate

The trigger clock synchronized with the input signal is required to collect data.

When BERT is installed in MP2110A, the synchronizing clock (Sync Out) can be used as the trigger clock.

When MP2110A-054 waveform analyze clock recovery is installed, the clock recovery unit can be set.

After the trigger clock is input to the MP2110A, set the symbol rate, clock rate, and divide ratio.

The symbol rate is the modulation speed of input signal to **Ch A In** or **Ch B In**.
The clock rate is the frequency of the trigger clock.
Divide Ratio is the ratio between data symbol rate and clock rate.
The value should be inputted to complete the following formula.

Symbol Rate = Clock Rate × Divide Ratio

⚠ CAUTION

- **The impedance of the Trigger Clk In connector is 50 Ω. Measurement may not be performed correctly if a cable with another impedance is used.**

- **The amplitude of the signal input to the Trigger Clk In connector is 2 Vp-p max. This is equivalent to + 10 dBm for a sine-wave signal. Inputting a signal with a larger voltage risks damaging the internal circuit**

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6.5.1 Setting Symbol Rate

Set the symbol rate of the signal input to **Ch A In** or **Ch B In**.

1. Click **Time**.

2. Click **Rate** tab.

3. Click the Tracking button of the Data Clock Rate to set to **Off**.

4. Click the Recalculate Option button to select **Clock Rate**.

5. Click the Divide Rate text box and input the division ratio.

6. Click the Symbol Rate text box and input the symbol rate.
   The clock rate is calculated by the division rate and symbol rate.

   Set the symbol rate and division rate so that the clock rate will be 15 000 000 kHz or less.

When BERT (MP2110A-011, MP2110A-012, or MP2110A-014) is installed, the bit rate value of PPG can be set to the symbol rate of the sampling oscilloscope using the following procedure.

1. Click **Time**.

2. Click **Rate** tab.

3. Click the Tracking button of the Data Clock Rate to select one of the following.

   Symbol Rate: PPG, Divide Ratio: Clock Output

   Symbol Rate: PPG, Divide Ratio: Sync Output

   Symbol Rate: PPG, Divide Ratio: User Defined

   When **Symbol Rate: PPG, Divide Ratio: User Defined** is selected, set Divide Ratio.

4. Connect the **Trigger Clk In** connector of Scope and a BERT connector.
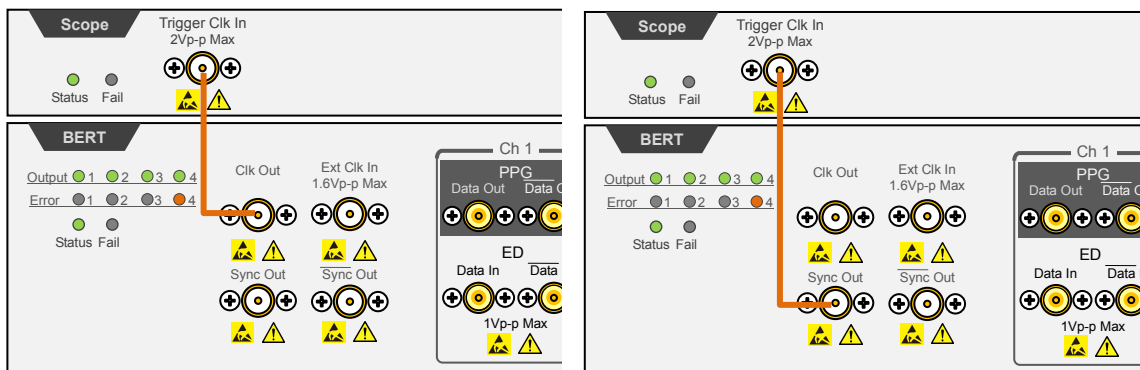
Bit Rate: PPG, Divide Ratio: Clock Output Is Selected   Bit Rate: PPG, Divide Ratio: Sync Output Is Selected

When **Symbol Rate: PPG, Divide Ratio: User Defined** is selected, input clock with the divided frequency of **Clk Out**, **Data Out**, or **Data Out** signal from BERT to the **Trigger Clk In** connector of Scope.

6.5.2 Setting Clock Rate and Divide Ratio

The symbol rate can be set by measuring the clock rate from the signal input to the **Trigger Clk In** connector of the front panel.

1. Click **Time**.

2. Click **Rate** tab.

3. Click the Tracking button of the Data Clock Rate to set to **Off**.

4. Click the Recalculate Option button to select **Symbol Rate**.

5. Click **Acquire Clock Rate**.
   The frequency is displayed in the Clock Rate text box.

   Confirm the waveform and signal level input to the **Trigger Clk In** connector when the frequency is not displayed.

6. When the clock frequency is not displayed at Clock Rate or the displayed frequency is not correct, click the Clock Rate text box and input the frequency.

7. Click the Divide Ratio text box and input the divide rate.
   The symbol rate is calculated by the divide rate and clock rate.

When using the BERT Sync Out as an external clock, the divide ratio is set as follows.

Sync Output settings	Pattern	Divide Ratio
1/8 Clock	–	8
1/16 Clock	–	16
1/40 Clock	–	40
Pattern Sync	PRBS 2^7–1	127
	PRBS 2^9–1	511
	PRBS 2^15–1	32767
	PRBS 2^23–1	8388607
	PRBS 2^31–1	214748647

When setting Sync Output to Pattern Sync, the data cannot be collected.

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6.6 Setting Pattern Length

When the Pulse mode is set as described in Section 6.7 "エラー! 参照元が見つかりません。", the pattern length can be set.
In the Pulse mode, the pattern is synchronized by collecting data at the pattern length time cycle.

6.6.1 NRZ

1.   Click **Time**.

2.   Click **Scale/Offset** tab.

3.   Click the Tracking button at Pattern Length, and then set to **Off.**

4.   Click the Length text box at Pattern Length.

5.   Input the pattern length by the symbol unit.

Note:

    The settable pattern length is up to 32768 (2^{15})

    When Text Pattern at PPG/ED is 2^31–1, Tracking cannot be set to **On** at Pattern Length.

    When Pattern Length Tracking is set to **On**, Test Pattern at PPG/ED cannot be set to 2^31–1.

When changing the PPG/ED pattern length settings using the MP2110A, the changed setting values can be set to the sampling oscilloscope automatically.

1.   Click **Time**.

2.   Click **Scale/Offset** tab.

3.   Click the Tracking button at Pattern Length, and then set to **On**.

4.   Click the Master button at Pattern Length.

5.   Select the PPG and ED with equal pattern lengths.

6.   Click the Length button of Pattern Length.

7.   Select Pattern Length.   Input Pattern Length when **Variable** is selected.

Table 6.6-1   Setting Length

Length	Pattern Length (symbols)
PRBS 2^7–1	127
PRBS 2^9–1	511
PRBS 2^13–1	8191
PRBS 2^15–1	32767
SSPRQ	65535

6.6.2 PAM4

1. Click **Setup**.

2. Click the Test Pattern button to select **Pattern Length**. Input Pattern Length when **Variable** is selected.

6.7 Collecting Data

The data collection method is composed of the following types.

Data synchronized method: Eye mode, Pulse mode, Coherent eye mode

Cumulative display for waveform: None, Infinite, Limited, Persistency, Average

Note:

In this document, measurement of one data item on the screen is described as "data capture" while obtaining one screen of data is described as "data collection".

To switch to Eye/Pulse/Coherent Eye mode

1. Click **Setup**.
2. When MP2110A-095 is installed, click the Signal Type button and select **NRZ** or **PAM4**.
3. In the Setup dialog box, click the Sampling Mode button to change it to **Eye**, **Pulse**, or **Coherent Eye**.

The Coherent Eye mode is used when calculating the waveform of Channel A and Channel B.
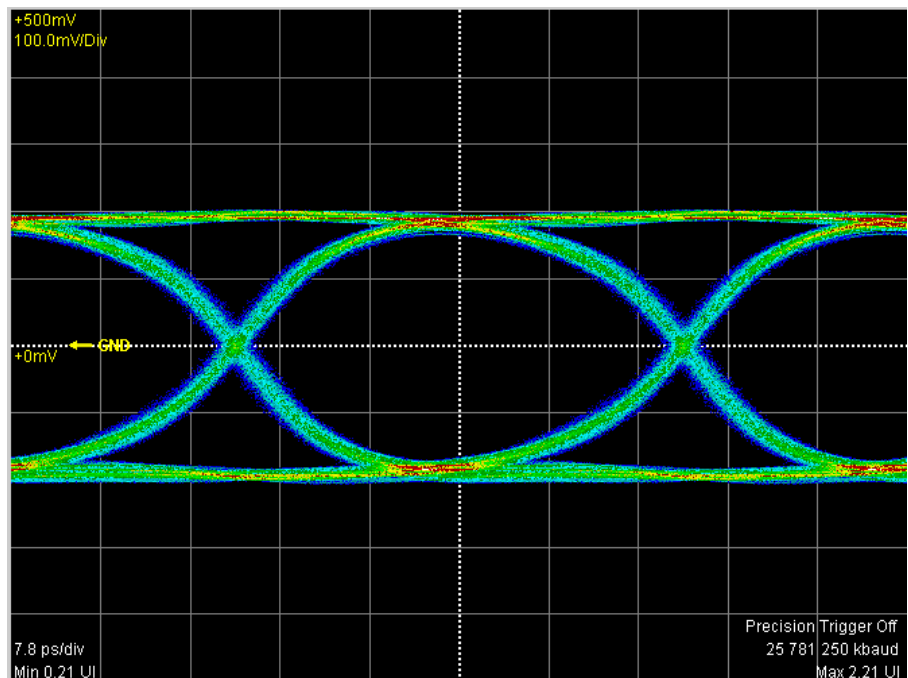
Figure 6.7-1   Eye Mode/Coherent Eye Mode Display Example
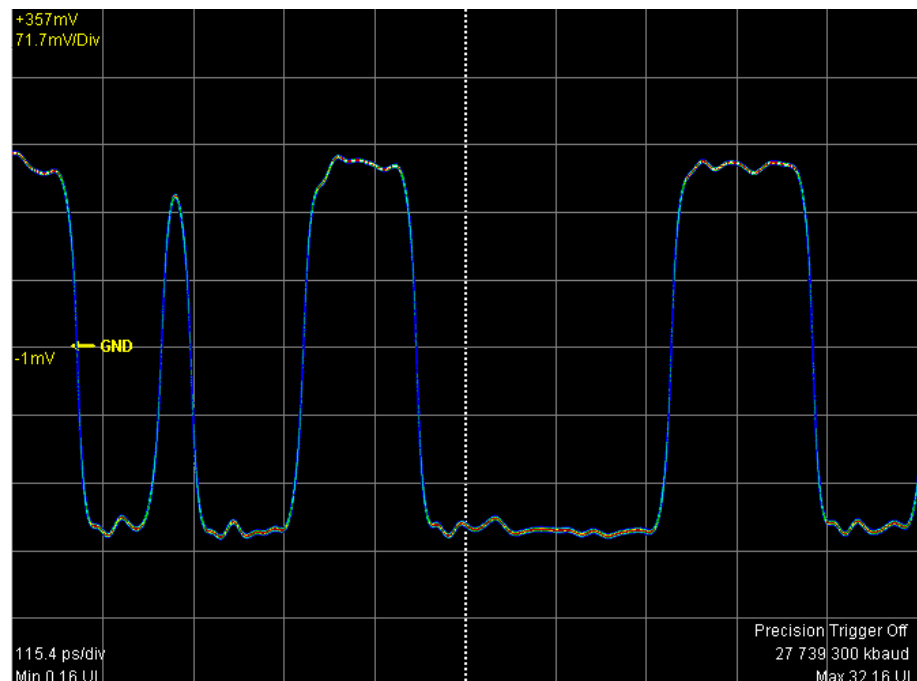
Figure 6.7-2 Pulse Mode Display Example

Setting overwritten waveform display

When setting the display method to **Infinite**, **Limited** or **Persistency**, the acquired data is overwritten on the screen.

1. Click **Setup** to open the Setup dialog box.

2. Select the single waveform data collection count from the following Number of Samples.

   For **Eye**: 1350, 2048, 4050

   For **Pulse**, **Coherent Eye**:

   512, 1024, 2048, 4096, 8192, 16384

   When Test Pattern is other than **Variable** in Coherent Eye, Number of Samples is fixed to **16384**.

   When there is only a small amount of captured data, the screen refresh time is short.

3. Click the Accumulation Type button, and set the items from the following lists:

   Infinite: Unlimited time to overwrite waveform

   Limited: The waveform is overwritten at the set time until it reaches the number of data or the numbers of waveforms. Data collection stops at the set time or when the data count is reached.

   Persistency: Deletes overwritten data after fixed time elapsed

4. When selecting **Limited** at step 3, set the at-end condition.

    ● To end overwriting waveform when the set time is passed, set Limit Type to **Time**.
    Click the Time text box to input the time.

    ● To end overwriting waveform when the data count set at the screen is reached, set Limit Type to **Sample**.
    Click the Samples text box to input the number of data.

    ● To stop waveform overwriting when the set time has elapsed, set Limit Type to **Waveform**.
    Click the Waveforms text box to input the number of waveforms.

5. When **Persistency** is selected at step 3, set the time for saving the overwritten data.
    Click the Time text box to input the time.

Deleting overwritten waveform display

1. Click **Setup** to open the Setup dialog box.

2. Click the Accumulation Type button to select **None**.

3. Click the Number of samples button to select the number of data displayed on the screen from the following:

    For **Eye**:   1350, 2048, 4050

    For **Pulse**, **Coherent Eye**:
                512, 1024, 2048, 4096, 8192, 16384
                When Test Pattern is other than **Variable** in Coherent Eye, Number of Samples is fixed to **16384**.
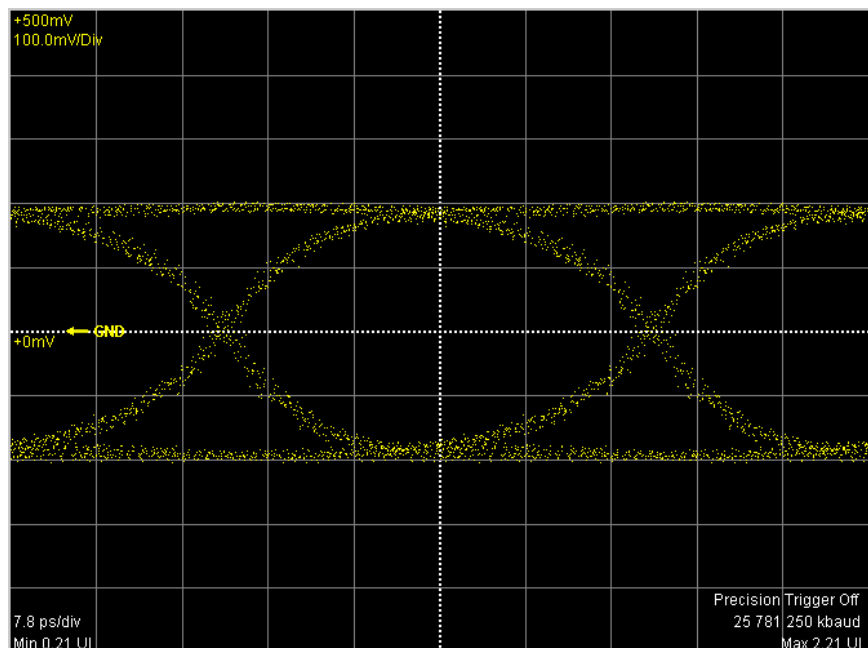
Figure 6.7-3   Accumulation Type Settings (None)
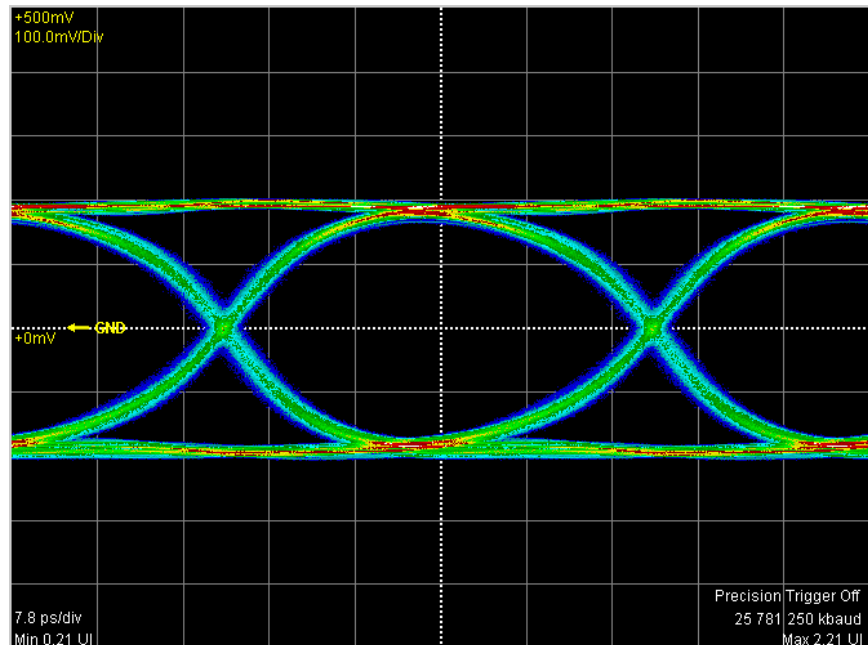
Figure 6.7-4   Accumulation Type Settings (Infinite)

Displaying averaging waveform

When setting the display method to **Averaging** at the pulse mode, the averaging process is performed. Averaging process is used to suppress waveform noise.

Note:

When **Averaging** is set, the precision trigger is disabled even when **Precision Trigger** is set to On.

1.   Click **Setup** to open the Setup dialog box.

2.   Click the Accumulation Type button to select **Averaging**.

3.   Click the Number of Samples button to select the number of data displayed on the screen.

4.   Click the Averaging text box to set the number of waveforms to perform averaging.

In averaging, the mean value of the data count input at Averaging   is calculated and the results are displayed on the screen. However, when 1 is input, no averaging is performed.
The number of averaging waveforms is displayed on the screen while executing averaging.
The waveform is captured a hundred times when the following condition is set, and a hundred averaging waveforms are displayed.

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- Accumulation Type   Average
- Averaging   100 wfms

Averaging 1   Averaging 100
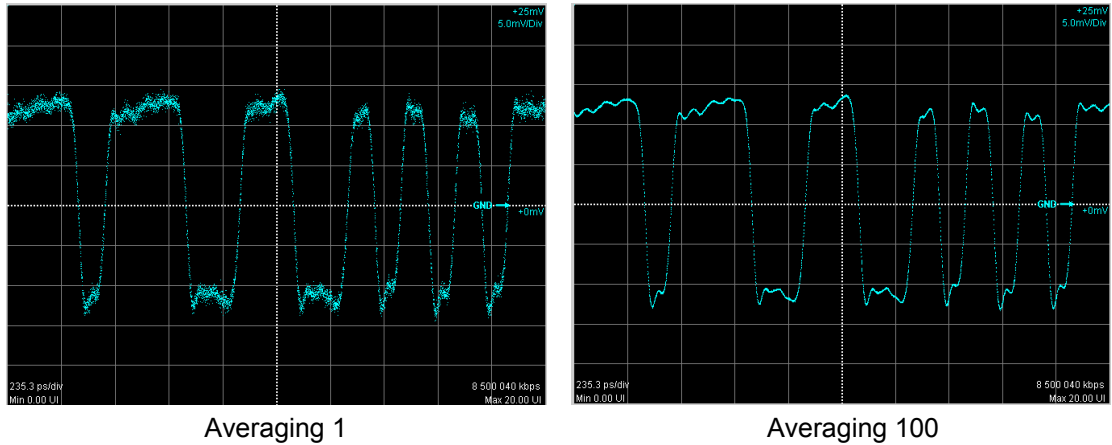
Figure 6.7-5   Example of Averaging Process

The averaging is calculated using the following formula.

Number of waveforms ≤Averaging setting count:

$$Ave(n) = \frac{(n-1) \times Ave(n-1) + S(n)}{n}$$

Averaging setting count ≤ Number of waveforms:

$$Ave(n) = \frac{(M-1) \times Ave(n-1) + S(n)}{M}$$

Ave(n): Averaging value
S(n):   Measurement value
M: Averaging setting count
n: Number of waveforms

The size of the noise is inversely proportional to the square root of the averaging setting count.
For example, if M is set to 100, the noise amplitude is compressed to about 1/10 compared to when M is set to 1.

Once the data collection is started, the waveform is displayed on the screen.

Starting data collection

1. Display the waveform of the channel with the monitor signal input.

   When monitoring the signal input to the **Ch A In** connector, click the Channel A trace display button to set the button display to **CH A On**.

   When monitoring the signal input to the **Ch B In** connector, click the Channel B trace display button to set the button display to **CH B On**.

2. Click the **Sampling** button to display **Sampling Run** at the button display.

   The elapsed time, number of samples and number of waveforms are displayed in the title bar when **Accumulation Type** is set to **Limited**.

   Samples: 81,920 - 10wfms / 100wfms

   When **Averaging** is set to 2 or more in the Pulse mode, the number of waveforms is displayed in the title bar.

The data collection can also be started by the **All Measurements Start** button shown in Figure 4.1-1.

Stopping data collection

Click the **Sampling** button, and then set to **Sampling Hold**. When, in the Setup dialog box, Accumulation Type is set to **Limited**, the data collection process stops when the at-end conditions are met.

The data collection can be started by clicking all measurement stop button as shown in Figure 4.1-1.

Discarding screen display

When temporarily deleting screen display:

Click the Channel A trace display button, and then set the button display to **CH A Off**.

Click the Channel B trace display button, and then set the button display to **CH B Off**.

The waveform is displayed when setting the button display to **CH A On** or **CH B On**.

When discarding collected data:

Click **Clear Display**.

The waveform is deleted even when the button display is set to **CH A On** or **CH B On**.

The discarded data cannot be displayed again.

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6.8 Adjusting Scales

6.8.1 Adjusting Scales Automatically

Measure the waveform amplitude and period, and then set to the easily viewable scale.

For Eye /Coherent Eye Mode
1. Select a channel to be displayed in the center of the waveform display area at **Active Channel Selection** when **CH A On** and **CH B On** are displayed. Set **Align During Auto Scale** to **On** to display the waveforms of both channels in the center.
2. Click **Auto Scale**. The waveform is displayed at the center of the waveform display area.
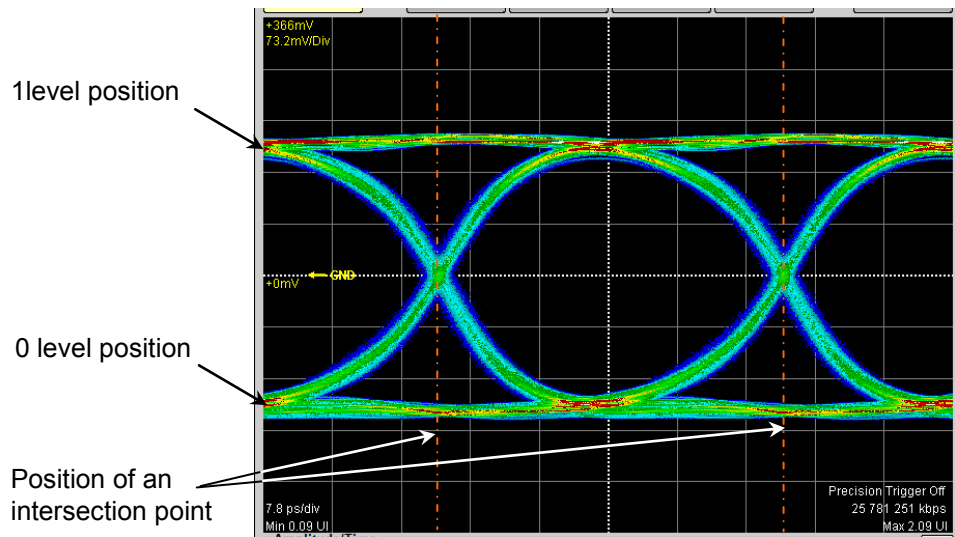
**Figure 6.8.1-1   Waveform Display after Auto Scale
(Eye/Coherent Eye Mode)**

When adjusting scale automatically, the two-bit waveform is displayed on the horizontal axis.
The Eye pattern waveform crossing points are 2.5 and 7.5 scale divisions from the left side.

At the vertical axis, "one" level 2.5 gridlines above center of grid, "zero" level 2.5 gridlines below center of grid.

Note:

When both CH A and CH B are set to ON, the offset at the time axis is adjusted according to the channel signal selected at Active Channel Selection.

When **Align During Auto Scale** is set to On, the Skew setting value

is adjusted to display the waveforms of both channels in the center of the waveform display area. The amplitude scale and vertical position for the waveforms of both channels are adjusted regardless of this setting.

In addition to the scale adjustment of waveform display area, Auto Scale automatically detects the division rate of the data rate of input signal and the trigger signal. Set **Divide Ratio Detect** to **Off** to not detect the division rate automatically. When **Tracking** of Data Rate and Clock Rate is set to **On**, the division rate of the data rate and the trigger signal is not detected.

For Pulse Mode
1.   Click **Auto Scale**.
2.   The waveform is displayed at the screen center.

1level position

0level position
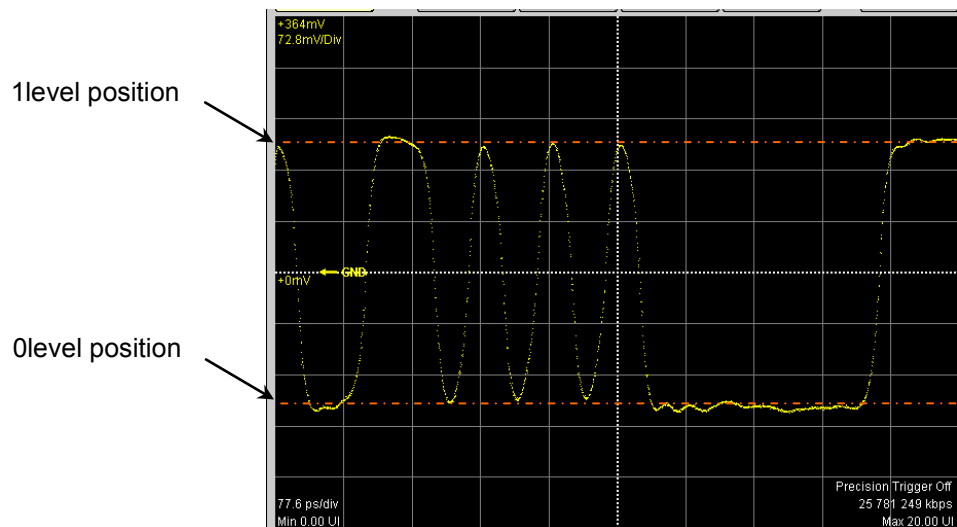
Figure 6.8.1-2   Waveform Display after Auto Scale (Pulse Mode, NRZ)

When the pattern length is 127 bits or less, a 20-bit waveform is displayed. When the pattern length is 128 bits or more, a 50-bit waveform is displayed.

The 1 level is adjusted on the vertical scale to the 2.5th scale up from the screen center and the 0 level is adjusted to the 2.5th scale down from the screen center.

6.8.2 Adjusting Vertical Axis

To adjust voltage or optical power at center of vertical axis
1.   Click **Scale/Offset** on the left side of the waveform display area.

2.   When the buttons are displayed, click the **Offset** button of Amplitude. The mouse icon is displayed in the button.
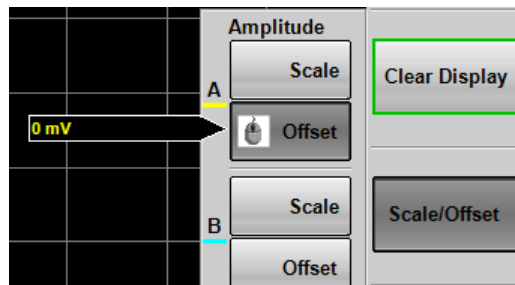
3.   Input the power voltage or optical power at the screen center position using the mouse wheel.

4.   When using the trace A, the input value is displayed at the left center of the waveform display area.
When using the trace B, the input value is displayed at the right center of the waveform display area.

To adjust voltage or optical power per scale:
1.   Click Scale/Offset in the right side of the waveform display area.

2.   When the buttons are displayed, click the Scale button. The mouse icon is displayed in the button.

3.   Input the voltage or optical power per scale using the mouse wheel.

4.   When using the trace A, the input value is displayed at the left upper corner of the waveform display area.
When using the trace B, the input value is displayed at the right upper corner of the waveform display area.

The vertical-axis can also be adjusted by directly entering the value in the Amplitude, O/E Dialog Box.

1.   Click **Amplitude O/E**.

2.   Click the Offset text box.

3.   Input the voltage or optical power at the screen center position.

4.   Click the Scale text box.

5.   Input the voltage or optical power per scale.

Setting same vertical scale for two waveforms

The vertical scales at Channel A and Channel B can be set to the equal value using the MP2110A-021, MP2110A-022 and MP2110A-032.

1. Click **Amplitude**.

2. Click the Channel A/B Tracking button, and set to **On**.
   And then, the text box for Channel A is only available.

3. Click the Scale, Offset, and Attenuation text boxes, and then set the value.

Note:

When the Channel A/B Tracking is set to **On**, the CH B scale, offset, and attenuator value are changed to the CH A values.

Click **Scale** and **Offset** at Amplitude on the right side of the screen, and then the value set using the rotary knob will be valid. In this case, the CH B scale and offset values are not displayed in the Amplitude dialog box.

Adjusting attenuation of attenuator

The attenuation amount of an external attenuator connected to the **Ch A In** and **Ch B In** connectors can be adjusted as described below.

1. Click **Amplitude**.

2. Click the Attenuation text box.

3. Input the attenuation.

The n dB attenuation is calculated by the following formula:

Electrical input: $10^{\frac{n}{20}}$

Optical input: $10^{\frac{n}{10}}$

6.8.3 Adjusting Horizontal Axis

Adjusting time at left edge of waveform display area

1. Click **Scale/Offset** in the right side of the waveform display area.

2. When the buttons are displayed, click the **Offset** button of Time. The rotary knob icon is displayed in the button.
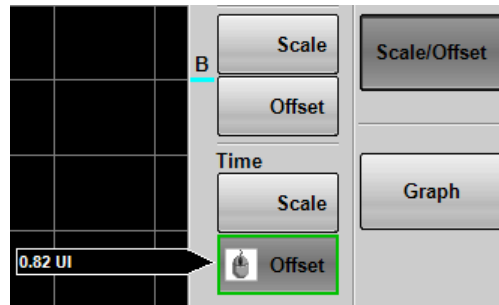
3. Input the time at left edge of screen using the mouse wheel.

4. The time entered is displayed at the left lower corner of the waveform display.

To switch the horizontal position units between UI (unit interval) and time (ps), click **Time** and the Unit button.

Adjusting the number of bits to display

Result window

1. Click **Scale/Offset** in the right side of the waveform display area.

2. When the buttons are displayed, click the **Scale** button of Time. The mouse icon is displayed in the button.

3. Input the number of bits per scale using the mouse wheel.

4. The sum of the value at the bottom left of the screen and the input value is displayed at the bottom right.

Time dialog box

1. Click **Time**.

2. Click the **Scale/Offset** tab.

3. Click UI on Screen text box.

4. Input the number of bits.

Adjusting the waveform position

1. Click **Time**.

2. Click the **Scale/Offset** tab.
   Changing Offset can adjust the position of single waveform,

3. Click the Skew text box and input the values.

The waveform moves right when a positive value is set.
The waveform moves left when a negative value is set.

6.9   Measuring Waveform

The waveform measurement methods are as follows.

For the explanation of the measurement items, refer to 1.5 "Technical Terms".

● Amplitude and time measurements
Select the measurement items from the following:

For NRZ
One Level, Zero Level, Eye Amplitude, Eye Height, Crossing, SNR, Average Power(dBm), Average Power(mW), Extinction Ratio, Jitter P-P, Jitter RMS, Rise Time, Fall Time, Eye Width, DCD, OMA(mW), OMA(dBm), VECP, OMA at Crossing

The Average Power(dBm), Average Power(mW), Extinction Ratio, OMA(mW), OMA(dBm), VECP, and OMA at Crossing can be measured when the input is optical.

For PAM4
TDECQ, Outer OMA, Outer Extinction Ratio, Linearity, Levels, Levels RMS, Levels P-P, Level Skews, Eye Levels, Eye Skews, Eye Heights, Eye Widths, Average Power(dBm), Average Power(mW)

TDECQ, Outer OMA, Outer Extinction Ratio, Average Power(dBm), and Average Power (mW) can be measured when the input is optical.

● Histogram
For NRZ, sets the screen field and displays the data distribution in the time or amplitude direction and the measurement results.

● Mask test
Sets the mask pattern and mask margin, and then measures the data count in the mask.
The set data count can measure the mask margin within the mask.

● Jitter analysis

For Eye
TJ, DJ (d-d), RJ (d-d), J2 Jitter, J9 Jitter, Eye Opening

For Advanced Jitter
TJ, DJ (d-d), RJ (d-d), J2 Jitter, J9 Jitter, Eye Opening, DDPWS, RJ (rms), PJ (p-p), DDJ (p-p), DCD, ISI (p-p), PJ Frequency

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Table 6.9-1   Measurement Method per Displayed Mode

Sampling Mode / Measurement Method	Eye	Pulse	Coherent Eye	Advanced Jitter
Measurement for amplitude and time	✓	–	✓	✓
Mask test	✓	✓	✓	–
Jitter analysis	✓	–	–	✓
Histogram	✓	✓	✓	✓

6.9.1 Setting and Displaying Measurement Items

Waveform amplitude and time can be measured when data is collected by **Eye** mode or **Coherent Eye** mode.
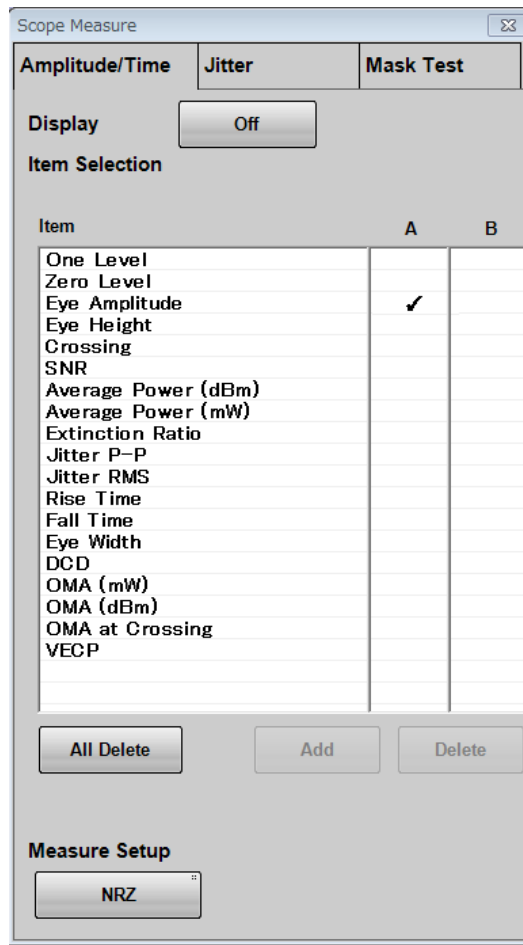
Figure 6.9.1-1   Amplitude/Time Tab When Signal Type is NRZ

To set measurement items:

1.   Click **Measure** to open the Measure dialog box.

2.   Click **Amplitude/Time** tab.

3.   Click the column A or B of a desired item on the Item list to display ✓.

4.   When you have selected all items to measure, click **Add**.

5.   Click the **Off** button of Display to turn it **On**.
     Make sure all the selected items are displayed in the Result window.

6.   Click the Measure Setup button.

7.   If MP2110A-054 is installed, click **Setup (NRZ Amplitude Time)** or **Setup (PAM4 Amplitude Time)**.

8.   The item selected for the Item Selection list is added.

9.   The measurement result is displayed in the button of the screen.

If the added item is the same as an item selected already for the same channel, that item cannot be added using Item Selection.

To display measurement area

Set the range to measure 1 level and 0 level of the NRZ waveform respectively.

1.   Click the **Setup (NRZ Amplitude Time)** at Measure Setup. The Setup (NRZ Amplitude Time) dialog box appears.

2.   Click **Offset from Crossing** and **Width** of EYE Boundary and set the values respectively. Refer to "Figure 6.9.1.1-2   Setting Item of EYE Boundary".

3.   The measurement item is shown in blue in the measurement result display area on the Result window.

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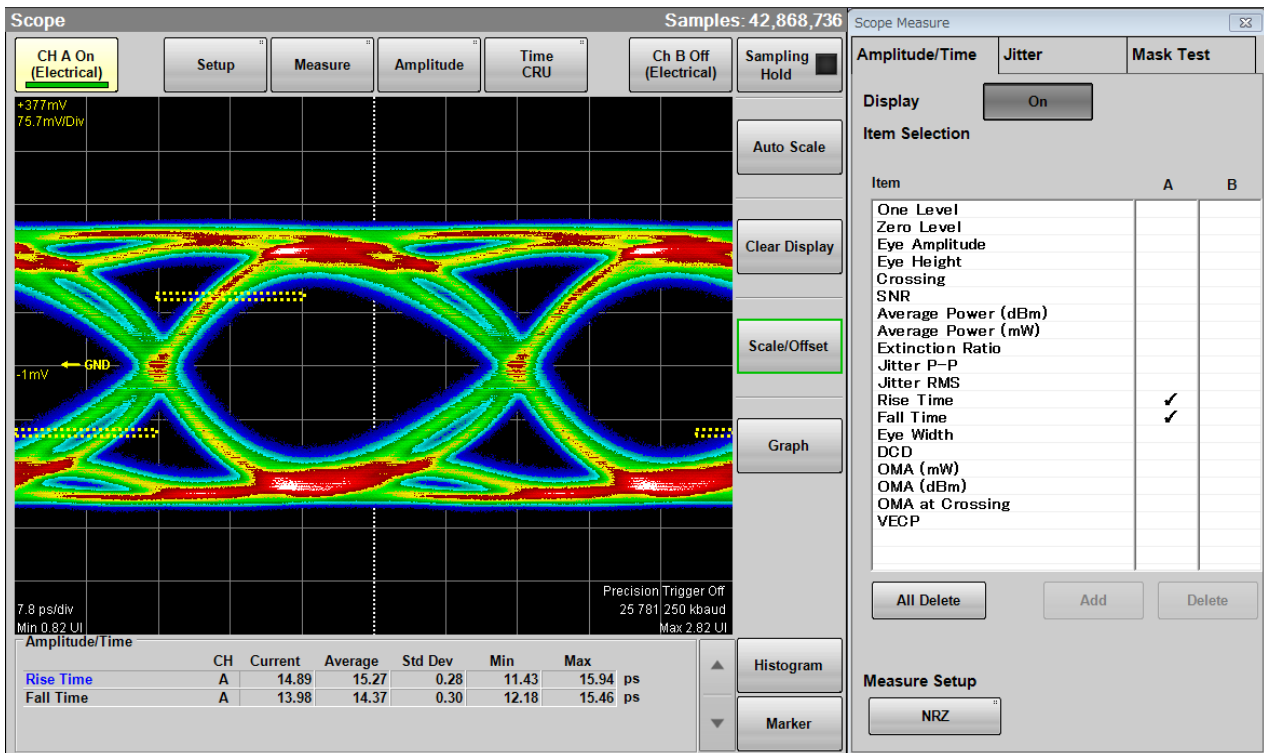
Figure 6.9.1-2   Display Example of EYE Boundary

If the item is measured properly in PAM4 waveform, PAM4 in blue is displayed. When there is a possibility the waveform may not have been measured correctly due to too small amplitude or too large jitter, channel name (CHA/CHB/CHA,CHB) and "NRZ?" in red is indicated as shown below.

When the PAM4 waveform is measured, PAM4? is displayed.

In this case, check the settings for the amplitude and trigger of the measured signal and make sure the connectors are secure.

**Figure 6.9.1-3   Appearance of Amplitude/Time Area
(When Measurement Results May Be Incorrect)**

When Extinction Ratio Correction is set to **On** on the Amplitude dialog box in Section 6.2.3.1, "*Corrected" is displayed in red beside the corrected measurement item.

When PAM4 waveform is measured in Coherent Eye, the lock marks are displayed beside the Outer OMA and Outer ExR results if the Sampling Scope is synchronized with the pattern (Pattern Lock).

Figure 6.9.1-4　Example of PAM4 Display

Deleting items

1. Click **Measure**. The Measure dialog box appears. The Measure dialog box is displayed.

2. Click **Amplitude/Time** tab.

3. Click the column A or B of a desired item on the Item list to select ✓.

4. Click **Delete**. The Results window items are removed.

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6.9.1.1   NRZ
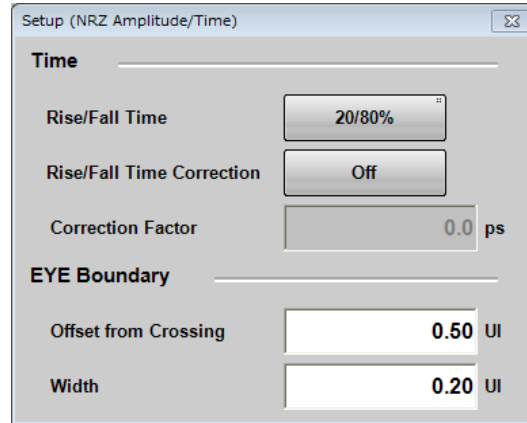
Figure 6.9.1.1-1   Setup (NRZ Amplitude/Time) Dialog Box

To change EYE Boundary

The 1 and 0 level measurement area can be changed.

1.   Click **NRZ** at Measure Setup.

2.   Click the Offset from Crossing text box to set the area center position.

3.   Click the Width text box to set the area width.
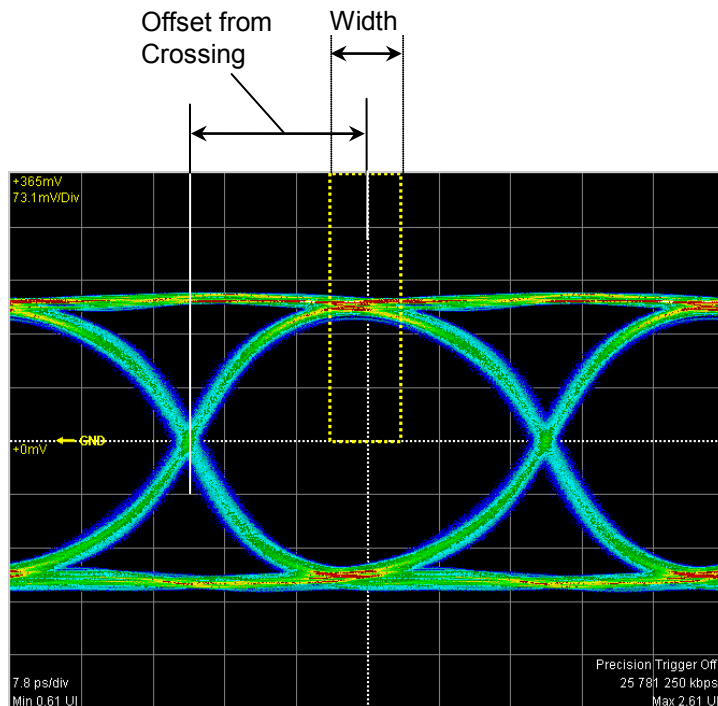
Figure 6.9.1.1-2   Setting Item of EYE Boundary

To set measurement method of rise/fall time

When measuring the rise time and fall time levels, select from amplitude 10/90% level or 20/80% level.

● Click the Rise/Fall Time button to display **10/90%** or **20/80%**.

The bandwidth of the sampling oscilloscope is corrected with the measurement value of the Rise/Fall time, and the corrected bandwidth is displayed.

1. Click **NRZ** at Measure Setup.

2. Click **Rise/Fall Time Correction** to set the button display to **On**.

3. Click the Correction Factor text box.

4. Input the correction value in ps.

The calculation formula is as follows:

$$Td = \sqrt{Tm^2 - Tc^2}$$

Td: display value (ps), Tm: measurement value (ps),
Tc: correction value (ps)

If the measurement value is larger than the correction value, the result displays N/A.

"Corrected" is displayed in red at the Rise/Fall time when Rise/Fall Time Correction is set to **On**.
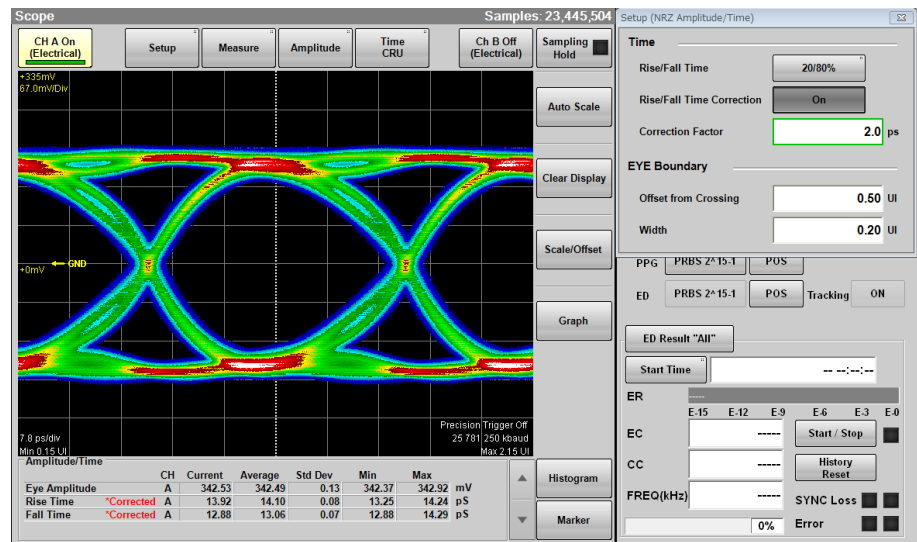
Figure 6.9.1.1-3   Display Example of Measurement Result

6.9.1.2 PAM4

Set the following measurement conditions for PAM4.
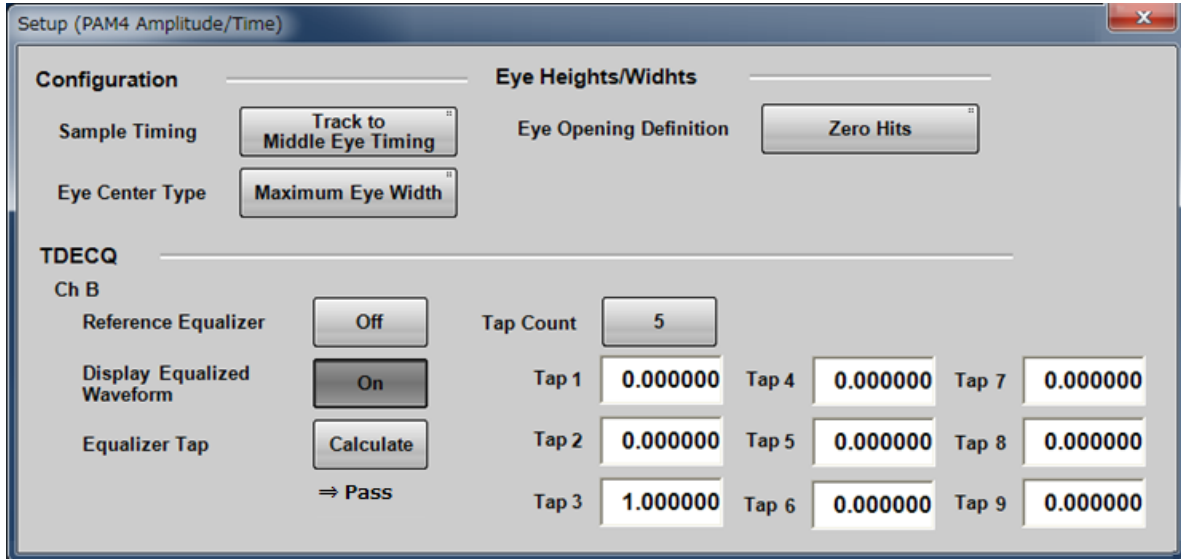
**Figure 6.9.1.2-1 Setup (PAM4 Amplitude/Time) Dialog Box
(Ch B Is Optical Interface)**

Setting position for PAM4 measurement

1. Click **PAM4** at Measure Setup.

2. Click the Sample Timing button to set the timing to measure Upper Eye and Lower Eye.

3. Click the Eye Center Type button to select a method to decide the Eye center.
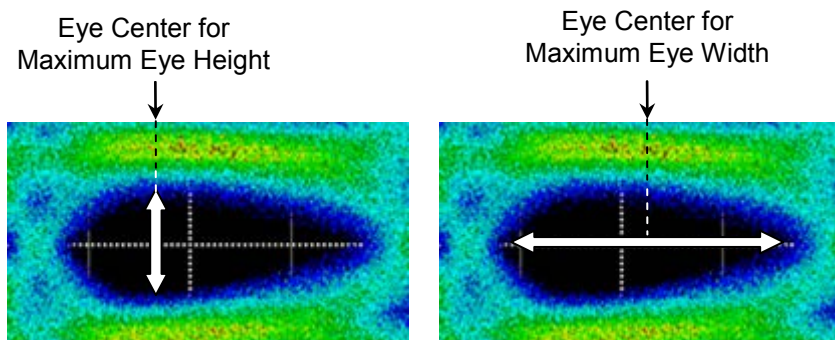
Figure 6.9.1.2-2 Example of Detected Eye Center

4. Click the Eye Opening Definition button to select a method to define the Eye opening.

Setting Reference Equalizer

Reference Equalizer is used to remove waveform deterioration due to a channel. Reference Equalizer uses FFE (Feed Forward Equalizer) and adds on by multiplying the waveform delayed in steps of 1 UI by coefficient.
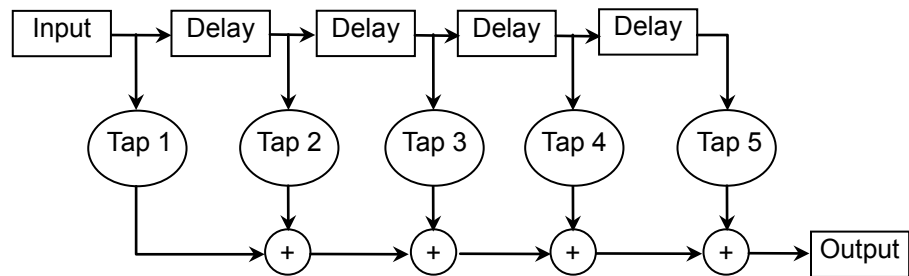
Figure 6.9.1.2-3   Block Diagram of Reference Equalizer (Tap Count=5)

Original Waveform   Waveform After Equalization
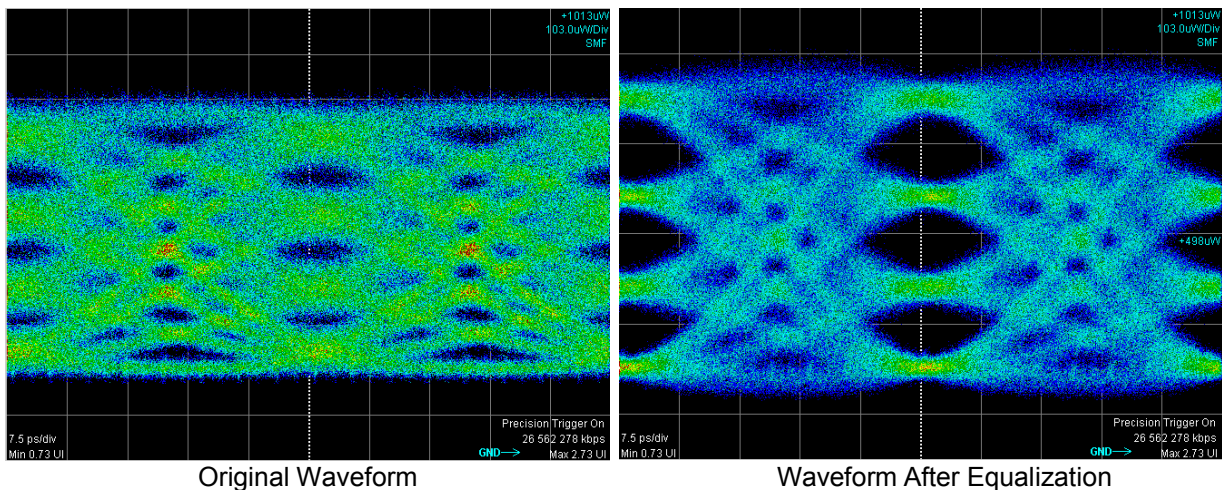
Figure 6.9.1.2-4   Example of TDECQ Improvement by Reference Equalizer

1.   Click **PAM4** at Measure Setup.

2.   Click **Reference Equalizer**   to set the button display to **On**.

3.   Clicking the Display Equalized Waveform button toggles the waveform display between before and after equalization.

4.   Click **Calculate** to calculate the optimal tap values. Click **Taps** to change the equalizer number or the tap value.

6.9.2 Mask Test

To execute the mask test, first select measurement channel and mask.
There are two types of mask tests as follows:

● Set the upper data error count and measure the mask margin.
● Set the mask margin and measure the error data count.
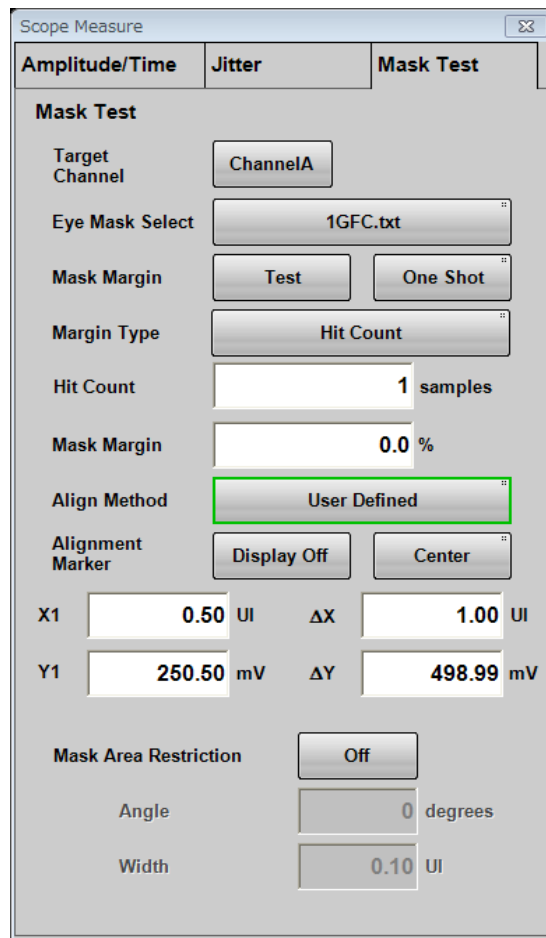
Figure 6.9.2-1   Setting Example of Mask Test

To select channel and mask

1. Click **Measure** to open the Measure dialog box.

2. Click **Mask Test** tab.

3. Click Target Channel button, and then select the channel to be measured. The next channel cannot be selected.

    - Channel whose signal type is set to PAM4.

    - Channel whose Sampling Mode is set to **Advanced Jitter**.

4. Click the Eye Mask Select button to select the mask.

5. The file selection dialog box is opened. Click the mask file and **OK**.

The selected mask or mask file is displayed in the **Current Mask** box of the measurement results. Refer to Figure 6.9.2-2 "Mask Test Example".

Table 6.9.2-1   Mask List

Mask Name	Standard	Bit Rate
100GbE-ER4_Tx.txt	100GbE-ER4	25.78125 Gbit/s
100GbE-LR4_Tx.txt	100GbE-LR4	25.78125 Gbit/s
100GbE-SR4_Rx.txt	100GbE-SR4	25.78125 Gbit/s
100GbE-SR4_Tx.txt	100GbE-SR4	25.78125 Gbit/s
100GbE-CLR4-FEC.txt	100GbE-CLR4 FEC	25.78125 Gbit/s
100GbE-CLR4.txt	100GbE-CLR4	25.78125 Gbit/s
100GbE-CWDM4.txt	100GbE-CWDM4	25.78125 Gbit/s
OTU-4.txt	OTU-4	27.952493 Gbit/s
32GFC_MM.txt	32GFC	28.05 Gbit/s
32GFC_SM.txt	32GFC	28.05 Gbit/s
8GFC_Elect_Rx.txt	8GFC	8.5 Gbit/s
8GFC_Elect_Tx.txt	8GFC	8.5 Gbit/s
InfiniBand_EDR_Cable_In_Liminting.txt	InfiniBand EDR	25.78125 Gbit/s
InfiniBand_EDR_Cable_Out_Liminting.txt	InfiniBand EDR	25.78125 Gbit/s
InfiniBand_EDR_Host_Out_Liminting.txt	InfiniBand EDR	25.78125 Gbit/s
InfiniBand_EDR_Stressed_In_Liminting.txt	InfiniBand EDR	25.78125 Gbit/s
HDMI_TP1.txt[1]	HDMI	[3]
HDMI_TP.txt[2]	HDMI	[3]

[1]: Mask file for HDMI transmitter

[2]: Mask file for HDMI receiver

[3]: Bit rate is unspecified.

To measure mask margin

1. Click **Setup**.

2. Click the Sampling Mode button to set the display **Eye** or **Coherent Eye**.

3. Click **Sampling** to set the display Run.

4. When the trace is displayed, click **Auto Scale**.
    Check that the eye pattern is displayed in the center of the screen.

5. Click **Measure**.

6. Click **Mask Test** tab.

7. Click the Target Channel button to set the channel.

8. Click the Eye Mask Select button.

9. The file selection screen is displayed. Click a mask file and **OK**.

10. Click the Align Method button to set to **Zero/One/Crossing**.

11. Click the Margin Type button, and then select a mode of specifying threshold for Mask Margin measurement, from **Hit Count** and **Hit Ratio***.

12. In the Hit Count or Hit Ratio box, set the threshold for Mask Margin measurement.

13. When performing the single measurement, click the button on the right side of Mask Margin and set to **One Shot**.

    When performing the measurement continuously, click the button on the right side of Mask Margin and set to **Continuous**.

14. Click **Update**.

15. When selecting **One Shot**, click **Test** of Mask Margin to set Sampling to Hold and measure Mask Margin. On the other hand, when selecting **Continuous**, set Sampling to Run to measure Mask Margin.

    Whichever of **One Shot** and **Continuous** is selected, the mask margin is measured so that the number of samples in the mask area becomes less than the value set for Hit Count or Hit Ratio.

*:   The relational expression of Hit Count and Hit Ratio is:

$$\text{Hit Count} = \frac{\text{Hit Ratio} \times \text{Total Samples}}{\text{Bit On Screen}}$$

To set Mask Margin and execute mask test

1. Click **Setup**.

2. Click the Sampling Mode button to set the display **Eye** or **Coherent Eye**.

3. Click **Sampling** to set the display Run.

4. When the trace is displayed, click **Auto Scale**.
   Check that the eye pattern is displayed in the center of the screen.

5. Click **Measure**.

6. Click **Mask Test** tab.

7. Click the Target Channel button to set the channel.

8. Click the Eye Mask Select button to select the mask.

9. Click the Align Method button to set to **Zero/One/Crossing**.

10. Click the right side button of Mask Margin to set to **One Shot**.

11. Click **Sampling** to set the display to Hold.

12. Click **Update**.

13 Click the mask margin text box.

14. Input the mask margin in the range of −100 to 100%.

15. The shape of the mask is changed, and the measurement result is displayed on the screen.

Note:

> When executing the Mask Test, run Auto Scale to set UI On Screen to 2.
> The Mask Test measured value is assured when UI On Screen is 2. If UI On Screen is 3 or more, the optimum Mask position may not be detected because the vertical scale setting is not optimum.

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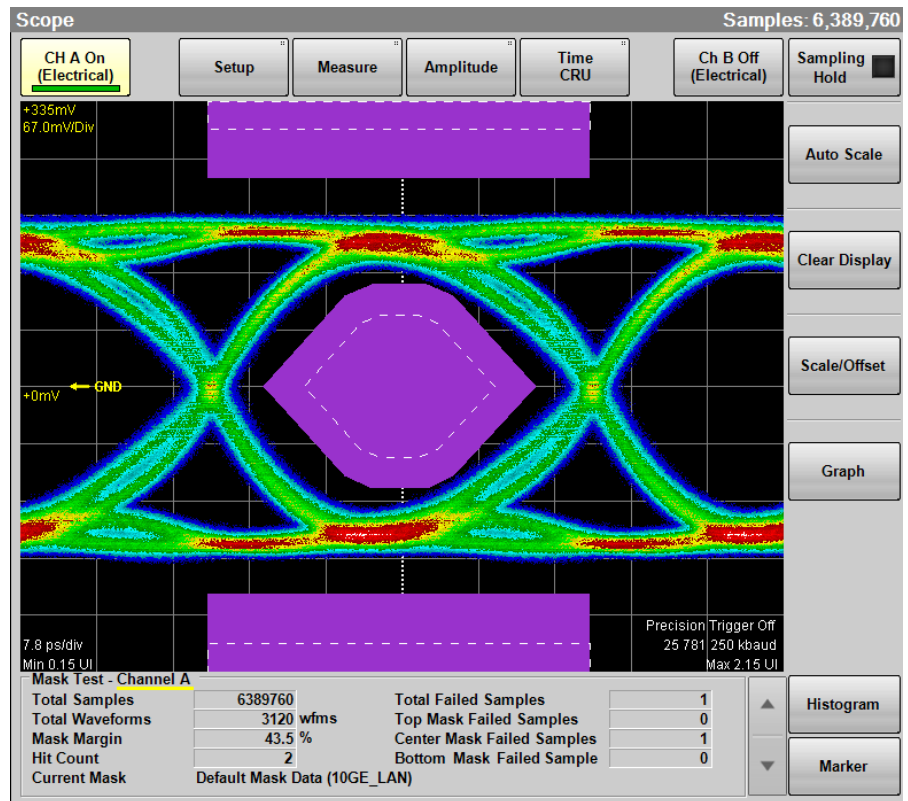
Figure 6.9.2-2   Mask Test Example

The following values are displayed in the measurement result:

Total Samples: Total data count displayed on the screen

Total Waveforms: Total waveform count displayed on the
                          screen

Mask Margin: Mask Margin measurement results or
                          settings

Hit Count or Hit Ratio: Threshold set for Mask Margin
                          measurement

Total Failed Samples: Total data count within three mask areas

Top Mask Failed Samples: Data count in top mask area

Center Mask Failed Samples: Data count in center mask area

Bottom Mask Failed Samples: Data count in bottom mask area

Current Mask: Present mask name

Adjusting mask position

To adjust mask position automatically
When Align Method is **Zero/One/Crossing**, click the Mask Alignment
Update.

When clicking the Mask Alignment **Update** calculate **Zero/One/Crossing**
of the currently described waveform and optimize the mask position
automatically.

The mask position is adjusted automatically if the Scale and Offset on the
screen are changed. However, the mask position cannot be changed.

To adjust mask position manually
When Align Method is **User Defined**, the mask position, width and
amplitude can be adjusted using the marker.
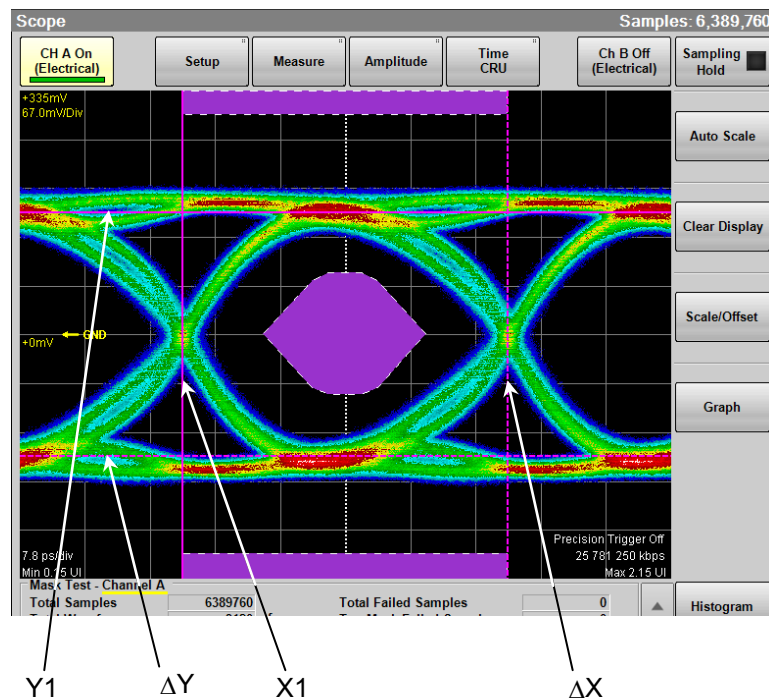
Figure 6.9.2-3   Example of Adjusting Mask Position Manually

1. Click the right side button of Alignment Marker   and set **Display On**
    to display the marker.

2. Click the X1 text box to set the mask position.

3. Click the ΔX text box to set the mask width.

4. Click the Y1 text box to set the level 1.

5. Click the ΔY text box to set the level 0.

Clicking **Center** moves the marker without depending on the waveforms.
In this case, the setting values of X1, ΔX, Y1, and ΔY are initialized.
Although the marker is not displayed at **Display Off**, the marker position
can be adjusted by changing the value in the text box.

To limit mask area

To examine in which part of the mask at the center the error occurs when
the error occurs in the mask test, the mask area can be limited.
Setting width and angle can limit the mask area.
If the mask area is limited, the error that occurs in an upper and lower
mask area is not measured.

Angle 0˚	Angle 45˚	Angle 45˚
Width 0.1 UI	Width 0.1 UI	Width 0.3 UI
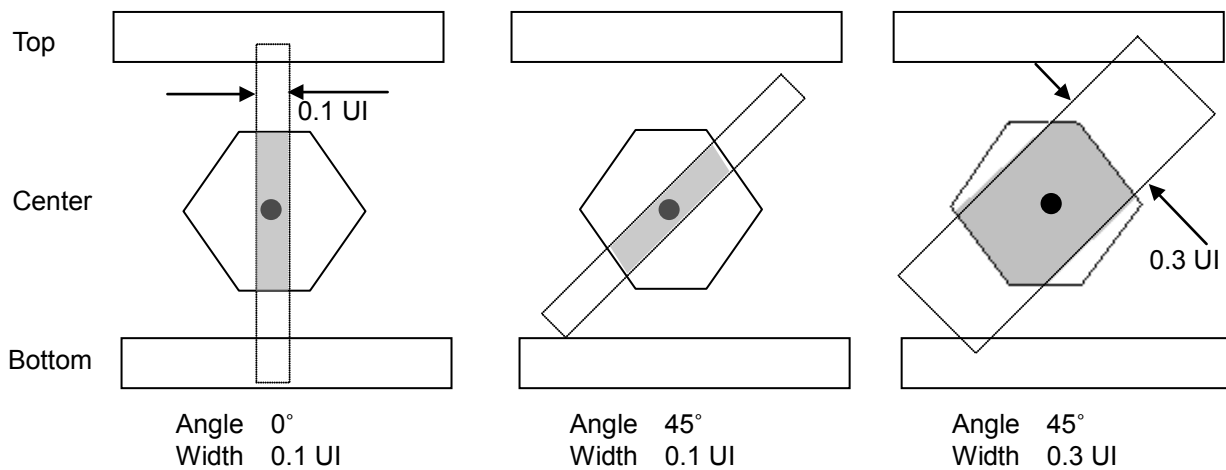
Figure 6.9.2-4   Example of Limiting Mask Area

1.   Click **Measure**.

2.   Click **Mask Test** tab

3   Click the Target Channel button to set the channel.

4.   Click the Mask Area Restriction button to set **On**.

5.   Click the **Angle** text box to set the angle within the range of –90 to
90.

6.   Click the **Width** text box to set the width within the range of 0.01 to
1.00.

"Restriction enabled" is displayed in the measurement result display area.
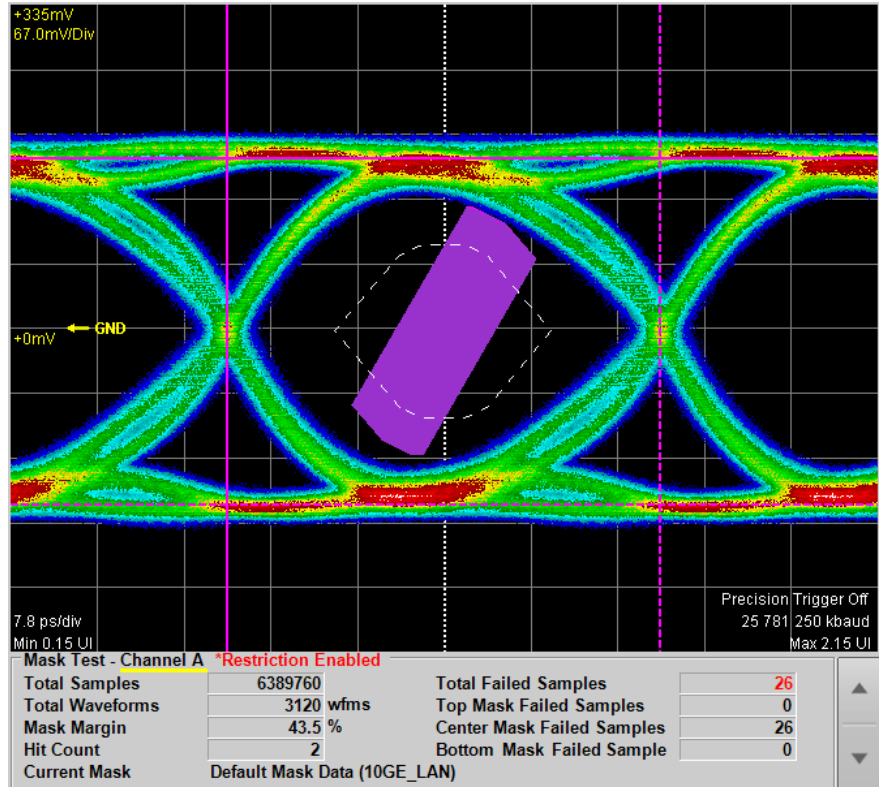
Figure 6.9.2-5   Example of Area Limited Mask Test

6.9.3 Jitter Analysis

The jitter analysis software displays the measurement results of the following items by jitter element.

- Numeric value (ps, UI Unit)
- Histogram
- Spectrum
- Pattern display per bit

Jitter can be analyzed when Sampling Mode of Scope is set to **Eye** or **Advanced Jitter**.

Sampling Mode is Eye

Analyzes the jitter measured from histogram in the time direction of Eye pattern waveform. Jitter that can be measured from the Eye pattern waveform is only TJ.
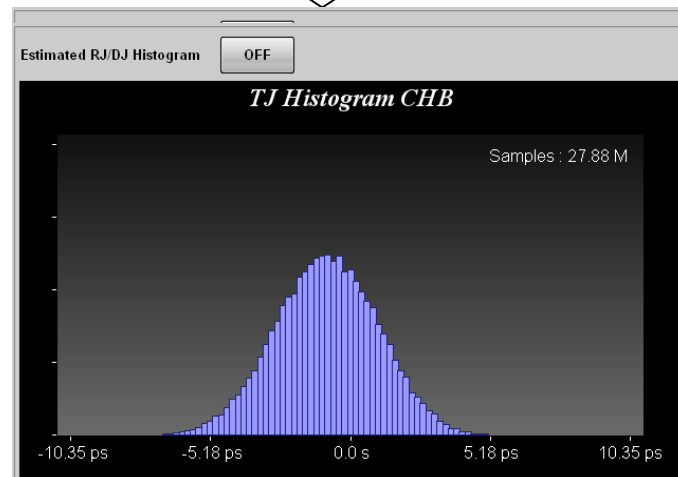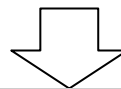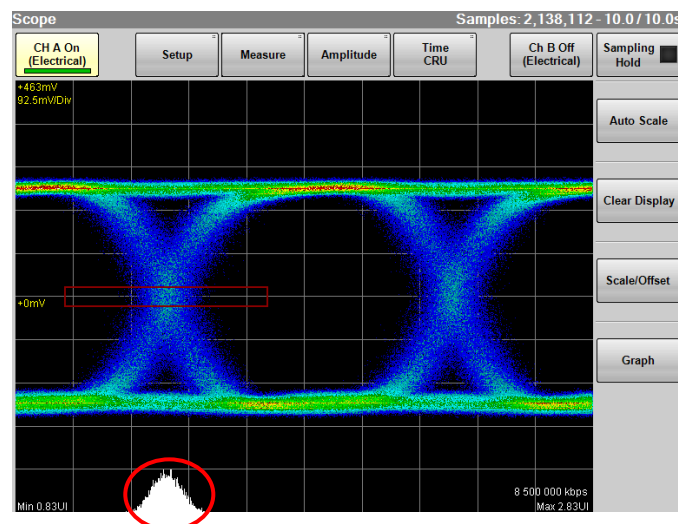
Figure 6.9.3-1   Example of Histogram Display

TJ for channel A and B and Bathtub can be measured simultaneously.
Also, Eye Mask can be measured simultaneously.
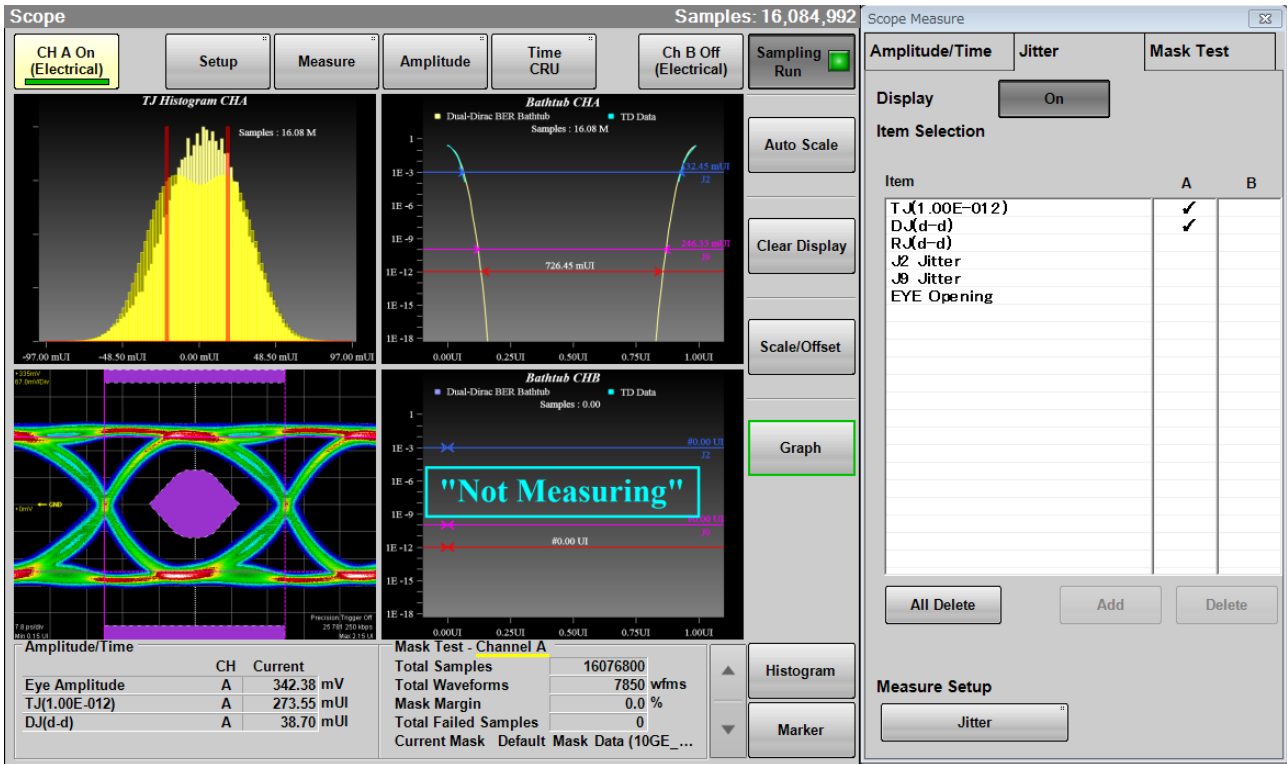
Figure 6.9.3-2   Display Example of Jitter Analysis and Eye Mask Test

When Channel Math of Scope is **Off**, jitter can be analyzed without any limit of pattern length.
When Channel Math of Scope is **On**, the jitter analysis can be performed on the waveforms of pattern length up to 32768.

When Extinction Ratio Correction is set to **On** on the Amplitude dialog box in Section 6.2.3.1, "*Corrected" is displayed in red beside the corrected measurement item.

When **Fixed RJ** is set to **On** on the Advanced tab of the Jitter Measure dialog box (Figure 6.2.3-7), "*Fixed" is displayed in red for RJ (d-d) and RJ (rms).

When Sampling Mode is Advanced Jitter

Jitter analysis is executed for the waveform measured in Pulse mode of Scope.
Jitter is measured for each point of bit rising and falling.
Therefore, TJ, Bathtub, RJ/PJ Histogram, DDJ Histogram, Composite Histogram, Jitter Spectrum Display (PJ vs Frequency), and Jitter Display for each bit (DDJ vs Bit or PDJ vs Bit) can be measured.

Jitter Analysis (Advanced Jitter) allows jitter analysis for waveforms up to 32768 of pattern length.
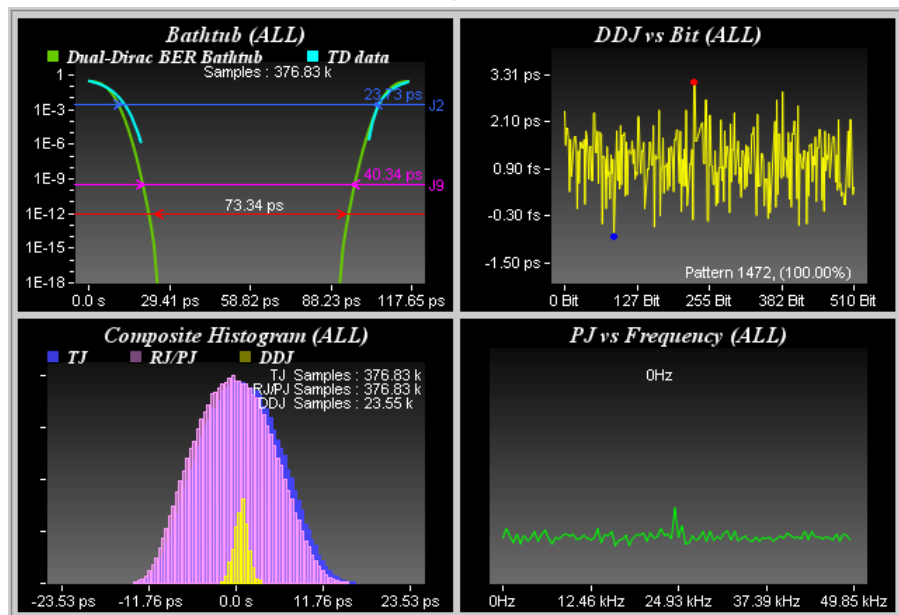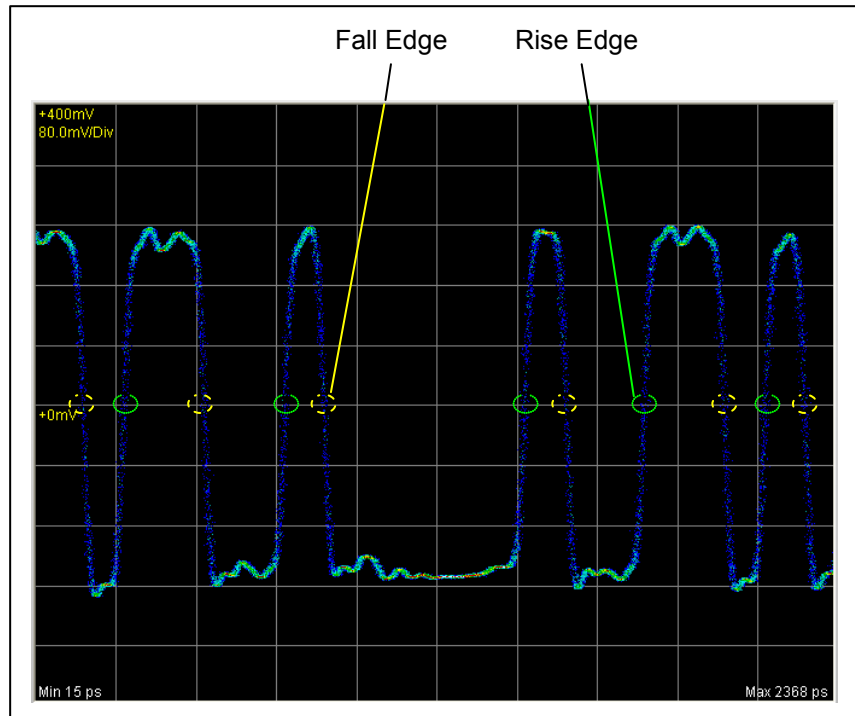
Figure 6.9.3-3   Measured Part and Display Example of Jitter Analysis (Advanced Jitter)

Jitter Analysis (Eye)

1. Click **Scope**.

2. Click **Setup** and set Sampling Mode to **Eye**. Set Signal Type to **NRZ** if it is displayed.

3. Click **Time** and set Data Clock Rate and Pattern Length.

4. Click **Sampling** to display **Sampling Run** at the button display.

5. Click **Auto Scale**.

6. To check EYE? error, click **Measure** > **Amplitude/Time** tab.

7. Turn Display Result to **On**.

8. Check that the eye pattern is displayed at the center of screen and EYE? error is not displayed.

9. Click **Jitter** tab.

10. Click the column A or B on the Item list to select a desired item.

11. Click **Add.** The measurement item is displayed on the Result window.
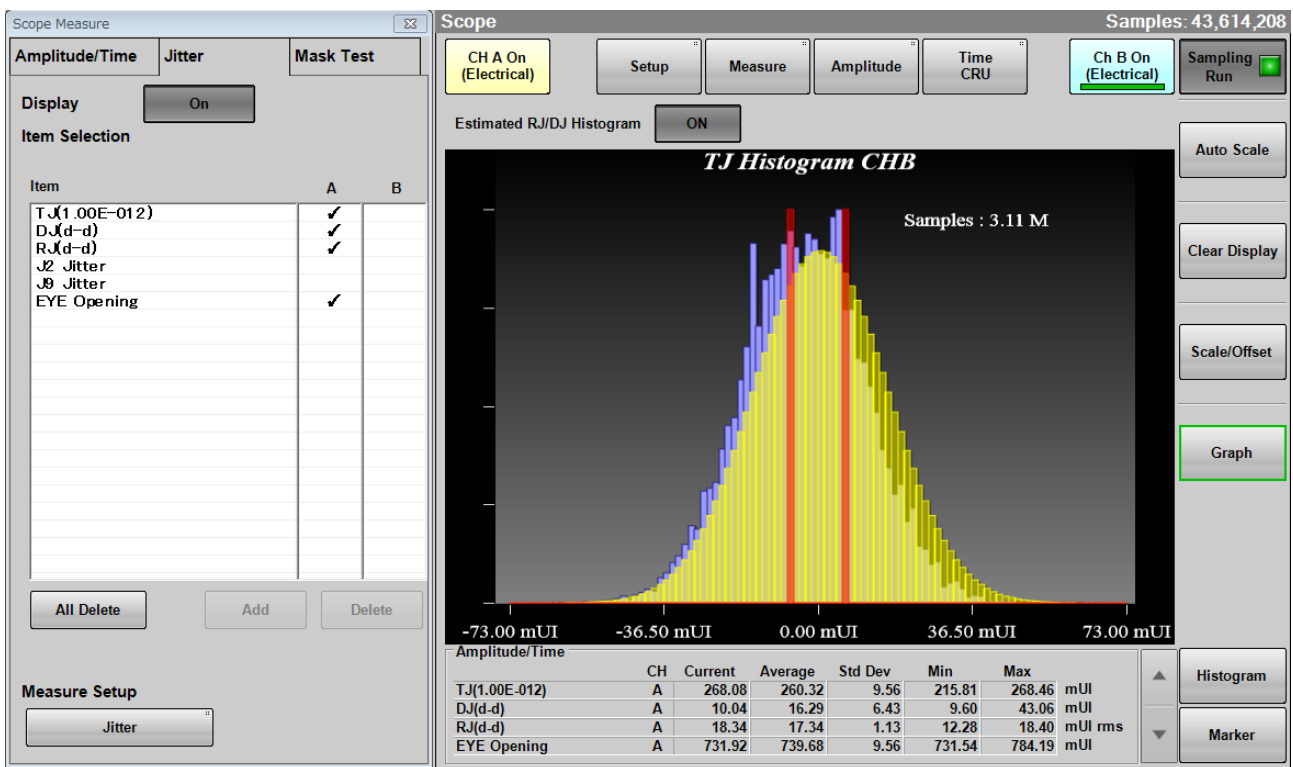
Figure 6.9.3-4   Display Example of Waveform

12. To change the measurement conditions, click **Jitter** of Measure Setup.

13. Click the TJ Measurement BER button to specify the BER to measure the eye aperture with the Bathtub graph.
    Set the following items as needed.

Fixed RJ, RJ Value, Correction Factor, DJ (Scale), RJ (Scale), RJ (rms), Define Threshold, Manual Crossing

14. Click **Sampling** to display **Sampling Run** at the button display.

15. Click **Graph** on the Result window. Click the button on the scroll bar to display the jitter graph.

Jitter Analysis (Advanced Jitter)

1. Click **Scope**.

2. Click **Setup** to set Sampling Mode to **Advanced Jitter**. Set Signal Type to **NRZ** if it is displayed.

3. Click the Limit Type button to set the limitation method for data to be measured. Proceed to step 5 when **None** is set.

4. Set Time, Waveforms, Sampling, or Patterns depending on the Limit Type setting.

5. Click **Measure**.

6. Click **Jitter** tab.

7. Click the column A or B on the Item list to select a desired item.

8. Click **Add**. The measurement item is displayed on the Result window.

9. Click **Algorithm** tab.

10. When PDJ measurement is executed, click the PDJ measurement button to set the display to **On**. Proceed to step 14 when **Off** is set.

11. Click the Standard button to specify the standard to be applied to the PDJ measurement.

12. Click the PDJ Filter button to specify the filter to be applied to the PDJ measurement.
    For the combination of standards and filters, refer to "Table 6.2.3-7 Settable Standards for PDJ measurement and Filter Sets (Unit Hz)".

13. Click the Measurement Edge Type button to set the edge for jitter measurement.

    All: Rising edge and falling edge

    Falling: Only falling edge

    Rising: Only rising edge

14. Click **Advanced** tab.

15. Click the TJ Measurement BER button to specify the BER to measure the eye aperture with the Bathtub graph.
    Set the following items as needed.
    Fixed RJ, RJ Value, Correction Factor, DJ (Scale), RJ (Scale), RJ (rms), Define Threshold, Manual Crossing

16. Click **Sampling** to display **Sampling Run** at the button display.

17. Click **Graph** on the Result window. Click the button on the scroll bar to display the jitter graph.

Starting/finishing Analysis

To start the jitter analysis, click **Sampling** on the Result window. The button lamp lights green during the analysis.

"Processing" is displayed on the screen until the analysis result is displayed.

When clicking **Sampling** during the analysis, the button lamp is lit off and then the analysis is finished.

For **Pattern**, **Sample**, **Time**, or **Waveforms** of the Limit Type on **General** tab of Setup dialog box, when jitter analysis data reaches to the limitation, the measurement is finished.

Note:

Operations of selection items **All** and **Scope** under **Open** and **Save** of System Menu are disabled.

All Measurements: [■]
⊘ is displayed on the button.
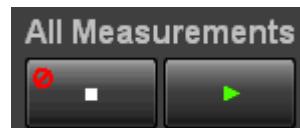
The following message dialogs are displayed when analysis errors occur.

Table 6.9.3-1   Jitter Analysis Error Message

Message	Description
Illegal Error	An unexpected error has occurred.
EYE?	EYE? error has occurred in Scope. Change settings of Scope so that EYE? error will not occur.
Pattern Lost	The set pattern length does not meet the actual pattern length. Set Pattern Length of Scope correctly.
TIE Error*	The jitter has exceeded 1 UI.
Time Out	Data cannot be acquired from Scope. Confirm that waveform displays in Scope.

*:   Time Interval Error

6.9.4 Measurement Using Histogram

The histogram display displays the data distribution in the set field to measure the mean, standard deviation, and dispersion width.

To display histogram, set the axis, time, or amplitude for measuring histogram. And then, set the screen area to display histogram using the histogram marker. Also, the histogram marker position can be set by clicking the screen or using the mouse.
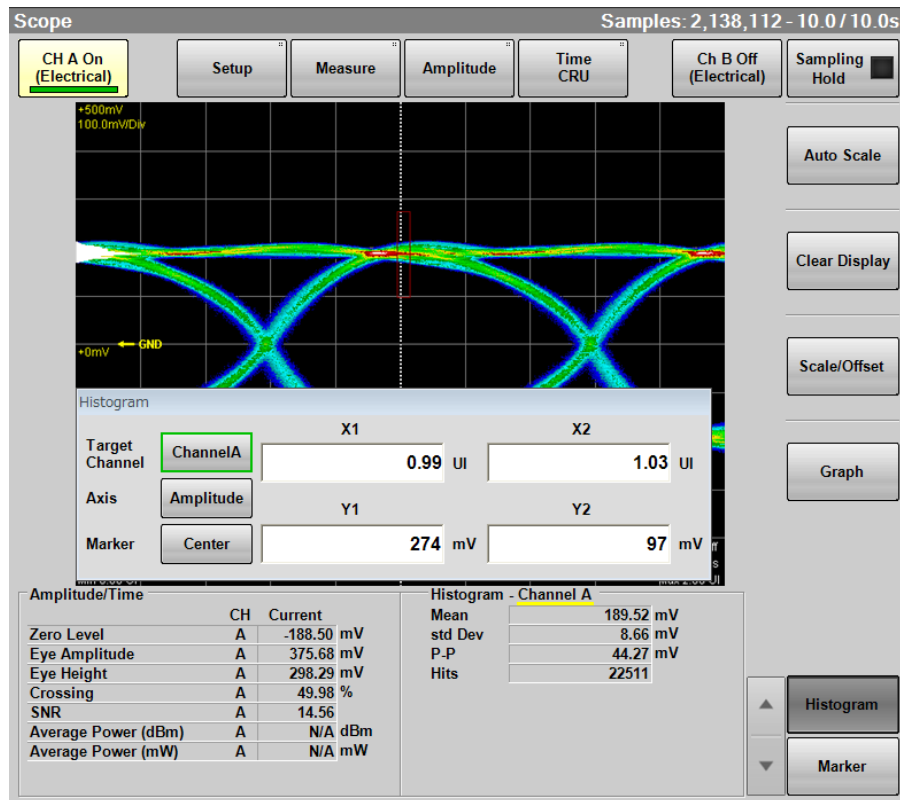
Figure 6.9.4-1   Setting Example of Histogram Measurement

1. Click **Histogram** to open the Histogram panel. The Histogram panel can be moved anywhere on the Scope window.

2. Click the Target Channel button, and then select the channel to be measured.

3. To measure the histogram in the time direction, click the Axis button to change it to **Time**.
   To measure the histogram in the amplitude direction, click the Axis button to change it to **Amplitude**.

4. Input the value to the histogram marker X1, X2, Y1, and Y2, and then set the area.
   The area border to set the histogram marker is as shown in the following figure.
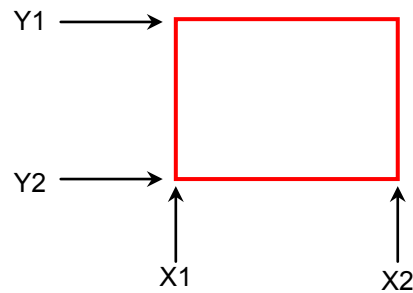
   Toughing the screen and dragging the marker change the histogram marker position.

5. The measurement result of the data within the area is displayed.

   Mean: average value

   Std Dev: standard deviation

   P-P: difference between maximum value and minimum value (Peak to Peak)

   Hits: data count within area

To Histogram marker at screen center:

Click **Center** at Marker to center the marker in the middle of screen.

When histogram measurement is turned on, depending upon the previous settings, the X and Y coordinates of the histogram window may be set beyond the boundaries of the current display screen. If this occurs, clicking **Center** makes it easy to set the area.

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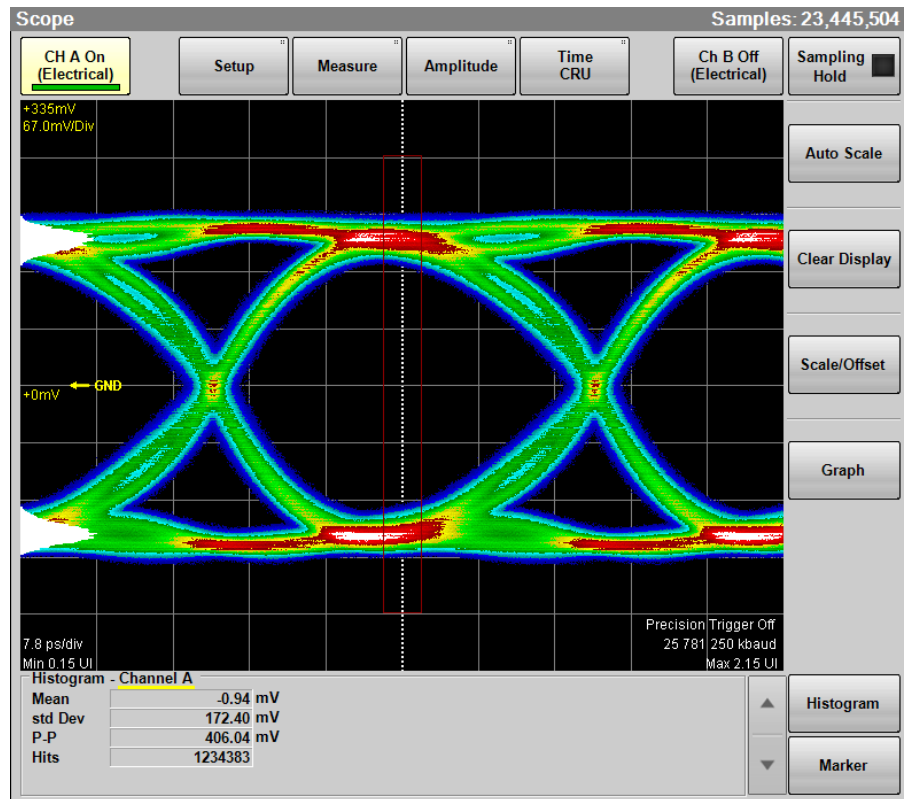
Figure 6.9.4-2   Histogram Measurement Example (Amplitude)
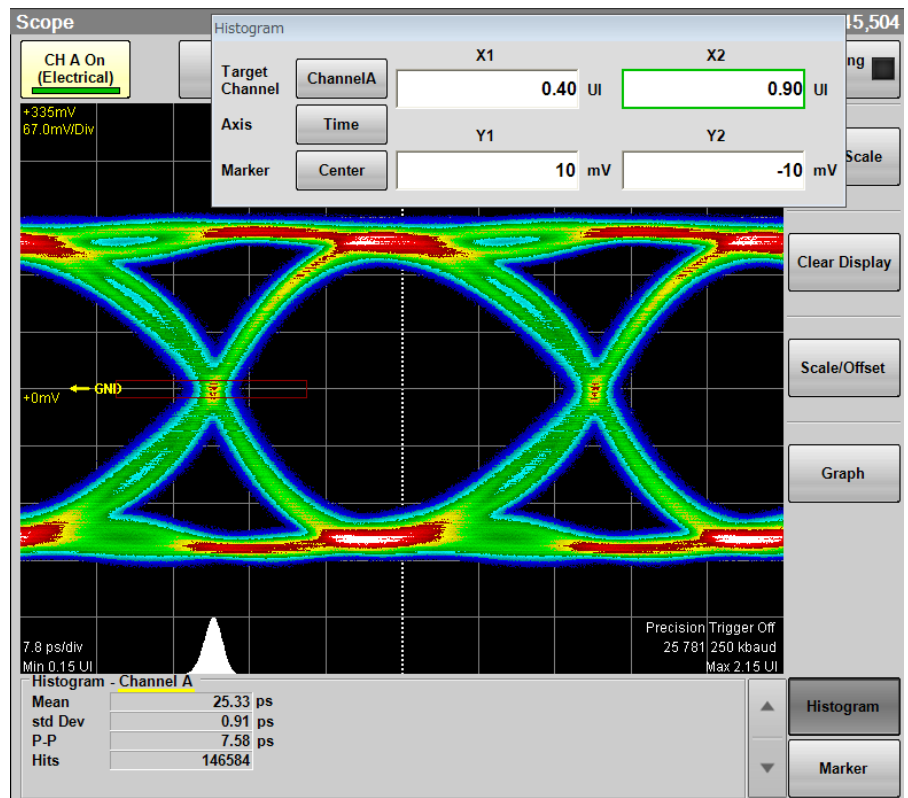
Figure 6.9.4-3   Histogram Measurement Example (Time)

6.9.5 Using Marker

The marker is used to read the amplitude and time values of the waveform.
Also, the level and time differences between two points can be measured.

There are two markers each for the x- and y-axes. Display of each marker can be set to on or off separately.

1. Click **Marker** to display the marker panel.
    The marker panel can be moved in the Scope window.

Marker				
X1 Off	X2 Off	Y1 Off	Y2 Off	All Off
X1	X2	Y1	Y2	Center
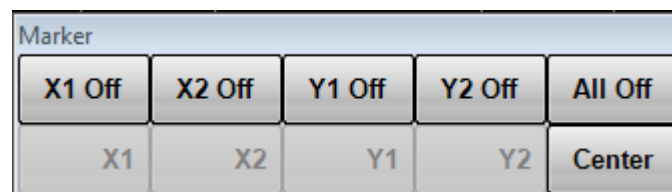
2. To display the marker, click the upper line buttons other than **All Off**. When the marker is displayed, the lower line buttons are invalid.

3. To move the marker, click the lower line buttons other than **Center**. The selected marker button is changed to the in-use display, and then the icon is displayed.

Marker				
X1 On	X2 On	Y1 On	Y2 On	All Off
🖱 X1	X2	Y1	Y2	Center

4. Set the marker position using the mouse wheel.
    The marker position and time/level differences are displayed.

    Marker Panel

X1 Off, X1 On, X2 Off, X2 On, Y1 Off, Y1 On, Y2 Off, Y2 On	Sets marker display
X1, X2, Y1, Y2	Selects marker to be moved
Center	Centers marker in the screen
All Off	Hide all markers

When the measurement result is displayed, click ▲ ▼ at the left side of **Marker** to switch the marker display.
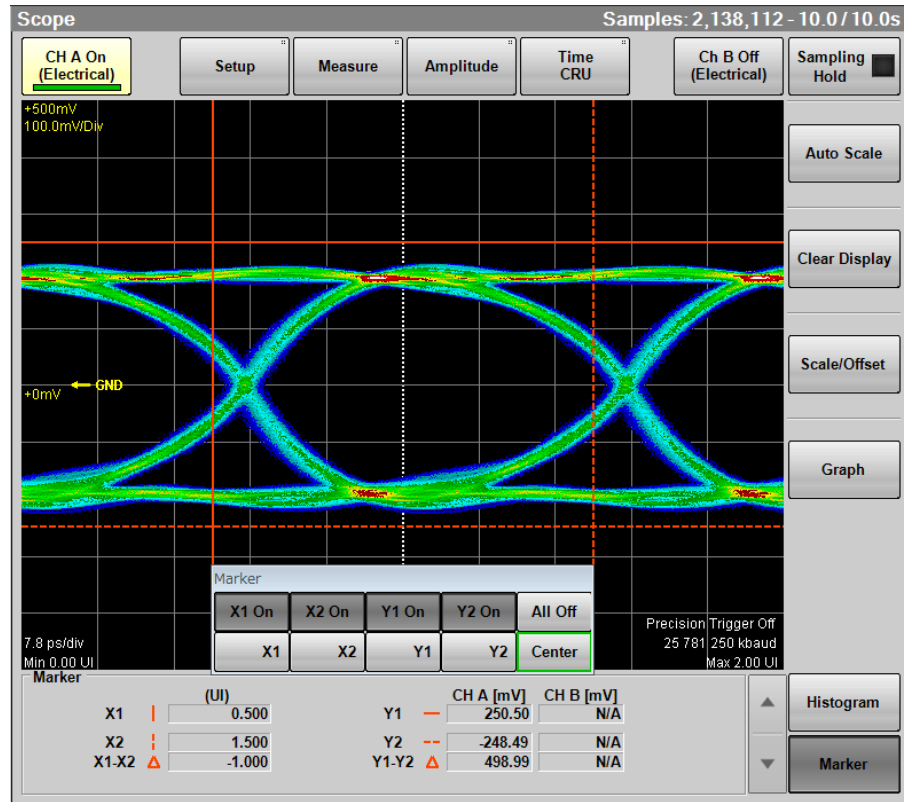
Figure 6.9.5-1   Marker Display

6.9.6 Displaying Waveform Calculation

The calculated math results for the two CH A and CH B waveforms can be displayed as a different waveform. The calculated math results can be measured at Section 6.9.1 "Setting and Displaying Measurement Items".

Note:

When calculating the EYE pattern waveform, set Sampling Mode to **Coherent Eye** and collect the data.

If Sampling Mode is set to **Eye** and data is collected, a computational error occurs.

Setting waveform calculation method and vertical scale

1. Click **Amplitude** to open the Amplitude dialog box.
2. Click the Channel Math button to set the button display to **On**.
3. Click the Define Function button and select the calculation method from the following:
   CH A+CH B
   CH A–CH B
   CH B–CH A

```
Channel Math ──────────────────────────

                              ┌─────────┐
                              │   On    │
                              └─────────┘

    Define Function       ┌────────────────┐
                          │   CH A + CH B  │
                          └────────────────┘

    Scale                    125.0 mV/Div

    Offset                     0.0 mV
```
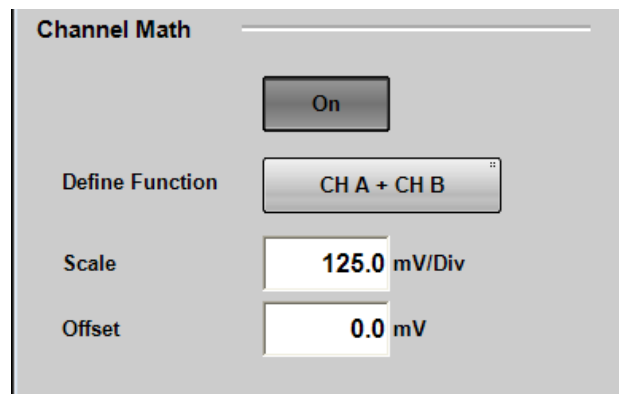
4. Click the Scale text box.
5. Input the voltage per vertical scale.
6. Click the Offset text box.
7. Input the voltage for the center of the vertical scale.

For the adjustment method of the time axis, refer to 6.8.3 "Adjusting Horizontal Axis".
Even when the calculated waveform is displayed, **Auto Scale** works.

To close the waveform calculation display, click the Channel Math button and set the button display to **Off**.

6.9.7 Using Trace Memory

The trace memory is a function to save the measurement waveform in the memory.

The waveform saved in the trace memory calls the reference trace.

To save the waveform in the trace memory

1. Click **Setup** to open the Setup dialog box.

2. Click the **Utilities** tab.

3. Click the Ref. Trace Channel button and select the channel to be saved from the following.
    Ch A & Ch B, **Ch A**, **Ch B**

4. Click **Set Reference**.
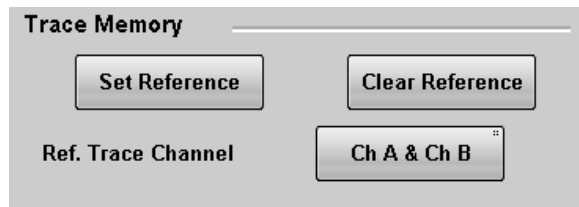
5. The trace waveform is displayed in the screen.
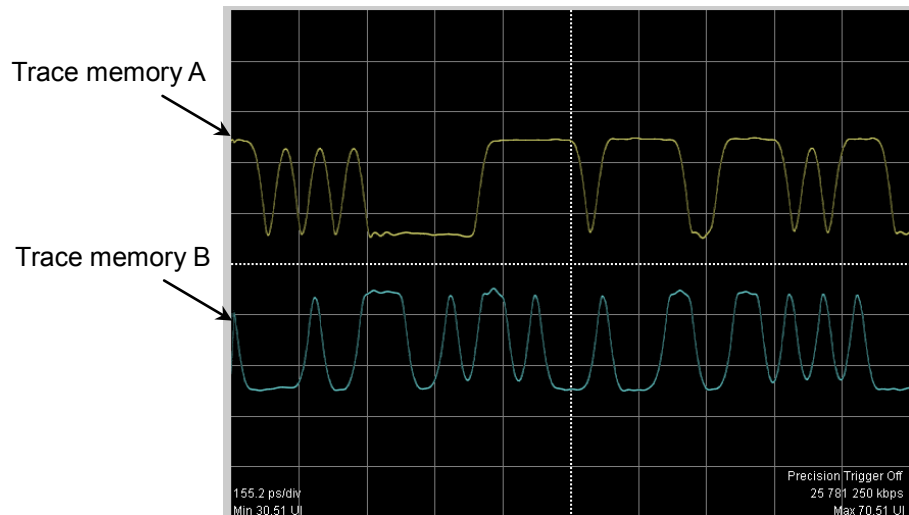
Figure 6.9.7-1   Waveform Display of Trace Memory

To delete the trace memory waveform

1. Click **Setup** to open the Setup dialog box.

2. Click the **Utilities** tab.

3. Click **Clear Reference** to delete both reference traces in Channel A and B.

6.9.8 Displaying a Label

This section describes how to display an arbitrary string (label) in the Scope screen.
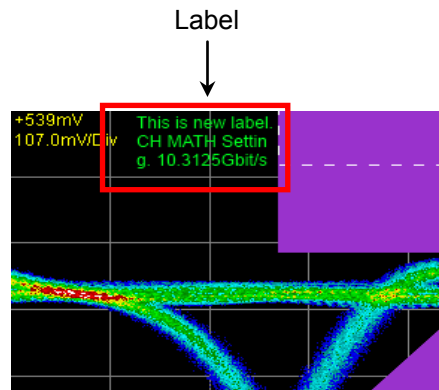
Label

Figure 6.9.8-1   Label Display

Displaying a label

1. Click **Setup** to open the Setup dialog box.

2. Click **Utilities** tab.

3. Set **Preset Information** to **Off** to specify the start position of label display. Set **Preset Information** to **On** to display the label at the fixed area as shown in Figure 6.9.8-1.

4. Click **Add** of **Label** to enter the character string for a new label. Inputting a line feed code (\n) starts a new line.
    When **Preset Information** is set to **Off** at step 3, specify the start position of label display (in the waveform display area, the position of upper left is (0, 0) and the position of lower right is (665, 497)).

5. Click **OK** on the software keyboard, and the label is displayed on the screen.

Note:

> Up to 1023 characters can be entered. However, all characters may not be displayed because the characters that can be displayed are limited.

> The color of the label cannot be changed.

Deleting the displayed label

1. Click **Setup** to open the Setup dialog box.

2. Click **Utilities** tab.

3. Click **Delete** for Delete Label, and the displayed label is deleted.

6

How to Operate Sampling Scope

6.9.9 Saving Measurement Results

The sampling oscilloscope results can be saved in the following file types:

- Screen image
  The image of the entire screen or only the measurement screen is saved to a PNG or JPEG file.
- Measurement result
  The waveform is saved as a text file or CSV file.
- Measurement conditions
  The setting values in the Amplitude O/E, Measurement, Setup, and Time CRU dialog boxes are saved to a file.

To save screen image

When saving the entire screen

1. Click **Screen Copy** at the system menu. The file selection screen is displayed.
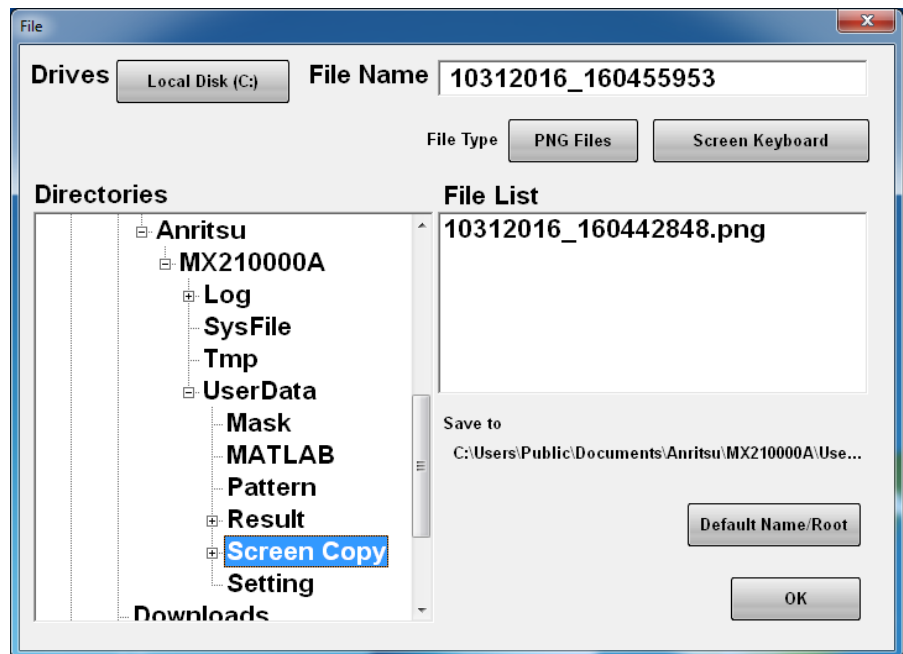
2. Click the Drives button and the Directories field to set the save destination folder. The path to the save folder is displayed at the Save to field.

3. The file format to be saved is displayed in the right button of the file type. Clicking the button can set the file format.

4. To set the file name, click **Screen Keyboard** and input the file name.

5. When overwriting an existing file, click the file name displayed at File List.

6. Click **OK** to save the screen image.
   When overwriting a file, a confirmation dialog box is displayed.

The path to the default folder is:
C:\Users\Public\Documents\Anritsu\MX210000A\UserData\Screen
Copy

The date and time are recorded in the default file name.

When saving the measurement screen:

1. Click **Setup**.

2. Click **Utilities**.

3. To save the waveform as a color image, select **Color Grade** at
    Waveform Color .
    To save the waveform as a monochrome image, select **Gray Scale** at
    Waveform Color.

4. To save both waveform and measurement results as an image, switch
    the option for Waveforms only   to **Off**.
    To save only the waveform as an image, switch the option for
    Waveforms only to **On**.

5. To save a screenshot using monitor color, set Inverse background
    color to **Off**.
    To reverse the screen color, set Inverse background color to **On**.
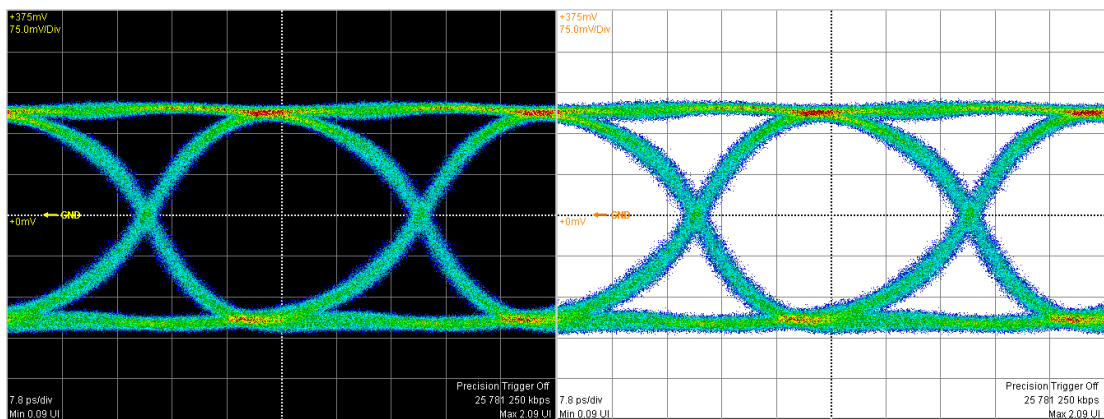
Inverse Off   Inverse On

6. Click **Capture**. The file selection screen same as the entire screen to
    be saved is displayed.

7. Set the file format, folder and file name and click **OK**.

8. The image png file is saved in the following path when the folder is
    set to the default.

    C:\Users\Public\Documents\Anritsu\MX210000A\UserData\Screen
    Copy

To save measurement condition or measurement result

1. Click **Save** at the system menu.

2. Click **Scope**.

3. When saving the measurement condition, click **Setting**.
   When saving the measurement result, click **Result**.

4. Input the file name.

5. Click **OK** or press the rotary knob.

The measurement condition file is saved in the following folder.
The extension for saved files is WFS.
C:\Users\Public\Documents\Anritsu\MX210000A\UserData\Setting

The measurement result file is saved in the following folder.
The extension of the measurement data file is CSV and TXT.
C:\Users\Public\Documents\Anritsu\MX210000A\UserData\Result\CSV
C:\Users\Public\Documents\Anritsu\MX210000A\UserData\Result\TXT

The measurement results file saves the number of samples per screen pixel.

```
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 2 9 16 30 30 39 39 23 17 5 4 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 4 6 37 78 112 204 211 241 209 167 89 66 34 14 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 3 9 34 54 105 127 134 138 152 122 112 132 112 103 55 39 23 7 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 2 5 14 32 72 70 104 101 88 59 35 25 51 57 76 89 62 43 24 6 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 1 3 8 44 47 75 88 71 58 37 17 10 7 9 28 43 51 47 49 22 10 6 2 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 1 6 13 43 50 60 81 83 62 44 21 8 1 4 12 22 37 39 42 43 53 21 12 2 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 3 4 12 30 50 84 111 65 82 33 18 7 3 0 1 5 6 32 38 49 41 47 38 26 7 1 1 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 3 3 14 44 66 83 83 81 52 35 16 7 1 2 1 0 1 3 24 19 42 48 45 33 18 18 7 0 0 0 0 0 1 1 5 10 1
0 0 0 0 0 0 0 0 0 4 10 31 46 84 97 100 82 50 43 14 4 2 0 0 1 1 9 16 44 60 58 55 45 26 14 6 1 0 3 4 16 48 55 1
0 0 0 0 0 0 0 0 1 4 33 54 110 126 160 144 106 65 39 10 4 1 0 0 0 0 1 3 6 35 55 80 74 80 70 37 15 9 9 33 78 111
0 0 0 0 0 0 0 1 2 7 17 57 63 97 114 126 79 62 25 15 6 0 0 0 0 0 0 0 4 14 22 47 67 82 65 54 32 41 55 89 106 135
0 0 0 0 0 0 0 2 5 30 46 75 94 128 93 61 44 15 9 0 1 0 0 0 0 0 0 0 2 4 16 35 71 110 113 151 134 156 136 159 135
0 0 0 0 0 2 2 9 13 38 69 93 95 64 46 43 12 6 3 0 0 0 0 0 0 0 0 0 1 5 8 45 55 122 155 231 206 217 139 117 40 1
0 0 0 0 0 2 1 8 14 25 63 59 51 60 41 24 8 1 1 0 0 0 0 0 0 0 0 0 1 4 5 17 14 20 29 15 9 9 3 0 0 0 0 0 0 0
0 0 0 0 0 1 2 10 14 39 58 49 56 44 23 9 4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 3 9 17 38 49 42 69 46 25 6 8 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 6 8 18 21 30 37 31 19 8 4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 1 1 0 5 5 10 27 28 31 29 13 2 4 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 1 1 6 12 21 29 29 25 13 8 4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 2 4 7 4 20 21 28 17 9 4 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 2 3 5 5 23 18 25 7 10 3 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 1 3 7 14 17 24 21 17 8 0 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 1 0 2 7 11 17 29 29 17 14 8 2 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
```

Figure 6.9.9-1   File Example of Screen Data

Amplitude/Time Measurement
[Results]
One Level CH A 187.18 187.20 0.06 186.49 187.31
One Level CH B N/A N/A N/A N/A N/A
Zero Level CH A -188.50 -188.52 0.13 -190.35 -188.43
Zero Level CH B N/A N/A N/A N/A N/A
Eye Amplitude CH A 375.68 375.72 0.10 375.58 376.84
Eye Amplitude CH B N/A N/A N/A N/A N/A
Eye Height CH A 298.29 298.35 0.27 297.76 301.13
Eye Height CH B N/A N/A N/A N/A N/A
Crossing CH A 49.98 50.04 0.09 49.91 50.47
Crossing CH B N/A N/A N/A N/A N/A
SNR CH A 14.56 14.57 0.04 14.47 14.93
SNR CH B N/A N/A N/A N/A N/A
Average Power (dBm) CH A N/A N/A N/A N/A N/A
Average Power (dBm) CH B N/A N/A N/A N/A N/A
Average Power (mW) CH A N/A N/A N/A N/A N/A
Average Power (mW) CH B N/A N/A N/A N/A N/A
Extinction Ratio CH A N/A N/A N/A N/A N/A
Extinction Ratio CH B N/A N/A N/A N/A N/A
Jitter P-P CH A 5.25 4.94 0.26 2.80 5.25
Jitter P-P CH B N/A N/A N/A N/A N/A
Jitter RMS CH A 0.67 0.68 0.01 0.57 0.71
Jitter RMS CH B N/A N/A N/A N/A N/A
Rise Time CH A 13.12 13.11 0.01 13.06 13.14
Rise Time CH B N/A N/A N/A N/A N/A
Fall Time CH A 12.18 12.17 0.01 12.05 12.23
Fall Time CH B N/A N/A N/A N/A N/A
Eye Width CH A 34.81 34.78 0.08 34.57 35.40
Eye Width CH B N/A N/A N/A N/A N/A
DCD CH A 4.21 4.23 0.30 3.31 5.26
DCD CH B N/A N/A N/A N/A N/A
OMA (mW) CH A N/A N/A N/A N/A N/A
OMA (mW) CH B N/A N/A N/A N/A N/A
OMA (dBm) CH A N/A N/A N/A N/A N/A
OMA (dBm) CH B N/A N/A N/A N/A N/A
OMA at Crossing CH A N/A N/A N/A N/A N/A
OMA at Crossing CH B N/A N/A N/A N/A N/A
VECP CH A N/A N/A N/A N/A N/A
VECP CH B N/A N/A N/A N/A N/A

Waveform
665x497
CH A
0 0 0 0 0 0 0 0 0 0 0 0 0.....(waveform data)
CH B
0 0 0 0 0 0 0 0 0 0 0 0 0.....(waveform data)

Figure 6.9.9-2   File Example of Amplitude/Time Measurement Data (NRZ)

6

Amplitude/Time Measurement
[Results]
One Level CH A N/A N/A N/A N/A N/A
One Level CH B N/A N/A N/A N/A N/A
Zero Level CH A N/A N/A N/A N/A N/A
Zero Level CH B N/A N/A N/A N/A N/A
Eye Amplitude CH A N/A N/A N/A N/A N/A
Eye Amplitude CH B N/A N/A N/A N/A N/A
Eye Height CH A N/A N/A N/A N/A N/A
Eye Height CH B N/A N/A N/A N/A N/A
Crossing CH A N/A N/A N/A N/A N/A
Crossing CH B N/A N/A N/A N/A N/A
SNR CH A N/A N/A N/A N/A N/A
SNR CH B N/A N/A N/A N/A N/A
Average Power (dBm) CH A N/A N/A N/A N/A N/A
Average Power (dBm) CH B -2.90 -3.04 0.03 -3.10 -2.90
Average Power (mW) CH A N/A N/A N/A N/A N/A
Average Power (mW) CH B 0.51 0.50 0.00 0.49 0.51
Extinction Ratio CH A N/A N/A N/A N/A N/A
Extinction Ratio CH B N/A N/A N/A N/A N/A
Jitter P-P CH A N/A N/A N/A N/A N/A
Jitter P-P CH B N/A N/A N/A N/A N/A
Jitter RMS CH A N/A N/A N/A N/A N/A
Jitter RMS CH B N/A N/A N/A N/A N/A
Rise Time CH A N/A N/A N/A N/A N/A
Rise Time CH B N/A N/A N/A N/A N/A
Fall Time CH A N/A N/A N/A N/A N/A
Fall Time CH B N/A N/A N/A N/A N/A
Eye Width CH A N/A N/A N/A N/A N/A
Eye Width CH B N/A N/A N/A N/A N/A
DCD CH A N/A N/A N/A N/A N/A
DCD CH B N/A N/A N/A N/A N/A
OMA (mW) CH A N/A N/A N/A N/A N/A
OMA (mW) CH B N/A N/A N/A N/A N/A
OMA (dBm) CH A N/A N/A N/A N/A N/A
OMA (dBm) CH B N/A N/A N/A N/A N/A
OMA at Crossing CH A N/A N/A N/A N/A N/A
OMA at Crossing CH B N/A N/A N/A N/A N/A
VECP CH A N/A N/A N/A N/A N/A
VECP CH B N/A N/A N/A N/A N/A
TDECQ CH A N/A N/A N/A N/A N/A
TDECQ CH B N/A N/A N/A N/A N/A
Outer OMA CH A N/A N/A N/A N/A N/A
Outer OMA CH B 618.73 615.35 6.15 604.20 626.78
Outer ExR CH A N/A N/A N/A N/A N/A
Outer ExR CH B 5.94 5.91 0.10 5.68 6.12
Linearity CH A N/A N/A N/A N/A N/A
Linearity CH B 0.89 0.90 0.04 0.87 1.02
Level(3) CH A N/A N/A N/A N/A N/A
Level(3) CH B 743.47 746.98 3.64 743.09 752.83
Level(2) CH A N/A N/A N/A N/A N/A
Level(2) CH B 566.28 568.93 3.02 564.63 573.57
Level(1) CH A N/A N/A N/A N/A N/A
Level(1) CH B 399.08 400.81 2.40 397.89 406.73
Level(0) CH A N/A N/A N/A N/A N/A
Level(0) CH B 253.40 254.81 2.23 253.40 261.47
Level(3) RMS CH A N/A N/A N/A N/A N/A

Level(2) RMS CH A N/A N/A N/A N/A N/A
Level(2) RMS CH B 33.87 34.25 0.59 33.17 35.49
Level(1) RMS CH A N/A N/A N/A N/A N/A
Level(1) RMS CH B 32.50 32.41 1.36 28.81 34.41
Level(0) RMS CH A N/A N/A N/A N/A N/A
Level(0) RMS CH B 28.13 28.57 1.09 27.58 31.76
Level(3) P-P CH A N/A N/A N/A N/A N/A
Level(3) P-P CH B 198.86 193.96 10.46 167.79 205.07
Level(2) P-P CH A N/A N/A N/A N/A N/A
Level(2) P-P CH B 167.79 171.36 7.34 153.29 180.21
Level(1) P-P CH A N/A N/A N/A N/A N/A
Level(1) P-P CH B 155.36 153.47 11.08 134.64 176.07
Level(0) P-P CH A N/A N/A N/A N/A N/A
Level(0) P-P CH B 151.21 149.33 5.03 136.71 157.43
Level(3) Skew CH A N/A N/A N/A N/A N/A
Level(3) Skew CH B 0.00 0.00 0.00 0.00 0.00
Level(2) Skew CH A N/A N/A N/A N/A N/A
Level(2) Skew CH B 0.00 0.00 0.00 0.00 0.00
Level(1) Skew CH A N/A N/A N/A N/A N/A
Level(1) Skew CH B 0.00 0.00 0.00 0.00 0.00
Level(0) Skew CH A N/A N/A N/A N/A N/A
Level(0) Skew CH B 0.00 0.00 0.00 0.00 0.00
Eye(Upper)   Level CH A N/A N/A N/A N/A N/A
Eye(Upper)   Level CH B 654.13 657.71 7.60 647.92 670.70
Eye(Middle) Level CH A N/A N/A N/A N/A N/A
Eye(Middle) Level CH B 484.27 483.71 6.90 465.63 494.63
Eye(Lower)   Level CH A N/A N/A N/A N/A N/A
Eye(Lower)   Level CH B 326.84 327.97 7.67 316.49 349.63
Eye(Upper)   Skew CH A N/A N/A N/A N/A N/A
Eye(Upper)   Skew CH B 0.00 0.00 0.00 0.00 0.00
Eye(Middle) Skew CH A N/A N/A N/A N/A N/A
Eye(Middle) Skew CH B 0.00 0.00 0.00 0.00 0.00
Eye(Lower)   Skew CH A N/A N/A N/A N/A N/A
Eye(Lower)   Skew CH B 0.00 0.00 0.00 0.00 0.00
Eye(Upper)   Height CH A N/A N/A N/A N/A N/A
Eye(Upper)   Height CH B 4.14 4.52 1.19 4.14 8.29
Eye(Middle) Height CH A N/A N/A N/A N/A N/A
Eye(Middle) Height CH B 4.14 4.33 0.60 4.14 6.21
Eye(Lower)   Height CH A N/A N/A N/A N/A N/A
Eye(Lower)   Height CH B 4.14 4.14 N/A 4.14 4.14
Eye(Upper)   Width CH A N/A N/A N/A N/A N/A
Eye(Upper)   Width CH B 0.45 1.20 1.36 0.34 5.10
Eye(Middle) Width CH A N/A N/A N/A N/A N/A
Eye(Middle) Width CH B 0.57 1.59 1.90 0.57 7.25
Eye(Lower)   Width CH A N/A N/A N/A N/A N/A
Eye(Lower)   Width CH B 0.23 0.63 0.59 0.23 2.38
Average Power (dBm) CH A N/A N/A N/A N/A N/A
Average Power (dBm) CH B -2.90 -3.04 0.03 -3.10 -2.90
Average Power (mW) CH A N/A N/A N/A N/A N/A
Average Power (mW) CH B 0.51 0.50 0.00 0.49 0.51

Waveform
665x497
CH A
0 0 0 0 0 0 0 0 0 0 0 0.....(waveform data)
CH B
0 0 0 0 0 0 0 0 0 0 0 0.....(waveform data)

Figure 6.9.9-3   A File Example of Amplitude/Time&Mask Measurement Data (PAM4)

Amplitude/Time and Histogram Measurement - Channel A
[Setups]
Axis Time
X1 Marker 0.50UI
X2 Marker 1.50UI
Y1 Marker 9mV
Y2 Marker -10mV
[Results]
One Level CH A 189.65 189.84 0.13 189.60 190.04
One Level CH B N/A N/A N/A N/A N/A
Zero Level CH A -185.34 -185.48 0.14 -185.73 -185.12
Zero Level CH B N/A N/A N/A N/A N/A
Eye Amplitude CH A 374.99 375.31 0.26 374.72 375.73
Eye Amplitude CH B N/A N/A N/A N/A N/A
Eye Height CH A 327.54 327.74 0.27 326.40 328.27
Eye Height CH B N/A N/A N/A N/A N/A
Crossing CH A 49.89 49.82 0.17 49.47 50.66
Crossing CH B N/A N/A N/A N/A N/A
SNR CH A 23.71 23.67 0.04 23.12 23.76
SNR CH B N/A N/A N/A N/A N/A
Average Power (dBm) CH A N/A N/A N/A N/A N/A
Average Power (dBm) CH B N/A N/A N/A N/A N/A
Average Power (mW) CH A N/A N/A N/A N/A N/A
Average Power (mW) CH B N/A N/A N/A N/A N/A
Extinction Ratio CH A N/A N/A N/A N/A N/A
Extinction Ratio CH B N/A N/A N/A N/A N/A
Jitter P-P CH A 11.68 11.71 0.84 7.78 14.86
Jitter P-P CH B N/A N/A N/A N/A N/A
Jitter RMS CH A 1.83 1.87 0.07 1.77 2.19
Jitter RMS CH B N/A N/A N/A N/A N/A
Rise Time CH A 35.16 27.11 5.94 22.66 35.68
Rise Time CH B N/A N/A N/A N/A N/A
Fall Time CH A 33.16 25.65 5.45 21.53 33.50
Fall Time CH B N/A N/A N/A N/A N/A
Eye Width CH A 106.25 106.41 0.46 104.43 107.01
Eye Width CH B N/A N/A N/A N/A N/A
DCD CH A 1.80 1.06 0.45 0.00 2.11
DCD CH B N/A N/A N/A N/A N/A
OMA (mW) CH A N/A N/A N/A N/A N/A
OMA (mW) CH B N/A N/A N/A N/A N/A
OMA (dBm) CH A N/A N/A N/A N/A N/A
OMA (dBm) CH B N/A N/A N/A N/A N/A
OMA at Crossing CH A N/A N/A N/A N/A N/A
OMA at Crossing CH B N/A N/A N/A N/A N/A
VECP CH A N/A N/A N/A N/A N/A
VECP CH B N/A N/A N/A N/A N/A
Mean 100.62
Std Dev 1.87
P-P 11.68
Hits 3835
Hit Point Detail
0.50UI 0 Hits
0.50UI 0 Hits
0.51UI 0 Hits
0.51UI 0 Hits
0.51UI 0 Hits
          :
          :
(Hit　Point data)

Waveform
665x497
CH A
0 0 0 0 0 0 0 0 0 0 0 0 0.....(waveform data)
CH B

Figure 6.9.9-4　File Example of Amplitude/Time&HistogramMeasurement Data (NRZ)

6

How to Operate Sampling Scope

Histogram Measurement - Channel A
[Setups]
Axis Amplitude
X1 Marker 0.73UI
X2 Marker 0.75UI
Y1 Marker 287mV
Y2 Marker -276mV
[Results]
Mean 5.27
Std Dev 188.49
P-P 423.91
Hits 11979
Hit Point Detail
287mV 0 Hits
284mV 0 Hits
281mV 0 Hits
279mV 0 Hits
276mV 0 Hits
273mV 0 Hits
270mV 0 Hits
268mV 0 Hits
   :
   :
(Hit Point data)

Waveform
665x497
CH A
0 0 0 0 0 0 0 0 0 0 0 0.....(waveform data)
CH B
0 0 0 0 0 0 0 0 0 0 0 0.....(waveform data)

Figure 6.9.9-5   File Example of Histogram Measurement Data

Mask Measurement - Channel A
[Setups]
Current Mask 8G Optical Fibre Channel Mask (8.5 Gbps)
[Results]
Total Samples 991111
Total Waveforms 121
Mask Margin 0
Hit Count 1
Total Failed Samples 0
Top Mask Failed Samples 0
Center Mask Failed Samples 0
Bottom Mask Failed Samples 0

Waveform
665x497
CH A
0 0 0 0 0 0 0 0 0 0 0 0.....(waveform data)
CH B
0 0 0 0 0 0 0 0 0 0 0 0.....(waveform data)

Figure 6.9.9-6   File Example of Mask Measurement Data

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How to Operate Sampling Scope

```
Anritsu;MP2110A;TXT-------------------------------------------------- [TJ Histogram][CHB]
Option                          54,96,            Total Samples
[Setup]                                                              -
Measure Selection               Jitter            [Bathtub][CHA]
Signal Bitrate                  25781252 kbit/s   Measure Edge Type                    ALL
Divide Ratio                    4                 Total Samples                        0
Pattern Length                  511               Unit Interval    BER(Estimate)   BER(Actual)
Target Channel                  CHA               0.000000e+000    -               -
Accumulation Type               Infinite          1.000000e-002    -               -
Measure Algorithm               Histogram         2.000000e-002    -               -
TJ Measurement BER (CHA)        1.00E-012         3.000000e-002    -               -
TJ Measurement BER (CHB)        -                 4.000000e-002    -               -
Fixed RJ (CHA)                  OFF               5.000000e-002    -               -
Fixed RJ (CHB)                  -                 6.000000e-002    -               -
RJ Value (CHA)                  1.00 ps rms       7.000000e-002    -               -
RJ Value (CHB)                  -                 8.000000e-002    -               -
Correction Factor (CHA)         OFF               9.000000e-002    -               -
Correction Factor (CHB)         -                 1.000000e-001    -               -
DJ (Scale) (CHA)                1.00              1.100000e-001    -               -
DJ (Scale) (CHB)                -                 1.200000e-001    -               -
RJ (Scale) (CHA)                1.00              1.300000e-001    -               -
RJ (Scale) (CHB)                -                 1.400000e-001    -               -
RJ (rms) (CHA)                  1.00 ps                            :
RJ (rms) (CHB)                  -                                  :
Define Threshold (CHA)          Auto              [Bathtub][CHB]
Define Threshold (CHB)          -                 Measure Edge Type                    ALL
Manual Crossing (CHA)           50.00 %           Total Samples                   -          :
Manual Crossing (CHB)           -                                  :
Jitter Unit                     UI

[Jitter Measurement Results]
TJ(1.00E-012) (CHA)             -
TJ(1.00E-012) (CHB)             -
DJ(d-d) (CHA)                   -
DJ(d-d) (CHB)                   -
RJ(d-d) (CHA)                   -
RJ(d-d) (CHB)                   -
EYE Opening (CHA)               -
EYE Opening (CHB)               -
J2 Jitter (CHA)                 -
J2 Jitter (CHB)                 -
J9 Jitter (CHA)                 -
J9 Jitter (CHB)                 -

[TJ Histogram][CHA]
Total Samples                   0
Edge Deviation                  Number Hits
-3.330000e+001                  0
-3.263400e+001                  0
-3.196800e+001                  0
-3.130200e+001                  0
-3.063600e+001                  0
-2.997000e+001                  0
-2.930400e+001                  0
-2.863800e+001                  0
-2.797200e+001                  0
-2.730600e+001                  0
-2.664000e+001                  0
-2.597400e+001                  0
-2.530800e+001                  0
-2.464200e+001                  0
-2.397600e+001                  0
-2.331000e+001                  0
-2.264400e+001                  0
-2.197800e+001                  0
              :
```

Figure 6.9.9-7   Example of Text File Saved in Jitter Analysis (Eye)

Anritsu;MP2110A;TXT--

Option	54,96,
[Setup]	
Measure Selection	Jitter
Signal Bitrate	25781253 kbit/s
Divide Ratio	4
Pattern Length	511
Target Channel	CHA
Accumulation Type	Infinite
Measure Algorithm	Pattern Search
PDJ Measurement	OFF
Standard	STM-0 (51.84M)
PDJ Filter	LP (-400k)
Measure Edge Type	ALL
TJ Measurement BER	1.00E-012
Fixed RJ	OFF
RJ Value	1.00 ps rms
Correction Factor	OFF
DJ (Scale)	1.00
RJ (Scale)	1.00
RJ (rms)	1.00 ps
Define Threshold	Auto
Manual Crossing	50.00 %
Jitter Unit	UI

[Jitter Measurement Results]	
TJ(1.00E-012)	3.140417e-001
DJ(d-d)	8.390266e-002
RJ(d-d)	1.635676e-002
RJ(rms)	1.359732e-002
PJ(p-p)	1.058215e-002
DDJ(p-p)	1.546195e-001
DCD	5.149242e-002
ISI(p-p)	1.156035e-001
EYE Opening	6.859583e-001
J2 Jitter	1.757512e-001
J9 Jitter	2.873651e-001
DDPWS	8.839424e-002
PJ Frequency	-

[TJ Histogram]	
Measure Edge Type	ALL
Total Samples	1355776
Edge Deviation	Number Hits
-1.390000e-001	0
-1.362200e-001	0
-1.334400e-001	0
-1.306600e-001	0
-1.278800e-001	0
-1.251000e-001	0
-1.223200e-001	0
-1.195400e-001	0
-1.167600e-001	0
-1.139800e-001	0
-1.112000e-001	0
-1.084200e-001	0
-1.056400e-001	1
-1.028600e-001	1
-1.000800e-001	0
-9.730000e-002	9
-9.452000e-002	47
-9.174000e-002	71
:	
:	

[RJ/PJ Histogram]	
Measure Edge Type	ALL
Total Samples	1355776
Edge Deviation	Number Hits
-7.500000e-002	0
-7.350000e-002	0
-7.200000e-002	0
-7.050000e-002	0
-6.900000e-002	0
-6.750000e-002	0
-6.600000e-002	0
-6.450000e-002	0
-6.300000e-002	0
-6.150000e-002	0
-6.000000e-002	0
:	
:	

[DDJ Histogram]	
Measure Edge Type	ALL
Total Samples	84736
Edge Deviation	Number Hits
-8.800000e-002	0
-8.607000e-002	0
-8.414000e-002	0
-8.221000e-002	0
-8.028000e-002	0
-7.835000e-002	10
-7.642000e-002	310
-7.449000e-002	10
-7.256000e-002	17
-7.063000e-002	641
-6.870000e-002	379
:	
:	

[DDJ Histogram]	
Measure Edge Type	RISE
Total Samples	42368
Edge Deviation	Number Hits
-8.800000e-002	0
-8.607000e-002	0
-8.414000e-002	0
-8.221000e-002	0
-8.028000e-002	0
-7.835000e-002	8
-7.642000e-002	270
-7.449000e-002	8
-7.256000e-002	14
-7.063000e-002	559
-6.870000e-002	330
:	
:	

[DDJ Histogram]	
Measure Edge Type	FALL
Total Samples	42368
Edge Deviation	Number Hits
-8.800000e-002	0
-8.607000e-002	0
-8.414000e-002	0
-8.221000e-002	0
-8.028000e-002	0
-7.835000e-002	0
-7.642000e-002	0
-7.449000e-002	0
-7.256000e-002	0
-7.063000e-002	0
-6.870000e-002	0
:	
:	

Figure 6.9.9-8   Example of Text File Saved in Jitter Analysis (Advanced Jitter)

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How to Operate Sampling Scope

[Composite Histogram (TJ)]			[Bathtub]		
Measure Edge Type	ALL		Measure Edge Type		ALL
Total Samples	1355776		Total Samples		1355776
Edge Deviation	Number Hits		Unit Interval	BER(Estimate)	BER(Actual)
-1.390000e-001	0		0.000000e+000	2.507171e-001	1.988485e-001
-1.362200e-001	0		1.000000e-002	2.447819e-001	1.585160e-001
-1.334400e-001	0		2.000000e-002	2.292430e-001	1.297830e-001
-1.306600e-001	0		3.000000e-002	1.945758e-001	1.015429e-001
-1.278800e-001	0		4.000000e-002	1.401674e-001	6.533085e-002
-1.251000e-001	0		5.000000e-002	8.070605e-002	3.360140e-002
-1.223200e-001	0		6.000000e-002	3.547614e-002	1.355748e-002
-1.195400e-001	0		7.000000e-002	1.153317e-002	4.245349e-003
-1.167600e-001	0		8.000000e-002	2.715055e-003	8.650327e-004
-1.139800e-001	0		9.000000e-002	4.564126e-004	1.019859e-004
-1.112000e-001	0		1.000000e-001	4.302756e-005	2.586599e-006
:			1.100000e-001	3.470762e-006	3.695142e-007
:			1.200000e-001	1.958029e-007	-

[Composite Histogram (RJ/PJ)]

		[PJ vs. Frequency]	
Measure Edge Type	ALL	Measure Edge Type	ALL
Total Samples	1355776	Frequency	PJ
Edge Deviation	Number Hits	0	-7.134485e+001
-1.390000e-001	0	122	-7.337275e+001
-1.362200e-001	0	245	-7.609208e+001
-1.334400e-001	0	368	-7.158152e+001
-1.306600e-001	0	491	-7.346856e+001
-1.278800e-001	0	613	-7.584631e+001
-1.251000e-001	0	736	-7.361331e+001
-1.223200e-001	0	859	-7.669788e+001
-1.195400e-001	0	982	-6.107312e+001
-1.167600e-001	0	1105	-7.011509e+001
-1.139800e-001	0	1227	-7.508716e+001
-1.112000e-001	0	1350	-7.690627e+001

[Composite Histogram (DDJ)]

Measure Edge Type	ALL
Total Samples	84736
Edge Deviation	Number Hits
-1.390000e-001	0
-1.362200e-001	0
-1.334400e-001	0
-1.306600e-001	0
-1.278800e-001	0
-1.251000e-001	0
-1.223200e-001	0
-1.195400e-001	0
-1.167600e-001	0
-1.139800e-001	0
-1.112000e-001	0

[DDJ vs. bit]

Measure Edge Type		ALL
Pattern Length		511
DDJ/PDJ vs Bit Current Pattern		5.296000e+003 patterns
Bit Number	Pattern	DDJ
0	1	-1.689937e-002
1	1	-
2	0	1.068998e-003
3	1	-1.924671e-002
4	1	-
5	0	-6.249656e-003
6	1	-1.554626e-002
7	0	4.819819e-002
8	0	-
9	1	-5.431253e-002

Figure 6.9.9-8   Example of Text File Saved in Jitter Analysis (Advanced Jitter) (Cont'd)

Chapter 7 Performance Test

This chapter describes how to test the performance of the MP2110A.

7

Performance Test

7.1 Performance Test for Pulse Pattern Generator

This section describes the performance test items for the pulse pattern generator.

- Operation frequency range
- Frequency accuracy

⚠ CAUTION

Connect a 50 Ω terminator to unused input/output connectors.

7.1.1 Required equipment

The following table shows the equipment required for the performance test.

Before starting performance tests, warm up the MP2110A and the measuring instruments for at least 1 hour.

Table 7.1.1-1   Equipment for Performance Test

Product Name	Required Performance	Recommended Equipment
Sampling oscilloscope	Electrical interface Bandwidth: 40 GHz or more	MP2110A (Anritsu)
Frequency counter	Frequency range: 500 MHz to 20 GHz Accuracy: 0.1 ppm max.	MF2412C (Anritsu)

7.1.2 Frequency accuracy

(1)   Specification

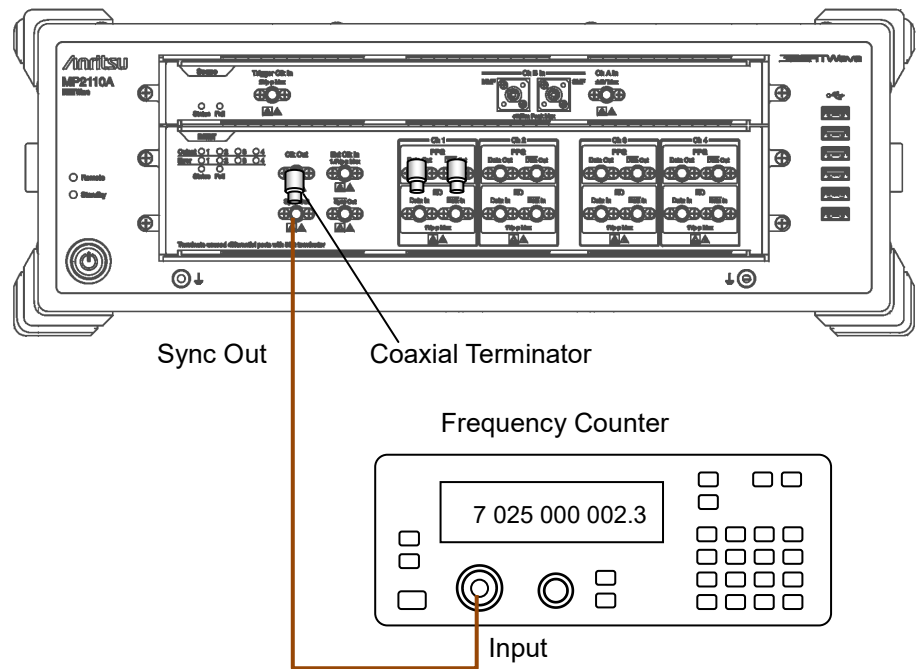±10 ppm (One hour after power on)

(2)   Setup

Figure 7.1.2-1   Operation Frequency Range Test Setup

(3) Procedure

1. Connect the **Sync Out** connector to the input connector of the frequency counter.

2. Connect coaxial terminators to $\overline{\text{Sync}}$ **Out** connector.

3. Click **PPG/ED Ch1**. Set the value as follows:

Item	Setting Value
Reference Clock	Internal
Bit Rate	Variable 28 200 000 kbit/s 0 ppm
Sync Output	PPG_1/8 Clk
Test Pattern (PPG)	PRBS 2^31–1, POS

4. Read the setting value of the frequency counter.

5. Check that the read value multiplied by 4 is within the following range.
    3 525 000 ±35.25 kHz

6. Set Bit Rate to 24 300 000 kbit/s.
    When the MP2110A-093 is added, input 9 500 000 kbit/s.

7. Read the value measured by the frequency counter.

8. Check that the read value is within the following limited values.
    Without the MP2110A-093:   3 037 500±30.37 kHz
    With the MP2110A-093:   1 187 500±11.87 kHz

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Performance Test

7.1.3 Waveform

(1) Specification

Amplitude: 0.1 to 0.8 Vp-p

Accuracy: (±20% of setting) ±20 mV

Data Crossing: 50±10%
                   (Amplitude: 0.3 Vp-p, Bit rate: 25.78125 Gbit/s)

Rise/fall time: 17 ps
                   (Amplitude: 0.3 Vp-p, Percentage: 20-80%, Bit
                   rate: 25.78125 Gbit/s)

Jitter (RMS):   0.9 ps (Amplitude 0.3 Vp-p, 25.78125 Gbit/s)

(2) Setup

Figure 7.1.3-1 and Figure 7.1.3-2 show the connection diagrams
when performing the test using one MP2110A.

Figure 7.1.3-3 and Figure 7.1.3-4 show the connection diagrams
when performing the test using two MP2110As (one MP2110A is used
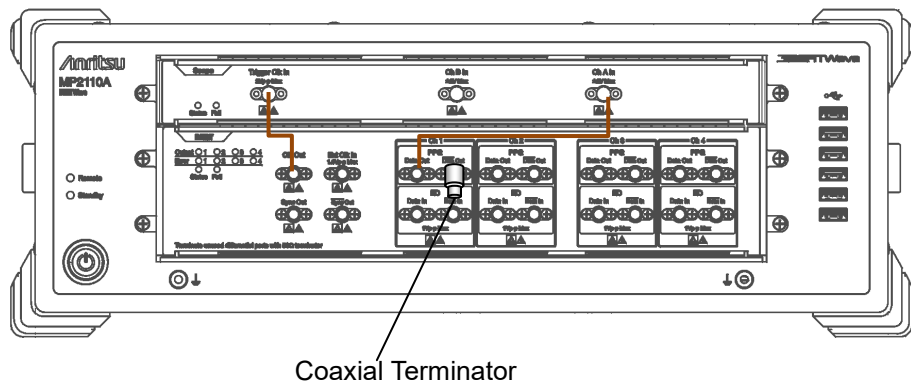as the sampling oscilloscope).

Coaxial Terminator
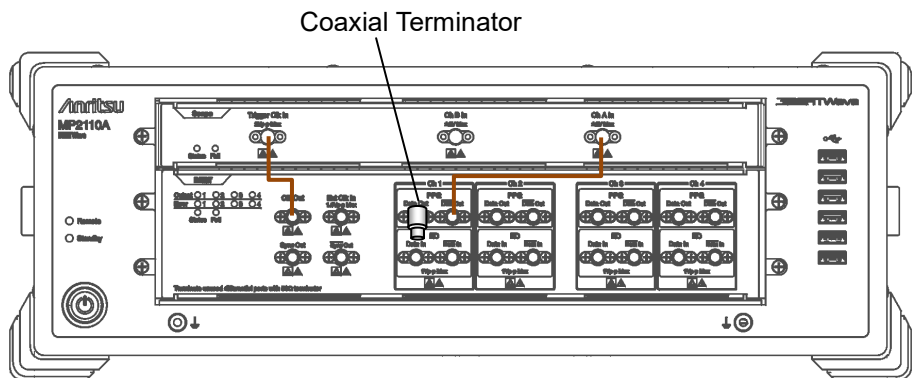
Figure 7.1.3-1   PPG1 Data Out Waveform Test Connection Diagram

Coaxial Terminator

Figure 7.1.3-2   PPG1 D̄āt̄ā Out Waveform Test Connection Diagram

Coaxial Terminator

Sampling oscilloscope
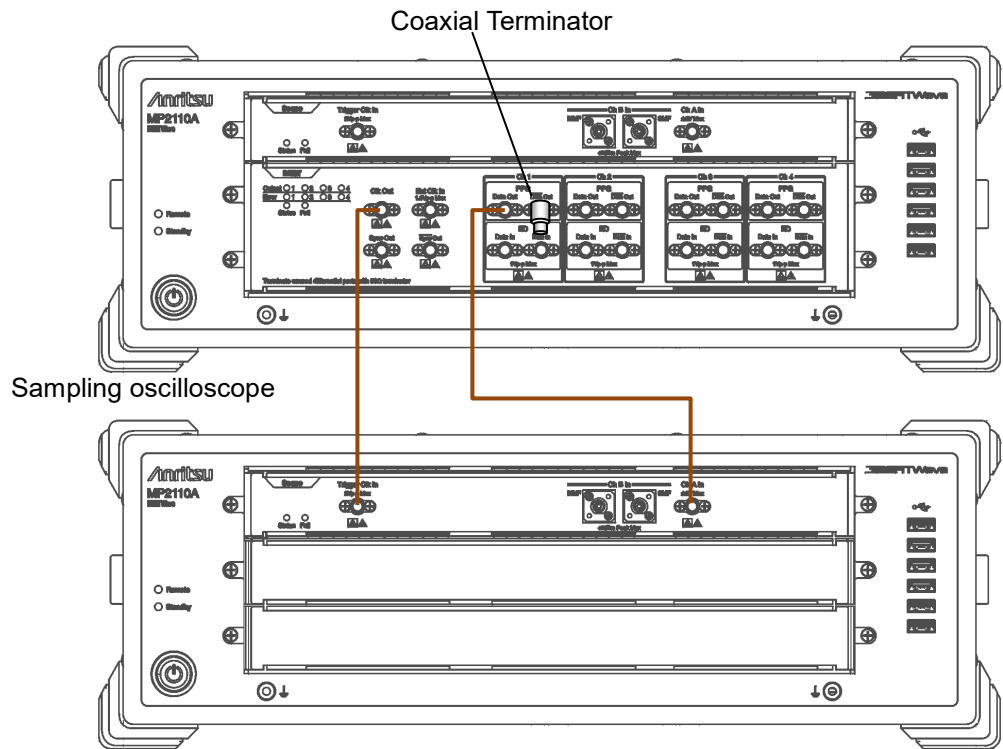
Figure 7.1.3-3   PPG1 Data Out Waveform Test Connection Diagram

Coaxial Terminator

Sampling oscilloscope

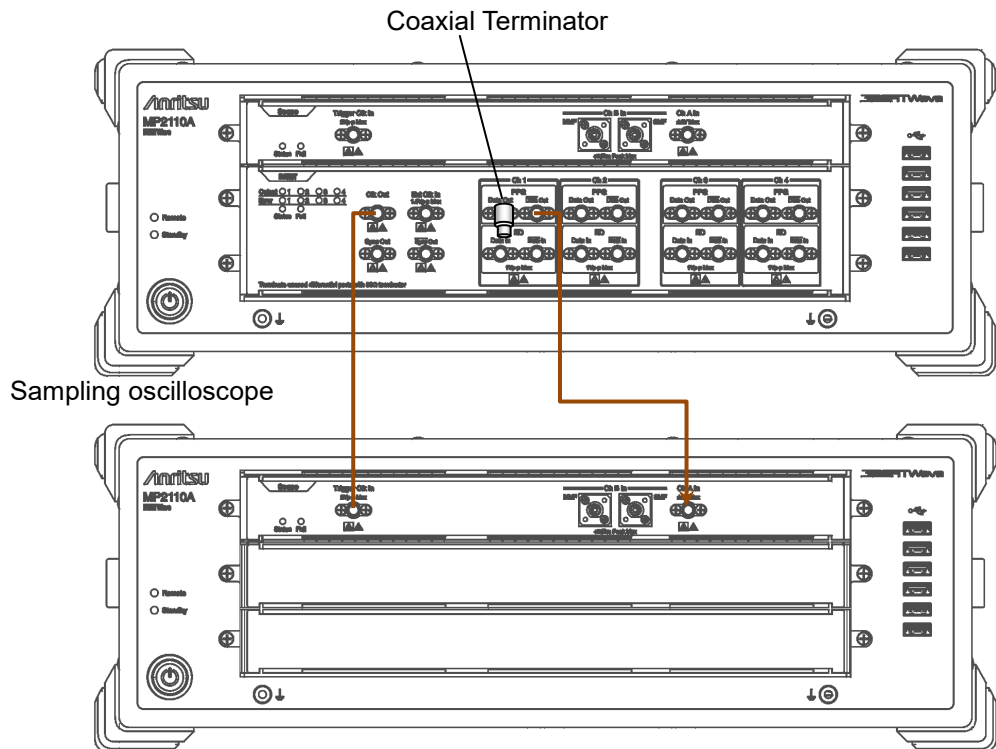**Figure 7.1.3-4   PPG1 $\overline{\text{Data}}$ Out Waveform Test Connection Diagram**

(3)   Procedure

1.   Connect the coaxial terminator to the **PPG1 Datā Out** connector.

2.   Connect the **Clk Out** connector and the **Trigger Clk In** connector of the sampling oscilloscope using a coaxial cable.

3.   Connect the **PPG1 Data Out** connector and the **Ch A In** of the sampling oscilloscope using a coaxial cable.

4.   Click **PPG/ED Ch1**. Set the value as follows:

Item	Setting Value
Reference Clock	Internal
Bit Rate	100GbE/4 (25.78125G), 0 ppm
Clock Output	Ch1/2
PPG Amplitude	0.1
External ATT	0
Test Pattern (PPG)	PRBS 2^31–1, POS
PPG Data/XData	ON

5.   Click **Scope**. Set the value as follows:

Dialog Box	Item	Setting Value
Setup	Signal Type	NRZ
	Sampling Mode	Eye
	Number of Samples	4050
	Accumulation Time	Persistency
	Limit Type	10.0 sec
Amplitude	Scale	100 mV/Div
	Offset	0 mV
Time	Tracking	Symbol Rate: PPG, Divide Ratio: Clock Output*
Measure - Amplitude/Time	Display	On
	Item	(A) Eye Amplitude,
	Rise/Fall Time	20/80%

*:   Set it to Off when using two MP2110As (Figure 7.1.3-3 and Figure 7.1.3-4), and input Divide Ratio.

6.   Click **CH A**, **Sampling Hold**, and **Auto Scale** of Scope, and measure the eye amplitude.

7.   Click **PPG/ED Ch1**.

8.   Set Amplitude to 0.8 Vp-p.

9.   Click **Scope**. Measure the EYE amplitude on the sampling oscilloscope.

10. Click **PPG/ED Ch1**.

11. Set Amplitude to 0.3 Vp-p.

12. Click **Scope**. Set the value as follows:

Dialog Box	Item	Setting Value
Measure - Amplitude/Time	Item	(A) Fall Time
		(A) Rise Time
		(A) Crossing
		(A) Jitter (RMS)

13. Measure the amplitude, rise/fall time, and Data Crossing on the sampling oscilloscope.

14. Connect the coaxial terminator to the **PPG1 Data Out** connector. (Refer to Figure 7.1.3-4.)

15. Connect the **PPG1** $\overline{\text{Data}}$ **Out** connector to the **Ch A In** connector of the sampling oscilloscope.

16. Repeat steps 4 to 13.

For PPG2 to PPG4, perform tests in the same way. For PPG3 and PPG4 test, change the Clock Output in step 4 to the following value.

Item	Setting Value
Clock Output	Ch3/4

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Performance Test

7.1.4 Skew

(1)   Specification

±8 ps   (Amplitude 0.3 Vp-p, 25.78125 Gbit/s)
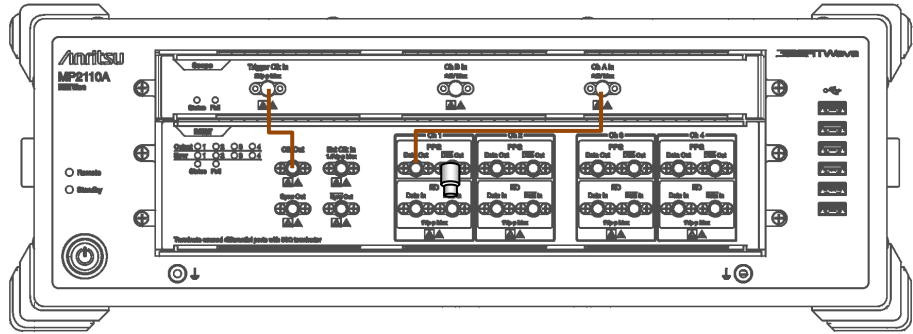
(2)   Setup

Figure 7.1.4-1   PPG1 Data Out Skew Test Connection Diagram
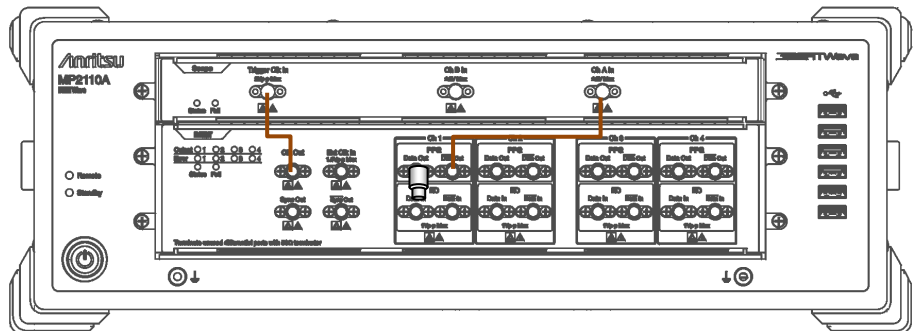

Figure 7.1.4-2   PPG1 $\overline{\text{Data}}$ Out Skew Test Connection Diagram

(3)   Procedure

1.   Connect the **Clk Out** connector and the **Trigger Clk In** connector of the sampling oscilloscope using a coaxial cable.

2.   Connect the **PPG1 Data Out** connector and the **Ch A In** of the sampling oscilloscope using a coaxial cable.

3.   Connect the coaxial terminator to the **PPG1 $\overline{\text{Data}}$ Out** connector. (refer to Figure 7.1.4-1).

4.   Click **PPG/ED Ch1**. Set the value as follows:

Item	Setting Value
Reference Clock	Internal
Bit Rate	100GbE/4 (25.78125G), 0 ppm
Clock Output	Ch1/2
PPG Amplitude	0.3
External ATT	0
Test Pattern (PPG)	PRBS 2^9–1, POS
PPG Data/XData	ON

5.   Click **Scope**. Set the value as follows:

Dialog Box	Item	Setting Value
Setup	Signal Type	NRZ
	Sampling Mode	Eye
	Number of Samples	4050
	Accumulation Time	Persistency
	Limit Type	10.0 sec

6.   Display the X1 marker by clicking **Marker** of Scope, and move the X1 marker to the left cross-point.

7.   Connect the coaxial terminator to the **PPG1 Data Out** connector.

8.   Connect the **PPG1 $\overline{\text{Data}}$ Out** connector to the **Ch A In** connector of the sampling oscilloscope. (refer to Figure 7.1.4-2).

9.   Display the X2 marker by clicking **Marker** of Scope, and move the X2 marker to the left cross-point.

10.   When the time unit is **UI**, change Unit in the **Scale/Offset** tab to **Time** by clicking **Time** of Scope.

11.   Measure the time lag of two waveforms using the X1 and X2 markers. Note that the polarities of two waveforms are inverted.
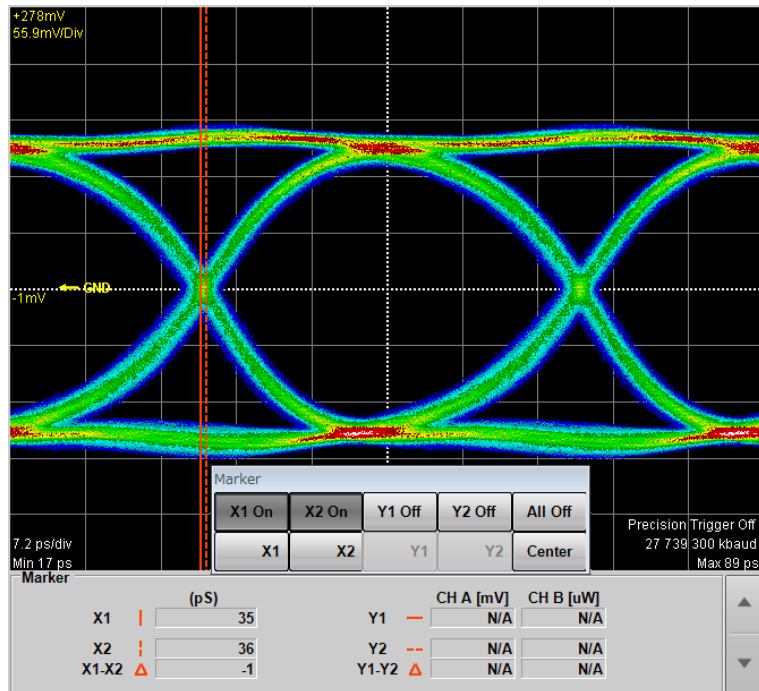
7

Performance Test

Figure 7.1.4-3   Measurement Example of Skew

For PPG2 to PPG4, perform a test in the same way. For PPG3 and PPG4 test, change the Clock Output in step 4 to the following value.

Item	Setting Value
Clock Output	Ch3/4

7.2 Performance Test for Error Detector

This section describes the performance test items for the error detector.

- Operating frequency
- Rx sensitivity
- Maximum input level and patterns
- Error detection

Before testing the performance of the ED, confirm that the performance of the tested pulse pattern generator satisfies the specifications.

7.2.1 Required equipment

The following table shows the equipment required for the performance test.

Before starting performance tests, warm up the MP2110A and the measuring instruments for at least 1 hour.

Table 7.2.1-1   Equipment for Performance Test

Product Name	Required Performance	Recommended Equipment
Sampling oscilloscope	Electrical interface Bandwidth: 40 GHz or more	MP2110A (Anritsu)
Fixed attenuator	20 dB, K connector Bandwidth: DC to 40 GHz	41KC-20 (Anritsu)

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Performance Test

7.2.2 Operating frequency

(1)   Specification

Without MP2110A-093:

24.3 Gbit/s −100 ppm to 28.2 Gbit/s +100 ppm
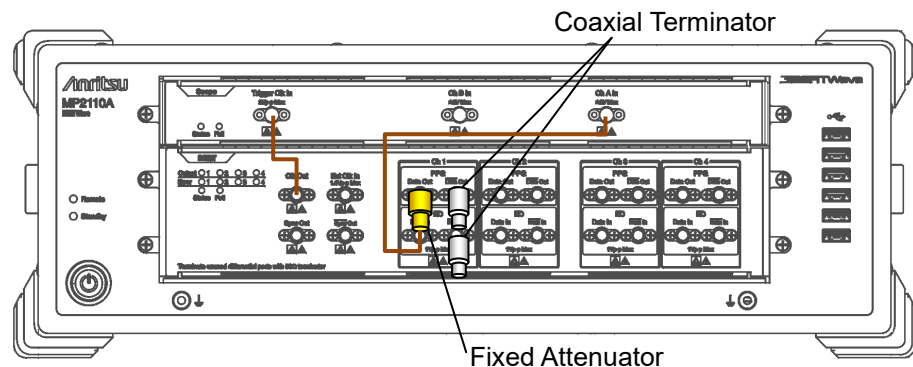
With MP2110A-093:

24.3 Gbit/s −100 ppm to 28.2 Gbit/s +100 ppm,
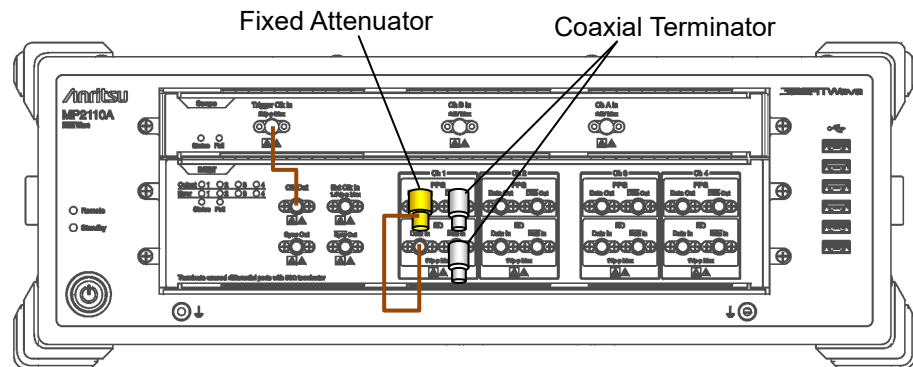
9.5 Gbit/s −100 ppm to 14.2 Gbit/s +100 ppm

BER 10^{-12} or less under the following conditions:

- Amplitude: 0.05 Vp-p
- Pattern: PRBS2^31−1
- Mark ratio: 50%
- Single-end
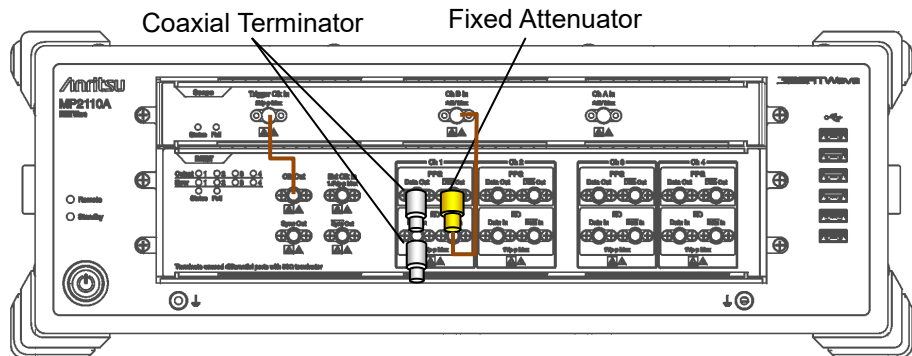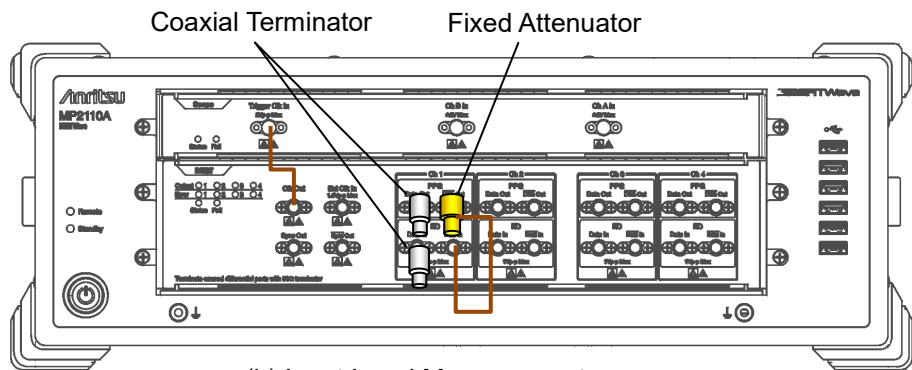- Back-to-back connection

(2)   Setup

(a) Amplitude Check

(b) Input Level Measurement

Figure 7.2.2-1   ED1 Data In Input Sensitivity Test Connection Diagram

(a) Amplitude Check

(b) Input Level Measurement

Figure 7.2.2-2   ED1 Data In Input Sensitivity Test Connection Diagram

(3)   Procedure

1.   Connect the **Clk Out** connector and the **Trigger Clk In** connector of the sampling oscilloscope using a coaxial cable.

2.   Connect the coaxial terminator to the **ED1 $\overline{\text{Data}}$ In** and **PPG1 $\overline{\text{Data}}$ Out** connector.

3.   Attach a 20 dB fixed attenuator to the **PPG1 Data Out** connector. (Refer to (a) in Figure 7.2.2-1.)

4.   Connect the 20 dB fixed attenuator and **Ch A In** connectors using a coaxial cable.

5.   Click **PPG/ED Ch1**. Set the value as follows:

Item	Setting Value
Reference Clock	Internal
Bit Rate	When MP2110A-093 is not added: 24300000 kbit/s, −100 ppm When MP2110A-093 is added: 9500000 kbit/s, −100 ppm
Clock Output	Ch1/2
PPG Amplitude	0.5
External ATT	0
Test Pattern (PPG)	PRBS 2^31−1, POS
Test Pattern (ED)	PRBS 2^31−1, POS
ED Input Condition	Single-Ended Data
Threshold	0 mV
PPG Data/XData	ON
Gating Cycle	Single
Gating Period	45 s

6.   Click **Scope**. Set the value as follows:

Dialog Box	Item	Setting Value
Setup	Signal Type	NRZ
	Sampling Mode	Eye
	Number of Samples	4050
	Accumulation Time	Persistency
	Limit Type	10.0 sec
Time	Tracking	Symbol Rate: PPG, Divide Ratio: Clock Output
Measure - Amplitude/Time	Display	On
	Item Selection	(A) Eye Amplitude

7.   In the Scope window, click **CH A** to measure the amplitude.

8.   Adjust the PPG1 Amplitude so that the Scope amplitude is 50±1 mV.

9. Connect the 20 dB fixed attenuator and **ED1 Data In** connectors using a coaxial cable. (Refer to (b) in Figure 7.2.2-1.)

10. Click **Start** at All Measurements.

11. Record the error rate ER for the ED Result after measurement is complete.

12. Connect the 20 dB fixed attenuator and **Ch A In** connectors using a coaxial cable.

13. Click **PPG/ED Ch1**. Change Bit Rate to following value.

    28200000 kbit/s, 100 ppm

14. Repeat steps 7 and 11.

15. Connect coaxial terminators to the **PPG1 Data Out** and **ED1 Data In** connectors. (Refer to (a) in Figure 7.2.2-2.)

16. Attach a 20 dB fixed attenuator to the **PPG1 $\overline{\text{Data}}$ Out** connector.

17. Connect the **PPG1 $\overline{\text{Data}}$ Out** and **Ch A In** connectors using a coaxial cable.

18. Repeat steps 7 and 8.

19. Connect the 20 dB fixed attenuator and **ED1 $\overline{\text{Data}}$ In** connectors using a coaxial cable. (Refer to (b) in Figure 7.2.2-2.)

20. Click **PPG/ED Ch1**.

21. Set Data Input Condition to **Single-Ended XData**.

22. Repeat steps 10 to 11.

23. Click **PPG/ED Ch1**. Change Bit Rate to following value.

    When MP2110A-093 is not added: 24300000 kbit/s, −100 ppm

    When MP2110A-093 is added: 9500000 kbit/s, −100 ppm

24. Connect the 20 dB fixed attenuator and **Ch A In** connectors using a coaxial cable.

25. Repeat steps 7 and 8.

26. Connect the 20 dB fixed attenuator and **ED1 $\overline{\text{Data}}$ In** connectors using a coaxial cable. (Refer to (b) in Figure 7.2.2-2.)

27. Repeat steps 10 and 11.

For ED2 to ED4, perform tests in the same way. For ED3 and ED4 test, change the Clock Output in step 4 to the following value.

Item	Setting Value
Clock Output	Ch3/4

7

Performance Test

7.2.3 Rx sensitivity

(1) Specification

40 mVp-p

BER 10^{-12} or less under the following conditions:

- Bit rate: 25.78125 Gbit/s
- Pattern: PRBS31
- Mark ratio: 50%
- Single-end
- Back-to-back connection

(2) Setup

Same as Figure 7.2.2-1 and Figure 7.2.2-2.

(3) Procedure

1. Connect the **Clk Out** connector and the **Trigger Clk In** connector of the sampling oscilloscope using a coaxial cable.

2. Connect the coaxial terminator to the **PPG1 $\overline{\text{Data}}$ Out** and **ED1 $\overline{\text{Data}}$ In** connector.

3. Attach a 20 dB fixed attenuator to the **PPG1 Data Out** connector. (Refer to (a) in Figure 7.2.2-1.)

4. Connect the 20 dB fixed attenuator and **Ch A In** connectors using a coaxial cable.

5. Click **PPG/ED Ch1**. Set the value as follows:

Item	Setting Value
Reference Clock	Internal
Symbol Rate	100GbE/4 (25.78125G), 0 ppm
Clock Output	Ch1/2
PPG Amplitude	0.4
External ATT	0
Test Pattern (PPG)	PRBS 2^31–1, POS
Test Pattern (ED)	PRBS 2^31–1, POS
ED Input Condition	Single-Ended Data
Threshold	0 mV
PPG Data/XData	ON
Gating Cycle	Single
Gating Period	45 s

6. Click **Scope**. Set the value as follows:

Dialog Box	Item	Setting Value
Setup	Signal Type	NRZ
	Sampling Mode	Eye
	Number of Samples	4050
	Accumulation Time	Persistency
	Limit Type	10.0 sec
Time	Tracking	Bit Rate: PPG, Divide Ratio: Clock Output
Measure - Amplitude/Time	Display	On
	Item	(A) Eye Amplitude

7. In the Scope window, click **CH A** to measure the amplitude.

8. Adjust the PPG1 Amplitude so that the Scope EYE amplitude is 40±1 mV.

9. Connect the 20 dB fixed attenuator and **ED1 Data In** connectors using a coaxial cable. (Refer to (b) in Figure 7.2.2-1.)

10. Click **Start** at All Measurements.

11. Record the error rate ER for the ED Result after measurement is complete.

12. Connect coaxial terminators to the **PPG1 Data Out** and **ED1 Data In** connectors. (Refer to (a) in Figure 7.2.2-2.)

13. Attach a 20 dB fixed attenuator to the **PPG1 $\overline{\text{Data}}$ Out** connector.

14. Connect the 20 dB fixed attenuator and **Ch A In** connectors using a coaxial cable.

15. Repeat steps 7 and 8.

16. Connect the 20 dB fixed attenuator and **ED1 $\overline{\text{Data}}$ In** connectors using a coaxial cable. (Refer to (b) in Figure 7.2.2-2.)

17. Click **PPG/ED Ch1**.

18. Set Data Input Condition to **Single-Ended XData**.

19. Repeat steps 10 and 11.

For ED2 to ED4, perform tests in the same way. For ED3 and ED4 test, change the Clock Output in step 4 to the following value.

Item	Setting Value
Clock Output	Ch3/4

7

Performance Test

7.2.4 Maximum input level and patterns

(1) Specification

800 mVp-p

BER 10^{-12} or less under the following conditions:

- Bit rate:
  When MP2110A-093 is not added: 24.3 to 28.2 Gbit/s
  When MP2110A-093 is added: 9.5 to 28.2 Gbit/s

- Pattern: PRBS31, PRBS23, PRBS15, PRBS9, PRBS7
- Mark ratio: 50%
- Single-end
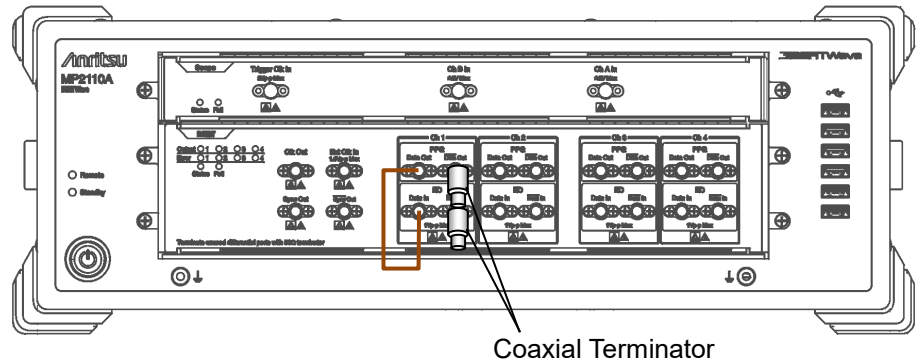- Back-to-back connection

(2) Setup

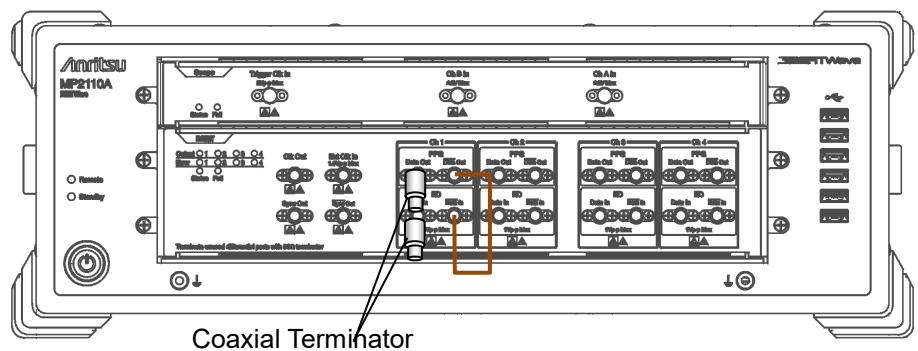Coaxial Terminator

Figure 7.2.4-1   ED1 Data In Pattern Test Connection Diagram

Coaxial Terminator

Figure 7.2.4-2   ED1 $\overline{\text{Data}}$ In Pattern Test Connection Diagram

(3) Procedure

1. Connect coaxial terminators to the **PPG1 $\overline{\text{Data}}$ Out** and **ED1 $\overline{\text{Data}}$ In** connectors. (Refer to Figure 7.2.4-1.)

2. Connect the **PPG1 Data Out** and **ED1 Data In** connectors using a coaxial cable.

3. Click **PPG/ED Ch1**. Set the value as follows:

Item	Setting Value
Reference Clock	Internal
Symbol Rate	100GbE/4 (25.78125G), 0 ppm
Clock Output	Ch1/2
PPG Amplitude	0.8
External ATT	0
Test Pattern (PPG)	PRBS 2^31–1, POS
Test Pattern (ED)	PRBS 2^31–1, POS
ED Input Condition	Single-Ended Data
Threshold	0 mV
PPG Data/XData	ON
Gating Cycle	Single
Gating Period	45 s (28.2 Gbit/s or 24.3 Gbit/s) 120 s (9.5 Gbit/s)

4.   Click **Start** at All Measurements.

5.   After measurement, confirm that the error count of the ED
     Result is 0.

6.   Change Test Pattern for (PPG) and (ED) in succession to **PRBS
     2^7–1**, **PRBS 2^9–1**, **PRBS 2^15–1**, and **PRBS 2^23–1**, and
     repeat steps 4 and 5 each time.

7.   Connect coaxial terminators to the **PPG1 Data Out** and **ED1 Data
     In** connectors. (Refer to Figure 7.2.4-2.)

8.   Connect the **PPG1** $\overline{\textbf{Data}}$ **Out** and **ED1** $\overline{\textbf{Data}}$ **In** connectors using
     a coaxial cable.

9.   Click **PPG/ED Ch1** and set ED Input condition to **Single-Ended
     XData**.

10. Repeat steps 3 to 6.

11. Change the Bitrate to the following value,

     When MP2110A-093 is not added: 24.3 Gbit/s

     When MP2110A-093 is added: 9.5 Gbit/s

12. Repeat steps 1 to 10.

For ED2 to ED4, perform tests in the same way. For ED3 and ED4 test,
change the Clock Output in step 3 to the following value.

Item	Setting Value
Clock Output	Ch3/4

7

Performance Test

7.2.5 Error detection

(1) Specification

Error detection is possible under the following conditions:

- Amplitude: 50 mV
- Bit rate: 25.78125 Gbit/s
- Pattern: PRBS31
- Mark ratio: 50%
- Single-end
- Back-to-back connection

(2) Setup

Same as Figure 7.2.2-1 and Figure 7.2.2-2.

(3) Procedure

1. Connect the **Clk Out** connector and the **Trigger Clk In** connector of the sampling oscilloscope using a coaxial cable.

2. Connect the coaxial terminator to the **ED1** $\overline{\textbf{Data}}$ **In**, and **PPG1** $\overline{\textbf{Data}}$ **Out** connector.

3. Attach a 20 dB fixed attenuator to the **PPG1 Data Out** connector. (Refer to (a) in Figure 7.2.2-1.)

4. Connect the 20 dB fixed attenuator and **Ch A In** connectors using a coaxial cable.

5. Click **PPG/ED Ch1**. Set the value as follows:

Item	Setting Value
Reference Clock	Internal
Symbol Rate	100GbE/4 (25.78125G), 0 ppm
Clock Output	Ch1/2
PPG Amplitude	0.5
External ATT	0
Test Pattern (PPG)	PRBS 2^31–1, POS
Test Pattern (ED)	PRBS 2^31–1, POS
ED Input Condition	Single-Ended Data
Threshold	0 mV
PPG Data/XData	ON
Gating Cycle	Single
Gating Period	45 s

6. Click **Scope**. Set the value as follows:

Dialog Box	Item	Setting Value
Setup	Signal Type	NRZ
	Sampling Mode	Eye
	Number of Samples	4050
	Accumulation Time	Persistency
	Limit Type	10.0 sec
Time	Tracking	Symbol Rate: PPG, Divide Ratio: Sync Output
Measure - Amplitude/Time	Display	On
	Item	(A) Eye Amplitude

7. In the Scope window, click **CH A** to measure the amplitude.

8. Adjust the PPG Amplitude so that the Scope amplitude is 50 ±1 mV.

9. Connect the 20 dB fixed attenuator and **ED1 Data In** connectors using a coaxial cable. (Refer to (b) in Figure 7.2.2-1.)

10. Click **Start** at All Measurements.

11. Click **Insert Error** at **PPG/ED1** once.

12. After measurement, confirm that the error count is 20.

13. Connect coaxial terminators to the **PPG1 Data Out** and **ED1 Data In** connectors. (Refer to (a) in Figure 7.2.2-2.)

14. Attach a 20 dB fixed attenuator to the **PPG1** $\overline{\text{Data}}$ **Out** connector.

15. Connect the 20 dB fixed attenuator and **Ch A In** connectors using a coaxial cable.

16. Repeat steps 7 and 8.

17. Connect the 20 dB fixed attenuator and **ED1** $\overline{\text{Data}}$ **In** connectors using a coaxial cable. (Refer to (b) in Figure 7.2.2-2.)

18. Click **PPG/ED Ch1**. Set the value as follows:

19. Set Data Input Condition to **Single-Ended XData**.

20. Repeat steps 10 to 12.

For ED2 to ED4, perform tests in the same way. For ED3 and ED4 test, change the Clock Output in step 5 to the following value.

Item	Setting Value
Clock Output	Ch3/4

7.3 Performance Test for Sampling Oscilloscope

This section describes the performance test item for the sampling oscilloscope.

- Amplitude accuracy
- CRU

7.3.1 Required equipment

The following table shows the equipment required for the performance test.

Before starting performance tests, warm up the MP2110A and measuring instruments for at least 1 hour.

Table 7.3.1-1   Equipment for Performance Test

Product Name	Required Performance		Recommended Equipment
Pulse Pattern Generator	Clock frequency: Amplitude:	7 GHz 0.5 Vp-p	MP2110A (Anritsu)
DC Power Source*1	Power voltage: Power current: Setting accuracy: With current limiting function	±2.5 V ±50 mA 1% or less	2400 (Keithley Instruments)
Light Source*2	Wavelength: Output level range: Level stability:	850, 1310, 1550 nm +3 dBm or more ±0.05 dB	
Optical Power Meter*2	Wavelength: Level range: Accuracy: Linearity	750 to 1700 nm –40 to +10 dBm (100 nW to 10 mW) 5% ±0.05 dB or less	8163B+81623B (Keysight Technologies)

Programmable Optical Attenuator*2	For single-mode fiber:
	    Wavelength:
	    Insertion loss:
	    Attenuation:
	    Resolution:
	For multi-mode fiber:
	    Wavelength:
	    Insertion loss:
	    Attenuation:
	    Resolution:
		
		1200 to 1600 nm
		3 dB or less
		0 to 30 dB
		0.1 dB or less
		
		800 to 900 nm
		3 dB or less
		0 to 30 dB
		0.1 dB or less
			G0350F (Anritsu)
			
			G0351F (Anritsu)

Fixed Attenuator*3	20 dB K connector Bandwidth:	 DC to 40 GHz	41KC-20 (Anritsu)

*1: Required for MP2110A-021, MP2110A-023, and MP2110A-033

*2: Required for MP2110A-022, MP2110A-023, MP2110A-025,
MP2110A-026, MP2110A-032, MP2110A-033, MP2110A-035, and
MP2110A-036

*3: Required for MP2110A-054

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Performance Test

7.3.2 Amplitude accuracy

(1)   Specification

(–2%–offset amplitude accuracy) to (+2%+offset amplitude accuracy)

The offset amplitude accuracy after calibration is as shown in the following figure.
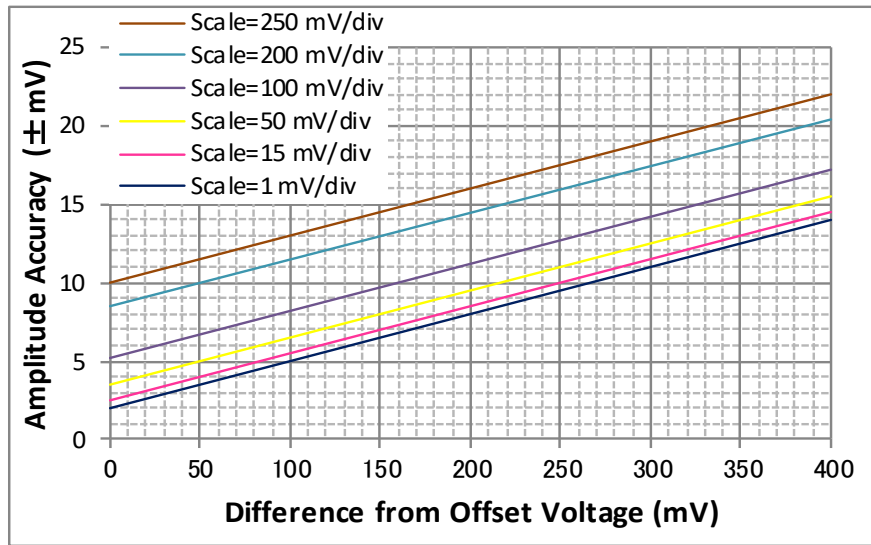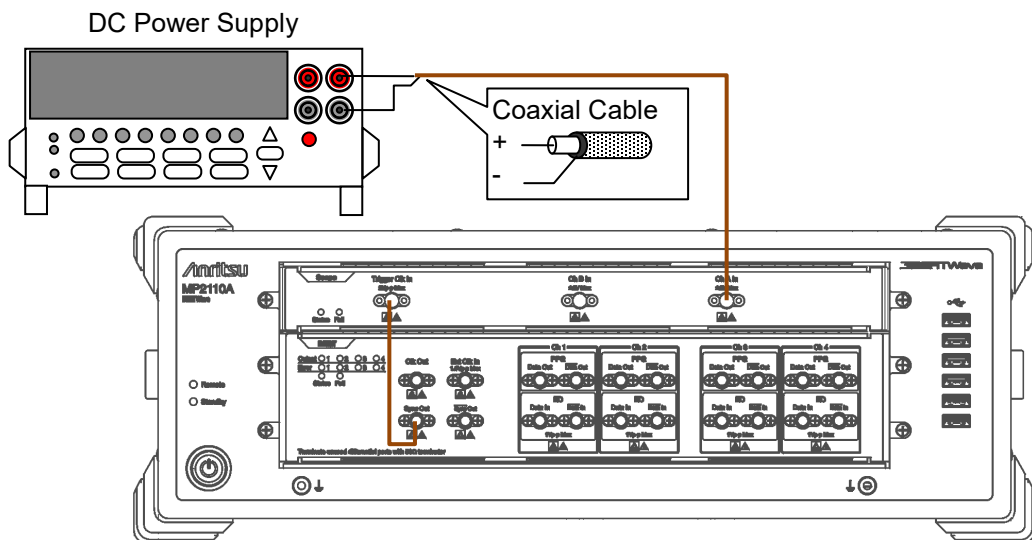

Figure 7.3.2-1   Offset Amplitude Accuracy

(2)   Setup

**Figure 7.3.2-2   Amplitude Accuracy Test Connection Diagram
(When using a PPG of MP2110A)**
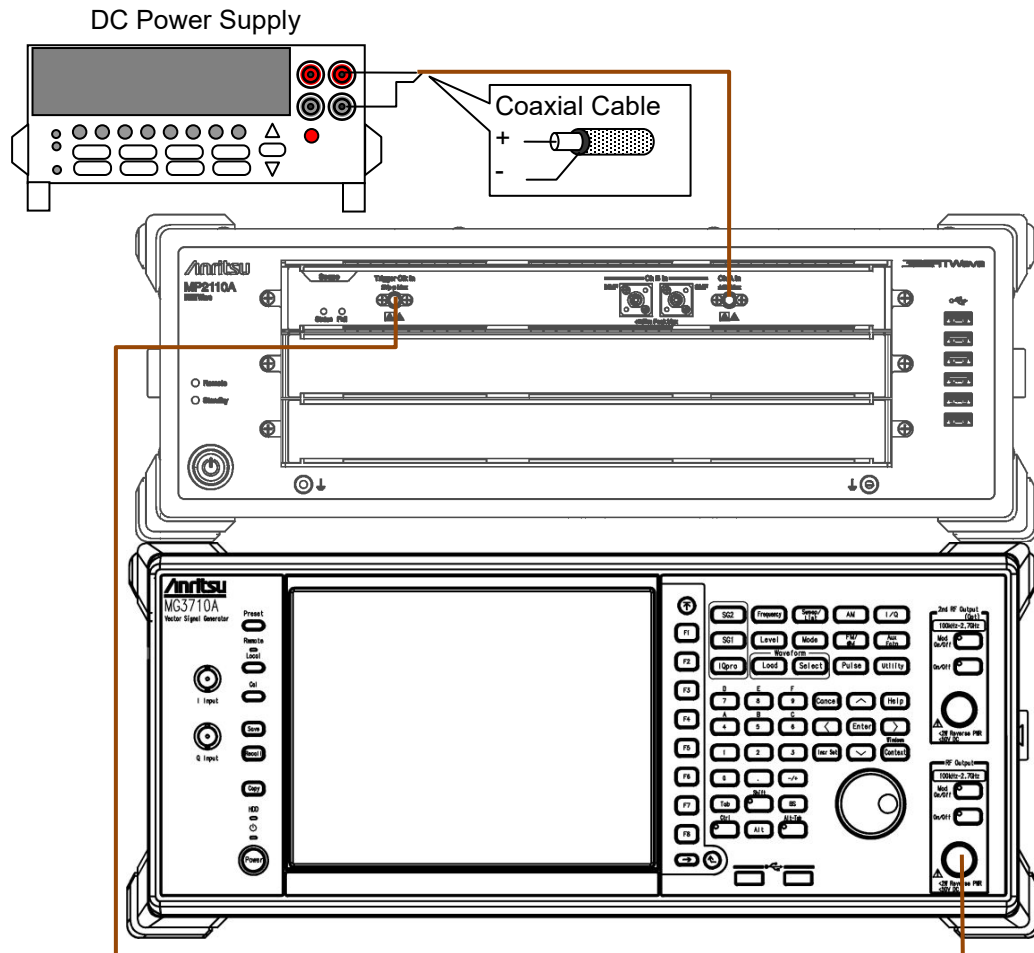
**Figure 7.3.2-3   Amplitude Accuracy Test Connection Diagram
(When using a signal generator)**

(3) Procedure

1. In case of Figure 7.3.2-2, connect the **Sync Out** connector and
    the **Trigger Clk In** connector using a coaxial cable.
    In case of Figure 7.3.2-3, connect the **Trigger Clk In** connector
    and the signal generator output connector using a coaxial cable.

2. In case of Figure 7.3.2-2, click **PPG/ED Ch1**. Set the value as
    follows:

Item	Setting Value
Reference Clock	Internal
Bit Rate	Variable, 28 Gbit/s, 0 ppm
Sync Output	PPG_1/8 Clk

In case of Figure 7.3.2-3, set the signal generator as follows:

Frequency: 3.5 GHz

Amplitude: 0.5 Vp-p (at sine-wave –2.0 dBm)

7

Performance Test

3.   Click **Scope**. Set the value as follows:

Dialog Box	Item	Setting Value
Setup	Signal Type	NRZ
	Sampling Mode	Eye
	Number of Samples	2048
	Accumulation Time	None
Time	Tracking	Off
	Divide Ratio	8
	Unit	UI
	UI On Screen	2
	Offset	0
Amplitude	CH A Scale	50 mV/Div.
	CH A Offset	50 mV
	CH A Attenuation	0 dB
Histogram	Target Channel	Channel A
	Axis	Amplitude
	X1	0
	X2	2
	Y1	–250 mV
	Y2	250 mV

4.   Set the Current Limit of DC Power Source to 20 mA.

5.   Set the DC voltage to 0 V.

6.   Connect the DC Power Source to **Ch A In**.
     Connect the center conductor of the coaxial cable to plus and the shield to minus.

7.   Click **CH A** to set to On.

8.   Click **Sampling** to set to Run.

9.   Record a standard deviation (Std Dev) and an average value (Mean) of the histogram measurement result.

10. Set the DC voltage to 200 mV.

11. Record the average value of the histogram measurement result.

12. Set the DC voltage to –200 mV.

13. Record the average value of the histogram measurement result.

With the MP2110A-021, test the amplitude accuracy for Ch B after measuring the amplitude accuracy for Ch A.

1. Click **Scope**. Set the value as follows:

Dialog Box	Item	Setting Value
Amplitude	CH B Scale	50 mV/Div.
	CH B Offset	50 mV
	CH B Attenuation	0 dB
Histogram	Target Channel	Channel B

2. Set the DC voltage to 0 V.

3. Connect the DC Power Source to **Ch B In**.
    Connect the center conductor of the coaxial cable to plus and the shield to minus.

4. Click **CH B** to set to On.

5. Click **Sampling** to set to Run.

6. Record a standard deviation (Std Dev) and an average value (Mean) of the histogram measurement result.

7. Set the DC voltage to 200 mV.

8. Record the average value of the histogram measurement result.

9. Set the DC voltage to –200 mV.

10. Record the average voltage of the histogram measurement result.

7.3.3 Optical Power Meter

(1)   Specification

Accuracy: ±0.35 dB if the input level is −12 dBm or greater

(2)   Setup

Light Source

Programmable
Optical Attenuator

Optical Fiber

Optical Power Meter
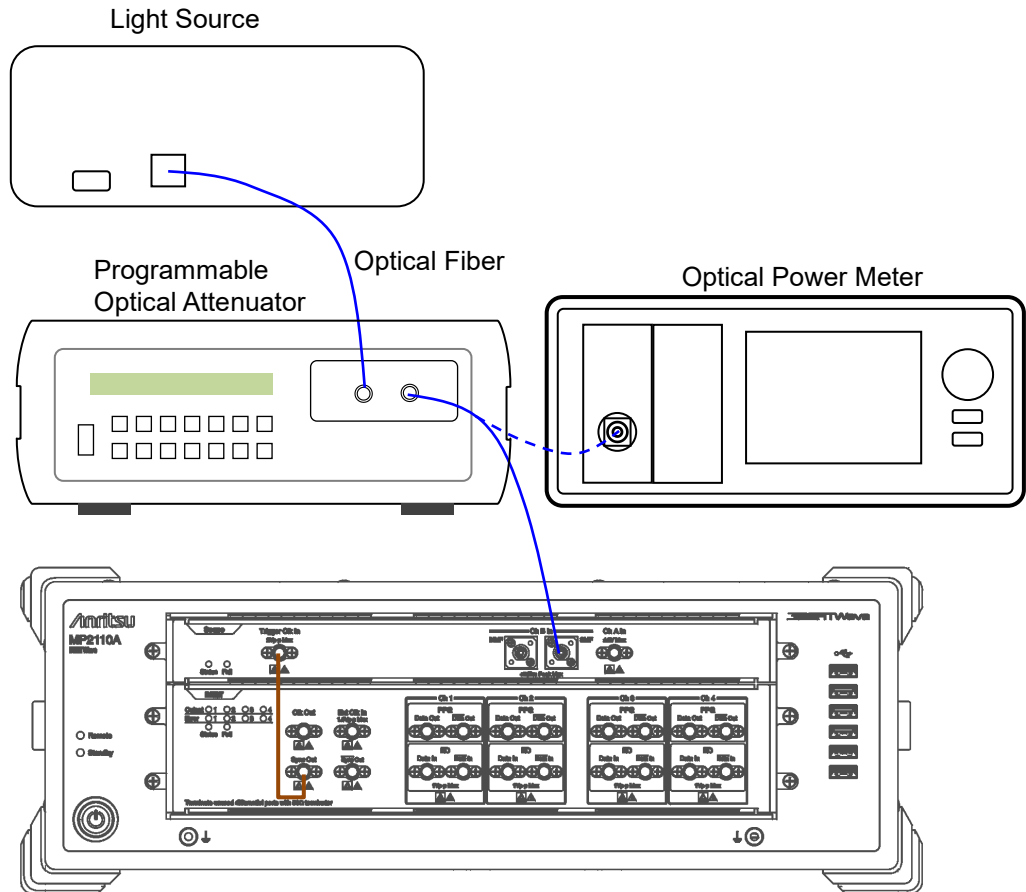
Figure 7.3.3-1   Optical Power Meter Test Connection Diagram
(SMF, When using a PPG of MP2110A)
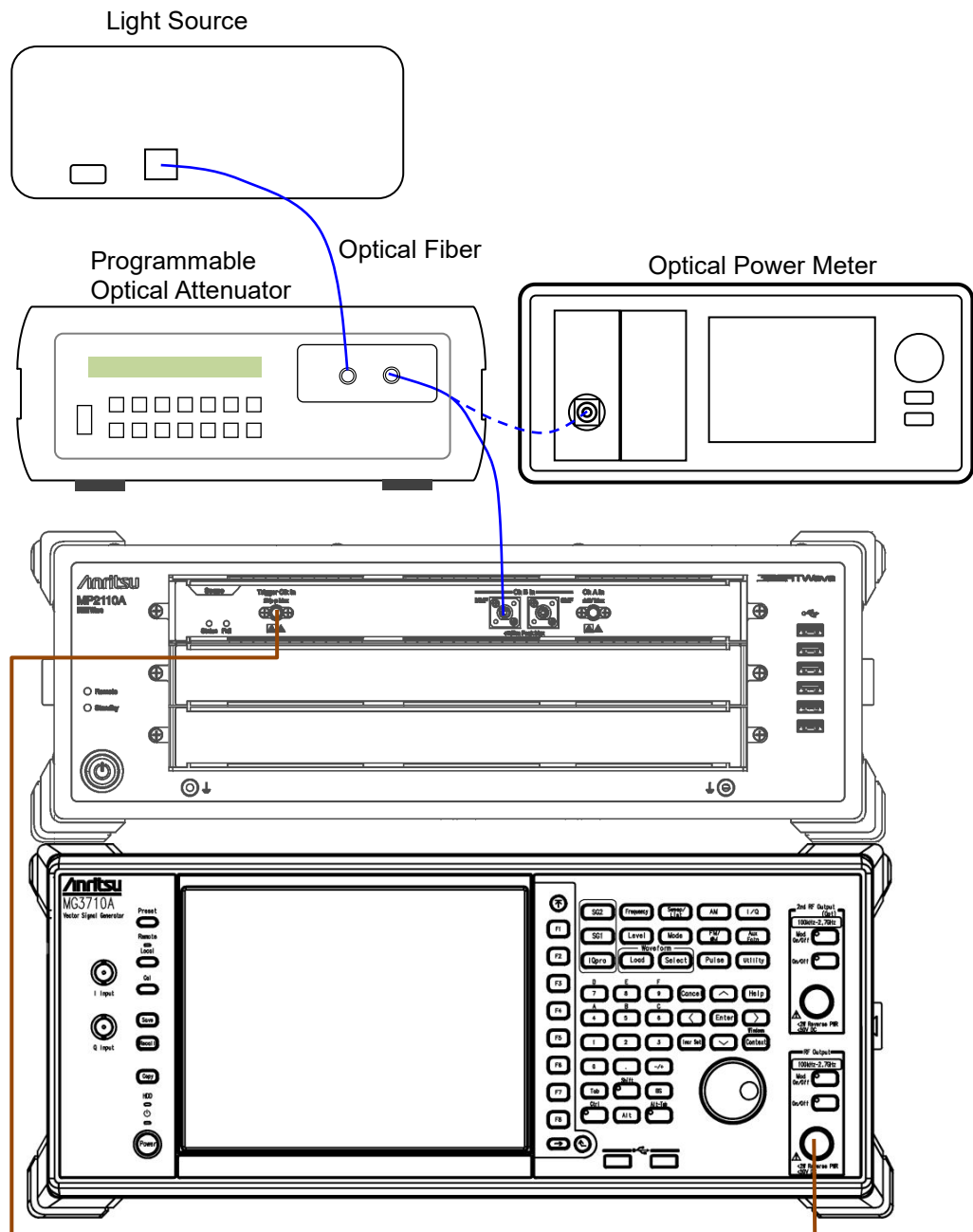
**Figure 7.3.3-2 Optical Power Meter Test Connection Diagram
(MMF, when using a signal generator)**

(3)   Procedure

The SMF performance test for CH B is explained below.

1.   In case of Figure 7.3.3-1, connect the **Sync Out** connector and the **Trigger Clk In** connector using a coaxial cable.
In case of Figure 7.3.3-2, connect the **Trigger Clk In** connector and the signal generator output connector using a coaxial cable.

2.   In case of Figure 7.3.3-1, click **PPG/ED Ch1**. Set the value as follows:

Item	Setting Value
Reference Clock	Internal
Bit Rate	Variable, 28 Gbit/s, 0 ppm
Sync Output	PPG_1/8 Clk

In case of Figure 7.3.3-2, set the signal generator as follows:
Frequency: 3.5 GHz
Amplitude: 0.5 Vp-p (at sine-wave –2.0 dBm)

3.   Confirm that no light has been input to the optical connector (SMF or MMF) for **Ch B In**.

4.   Click **Scope**. Set the value as follows:

Dialog Box	Item	Setting Value
Setup	Signal Type	NRZ
	Sampling Mode	Eye
	Number of Samples	2048
	Accumulation Time	Persistency
	Limit Type	10.0 sec
Time	Tracking	Off
	Divide Ratio	8
	Unit	UI
	UI On Screen	2
	Offset	0
Amplitude	CH B Scale	20 μW/Div.
	CH B Offset	60 μW
	CH B Attenuation	0 dB
	Input Connector (Wavelength)	SMF 1310 nm
Measure - Amplitude/Time	Display	On
	Item	(B) Average Power (dBm)

5.   Click **Calibrate Module** of Amplitude. Click **OK** after completing the calibration.

6.   Prepare the variable optical attenuator for single-mode fiber.

7.   Connect the output connector of the light source and the input connector of the programmable optical attenuator, using a single-mode optical fiber.

8.   Connect the output connector of the programmable optical attenuator and the optical power meter, using a single-mode optical fiber.

9.   Set the light source wavelength to 1310 nm.

10. Set the optical power meter wavelength to 1310 nm.

11. Set the light source output to On.

12. Adjust the programmable optical attenuation to set the optical power meter display to around –9 dBm (0.126 mW).

13. Record the optical power meter display P (dBm).

14. Disconnect the optical fiber from the optical power meter and connect it to the **SMF** connector of **Ch B In**.

15. Click **Scope**. Set the value as follows:
     CH_A: Off
     CH_B: On

16. Click **Sampling** to set to Run.

17   Record the displayed Average Power (dBm).

18. Connect the output connector of the programmable optical attenuator and the optical power meter, using a single-mode optical fiber.

19. Set the light source wavelength to 1550 nm.

20. Set the optical power meter wavelength to 1550 nm.

21. Set the Input Connector (Wavelength) to **SMF 1550 nm**.

22. Repeat steps 11 to 17.

7

Performance Test

The MMF performance test for CH B is explained below.

1. In case of Figure 7.3.3-1, connect the **Sync Out** connector and the **Trigger Clk In** connector using a coaxial cable.
   In case of Figure 7.3.3-2 connect the **Trigger Clk In** connector and the signal generator output connector using a coaxial cable.

2. In case of Figure 7.3.3-1, click **PPG/ED Ch1**. Set the value as follows:

Item	Setting Value
Reference Clock	Internal
Bit Rate	Variable, 28 Gbit/s, 0 ppm
Sync Output	PPG_1/8 Clk

   In case of Figure 7.3.3-2, set the signal generator as follows:
   Frequency: 3.5 GHz
   Amplitude: 0.5 Vp-p (at sine-wave –2.0 dBm)

3. Confirm that no light has been input to the optical connector (SMF or MMF) for **Ch B In**.

4. Click **Scope**. Set the value as follows:

Dialog Box	Item	Setting Value
Setup	Signal Type	NRZ
	Sampling Mode	Eye
	Number of Samples	2048
	Accumulation Time	Persistency
	Limit Type	10.0 sec
Time	Tracking	Off
	Divide Ratio	8
	Unit	UI
	UI On Screen	2
	Offset	0
Amplitude	CH B Scale	50 µW/Div.
	CH B Offset	150 µW
	CH B Attenuation	0 dB
	Input Connector (Wavelength)	MMF 850 nm
Measure - Amplitude/Time	Display	On
	Item	(B) Average Power (dBm)

5. Click **Calibrate Module** of Amplitude. Click **OK** after completing the calibration.

6. Prepare the variable optical attenuator for multimode fiber.

7. Connect the output connector of the light source and the input connector of the programmable optical attenuator, using a multi-mode optical fiber.

8.   Connect the output connector of the programmable optical attenuator and the optical power meter, using a multi-mode optical fiber.

9.   Set the light source wavelength to 850 nm.

10. Set the optical power meter wavelength to 850 nm.

11. Set the light source output to On.

12. Adjust the programmable optical attenuation to set the optical power meter display to around –5 dBm (0.316 mW).

13. Record the optical power meter display P (dBm).

14. Disconnect the optical fiber from the optical power meter and connect it to the **MMF** connector of **Ch B In**.

15. Click **Scope**. Set the value as follows:
     CH_A: Off
     CH_B: On

16. Click **Sampling** to set to Run.

17   Record the displayed Average Power (dBm).

7.3.4 CRU

(1) Specification

Sensitivity: 20 mVp-p or less

25.78125 Gbit/s, PRBS2^{31}–1 NRZ, Loop BW = 10 MHz, Single-ended, Mark ratio 1/2, Using MP2110A PPG

Additive jitter: 400 fs or less

25.78125 Gbit/s, 26.5625 Gbit/s, 28.05 Gbit/s, Input amplitude 400±100 mVp-p, 1/4Clock Pattern, ,Loop BW = 10 MHz, Single-ended, Mark ratio 1/2, Using MP2110A PPG

(2) Setup
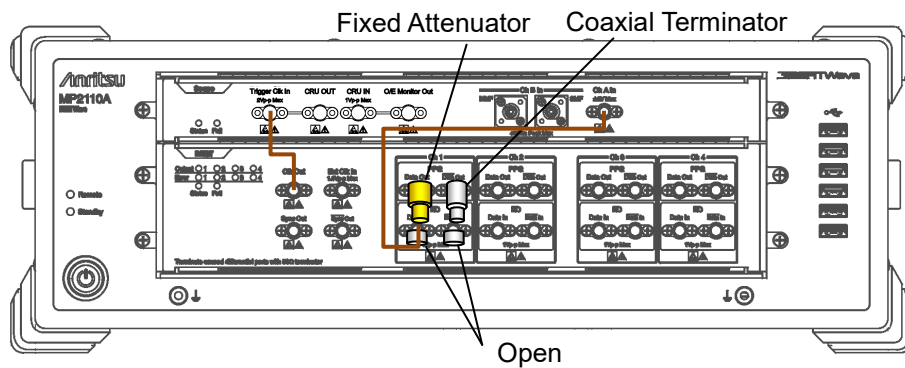
(a) Amplitude Check
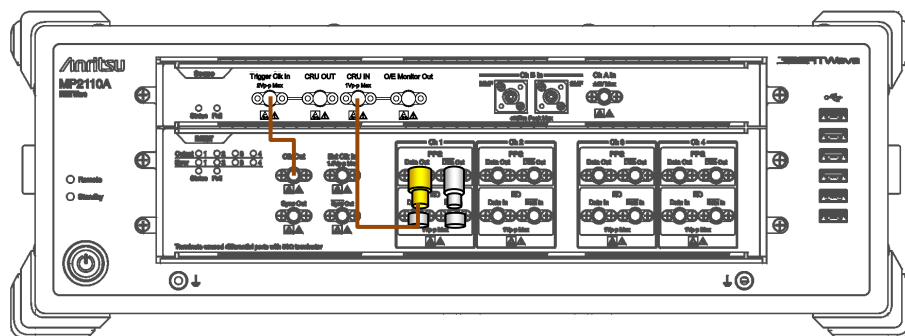
(b) CRU Sensitivity Test

Figure 7.3.4-1   CRU Sensitivity Test Connection Diagram

Coaxial Terminator   Open
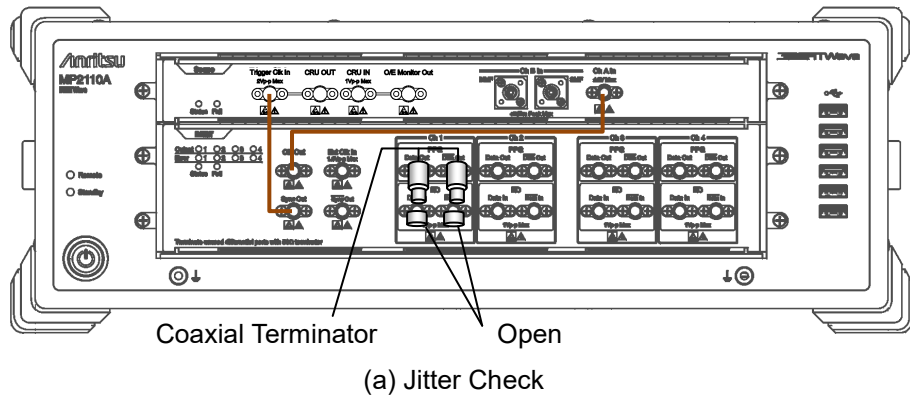
(a) Jitter Check
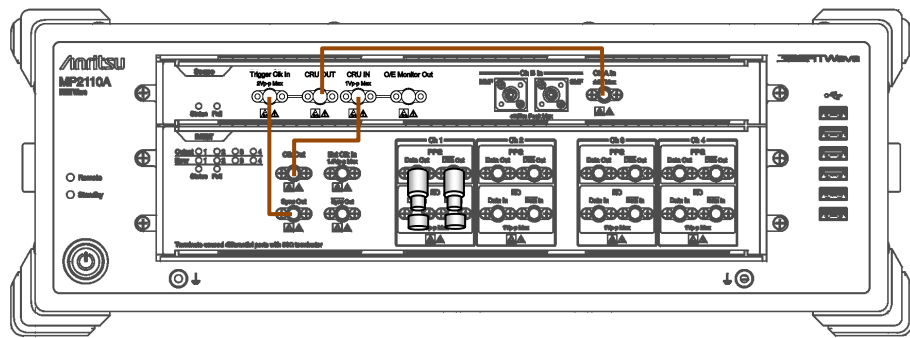
(b) Additive Jitter Test

Figure 7.3.4-2   Additive Jitter Test Connection Diagram

7

Performance Test

(3)   Procedure

Sensitivity Test

1. Connect **Clk Out** with **Trigger Clk In** using a coaxial cable.

2. Connect a coaxial connector to **PPG1** $\overline{\textbf{Data}}$ **Out**.

3. Connect an Open connectors to **ED1 Data In**, and **ED1** $\overline{\textbf{Data}}$ **In** respectively.

4. Connect a 20 dB fixed attenuator to **PPG1 Data Out**. Refer to Figure 7.3.4-1(a).

5. Connect a 20 dB fixed attenuator with **Ch A In** using a coaxial cable.

6. Click **PPG/ED Ch1** and configure as follows.

Item	Setting Value
Reference Clock	Internal
Bit Rate	25781250 kbit/s
Clock Output	Ch1/2
PPG Amplitude	0.2
External ATT	0
Test Pattern (PPG)	PRBS 2^31–1, POS
PPG Data/XData	ON

7. Click **Scope** and configure as follows.

Dialog Box	Item	Setting Value
Setup	Signal Type	NRZ
	Sampling Mode	Eye
	Number of Samples	4050
	Accumulation Time	Persistency
	Limit Type	10.0 sec
Time - Rate	Tracking	Symbol Rate: PPG, Divide Ratio: Clock Output
Time - CRU	Operation Mode	Recovery
	Operation Rate	100GbE/4 (25.78125G)
	CRU Loop BW	10 MHz

8. Click **CH A** of Scope and measure the amplitude.

9. Adjust PPG Amplitude to make the eye amplitude on Scope 20 ± 1 mV.

10. Connect a 20 dB fixed connector with **CRU In** using a coaxial cable.   Refer to Figure 7.3.4-1 (b).

11. Click **Time** of Scope and click **CRU** tab.

12. Confirm Lock Status turning to Lock in green.

Additive Jitter Test

1. Remove the 20 dB fixed attenuator from **PPG1 Data Out**. Refer to Figure 7.3.4-2 (a).

2. Connect a coaxial connector to **PPG1 Data Out**.

3. Connect **Sync Out** with **Trigger Clk In** using a coaxial cable.

4. Connect **Clk Out** with **Ch A In** using a coaxial cable.

5. Click **PPG/ED Ch1** and configure as follows.

Item	Setting Value
Reference Clock	Internal
Bit Rate	25781250 kbit/s
Sync Out	PPG1_1/8Clk
Clk Out	Ch1/2
Test Pattern (PPG)	PRBS2^31-1
PPG Data/XData	ON

6. Click **Scope** and configure as follows.

Dialog Box	Item	Setting Value
Setup	Signal Type	NRZ
	Sampling Mode	Eye
	Number of Samples	4050
	Accumulation Time	Persistency
	Limit Type	10.0 sec
Time - Rate	Tracking	Symbol Rate: PPG, Divide Ratio: UserDefined
	Divide Ratio	4
Time - Scale/Offset	Unit	UI
	UI on Screen	1 UI
Time - CRU	Operation Mode	Recovery
	Operation Rate	100GbE/4 (25.78125G)
	CRU Loop BW	10 MHz
Measure	Display	On
	Item	(A) Jitter RMS
Amplitude	Scale	20.0 mV/Div
	Offset	0 mV

7. Click **CH A** of Scope.

8. Adjust Offset in Time - Scale/Offset tab so that the cross point is displayed at center of the window.

7

Performance Test
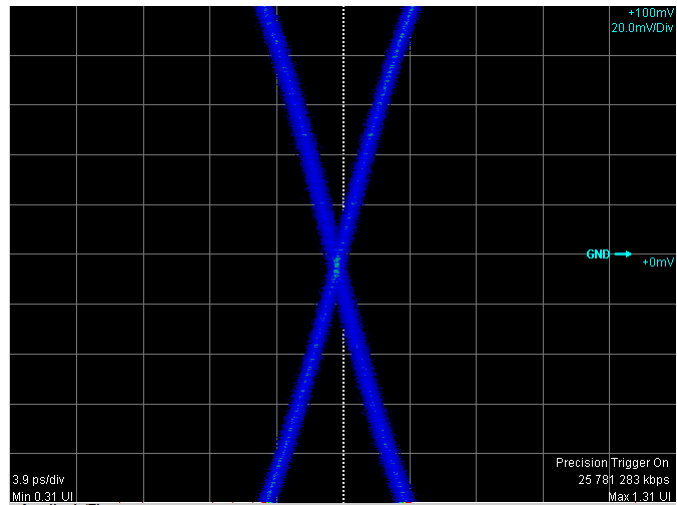
9. Record jitter RMS measurement value.

10. Connect **Clk Out** with **CRU In** using a coaxial cable. Refer to Figure 7.3.4-2 (b).

11. Connect **CRU Out** with **Ch A In** using a coaxial cable. Refer to Figure 7.3.4-2 (b).

12. Click **Time** of Scope and then click **CRU** tab.

13. Confirm Lock Status turning to Lock in Green.

14. Click **CH A** of Scope.

15. Adjust Offset in Time - Scale/Offset tab so that the cross point is displayed at center of the window.

16. Record jitter RMS measurement value.

17. Calculate the added jitter J_{Add} using the following formula.

$$J_{Add} = \sqrt{(J_{CRU})^2 - (J_{PPG})^2}$$

J_{CRU}: Measured value in step 16.
J_{PPG}: Measured value in step 9.

18. Change PPG1 Bit Rate and Scope Operation Rate to the following values and repeat the step from 4 to 17.

PPG1 Bit Rate	Scope – CRU Operation Rate
26562500 kbit/s	400GbE/8 (26.5625G)
28050000 kbit/s	32GFC (28.05G)

Chapter 8 Maintenance

This chapter describes maintenance, storage and disposal procedures.

8

Maintenance

8.1 Daily Maintenance

Before daily maintenance of the MP2110A, be sure to turn the power off and unplug it from the AC outlet.

Panel surface dirt

When surface dirt is noticeable, after the MP2110A has been used in a dusty environment, or when the MP2110A has not been used for an extended period of time, wipe its surface with a cloth moistened in detergent and wrung enough.

Loose screws

Use a Phillips screwdriver to tighten screws.

8.2 Replacement of Optical Connector

The standard optical connector is the FC type. The optical connector of the plug-in unit and pull-out type optical sensor can be removed and replaced with another connector (sold separately), and its interior can be cleaned. For information, Figure 8.2-1 shows the connector type.
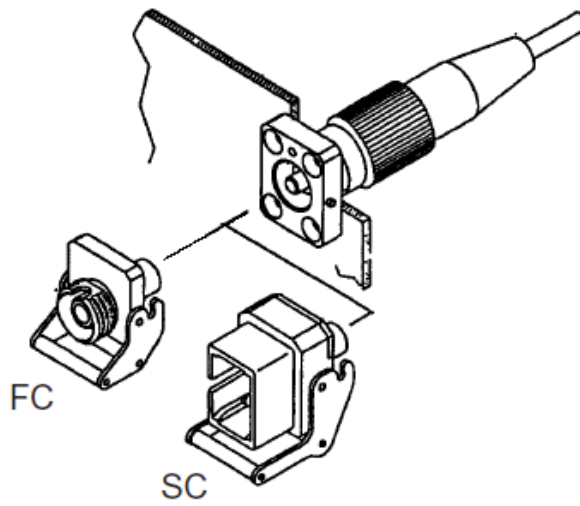
Figure 8.2-1   Connector Type

⚠ WARNING

Do not look into the connection surface of the optical fiber cable of the light source optical connector or the end face of the optical fiber cable connected to the light source as invisible laser light output may cause visual deficit and other problems.

⚠ CAUTION

Before replacing the optical fiber cable, be sure not to damage the connector and connection surface with connector.

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Maintenance

To remove the optical connector:

1.   Open the cover.

2.   Pull up the connector lever toward you.

3.   Check that the latch has been released, and then, gently pull the connector out straight toward you.

Latch
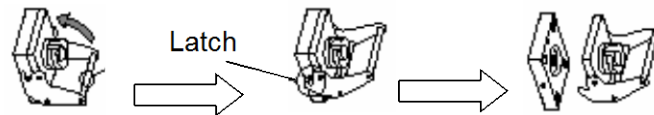
Figure 8.2-2   How to Remove the Optical Connector

8.3 Optical Connector/Optical Adapter Cleaning

Cleaning the Ferrule End Surface

Use an approved adapter cleaner to clean the ferrule end surface in the optical connector. The ferrule in the optical connectors needs periodic cleaning. Although the following procedures use the FC connector and adapter as an example, use the same methods when cleaning other connector and adapter types.

1.   Remove the currently connected adapter by raising the adapter lever (you will hear a "click" when the latch disengages) and then gently pull the adapter straight towards you.
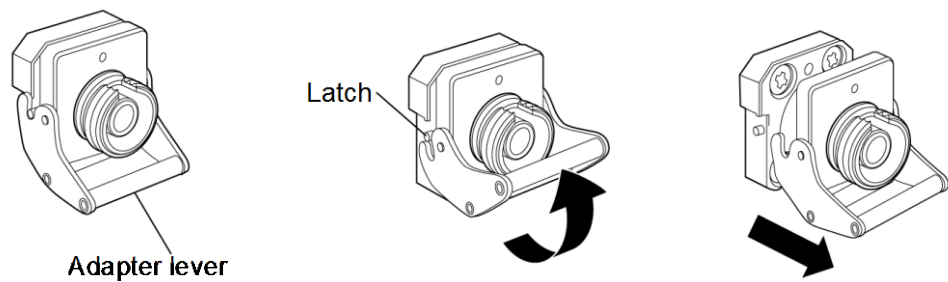
2   Moisten an adapter cleaner with isopropyl alcohol and then use it to clean the end surface and sides of the ferrule.
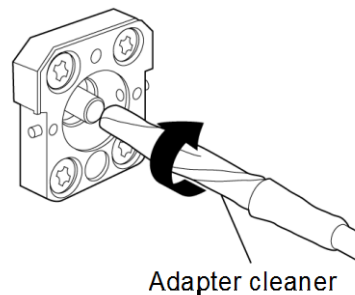
3. Press the tip of a new (dry) adapter cleaner into the ferrule end surface and then wipe in one direction 2 or 3 times to dry the surface.
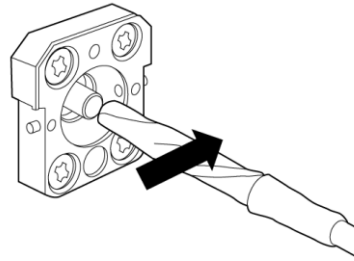
4. Clean the adapter interior with adapter cleaner.
(Refer to "Cleaning the optical adapter" below.)

5. Attach the adapter in the reverse order. Be careful not to scratch the ferrule end surface.

Cleaning the Optical Adapter

Use an approved adapter cleaner to clean the optical fiber cable optical adapter. Although the following procedures use the FC connector and adapter as an example, use the same methods when cleaning other connector and adapter types.

Insert adapter cleaner into the split sleeve of the optical adapter. Rotate the adapter cleaner in one direction while moving it back and forth.
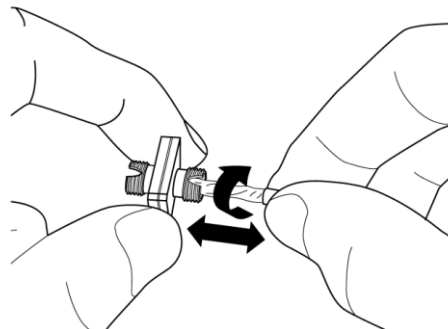
Note:

Check the ferrule diameter and use a cleaner only for the 1.25 mm or 2.5 mm adapter.

Cleaning the Optical Fiber Cable Ferrule End Surface

Use an approved ferrule cleaner to clean the optical fiber cable ferrule end surface. Although the following procedures use the FC connector and adapter as an example, use the same methods when cleaning other connector and adapter types.

1.   Pull the ferrule cleaner lever to expose the cleaning surface.
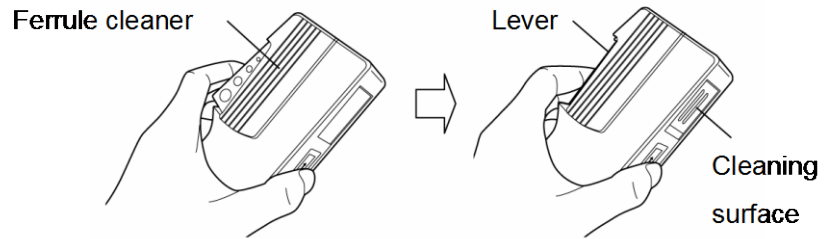
2.   Hold the lever in the opened position, press the optical connector ferrule end into the cleaning surface, and then rub in one direction as shown in the following figure.

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Maintenance
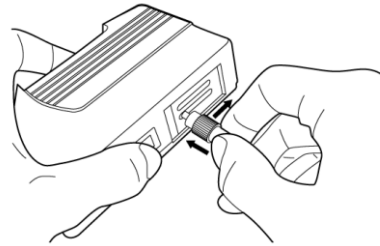
8.4 Displaying Software Version

Refer to Section 4.3.11 System Information for the software version display method.

8.5 Adding an Option License

For adding an option license, the software of version 6 or later is required. If the software is version 5, download the latest installer from Anritsu Web site and update the software.

<Procedure>

1. Copy the customer-owned license file (lservrc) to the MP2110A desktop.

2. Click **License** in Start Menu.
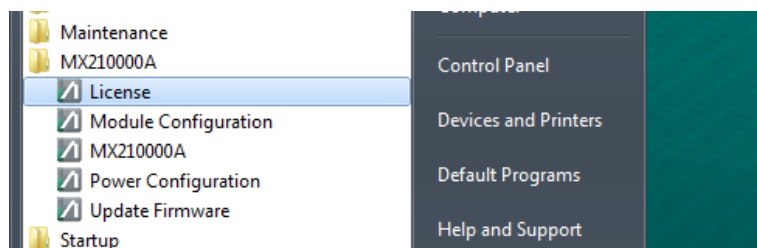
3. Click **Open** on License Installer dialog box.
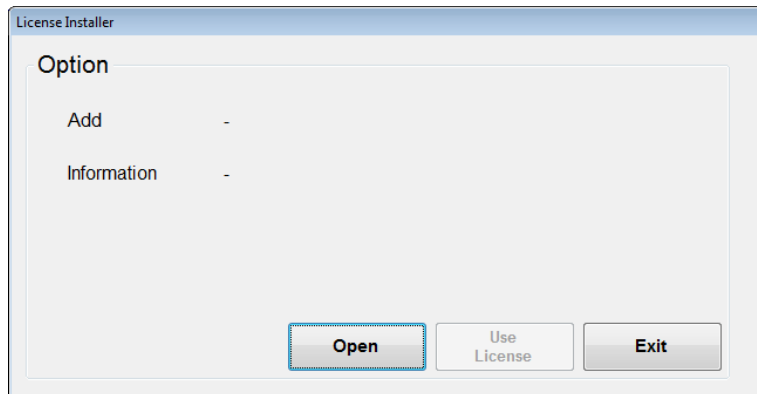
4. Select the license file copied in step 1.

5. Clicking **OK** to close the file selection dialog box, the option number to add and then its license key are displayed to **Option** field.

6. Click **Use License**.

7. Wait for a while and Completed dialog box is displayed. Click **OK**.

8. Click **Exit** to close License Installer dialog box.

9. Double-click MX210000A on the Desktop to launch the application.

10. Show the software version and confirm the presence of the option.

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8.6   System Recovery Function

The MP2110A has system recovery function to restore data on the hard disk to the factory shipment status. These functions can be used in the event of system instability.

⚠ CAUTION

Fully understand the following and back up all necessary data before performing a system recovery.

- **Executing system recovery restores the original Windows factory settings, and reverts the data stored on the C drive to the original factory state. All data such as applications and updates subsequently added, measurement conditions saved, measurement results, and screen captures will therefore be deleted.**

- **Data deleted by these functions cannot be restored.**

- **The MX210000A BERTWave Control Software must be re-installed if system recovery is performed. Before performing system recovery, prepare the MX210000A software installer for the version you are using.**

<Procedure>
1.   Disconnect the MP2110A from the network if connected.
2.   Connect the keyboard and mouse to the mainframe, and then turn the MP2110A power On.

3.   Press the **F8** key on the keyboard. The following screen will appear.

```
Choose Advanced Options for: Windows Server 2012 Release Candidate
(Use the arrow keys to highlight your choice.)

    Repair Your Computer

    Safe Mode
    Safe Mode with Networking
    Safe Mode with Command Prompt

    Enable Boot Logging
    Enable low-resolution video
    Last Known Good Configuration (advanced)
    Debugging Mode
    Disable automatic restart on system failure
    Disable Driver Signature Enforcement
    Disable Early Launch Anti-Malware Driver

    Start Windows Normally

Description: View a list of system recovery tools you can use to repair
            startup problems, run diagnostics, or restore your system.

ENTER=Choose                                              ESC=Cancel
```

4.   Use the keyboard cursor keys to select **Repair Your Computer**, and then press **Enter**.

5.   Click **Next**.
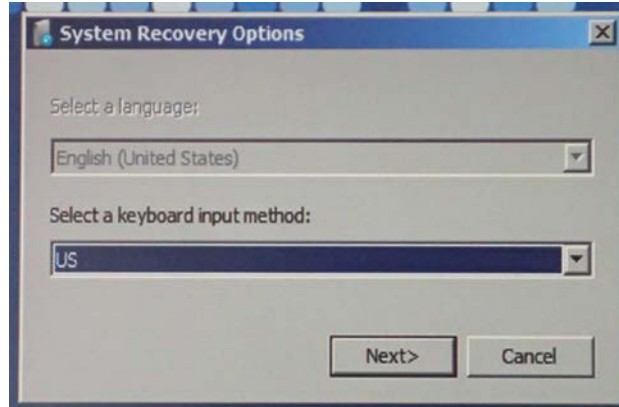
6.   Click **OK**. Leave the Password box blank.

7.   Click **Reinstall Windows**.
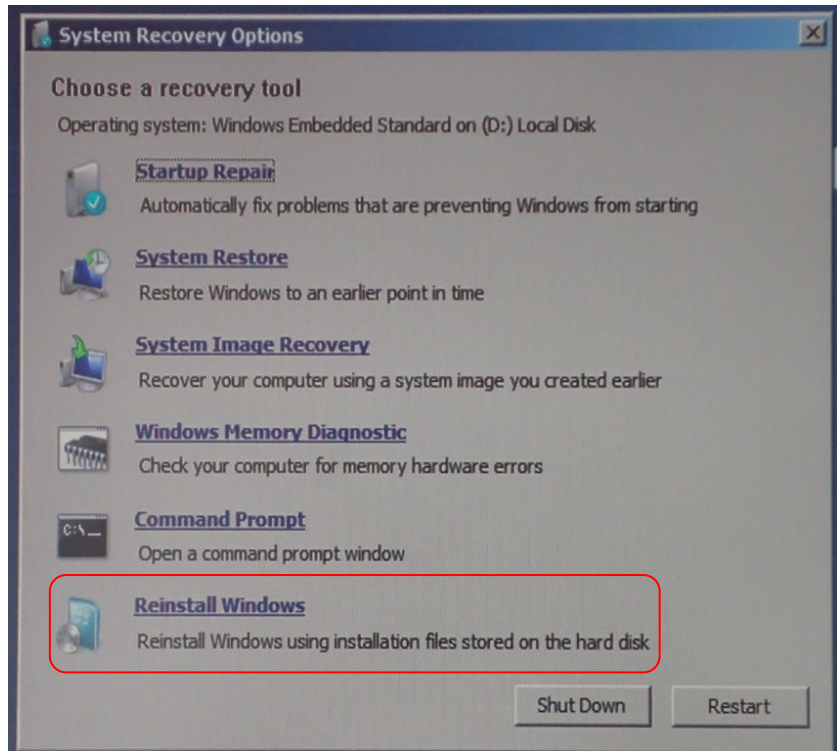
8.   Click **Yes**.
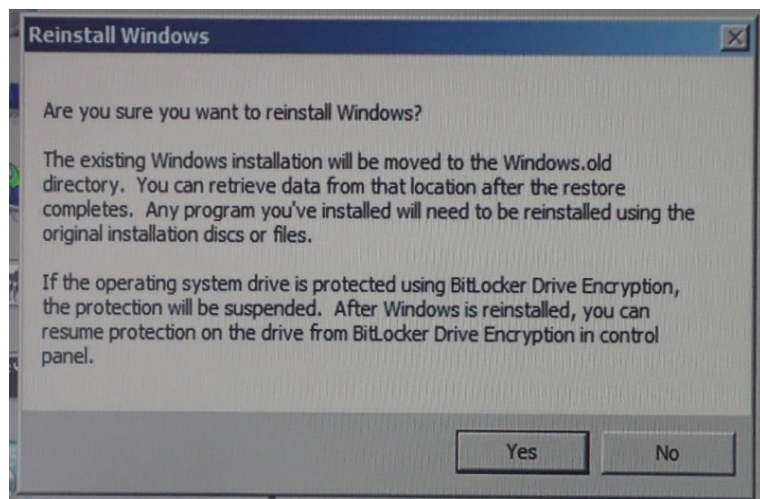
9. The recovery processing requires 10 to 30 minutes. The Recovery dialog box is displayed after restarting MP2110A several times.
    Click **Restore my files**.
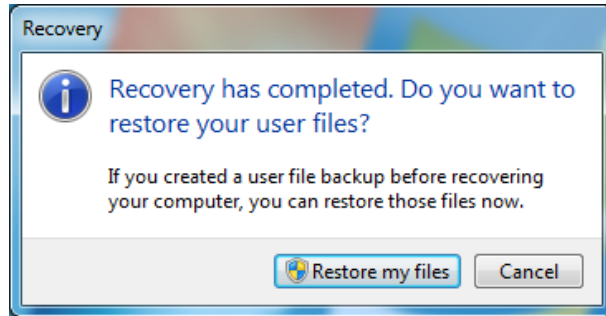
10. Click **Cancel**.
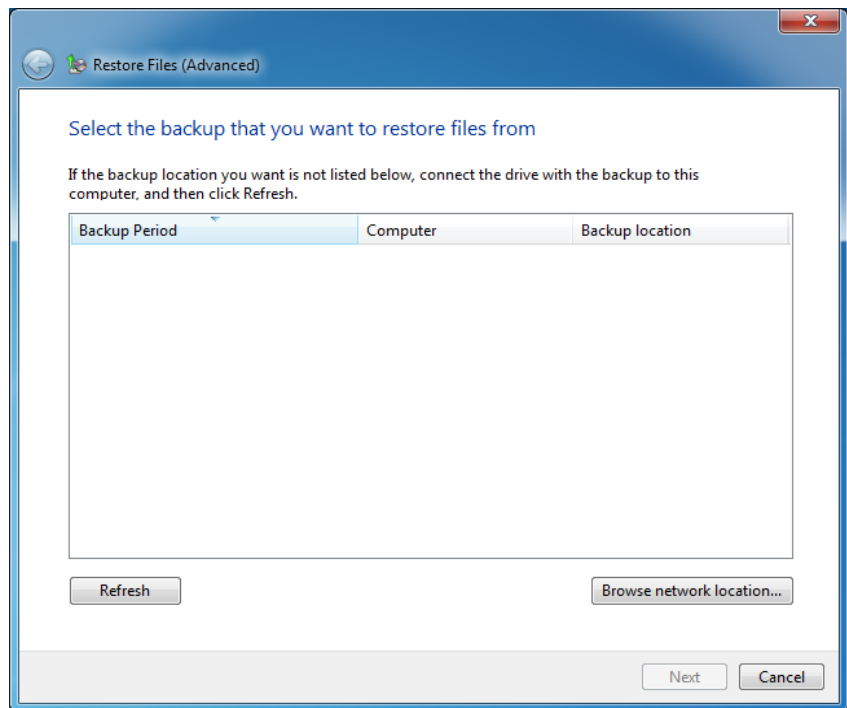
11. Start Internet Explorer, and open the following folder.
    C:\Program Files\Anritsu\PreSetup

12. Right-click "Recovery.bat" and click **run as administrator**.

13. Start Internet Explorer after restarting MP2110A. And check that the following folder is deleted.
    c:\Windows.old
    If the folder has not been deleted, repeat steps 11 and 12.

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Maintenance

14. Click Network Connections in the Control Panel.
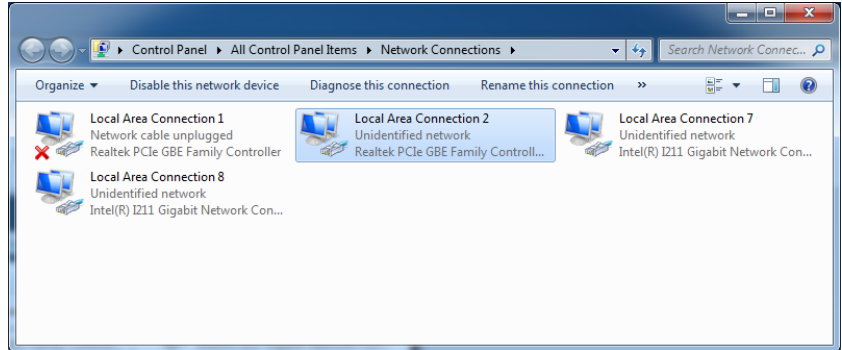
15. Connect the cable to the Ethernet connector on the left side of the rear panel to establish the link.

Ethernet cable
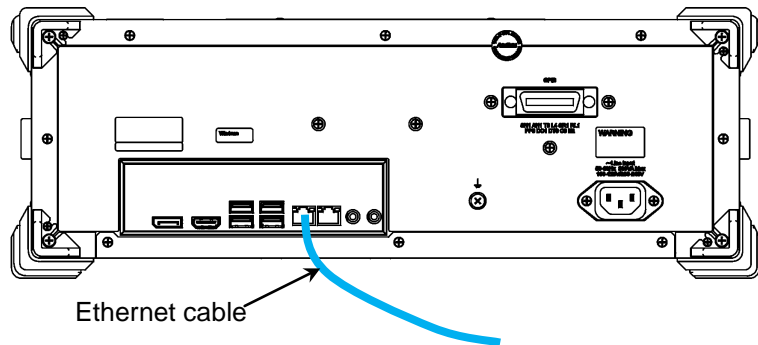
16. Right-click the Realtek PCIe GBE Family Controller icon where the cross mark (×) is not displayed.

17. Click **Rename**.

18. Change the name to "Local Area Connection (Left)".

19. Right-click other Realtek PCIe GBE Family Controller icon.

20. Click **Rename**.

21. Change the name to "Local Area Connection (Right)".
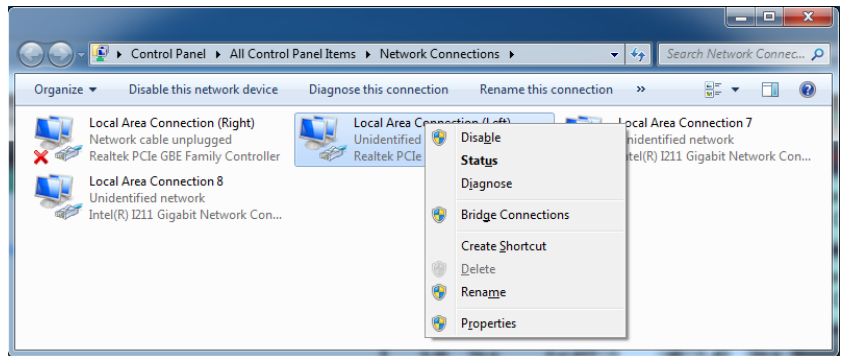
22. Right-click the Intel ® I211 Gigabit Network Connection icon.

23. Click **Rename**.

24. Change the name to "DO NOT CHANGE 1".

25. When there are two Intel ® I211 Gigabit Network Connection icons, right-click other Intel ® I211 Gigabit Network Connection icon.

26. Click **Rename**.
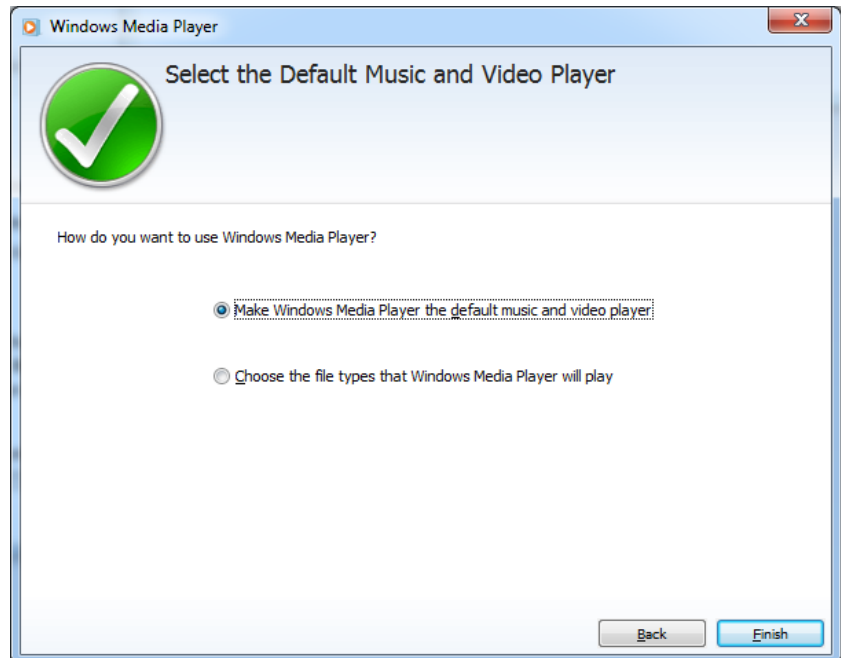
27. Change the name to "DO NOT CHANGE 2".
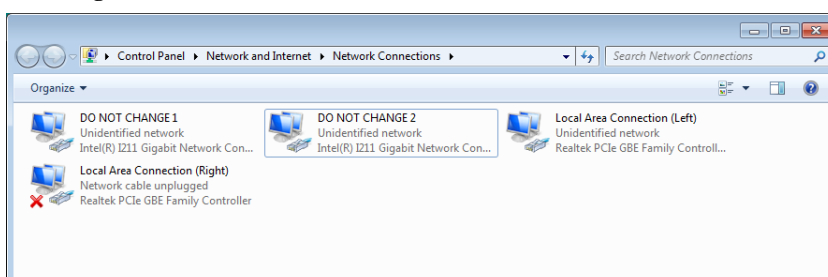
28. Click **All Programs → Windows Media Player** from the start menu.

29. Click **Custom Settings**, and click **Next**.

30. Check that all check boxes are not selected, and click **Next**.
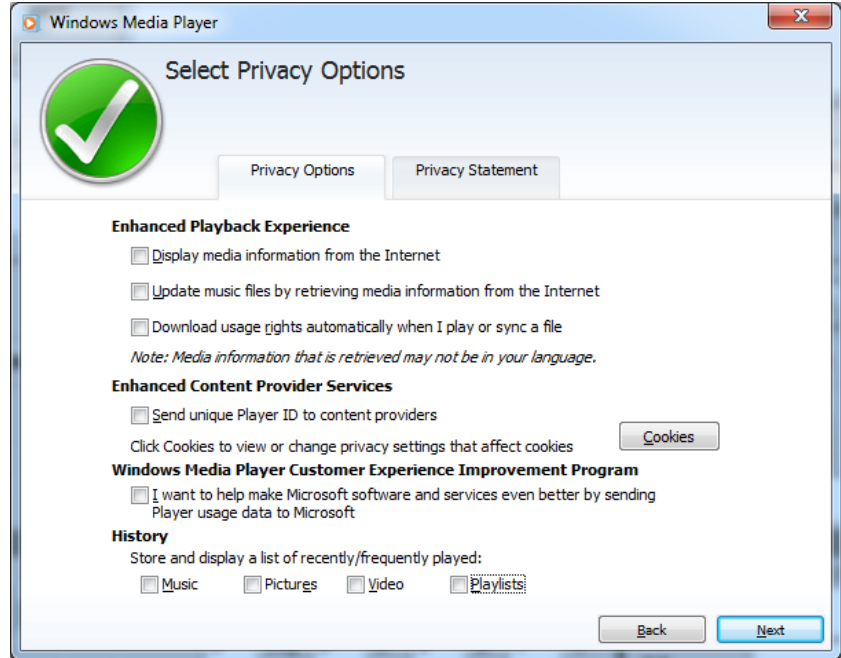
31. Click **Make Windows Media Player the default music and video player**, and click **Finish**.

32. Install the BERTWave Control Software (MX210000A) in accordance
     with the release note. The Module Configuration dialog box is
     displayed after launching the installer. Select the modules installed
     in MP2110A, and click **OK**.
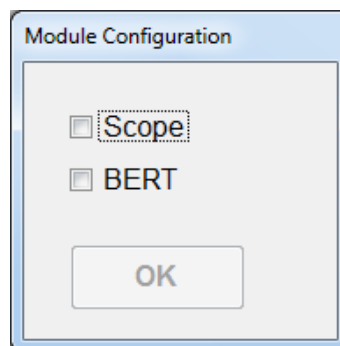
The above dialog box is displayed by clicking **MX210000A → Module
Configuration** from the start menu of Windows. If the wrong module
is selected, display the Module Configuration dialog box and select
the module again.

Checking operation

Check the operation using the following procedure after recovering the
system.

1.   Click **All Programs →MX210000A → MX210000A** from the start
     menu of Windows.

2.   Click **System Menu – Remote Control**. Check that Local Area
     Connection (Left) and Local Area Connection (Right) are displayed in
     the Remote Control dialog box (refer to Figure 4.3.10-1).

3.   Click **System Menu – Before Use**. Check that the video of
     countermeasure against static electricity is played back.

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Maintenance

8.7 Calibration

Regular maintenance such as periodic inspections and calibration is essential for the MP2110A for long-term stable performance. Regular inspection and calibration are recommended for using the MP2110A in its prime condition at all times. The recommended calibration cycle after delivery of the MP2110A is twelve months.

If you require support after delivery, contact an Anritsu Service and Sales office. Contact information can be found on the last page of the printed version of this manual, and is available in a separate file on the PDF version.

We may not provide calibration or repair if any of the following cases apply.

- Seven or more years have elapsed after production and parts for the instrument are difficult to obtain, or it is determined that reliability cannot be maintained after calibration/repair due to significant wear.
- Circuit changes, repair, or modifications are done without our approval.
- It is determined that the repair cost would be higher than the price of a new item.

8.8 Storage

Wipe off dust, fingerprint marks, stains, spots, etc. from the surface of the MP2110A before storing it.

Fit the attached coaxial connector cover to the coaxial connector on the front panel. Also, put the cap on the optical connector.

Put the power cord, DVD-ROM and other accessories in the accessory box and store it with the main frame.

For an Optical Scope, FC adaptor cap should be in place when the MP2110A is not in use to prevent foreign material from entering the optical connector.

Avoid storing the MP2110A in these places:
- In direct sunlight for extended periods
- Outdoors
- In excessively dusty locations
- In liquids, such as water, oil, organic solvents, and medical fluids, or places where these liquids may adhere
- In salty air or where chemically active gases (sulfur dioxide, hydrogen sulfide, chlorine, ammonia, nitrogen oxide, or hydrogen chloride etc.) are present
- Where toppling over may occur
- In the presence of lubricating oil mists
- In places at an altitude of more than 2,000 m
- In the presence of frequent vibration and mechanical shock, such as in cars, ships, and airplanes
- Places with temperatures and relative humidity in the following ranges:
  Temperature: lower than −20°C or higher than 60°C
  Humidity: 90% or more

Recommended storage conditions

It is recommended that the MP2110A be stored in a place that meets the ambient conditions suggested above, plus the following conditions, if it is not to be used for a long period of time:

- Temperature: 5 to 45°C
- Humidity: 40 to 80%
- Little temperature and humidity fluctuations within one day

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Maintenance

8.9 Transporting and Disposal

The following describes precautions for transporting and disposing of the BERTWave.

Repackaging

Repack the MP2110A in the packing material (box) in which it was delivered. If the packing material has been thrown away or damaged, repack the MP2110A in the following manner:

1. Prepare a corrugated cardboard, wooden, or aluminum box large enough to pack cushioning material in around the MP2110A.

2. Wrap the MP2110A in plastic or a similar material to avoid water droplets and dust.

3. Put the MP2110A in the box.

4. Pack the MP2110A in cushioning material so it does not move in the box.

5. Secure the outside of the box with packing cord, adhesive tape, bands, or other similar materials.

Transporting

Avoiding vibrations as much as possible and meet the recommended storage conditions during transport.

Disposal

Follow the instructions of your local waste disposal office when disposing of the MP2110A.
Before disposing of the MP2110A, dismantle or physically destroy any memory media it contains to ensure that any data saved in memory cannot be recovered by third parties.

Appendix A   Specifications

Appendix A describes the specifications for the MP2110A.
Only the specifications of the option installed at shipment are described
from Section A.2, "BERT" to Section A.4, "General Performance".
However, the specifications of the retrofit option and the specifications of
the option installed at shipment are the same.

Appendix

Appendix A

A.1 Configuration

Table A.1-1   Standard Configurations

Model/Ordering No.	Product Name	
MP2110A	– Main unit –	
	BERTWave	
	– Standard Accessories –	
	Power Code	1
J0617B	Replaceable optical connector (FC-PC)	*1
J1632A	TERMINATOR	*1
J1341A	OPEN	*1
J1627A	GND connection cable	1
J1763A	U Link Coaxial Cable (K)	1*2
J1764A	U Link Coaxial Cable (SMA)	1*2
Z0397A	FC Adaptor Cap	*1
Z1364A	MX210000A BERTWave Control Software CD-ROM	1

*1:   Quantity depends on the options. Refer to Table A.1-2 to Table A.1-4.

*2:   Only when MP2100A-054 is added

Table A.1-2   Connection Destination and Quantity of J0617B and Z0397A

Option	Connection Destination	Q'ty
MP2110A-022, MP2110A-032	Ch A In SMF, Ch A In MMF, Ch B In SMF, Ch B In MMF	4
MP2110A-023, MP2110A-033	Ch B In SMF, Ch B In MMF	2
MP2110A-025, MP2110A-035	Ch B In SMF	1
MP2110A-026, MP2110A-036	Ch B In MMF	1

Table A.1-3   Connection Destination and Quantity of J1632A

Option	Connection Destination	Q'ty
MP2110A-011	Data Out×1, $\overline{\text{Data}}$ Out×1, $\overline{\text{Sync}}$ Out×1	3
MP2110A-012	Data Out×2, $\overline{\text{Data}}$ Out×2, $\overline{\text{Sync}}$ Out×1	5
MP2110A-014	Data Out×4, $\overline{\text{Data}}$ Out×4, $\overline{\text{Sync}}$ Out×1	9
MP2110A-054	O/E Monitor Out ×1	1*

*:   When MP2110A-022, MP2110A-023, MP2110A-025, MP2110A-026, MP2110A-032, MP2110A-033, MP2110A-035, or MP2110A-036 is added.

Table A.1-4   Connection Destination and Quantity of J1341A

Option	Connection Destination	Q'ty
MP2110A-011	Ext Clk In, Clk Out, Sync Out×1, Data In×1, $\overline{\text{Data}}$ In×1	5
MP2110A-012	Ext Clk In, Clk Out, Sync Out×1, Data In×2, $\overline{\text{Data}}$ In×2	7
MP2110A-014	Ext Clk In, Clk Out, Sync Out×1, Data In×4, $\overline{\text{Data}}$ In×4	11
MP2110A-021	Trigger Clk In, Ch A In, Ch B In	3
MP2110A-022, MP2110A-032	Trigger Clk In	1
MP2110A-023, MP2110A-033	Trigger Clk In, Ch A In	2
MP2110A-025, MP2110A-035	Trigger Clk In	1
MP2110A-026, MP2110A-036	Trigger Clk In	1
MP2110A-054	CRU In ×1, CRU Out ×1	2

Appendix

Appendix A

Table A.1-5 Options

Model	Product Name
	– Options at Shipment –
MP2110A-011	1CH BERT[1],[2]
MP2110A-012	2CH BERT[1],[2]
MP2110A-014	4CH BERT[1],[2]
MP2110A-021	Dual Electrical Scope[1],[3]
MP2110A-022	Dual Optical Scope[1],[3]
MP2110A-023	Optical and Single-ended Electrical Scope[1],[3]
MP2110A-024	Precision Trigger[4]
MP2110A-025	Optical Scope for Singlemode[1],[3]
MP2110A-026	Optical Scope for Multimode[1],[3]
MP2110A-032	Dual Optical Scope Baseband Flat[1],[3]
MP2110A-033	Optical and Single-ended Electrical Scope Baseband Flat[1],[3]
MP2110A-035	Optical Scope for Singlemode Baseband Flat[1],[3]
MP2110A-036	Optical Scope for Multimode Baseband Flat[1],[3]
MP2110A-054	Clock Recovery (Electrical/Optical)[4]
MP2110A-093	PPG/ED Bit Rate Extension[5]
MP2110A-095	PAM4 Analysis Software[4]
MP2110A-096	Jitter Analysis Software[4]
	– Retrofit Options –
MP2110A-111	1CH BERT Retrofit[6]
MP2110A-112	2CH BERT Retrofit[7]
MP2110A-114	4CH BERT Retrofit[8]
MP2110A-121	Dual Electrical Scope Retrofit[9]
MP2110A-122	Dual Optical Scope Retrofit[9],[10]
MP2110A-123	Optical and Single-ended Electrical Scope Retrofit[9],[10]
MP2110A-124	Precision Trigger Retrofit[2]
MP2110A-125	Optical Scope for Singlemode Retrofit[9],[10]
MP2110A-126	Optical Scope for Multimode Retrofit[9],[10]
MP2110A-132	Dual Optical Scope Baseband Flat Retrofit[9],[10]
MP2110A-133	Optical and Single-ended Electrical Scope Baseband Flat Retrofit[9],[10]
MP2110A-135	Optical Scope for Singlemode Baseband Flat Retrofit[9],[10]
MP2110A-136	Optical Scope for Multimode Baseband Flat Retrofit[9],[10]
MP2110A-154	Clock Recovery (Electrical/Optical) Retrofit[4]
MP2110A-193	PPG/ED Bit Rate Extension Retrofit [5]
	– User-installable options –
MP2110A-395	PAM4 Analysis Software Retrofit[4]
MP2110A-396	Jitter Analysis Software Retrofit[4]

[1]: One or more these options are required.

[2]: Select one of the Scope options.
Scope options are MP2110A- x11, x12, and x14

[3]: Select one of the BERT options.
BERT options are MP2110A-x21, x22, x23, x25, x26, x32, x33, x35, and x36

*4: Can be selected with the Scope option.

*5: Can be selected with the BERT option.

*6: When MP2110A-x11, x12, or x14 is not installed

*7: When MP2110A-x12, or x14 is not installed

*8: When MP2110A-x14 is not installed

*9: When MP2110A-x21, x22, x23, x25, x26, x32, x33, x35, or x36 is not installed

*10: The following table shows available combinations of installed options and retrofit options.

Installed Option	Retrofit Option
MP2110A-022	MP2110A-132
MP2110A-023	MP2110A-133
MP2110A-025	MP2110A-135
MP2110A-026	MP2110A-136
MP2110A-032	MP2110A-122
MP2110A-033	MP2110A-123
MP2110A-035	MP2110A-125
MP2110A-036	MP2110A-126

A.2 BERT

A.2.1 Common Performances

Table A.2.1-1   Common Functions and Performances

Item	Specifications
Internal clock 　Frequency 　Accuracy 　Bit rate offset	 10 MHz ±10 ppm*1 ±100 ppm*2
Ext Clk In 　Frequency	

Without MP2110A-093	With MP2110A-093
607.5 MHz – 100 ppm to 705.0 MHz + 100 ppm	593.75 MHz – 100 ppm to 887.5 MHz + 100 ppm*3 607.5 MHz – 100 ppm to 705.0 MHz + 100 ppm*4

Connector	SMA, female
Termination	50 Ω, AC coupling
Amplitude	0.2 to 1.6 Vp-p
Waveform	Square or sine wave
Division ratio	

Without MP2110A-093	With MP2110A-093
1/40	1/16*3 1/40*4

Item	Specifications
Sync Output 　Division ratio 　Output Level 　Connector	 1/8, 1/16, 1/40, Pattern Sync High Level (V_{OH}):　　–0.2 to 0.05 V Low Level (V_{OL}):　　–1.2 to –0.7 V SMA, female

*1:　1 hour after power-on

*2:　The offset can adjust only when using the internal clock. (Common setting in all channels)

*3:　When operation bit rate is set to within 9.5 to 14.2 Gbit/s

*4:　When operation bit rate is set to within 24.3 to 28.2 Gbit/s

Table A.2.1-1   Common Functions and Performances (Cont'd)

Item	Specifications			
Clock Output*5				
Clock source*6	Ch1/2, Ch3/4			
Division ratio*7	**Without MP2110A-093**		**With MP2110A-093**	
	1/4		1/2*3 1/4*4	
Amplitude	0.3 to 0.5 Vp-p			
Duty	50±10%			
Connector	SMA, female			
Termination	50 Ω, AC coupling			

Item	Specifications			
Operation Bit Rate	**Without MP2110A-093**		**With MP2110A-093**	
	Standard Name	**Bit rate (Gbit/s)**	**Standard Name**	**Bit rate (Gbit/s)**
	Variable	24.3 to 28.2*8	Variable	24.3 to 28.2, 9.5 to 14.2*8
	32GFC	28.05	32GFC	28.05
	InfiniBand EDR	25.78125	InfiniBand EDR	25.78125
	100GbE/4	25.78125	100GbE/4	25.78125
	100GbE/4 FEC	27.7393	100GbE/4 FEC	27.7393
	OTU4	27.952493	OTU4	27.952493
			10GFC	10.51875
			10GFC FEC	11.3168
			16GFC	14.025
			InfiniBand x4	10
			InfiniBand FDR	14.0625
			10GbE WAN/PHY	9.95328
			10GbE LAN/PHY	10.3125
			OTU1e (10GbE FEC)	11.049107
			OTU2e (10GbE FEC)	11.095728
			OC-192/STM-64	9.95328
			OC-192/STM-64 FEC (G.975)	10.664228
			OTU2	10.709225

*5: It is output when Test Pattern is PRBS and 1/16Clock Pattern and it is not output when Test Pattern is 1/2Clock Pattern.

*6: Only when MP2110A-014

*7: Ratio of output clock frequency and bit rate

*8: The bit rate can be specified in 1 kbit/s steps.

Appendix

Appendix A

A.2.2 Pulse Pattern Generator

Table A.2.2-1   PPG

Item	Specifications				
Data Output*1					
Number of Channels	MP2110A-011: 1 (Data Out, $\overline{\text{Data}}$ Out)*2 MP2110A-012: 2 (Data Out, $\overline{\text{Data}}$ Out)*2 MP2110A-014: 4 (Data Out, $\overline{\text{Data}}$ Out)*2				
Amplitude					
Setting range	0.1 to 0.8 Vp-p / 0.01 V resolution (Single-ended) 0.2 to 1.6 Vp-p / 0.02 V resolution (Differential)				
Accuracy	±20 mV ±20% for settings*3				
Data Crossing	50%				
Accuracy	±10%*3,*4				
Rise/Fall time	typ. 15 ps*3,*4 (20-80%) max. 17 ps*3,*4 (20-80%)				
Jitter		MP2110A-011, MP2110A-012		MP2110A-014	
		typ.	max.	typ.	max.
	Jitter (RMS) *3,*4,*5,*6	600 fs	900 fs	600 fs*8, 900 fs*9	900 fs*8, 1200 fs*9
	Intrinsic RJ (RMS) *3,*4,*5,*7	400 fs	600 fs	400 fs*8, 800 fs*9	600 fs*8, 1000 fs*9
Skew	±8 ps max.*3,*4				
Connector	K, female				
Data format	NRZ				
Test pattern	PRBS: 2^7–1, 2^9–1, 2^15–1, 2^23–1, 2^31–1 Auxiliary pattern: 1/2 Clock Pattern, 1/16 Clock Pattern				
External attenuator factor	0 to 30 dB, 1 dB resolution Able to display the relative value of Data output and $\overline{\text{Data}}$ output.				
Function	Output on/off, logic invertible, error addition				

*1: These are measured in the MP2110A sampling scope (with MP2110A-024).
The clock output is used for the external trigger (Trigger) of the sampling scope.

*2: These can be output separately.

*3: When bit rate is set to 25.78125Gbit/s

*4: When amplitude is set to 0.3 Vp-p.

*5: These are measured in 25±5 degree Celsius.

*6: Test pattern is PRBS 2^31–1.

*7: Test pattern is 1/16 Clock Pattern.

*8: Selecting Clock Source to **Ch1/2** when measuring Ch1 and Ch2,
Selecting Clock Source to **Ch3/4** when measuring Ch3 and Ch4.

*9: Selecting Clock Source to **Ch3/4** when measuring Ch1 and Ch2,
 Selecting Clock Source to **Ch1/2** when measuring Ch3 and Ch4.

A.2.3 Error Detector

Table A.2.3-1   ED

Item	Specifications
Data Input	
Number of Channel	MP2110A-011: 1 (Data, $\overline{\text{Data}}$) (Single-ended, differential input)
	MP2110A-012: 2 (Data, $\overline{\text{Data}}$) (Single-ended, differential input)
	MP2110A-014: 4 (Data, $\overline{\text{Data}}$) (Single-ended, differential input)
Data format	NRZ, Mark ratio 50%, Single-ended or differential input
Amplitude	0.05 to 0.8 Vp-p
Termination	DC coupling, termination voltage 0 V
Threshold	–0.085 to +0.085 V*1, 1 mV resolution
Sensitivity	25 mVp-p*2,*3, typ. (25±5°C)
	40 mVp-p*2,*3, max.
Connector	K, female
Jitter tolerance*2,*4	Sinusoidal jitter amplitude 5 UI$_{\text{p-p}}$ 0.05 UI$_{\text{p-p}}$ 100 kHz 10 MHz 100 MHz

*1: Guaranteed under the following conditions:
 ・ Single-ended
 ・ External attenuator factor   0 dB

*2: Guaranteed under the following conditions:
 ・ Bit rate: 25.78125 Gbit/s
 ・ Pattern: PRBS2^31–1
 ・ Single-ended

*3: Guaranteed under the following conditions:
 ・ Mark ratio   1/2
 ・ Loop-back connection

*4: Amplitude: 50 mV

Table A.2.3-1   ED (Cont'd)

Item	Specifications
External attenuator factor	0 to 30 dB*5, 1 dB resolution
Test pattern	PRBS:2^7–1, 2^9–1, 2^15–1, 2^23–1, 2^31–1 Logic invertible

Measurement
  Alarm detection
  Bit error detection
 	
  Regenerating clock detection
  History
	
	Sync loss*6
	Total Error Rate: 0.0001E–18 to 1.0000E–03
	Total Error Count: 0 to 9999999, 1.0000E07 to 9.9999E17
	Able to detect the input signal frequency (sampling system).
	
	Sync loss, Bit error (able to reset the history indicator)

Gate settings
  Measurement time
  Gating cycle
  Current Display
	
	1 seconds to 9 days 23 hours 59 minutes 59 seconds
	Single / Repeat / Untimed
	Able to switch On or Off. (When it is Off, the result is updated after set time is passed)

Measurement time display	Start time, elapsed time, remaining time
Progress bar	Displays the measurement progress in a bar graph and percent figures.
PPG/ED tracking	Test Pattern

*5: The thresholds corrected by the external attenuation factor are displayed. The formulas are shown below:

Upper limit value = $-85 \times 10^{(\frac{ATT}{20})}$

Lower limit value = $85 \times 10^{(\frac{ATT}{20})}$

Resolution = $1.0 \times 10^{(\frac{ATT}{20})}$

*6: It is not synchronizing with Test Pattern.

A.3 Sampling Oscilloscope

A.3.1 Channel Configuration

Table A.3.1-1   Channel Configuration

Option	Ch A	Ch B
MP2110A-x21	Electrical channel	Electrical channel
MP2110A-x22, MP2110A-x32	Optical channel	Optical channel
MP2110A-x23, MP2110A-x33	Electrical channel	Optical channel
MP2110A-x25, MP2110A-x35	None	SMF Input Optical channel (No MMF Input)
MP2110A-x26, MP2110A-x36	None	MMF Input Optical channel (No SMF Input)

A.3.2 Common Performances

Table A.3.2-1   Common Functions and Performances

Item	Specifications		
Sampling System			
Sampling Mode	Eye, Pulse, Coherent Eye, Advanced Jitter*1		
Test Pattern*2			
		Without Option 095	With Option 095*3
		Variable	Variable, PRBS7 (127 symbols)*4, PRBS9 (511 symbols)*4, PRBS13 (8191 symbols)*4, PRBS15 (32767 symbols)*4, SSPRQ (65535 symbols)*4
Number of Samples	Number of samples on one screen <Eye>: 1350, 2048, 4050 <Pulse, Coherent Eye>: 512,1024,2048,4096,8192,16384*5		
Sampling	Run: Execute sampling Hold: Stop sampling		
Display	Ch A: ON/OFF Ch B: ON/OFF		

*1:   Available when Option 096 is installed

*2:   Trigger division ratio operates at 1, 2, 4, 8, 16, 32, 40, 48 or 64

*3:   Possible to analyze the following patterns with Pulse/Coherent Eye (Impossible to analyze with Variable)
PRBS7 (127 symbols), PRBS9 (511 symbols), PRBS13 (8191 symbols), PRBS15 (32767 symbols), SSPRQ (65535 symbols)

*4:   Operation is guaranteed at Symbol Rate of 9.95 Gbaud to 40 Gbaud. Possible to analyze when Symbol Length is same

*5:   Fixed to 16384 when Coherent Eye and Test Pattern are set

Table A.3.2-1 Common Functions and Performances (Cont'd)

Item	Specifications
Accumulation Type	Waveform display method None: Display with no accumulation Infinite: Display with unlimited accumulation Limited: Display with accumulation up to the specified sample number, time, or number of waveforms Persistency: Display with afterglow indication for the specified time Averaging: Display by averaging the specified number of waveforms Averaging can be selected only when Sampling Mode is set to Pulse When Sampling Mode is Advanced Jitter, only Infinite, Limited can be selected
Limit Type	Specifies cumulative completion condition when Accumulation Type is set to Limited Time: Measurement stops when the cumulative time exceeds the set time Sample: Measurement stops when the total cumulative number of samples exceeds the set number of samples. Waveform: Measurement stops when the total waveform sweep count exceeds the set sweep count. Pattern: Measurement stops if the total acquisition pattern count exceeds the set sweep count. Pattern can be selected when Sampling Mode is Advanced Jitter
Clear Display	Clears display drawing
Auto Scale	Sets Time Scale and Amplitude to optimum values automatically

A.3.3 Time Setting

Table A.3.3-1   Time Setting

Item	Specifications
Recalculation	Specifies the reference parameter 　Data Rate (Data Rate is automatically set when Clock Rate is entered) 　Clock Rate (Clock Rate is automatically set when Data Rate is entered)
Symbol Rate	Specifies the baud rate of the signal input to the Scope channel 　100 Mbaud to 60 Gbaud, 1 kbaud step
Clock Rate	Specifies the clock frequency input to Trigger In 　100 MHz to 15 GHz, 1 kHz step
Tracking	Function that sets Symbol Rate and Divide Ratio to values set by other options, when BERT or Clock Recovery option is installed
Divide Ratio Tracking Master	When BERT option is installed: Clock Output, Sync Output, User Defined When Clock Recovery option is installed: CRU
Acquire Clock Rate	Uptates Clock Rate by measuring the clock rate input to Trigger In (Data Rate is automatically set according to the Divide Ratio)
Divide Ratio	Ratio of Clock and Input Data (1 to 99. However, Pulse / Coherent Eye Mode works only when setting 1, 2, 4, 8, 16, 32, 40, 48, 64)[1]
Divide Ratio Detect	Detects Divide Ratio automatically
Precision Trigger[2] 　Enable 　Reset 　Alarm	 ON/OFF (Trigger Clock ON is possible at input frequency of 2.4 GHz or higher) Ability to redetect the internal correction value for Precision Trigger Ability to display status to the user when the internal correction value becomes inappropriate
Scale/Offset 　Unit 　UI On Screen 　Offset	 Specifies the horizontal axis unit of the screen UI, Time(ps) Specifies the number of UI on the screen 　Eye, Coherent Eye Mode: 1 to 100 UI (1 UI step) 　Pulse Mode:　　　　　　1 to 65535 UI (1 UI step) Sets time offset for trigger position 　0.00 to 32768.00 UI　(0.01 UI step)
Skew	Function of correcting Inter-channel skew Channel A : $\pm \dfrac{\text{UI On Screen}}{2}$　Display UI converted to ps (0.1 ps step) Channel B : $\pm \dfrac{\text{UI On Screen}}{2}$　Display UI converted to ps (0.1 ps step)

　*1:　48 is supported by Version 6 or later.

　*2:　Available when Option 024 is installed

Table A.3.3-1   Time Setting (Cont'd)

Item	Specifications
Pattern Length Tracking	Specifies capturing pattern length when using Pulse, Coherent Eye Mode BERT option is required*3. Tracks the Pattern length setting of BERT. PPG Ch1, PPG Ch2, PPG Ch3, PPG Ch4, ED Ch1, ED Ch2, ED Ch3, ED Ch4
Manual	Settable when Test Pattern in Table A.3.2-1 is Variable. Specifies the pattern length manually 1 to 32768 UI

*3:   When Test Pattern in Table A.3.2-1 is set to anything other than
        Variable, it cannot be set

A.3.4 Measurement

Table A.3.4-1   Measurement

Item	Specifications
Signal Type	Specifies the signal type of the target channel NRZ, PAM4*
Active Channel	Selects either Ch A or Ch B. When only 1 channel is displayed, the display channel becomes Active Channel, and when 2 channels are simultaneous displayed, the channel rendered last turned on becomes Active Channel.
Marker	X1: ON/OFF, X2: ON/OFF Y1: ON/OFF, Y2: ON/OFF

*:   PAM4 is selectable when Option 095 is installed

Table A.3.4-2   Amplitude/Time Measurement

Item	Specifications
Measurement Select	For channels with Signal Type set to NRZ, the following items can be measured One Level, Zero Level, Eye Amplitude, Eye Height, Crossing, SNR, Average Power (dBm)[1], Average Power(mW)[1], Extinction Ratio[1], Jitter p-p, Jitter RMS, Rise Time, Fall Time, Eye Width, DCD, OMA (dBm)[1], OMA (mW)[1], VECP[1,2], OMA at Crossing[1,2] For channels with Signal Type set to PAM4, the following items can be measured TDECQ[1], Outer OMA[1], Outer ExR[1], Linearity, Levels (Level 3, Level 2, Level 1, Level 0) , Levels RMS (Level 3, Level 2, Level 1, Level 0) , Levels P-P (Level 3, Level 2, Level 1, Level 0) , Level Skews (Level 3, Level 2, Level 1, Level 0), Eye Levels (Upper, Middle, Lower), Eye Skews (Upper, Middle, Lower), Eye Heights (Upper, Middle, Lower), Eye Widths (Upper, Middle, Lower), Average Power (dBm)[1], Average Power (mW)[1] When option 096 is installed on the channel whose Signal Type is NRZ, the following items can be measured [3] TJ (User Define)[4], RJ (d-d) , DJ (d-d) , J2 Jitter, J9 Jitter, Eye Opening[4] RJ (rms) PJ (p-p), DDJ (p-p), DCD, ISI (p-p), DDPWS, PJ Frequency[5]
Item Selection	Selects up to 4 or 32 items from Measurement Select and displays the result [6] Channel, Current Value, Average, Std.Dev, Min, Max
Measuring Area Marker	Displays the measurement area as a marker

*1:   When optical input channel is selected

*2:   Supported with Version 6 or later

*3: RJ (rms), PJ (pp), DDJ (pp), DCD, ISI (pp). DDPWS and PJ Frequency can be measured when Sampling Mode is set to Advanced Jitter.

*4: BER specified in TJ Measurement BER in the setting items

*5: Impossible to measure with differential signals

*6: Item 1 to 4 are available with Version 5.   Item 1 to 32 are available with Version 6 or later.

Table A.3.4-2   Amplitude/Time Measurement (Cont'd)

Item	Specifications

NRZ Measure Setup
  Eye Boundary
 	
  Rise/Fall Time
	Setup items for measuring NRZ
	Offset from Crossing: 0 to 1 UI (0.01 UI step)
	  Width: 0 to 1 UI (0.01UI step)
	Percentage: 10-90%, 20-80%
	Correction Factor: 0 to 9999.9 ps
	            (Correct actual Tr / Tf when inserting LPF)

PAM4 Measure Setup
  Sampling Timing
 	
  Eye Center Type
 	
  Eye Opening
  Definition
 	
  TDECQ Reference
  Equalizer
  Reference Equalizer
 	
  Display Equalized
  Waveform
 	
  Equalizer Taps
	Setup items for measuring PAM4*7
	"Track to Middle Timing": The phase of Middle EYE is the reference
	"Independent Timing": The phases of Upper, Middle and Lower are independent reference in each other.
	"Maximum Eye Width": The center of the eye opening at the amplitude where the Eye Width is the maximum is the reference.
	"Maximum Eye Height": The phase where Eye Height becomes maximum is the reference.
	"Zero Hits": The value at which the Eye opening becomes the largest in the sample evaluation is measured.
	"1E–01 to 1E–6": Error rate is set in step of 1E+01, The measurement result is calculated at the specified error rate.
	In the optical channel, whether to process a reference equalizer for TDECQ measurement is settable. *8
	"ON": Executes the process of Reference Equalizer.
	"OFF":Does not process the calculation.
	This function is available when the Reference Equalizer is ON.
	  "ON": Displays the waveform after Reference Equalizer process.
	  "OFF": Displays the waveform before the Reference Equalizer process.
	"Calculation": Executes the calculation for Tap optimizaion. After the calculation, whether the calculation was completed normally is indicated in the item of Status.
	"Number of Taps": The number of Taps for the Reference Equializer. Tap is selectable from 5, 7, 9.
	"Taps": The number of Taps for the Reference Equializer. The number is setteble up to 6 decimal places.
	"Status": The flag which indicates whether to the last calculation was completed successfully.

*7: Available when Option 095 is installed.

*8: Processing is possible when Signal Type of the target channel is PAM 4, Coherent Eye setting and Test Pattern is PRBS 7, PRBS 9, PRBS 13, PRBS 15 or SSPRQ.

Table A.3.4-3 Jitter Measurement

Item	Specifications
Jitter Measure Setup	Settings related to jitter measurement items[*1]
TJ Measurement BER	Sets the BER to measure TJ(User Define) and Eye Opening with the measurement result. Selectable up to 1.0E–001 to 1.0E–018, in 1.0E+001Step
Fixed RJ	Function to use User-specified value for RJ results "ON": Uses the value of Fixed RJ Factor "OFF": Uses the calculation result for jitter categorizing.
RJ Value	The value to be used when Fixed RJ is ON 0.01 to 999.99 ps, step 0.01 ps rms
Correction Factor	Function to correct results by Users "ON": Corrects the result. "OFF": Does not correct the result.
DJ (Scale)	Function to adjust Scale of DJ DJ = DJ (Scale) ×Measurement result 0.01 to 999.99, step 0.01
RJ (Scale)	Function to adjust Scale of RJ RJ = RJ (Scale) ×Measurement result 0.01 to 999.99, step 0.01
RJ (rms)	Function to adjust rms of RJ $RJ = \sqrt{(\text{Measurement result})^2 - \{RJ(\text{rms})\}^2}$ 0.01 to 999.99 psrms, step 0.01 psrms
Threshold Define	Definition of Crossing value to measure jitter Auto: Automatic adjustment with the use of Crossing value of Scope Manual: User input of Crossing to be measured
Threshold (Manual)	Crossing value to measure jitter 30 to 70%, step 1%
PDJ Measurement	Function to switch Pattern Dependent Jitter measurement method. Available at Advanced Jitter. "ON": Displays the result to regard DDJ as PDJ. "OFF": Displays the result to regard DDJ as DDJ.
PDJ Standard Filter	When PDJ Measurement is ON, the following filters are used for PDJ measurement depending on the Standard. Unit is Hz. <table><tr><td>Standard</td><td>HP0</td><td>HP1</td><td>HP1'</td><td>HP2</td><td>HP'</td><td>HP</td><td>LP</td><td>LP'</td></tr><tr><td>STM-0</td><td>10</td><td>100</td><td>–</td><td>20 k</td><td>–</td><td>12 k</td><td>400 k</td><td>–</td></tr><tr><td>STM-1</td><td>10</td><td>500</td><td>–</td><td>65 k</td><td>–</td><td>12 k</td><td>1.3 M</td><td>500</td></tr><tr><td>STM-4</td><td>10</td><td>1 k</td><td>–</td><td>250 k</td><td>–</td><td>12 k</td><td>5 M</td><td>1 k</td></tr><tr><td>STM-16</td><td>10</td><td>5 k</td><td>–</td><td>1 M</td><td>–</td><td>12 k</td><td>20 M</td><td>5 k</td></tr><tr><td>STM-64</td><td>10</td><td>20 k</td><td>10 k</td><td>4 M</td><td>50 k</td><td>12 k</td><td>80 M</td><td>20 k</td></tr><tr><td>STM-256</td><td>–</td><td>80 k</td><td>20 k</td><td>16 M</td><td>–</td><td>—</td><td>320 M</td><td>—</td></tr></table>
Measurement Edge	Switching of Edge to measure jitter Available at Advanced Jitter. "ALL": Measures both rising and falling transition "Rising": Measures only rising transition "Falling": Measures only falling transition. Depending on this setting, the result on the graph also displays the corresponding transition result.

*1: Available when Option 096 is installed.

Table A.3.4-4   Histogram

Item	Specifications
Histogram	Setting functions related to the Histogram measurement
Target Channel	OFF, Channel A, Channel B
Axis	Amplitude, Time
Marker	X1, X2, Y1, Y2
Result Display	Mean, Std. Dev, p-p, Hits

Table A.3.4-5   Mask Test

Item	Specifications
Mask Test	Setting functions related to the Mask Test measurement
Target Channel	OFF, Channel A, Channel B
Compliance Mask	Selects the Mask to be used for measurement from files.
Mask Margin Test Method	One Shot Continuous
Align Method	Function to specify the method to set Mask position.
Auto Align	Zero/One/Crossing
User Defined	Alignment Marker X1, ΔX, Y1, ΔY
Marker Display	ON/OFF
Mask Margin	−100 to +100%
Margin Type	Selects from Hit Count or Hit Ratio.
Hit Count	1 to 999999999[1]
Hit Ratio	$1E–12$ to $9E–1$[2]
Mask Area Restriction	ON/OFF Function to limit Mask effective area in Mask measurement
Angle	−90 to 90º (1º step)
Width	0.01 to 1 UI (0.01 step)
Result Display	Total Samples, Total Waveforms, Mask Margin [%], Hit Count, Total Failed Samples, Top Mask Failed Samples, Center Mask Failed Samples, Bottom Mask Failed Samples

*1: Fail Sample upper limit value for Margin measurement

*2: Hit Count is automatically set with the total sample and set probability.

A.3.5 MISC

Table A.3.5-1   MISC

Item	Specifications
EYE/Pulse Shot	Saves Result screen image as jpg or png format image.
Inverse Background Color	Saves EYE / Pulse Shot waveform area with reversing the color.
Waveforms Only	Saves only the waveform display area in the Result screen.
Preset Information	Function to select display / non-display of characters in the waveform display area
Waveform Color	Function to select the gradation table of the waveform at the time of cumulative setting.
Mask Color	Function to select the color of Mask displayed at Mask Test

Label
    New Label
 	
    Delete Label
	Function to display arbitrary character string on EYE / Pulse Scope screen
	One label is displayed on one screen. The maximum number of characters is 1023 characters.
	Deletes the displaying label.

Trace Memory	Function to store measurement waveform in internal memory
Trace Memory	Set/Clear
Reference Trace Channel	Select channel to store in internal memory Channel A, Channel B, Channel A & Channel B

A.3.6 Maintenance

Table A.3.6-1   Calibration

Item	Specifications
Calibration Application Test	Calibrates Amplitude (Offset and linearity calibration) and O / E Module Calibration of dark current / current system Self-diagnostic function

A.3.7 Horizontal System

Table A.3.7-1   Horizontal System

Item	Specifications
Trigger Clk In	
Connector	SMA Connector (f.)
Termination	50 Ω, AC Coupled
Trigger Clock Frequency	0.1 to 15.0 GHz 2.4 to 15.0 GHz[1]
Trigger Clock Input Sensitivity[2]	Typ. 100 mVp-p, Max. 200 mVp-p Typ. 200 mVp-p[1]
Maximum Amplitude	Min. 1.2 Vp-p
Maximum Amplitude (Before Damage)	2 Vp-p
Jitter, RMS	2.4 GHz or more, 15 GHz or less: Typ. 400 fs, Max. 1.35 ps Typ. 200 fs[1,3,4] , Max. 280 fs[1,3] 0.1 GHz or more, less than 2.4 GHz: Typ. 1.0 ps, Max. 1.5 ps

*1: When Option 024 is installed and Precision Trigger is ON.

*2: It is specified by inputting the square wave when the trigger clock frequency is 1 GHz or less.

*3: Evaluation by connecting the sine wave output of the MG3695A or equivalent to the Trigger input.

*4: At 25±5ºC

A.3.8 Digital System

Table A.3.8-1   Digital System

Item	Specifications
Sampling Speed	150 kSamples/s, Nominal
Effective Sampling Speed	250 kSamples/s, Nominal With Number of Sample = 1350, Symbol Rate = 25.78125 Gbaud, Clock Rate = 6.4453125 GHz, Eye Mode, UI on Screen = 2 UI
Process Speed	Effective process speed of Reference Equalizer Nominal 130 ksps @ 26.5625 Gbaud, Test Pattern = SSPRQ When setting Coherent Eye

A.3.9 Electrical Channel

Table A.3.9-1   Electrical Channel Function

Item	Specifications
Amplitude Setting	
Scale	Scale Setting on the vertical axis. Both ChA and ChB can be set as follows 1 to 200 mV/div, 1 mV step
Offset	Offset setting on the vertical axis. Both ChA and ChB can be set as follows –500 to 500 mV/div, 1 mV step
Attenuation	Function of correcting Amplitude Scale / Offset and measurement result in conjunction with the input attenuation of the attenuator connected to Data Input 0.00 to 30.00 dB, 0.01 dB step
Channel A/B Tracking*	Function to track the value of Scale, Offset, Attenuation of ChB to ChA ON/OFF
Channel Math*	Function to draw calculation results of ChA and ChB
Channel Math Enable	ON/OFF

Define Function	Selects the calculation method
	   ChA + ChB
	   ChA – ChB
	   ChB – ChA

Scale	Sets scale in Vertical Axis at displaying Channel Math calculation 1 to 200 mV/div, 1 mV step
Offset	Sets offset in Vertical Axis at displaying Channel Math calculation –500 to 500 mV/div, 1 mV step

*:   Not available with MP2110A-x23 or MP2110A-x33

Table A.3.9-2   Electrical Channel Performance

Item	Specifications

Data Input
  Connector
  Termination
  Maximum
  Amplitude
  Dynamic Range
  Amplitude Accuracy
	Electric Input Connector
	K Connector (f)
	50 Ω
	±2 V maximum input before damage
	
	±400 mV*1
	±2% of reading ± offset amplitude accuracy (refer to below fig. *2,*3)

Bandwidth (–3 dB) Flatness Noise RMS	Typ. 40 GHz Typ. ±1 dB (10 MHz to 30 GHz) Typ. 1.5 mV Max. 2.5 mV

*1:   Relative to amplitude offset

*2:   After internal calibration

*3:   Calculation example: At 400 mV amplitude reading value and 50 mV offset voltage
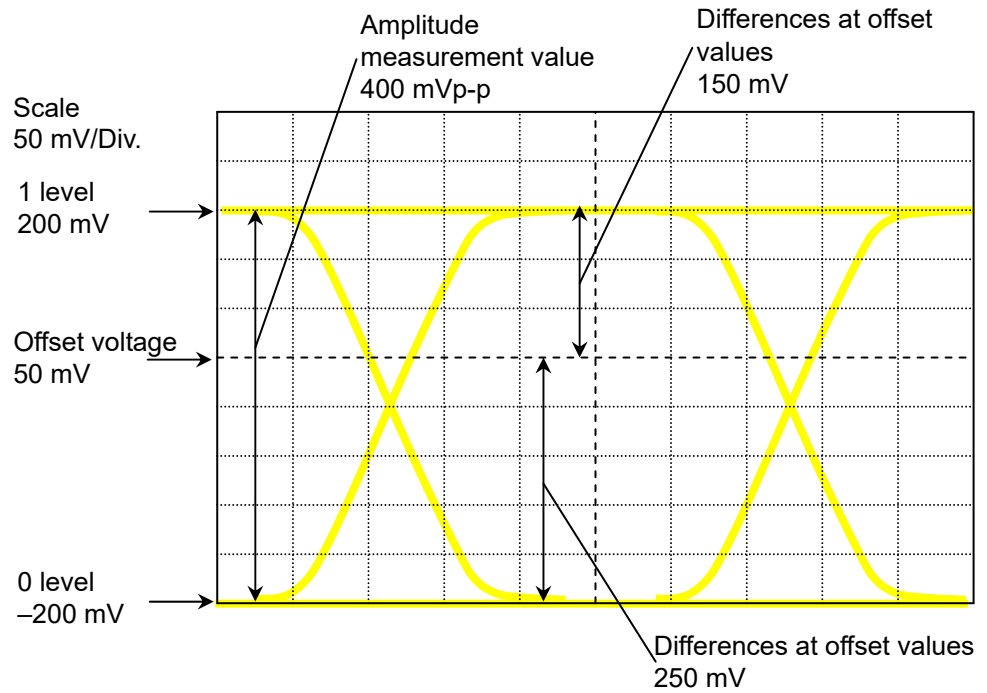
In this example, the difference between 1 level voltage (200 mV) and offset voltage (50 mV) is 150 mV. At a scale of 50 mV/div for a voltage difference of 150 mV, the amplitude accuracy is 8 mV. At 1 level accuracy, the difference is calculated as follows:

200 × 2% + 8 = 12   ±12 mV

The difference between 0 level voltage (–200 mV) and offset voltage (50 mV) is 250 mV. At the 50 mV/div scale for a voltage difference of 250 mV, the amplitude accuracy is 11 mV. At 0 level accuracy, the difference is calculated as follows:

200 × 2% + 11 = 15   ±15 mV

A.3.10 Optical Channel

Table A.3.10-1 Optical Channel Function

Item	Specifications
Amplitude Setting	
Scale	Scale setting on the vertical axis. Both ChA and ChB can be set as follows. 1 to 200 µW /div, 1 µW step
Offset	Offset setting on the vertical axis. Both ChA and ChB can be set as follows. −500 to 500µW/div, 1 µW step
Attenuation	Function of correcting Amplitude Scale / Offset and measurement result in conjunction with the input attenuation of the attenuator connected to Data Input 0.00 to 30.00 dB, 0.01 dB step
Channel A/B Tracking*	Function to track the value of Scale, Offset, Attenuation of ChB to ChA ON/OFF
Channel Math*	Function not available
Filter Selection	Sets the bandwidth of O/E Input Port to No Filter or Reference Receiver compliant filters. Refer to Filter Response in Table A.3.10-2 for supported filters.
ExR Correction	Extinction ratio correction function
Correction Enable	ON/OFF
Correction Value	−9.99 to +9.99 %, 0.01% step
Conversion Gain	Adjusts two conversion gains. One is for SMF Input and the other is for MMF Input.
Responsivity	Adjusts two responsivities. One is for SMF Input and the other is for MMF Input.
Calibration	Conversion Gain / Responsivity Calibration, O/E Calibration

    *:   Not available with MP2110A-x23, MP2110A-x33, MP2110A-x25, MP2110A-x35, MP2110A-x26 or MP2110A-x36

Appendix

Appendix A

Table A.3.10-2   Optical Channel Performance

Item	Specifications
Data Input	Optical Input Connector ChA, ChB
Connector	2 ports, for SMF O/E Module, MMF O/E Module
	FC Connector (SMF Input, MMF Input)
Fiber	62.5 μm GI Multimode fiber, accepts single mode fiber (SMF Input, MMF Input)
Wavelength	860 to 1650 nm (SMF Input)
	800 to 860 nm (MMF Input)
Bandwidth (No Filter)	Typ. 35 GHz (SMF Input)
	Typ. 25 GHz (MMF Input)
Filter Response	Supports the following specifications

NRZ	PAM4
100GbE/4 (25.78125Gbit/s)	400GbE/8 SMF (13.3GHz) [D]*
100GbE/4 FEC (27.7393Gbit/s)	400GbE/8 MMF (12.6GHz) [D]*
OTU4 (27.952493Gbit/s)	400GbE/8 (19.34GHz) [D]*
32GFC (28.05Gbit/s)	

Optical Noise

Conditions	When Option 054 is not installed	When Option 054 is installed
@1310 nm, OTU4 Filter	Typ. 3.4 μWrms, Max. 4.3 μWrms	Typ. 4.8 μWrms, Max. 6.1 μWrms
@1310 nm, No Filter	Typ.5.4 μWrms Max. 7.5 μWrms	Typ. 7.6 μWrms Max. 10.6 μWrms
@850 nm, OTU4 Filter	Typ. 6.7 μWrms Max. 8.4 μWrms	Typ. 9.5 μWrms Max. 11.9 μWrms
@850 nm, No Filter	Typ. 8.1 μWrms Max. 10.5 μWrms	Typ. 11.4 μWrms Max. 14.9 μWrms

Mask Sensitivity

When Option 054 is not installed	When Option 054 is installed
SMF: Typ. −15.0 dBm (1310 nm, OTU4 Filter) MMF: Typ. −12.0 dBm (850 nm, OTU4 Filter)	SMF: Typ. −12.0 dBm (1310 nm, OTU4 Filter) MMF: Typ. −9.0 dBm (850 nm, OTU4 Filter)
Estimated optical power at which Mask Margin (Hit Count 0) reaches 0% (calculated from the optical noise level)	

*:   When option 095 is installed, Coherent Eye is set and Test pattern is set other than Variable

Table A.3.10-2   Optical Channel Performance (Cont'd)

Item	Specifications
Maximum Input Power (Before Distortion)	Typ. –2 dBm (SMF Input), @ the signal of 1310 nm, ExR = 8 dB is observed.
	Typ. 0 dBm (MMF Input), @ the signal of 850 nm, ExR = 3 dB is observed.
Absolute Maximum Power (Before Damage)	\<Average\> +5 dBm (SMF Input), +7 dBm (MMF Input) \<Peak\> +8 dBm (SMF Input), +10 dBm (MMF Input)
Optical Return Loss	Typ. –18 dB (SMF Input), @ 1310 nm SMF Fiber is connected
	Typ. –13 dB (MMF Input), @ 850 nm MMF Fiber is connected

Optical Power Meter
  Range
  Accuracy
	
	0 to –18 dBm
	Typ.±0.35 dB (0 to –12 dBm)
	Typ. ±0.6 dB (–12 to –18 dBm)

OE Monitor Out
 	
  Conversion Gain
 	
  Connector
	Signal terminal to output after O/E conversion for CRU connection, added when Option 054 is installed.
	\<SMF Input\>
	  Typ. 60 V/W
	\<MMF Input\>
	  Typ. 33 V/W
	K Connector (f)

A.3.11 CRU (Option 054)

Table A.3.11-1   CRU Input

Item	Specifications
Data Format	NRZ, PAM4 available (PRBS pattern)
Operation Baud Rate	25.5 to 28.2 Gbaud
Sensitivity	Typ. 10 mVp-p [1], [2]
	Max. 20 mVp-p[1]
Maximum Amplitude	800 mVp-p
Maximum Amplitude (Before Damage)	1 Vp-p
Tolerance against consecutive 0s	500 bits or more at Zero Substitution Pattern PRBS $2^{15}-1$
Connector	K Connector (f)
Termination	50 Ω, AC Coupled

[1]: With 25.78125 Gbit/s, PRBS $2^{31}-1$ NRZ, Loop Bandwidth = 10 MHz, Single-ended, Mark ratio 1/2, Using MP2110A PPG

[2]: At 25±5°C

Table A.3.11-2   CRU Output

Item	Specifications
Output Mode	The signal output from CRU Output can be selected from Recovered Clock or input signal.
	The through output of the input signal can be output only when the input signal is Clock
Recovered Mode	When CRU Output is set to Recovery Clock
Amplitude	Typ. 480 mVp-p
Clock Frequency	12.75 to 14.1 GHz (Half Rate Clock)
Additive Jitter (RMS)	Typ. 250 fs[1], [2]
	Max. 400 fs[1]
Loop Bandwidth	Selectable from the list as follows.
	4MHz
	10MHz
	Bitrate/1667
	Attenuation: –20 dB/dec
Lock Detection	Detection function is available.
Through Mode	
Amplitude	Typ. 500 mVp-p
Operation Frequency	0.1 to 1.7625 GHz (1.7625 GHz is the 1/16 Clock of 28.2 GHz)
Additive Jitter (RMS)	Typ. 200 fs[1], [2]
	Max. 400 fs[1]
Connector	SMA, female
Termination	50 Ω, AC Coupled
Waveform Format	Square wave

*1:   With 25.78125 Gbit/s, 26.5625 Gbit/s, and 28.05 Gbit/s, 1/4Clock Pattern, Loop Bandwidth = 10 MHz, Single-ended, Mark ratio 1/2, Input amplitude 400±100 mVp-p, using MP2110A PPG

*2:   At 25±5°C

A.4 General Performance

Table A.4-1   Functions

Item	Specifications
LED indicator 　BERT Option 　Scope Option	Standby, Power, Remote Fail, Status, Output, Error Fail, Status
Function	Panel lock, initialization, minimization of application window
File operation	Setup file save/load, result file save, screen copy, (jpg or png file format)
Recovery Disk	OS recovery can be executed using this disk. The application is installed by the user.
Remote interface	Ethernet, GPIB
Peripheral Devices connection	HDMI, Display Port, USB3.0 (4 ports on rear panel), USB2.0 (6 ports on front panel), Ethernet (2 ports, 10/100/1000 Base-T), Line-Out, Mic
OS	Windows Embedded Standard 7*
Internal storage devices	SSD, 60 GB or more

*:   Operation not warranted when software installed after factory shipment

Table A.4-2   Environment Performance

Item	Specifications
EMC	EN61326-1, EN61000-3-2
LVD	EN61010-1
Power voltage*1,*2	AC 100 to 120 V, 200 to 240 V, 50 to 60 Hz
Power consumption	300 VA or less*2
Operating temperature	+5 to +40°C
Storage temperature	−20 to +60°C

*1:   Auto switch: 100/200 V

*2:   The power consumption in the typical configuration (MP2110A-014, 023) is 150 VA.

Table A.4-3   Size and Mass

Item	Specifications
Dimensions	142.5 mm(H) × 422 mm(W) × 389.4 mm(D), (excluding protrusions)
Mass	11 kg max.

B.1 System Menu

Table B.1-1   Initial Values of System Menu

Item			Initial Value
Dock/Undock			Dock
Remote Control			
	GPIB		
		Address	1
	Raw Socket		
		Port Number	5001

Appendix

Appendix B

B.2 PPG/ED

Table B.2-1   Initial Values of PPG/ED

Item	Initial Value
Data/XData	OFF
Bit Rate Standard	Variable
Bit Rate	25781250 kbit/s
Bit Rate Offset	0 ppm
PPG Amplitude	0.40 Vp-p
Ext ATT	0 dB
ED Input Condition	Single-Ended Data
Ext ATT	0 dB
Threshold	0 mV
PPG Test Pattern	PRBS 2^9–1
PPG Test Pattern Logic	POS
ED Test Pattern	PRBS 2^9–1
ED Test Pattern Logic	POS
ED Test Pattern Tracking	ON
ED Result	"All"
Result Time	Start Time
Reference CLK	Internal
Sync Out	PPG_1/8Clk
Clk Out	Ch1/2
Gating Cycle	Repeat
Gating Period	1 S
Current	ON

B.3 Scope

Table B.3-1   Initial Values of Result Window

Item	Initial Value
CH A	ON[*1] OFF[*2]
CH B	ON

*1: For MP2110A-021, MP2110A-022, MP2110A-023, MP2110A-032, and MP2110A-033

*2: For MP2110A-025, MP2110A-026, MP2110A-035, and MP2110A-036

For initial values of Scale/Offset, refer to Table B.3-6 "Amplitude Dialog Box".

Appendix

Appendix B

Table B.3-2   Setup Dialog Box

Item			Initial Value
General			
	Sampling		
		Sampling Type	NRZ
		Sampling Mode	Eye
		Number of Samples	2048
		Accumulation Type	Persistency
		Limit Type	Time
		Time	10.0 sec
		Samples	10 million
		Waveforms	100 wfms
		Averaging	10 wfms
		Pattern	10 patterns
Utilities			
	Screen Copy		
		EYE/Pulse Shot	Capture
		Inverts background color	Off
		Waveforms Only	Off
	Color		
		Waveform	Color Grade
		Mask	Purple
	Display Information		
		Preset Information	On
		Label	(None)
	Trace Memory		
		Ref. Trace Channel	Ch A & Ch B*1
			Ch B*2

*1: For MP2110A-021, MP2110A-022, MP2110A-023, MP2110A-032, and
     MP2110A-033

*2: For MP2110A-025, MP2110A-026, MP2110A-035, and MP2110A-036

Table B.3-3   Measure Dialog Box

Item	Initial Value
Amplitude/Time	
Display Result	Off
Jitter*1	
Display Result	Off
Mask Test	
Target Channel	Off
Eye Mask Select	N/A
Mask Margin	One Shot
Margin Type	Hit Count
Hit Count	1 samples
Hit Ratio	5E–05
Mask Margin	0%
Align Method	Zero/One/Crossing
Align Marker	Display Off
X1	0.5 UI
ΔX	1 UI
Y1	*2
ΔY	*2
Mask Area Restriction	Off
Angle	0 degrees
Width	0.10 UI

*1:   When MP2110A-096 is installed.

*2:   Initial value is not defined.

Table B.3-4   Setup (NRZ Amplitude/Time) Dialog Box

Item	Initial Value
Amplitude/Time	
Rise/Fall Time	20/80%
Rise/Fall Time Correction	Off
Correction Factor	0.0 ps
Eye Boundary	
Offset form Crossing	0.50 UI
Width	0.20 UI

Table B.3-5   Setup (PAM4 Amplitude/Time) Dialog Box

Item	Initial Value
Configuration	
Sample Timing	Track to Middle Eye Timing
Eye Center Type	Maximum Eye Height
EYE Height/Widths	
Eye Opening Definition	Zero Hits
TDECQ	
Reference Equalizer	Off
Display Equalized Waveforms	On
Equalizer Tap	
Tap Count	5
Taps	
0	0.50
1	0.50
2	0.50
3	0.50
4	0.50
5	0.50
6	0.50
7	0.50
8	0.50
9	0.50

Table B.3-6   Amplitude Dialog Box

Item			Initial Value
Scale Offset			
	Scale A		100 mV/Div*1 (None)*2
	Scale B		100 mV/Div*1 (None)*2
	Offset A		0 mV*3 0 μW*4
	Offset B		0 mV*1 0 μW*2
	Attenuation A		0 dB
	Attenuation B		0 dB
	Channel A/B Tracking*5		Off
	Channel Math		Off
		Define Function	CH A+CH B
		Scale	*6
		Offset	0 mV*1 0 μW*4

*1: For MP2110A-021

*2: For MP2110A-022, MP2110A-023, MP2110A-025, MP2110A-026, MP2110A-032, MP2110A-033, MP2110A-035, and MP2110A-036

*3: For MP2110A-021, MP2110A-023, and MP2110A-033

*4: For MP2110A-022 and MP2110A-023

*5: For MP2110A-021, MP2110A-022, and MP2110A-032

*6: Initial value is not defined.

Appendix

Appendix B

Table B.3-6   Amplitude Dialog Box (Cont'd)

Item	Initial Value
O/E	
Input Connector (Wavelength) (CH A) *4	SMF 1550nm*7
Input Connector (Wavelength) (CH B) *2	MMF 850nm*8 SMF 1550nm*9
Conversion Gain (CH A) *4	*10
Conversion Gain (CH B) *2	*10
Responsivity (CH A) *4	*10
Responsivity (CH B) *2	*10
Input Power (CH A) *4	−7.00 dBm
Input Power (CH B) *2	−7.00 dBm
Filter Selection (CH A) *4	No Filter
Filter Selection (CH B) *2	No Filter
Extinction Ratio Correction (CH A)*4	Off
Extinction Ratio Correction (CH B) *2	Off
Extinction Ratio Correction Factor (CH A) *4	0.00%
Extinction Ratio Correction Factor (CH B) *2	0.00%

*7:   For MP2110A-022 and MP2110A-032

*8:   For MP2110A-026 and MP2110A-036

*9:   For MP2110A-022, MP2110A-023, MP2110A-025, MP2110A-032, MP2110A-033, and MP2110A-035

*10: This value has been set at the factory to achieve Input Connector (Wavelength) default wavelength.

Table B.3-7   Time Dialog Box

Item			Initial Value
Rate			
	Data Clock Rate		
		Tracking	Off
		Recalculate Option	Clock Rate
		Clock Rate	6 445 313 kHz
		Divide Ratio	4
		Symbol Rate	25 781 250 kbaud
		Divide Ratio Detect	Off
		Precision Trigger*1	Off
Scale Offset			
	Unit		UI
	UI on Screen		2 UI
	Offset		0.00 UI
	Pattern Length		
		Tracking	Off
		Master	PPG1
		Length	511 symbols
	Skew		
		Channel A	0.0 ps
		Channel B	0.0 ps
		Align During Auto Scale	Off
CRU*2			
	Operation Mode		Off
	Clock Recovery		
		Operation Rate	Variable
		(Rate)	25 781 250 kbaud
		CRU Loop BW	10 MHz

*1: When MP2110A-024 is installed.

*2: When MP2110A-054 is installed.

Table B.3-8   Histogram Panel

Item	Initial Value
Target Channel	Off
Axis	Amplitude
X1	0.50 UI
X2	1.50 UI
Y1	100 mV[*1] 100 μW[*2]
Y2	−100 mV[*1] −100 μW[*2]

*1: For MP2110A-021, MP2110A-023, and MP2110A-033

*2: For MP2110A-022, MP2110A-025, MP2110A-026, MP2110A-032, MP2110A-035, and MP2110A-036

Table B.3-9   Marker Panel

Item	Initial Value
Marker Disp	Off
X1	Off
X2	Off
Y1	Off
Y2	Off

Appendix C File Specifications

Appendix C describes the specifications for mask files.

C.1 Mask file Specifications

The mask file specifications reading with Sampling Scope is as follows.

Table C.1-1   Mask File Specifications

Item	Specification
Save folder	C:\Users\Public\Documents\Anritsu\MX2 10000A\Mask
File extension	txt

The mask file is the text format file.

Describe the coordinates of the mask vertices, in which the mask margins are 100% (max.), 0%, and −100% (min), in the file.
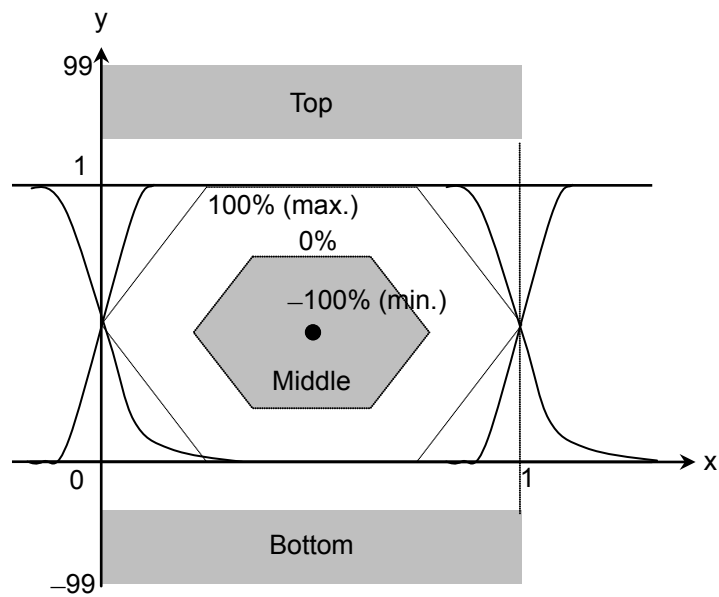
Figure C.1-1   Coordinate System of Mask

The following items are described in the mask file.

Table C.1-2   Details of Mask File

Item	Parameter to be set	Description
Version	Masks Version#1	Make sure that the version is written.
Mask name	Mask name	Mask name displayed on the measurement screen.
Mask type	Relative Mask Fixed Mask	Relative: Sets coordinate of amplitude direction by rate. The Mask coordinate varies with the amplitude of input signal. Fixed: Sets coordinate of amplitude direction at the fixed value. The Mask coordinate does not vary with the amplitude of input signal.
Coordinates in the top	TOP X Y X_min Y_min X_max Y_max	Specifies each X and Y coordinate in the area of Top/Middle/Bottom. As for X_min and Y_min, set the coordinate at –100% of Mask Margin.
Coordinates in the middle	MIDDLE X Y X_min Y_min X_max Y_max	As for X_max, and Y_max, set the coordinate at +100% of Mask Margin.
Coordinates in the bottom	BOTTOM X Y Y_min X_max Y_max	The coordinate can be set up to 10 points. If it is not used, set "–1".

```
>>>>>>>>>> START >>>>>>>>>>
Masks Version#1
<1GFC ; 1G Optical Fibre Channel Mask (1.0625 Gbps)> Relative Mask;
```

	X	Y	X_min	Y_min	X_max	Y_max
Top	0	99	0	99	0	99
	0	1.3	0	1.6	0	1
	1	1.3	1	1.6	1	1
	1	99	1	99	1	999
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1
Middle	X	Y	X_min	Y_min	X_max	Y_max
	0.215	0.5	0.5	0.5	0	0.5
	0.4	0.8	0.5	0.5	0.4	1
	0.6	0.8	0.5	0.5	0.6	1
	0.785	0.5	0.5	0.5	1	0.5
	0.6	0.2	0.5	0.5	0.6	0
	0.4	0.2	0.5	0.5	0.4	0
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1
Bottom	X	Y	X_min	Y_min	X_max	Y_max
	0	-99	0	-99	0	-99
	0	-0.2	0	-0.4	0	0
	1	-0.2	1	-0.4	1	0
	1	-99	1	-99	1	-99
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1
	-1	-1	-1	-1	-1	-1

```
>>>>>>>>>> END >>>>>>>>>>
```

Figure C.1-2   Example of Mask File

Appendix D   Performance Test Record Form

Document number: _____

Test Location: _____

Date: _____

Test person in charge: _____

Product name: _____

Serial number: _____

Software version: _____

_____

Option: _____

Power voltage: _____ V

Power frequency: _____ Hz

Ambient temperature: _____ °C

Relative humidity: _____ %

Instruments used: Model name _____   Serial number _____

Model name _____   Serial number _____

Model name _____   Serial number _____

Model name _____   Serial number _____

Remarks: _____

_____

_____

D.1 Pulse Pattern Generator

Measurement Uncertainty

The measurement uncertainly is up to double the amplitude measurement accuracy of the measuring instrument. When a value of which the measurement uncertainly is added or subtracted to/from the measurement value is in the range of the specifications, the value passes.

The measurement uncertainty of the frequency accuracy when using MF2412C Microwave Frequency Counter as the frequency counter is shown below.

Without MF2412C-003:   0.1 ppm
With MF2412C-003:   0.01 ppm

Refer to Amplitude accuracy in Table A.4.2-2 Electrical Channels Performance for the amplitude measurement uncertainty when using MP2110A as the sampling oscilloscope. Examples of calculating the amplitude measurement uncertainty are listed below.

Table D.1-1   Amplitude Measurement Uncertainty

Measured Value (V)	Measurement Accuracy (mV)*	Measurement Uncertainty (mV)
0.96	19.6	39.2
0.80	17.2	34.4
0.64	14.8	29.6
0.12	7.0	14.0
0.10	6.7	13.4
0.08	5.5	11.0

*:   The measurement uncertainty when Scale and Offset are set as follows:
   Scale：   100 mV/div
   Offset：   0 mV

Table D.1-2   Pulse Pattern Generator Performance Test Record Form (Without MP2110A-093)

Frequency Accuracy

Connector	Set Bit Rate (kbit/s)	Minimum Value (kHz)	Measured Value (kHz)	Maximum Value (kHz)	Pass/Fail
Sync Out	28200000	3524964.8		3525035.2	Pass/Fail
	24300000	3037469.6		3037530.4	Pass/Fail

Measurement Channel   PPG   1   2   3   4

Waveform (Amplitude)

Connector	Set Amplitude	Minimum Value	Measured Value	Maximum Value	Pass/Fail
Data Out	0.1 Vp-p	0.06 Vp-p	Vp-p	0.14 Vp-p	Pass/Fail
	0.8 Vp-p	0.62 Vp-p	Vp-p	0.98 Vp-p	Pass/Fail
$\overline{\text{Data}}$ Out	0.1 Vp-p	0.06 Vp-p	Vp-p	0.14 Vp-p	Pass/Fail
	0.8 Vp-p	0.62 Vp-p	Vp-p	0.98 Vp-p	Pass/Fail

Waveform

Connector	Item	Minimum Value	Measured Value	Maximum Value	Pass/Fail
Data Out	Crossing	40%	%	60%	Pass/Fail
	Rise Time		ps	17 ps	Pass/Fail
	Fall Time		ps	17 ps	Pass/Fail
	Jitter (rms)		ps	0.9 ps	Pass/Fail
$\overline{\text{Data}}$ Out	Crossing	40%	%	60%	Pass/Fail
	Rise Time		ps	17 ps	Pass/Fail
	Fall Time		ps	17 ps	Pass/Fail
	Jitter (rms)		ps	0.9 ps	Pass/Fail

Skew

Connector	Set Amplitude	Minimum Value	Measured Value	Maximum Value	Pass/Fail
Data Out, $\overline{\text{Data}}$ Out	0.3 Vp-p		ps	±8 ps	Pass/Fail

Table D.1-3   Pulse Pattern Generator Performance Test Record Form (With MP2110A-093)

Frequency Accuracy					
Connector	**Set Bit Rate (kbit/s)**	**Minimum Value (kHz)**	**Measured Value (kHz)**	**Maximum Value (kHz)**	**Pass/Fail**
Sync Out	28200000	3524964.8		3525035.2	Pass/Fail
	9500000	1187488.1		1187511.9	Pass/Fail
Measurement Channel PPG 1 2 3 4					
Waveform (Amplitude)					
Connector	**Set Amplitude**	**Minimum Value**	**Measured Value**	**Maximum Value**	**Pass/Fail**
Data Out	0.1 Vp-p	0.06 Vp-p	Vp-p	0.14 Vp-p	Pass/Fail
	0.8 Vp-p	0.62 Vp-p	Vp-p	0.98 Vp-p	Pass/Fail
$\overline{\text{Data}}$ Out	0.1 Vp-p	0.06 Vp-p	Vp-p	0.14 Vp-p	Pass/Fail
	0.8 Vp-p	0.62 Vp-p	Vp-p	0.98 Vp-p	Pass/Fail
Waveform					
Connector	**Item**	**Minimum Value**	**Measured Value**	**Maximum Value**	**Pass/Fail**
Data Out	Crossing	40%	%	60%	Pass/Fail
	Rise Time		ps	17 ps	Pass/Fail
	Fall Time		ps	17 ps	Pass/Fail
	Jitter (rms)		ps	0.9 ps	Pass/Fail
$\overline{\text{Data}}$ Out	Crossing	40%	%	60%	Pass/Fail
	Rise Time		ps	17 ps	Pass/Fail
	Fall Time		ps	17 ps	Pass/Fail
	Jitter (rms)		ps	0.9 ps	Pass/Fail
Skew					
Connector	**Set Amplitude**	**Minimum Value**	**Measured Value**	**Maximum Value**	**Pass/Fail**
Data Out, $\overline{\text{Data}}$ Out	0.3 Vp-p		ps	±8 ps	Pass/Fail

D.2 Error Detector

Table D.2-1   Error Detector Performance Test Record Form (Without MP2110A-093)

Measurement Channel ED 1 2 3 4					
Operating Frequency					
Connector	**Set Bit Rate**	**Minimum Value**	**ER Measured Value**	**Maximum Value**	**Pass/Fail**
Data Out	28200000 kbit/s			1E–12	Pass/Fail
	24300000 kbit/s			1E–12	Pass/Fail
$\overline{\text{Data Out}}$	28200000 kbit/s			1E–12	Pass/Fail
	24300000 kbit/s			1E–12	Pass/Fail
Rx Sensitivity					
Connector	**Set Bit Rate**	**Minimum Value**	**ER Measured Value**	**Maximum Value**	**Pass/Fail**
Data Out	25781250 kbit/s			1E–12	Pass/Fail
$\overline{\text{Data Out}}$	25781250 kbit/s			1E–12	Pass/Fail
Input Level • Pattern					
Connector	**Pattern**	**Minimum Value**	**ER Measured Value**	**Maximum Value**	**Pass/Fail**
Data Out	PRBS2^7–1			1E–12	Pass/Fail
	PRBS2^9–1			1E–12	Pass/Fail
	PRBS2^15–1			1E–12	Pass/Fail
	PRBS2^23–1			1E–12	Pass/Fail
	PRBS2^31–1			1E–12	Pass/Fail
$\overline{\text{Data Out}}$	PRBS2^7–1			1E–12	Pass/Fail
	PRBS2^9–1			1E–12	Pass/Fail
	PRBS2^15–1			1E–12	Pass/Fail
	PRBS2^23–1			1E–12	Pass/Fail
	PRBS2^31–1			1E–12	Pass/Fail

Table D.2-1 Error Detector Performance Test Record Form (Without MP2110A-093) (Cont'd)

Error Detection					
Connector	**Set Bit Rate**	**Minimum Value**	**EC Measured Value**	**Maximum Value**	**Pass/Fail**
Data Out	25781250 kbit/s			20	Pass/Fail
$\overline{\text{Data Out}}$	25781250 kbit/s			20	Pass/Fail

Table D.2-2   Error Detector Performance Test Record Form (With MP2110A-093)

Measurement Channel ED 1 2 3 4					
Operating Frequency					
Connector	**Set Bit Rate**	**Minimum Value**	**ER Measured Value**	**Maximum Value**	**Pass/Fail**
Data Out	28200000 kbit/s			1E–12	Pass/Fail
	9500000 kbit/s			1E–12	Pass/Fail
$\overline{\text{Data Out}}$	28200000 kbit/s			1E–12	Pass/Fail
	9500000 kbit/s			1E–12	Pass/Fail
Rx Sensitivity					
Connector	**Set Bit Rate**	**Minimum Value**	**ER Measured Value**	**Maximum Value**	**Pass/Fail**
Data Out	25781250 kbit/s			1E–12	Pass/Fail
$\overline{\text{Data Out}}$	25781250 kbit/s			1E–12	Pass/Fail
Input Level • Pattern					
Connector	**Pattern**	**Minimum Value**	**ER Measured Value**	**Maximum Value**	**Pass/Fail**
Data Out	PRBS2^7–1			1E–12	Pass/Fail
	PRBS2^9–1			1E–12	Pass/Fail
	PRBS2^15–1			1E–12	Pass/Fail
	PRBS2^23–1			1E–12	Pass/Fail
	PRBS2^31–1			1E–12	Pass/Fail
$\overline{\text{Data Out}}$	PRBS2^7–1			1E–12	Pass/Fail
	PRBS2^9–1			1E–12	Pass/Fail
	PRBS2^15–1			1E–12	Pass/Fail
	PRBS2^23–1			1E–12	Pass/Fail
	PRBS2^31–1			1E–12	Pass/Fail

Appendix

Appendix D

Table D.2-2   Error Detector Performance Test Record Form (With MP2110A-093) (Cont'd)

Error Detection					
Connector	**Set Bit Rate**	**Minimum Value**	**EC Measured Value**	**Maximum Value**	**Pass/Fail**
Data Out	25781250 kbit/s			20	Pass/Fail
$\overline{\text{Data Out}}$	25781250 kbit/s			20	Pass/Fail

D.3 Sampling Oscilloscope

Amplitude Accuracy

Table D.3-1   Level Accuracy

Connector	Setting Voltage	Minimum Value	Measured Value	Maximum Value	Pass/Fail
Ch A	+200 mV	+186.5 mV	mV	+213.5 mV	Pass/Fail
	−200 mV	−213.5 mV	mV	−186.5 mV	Pass/Fail
Ch B	+200 mV	+186.5 mV	mV	+213.5 mV	Pass/Fail
	−200 mV	−213.5 mV	mV	−186.5 mV	Pass/Fail

Optical Power Meter: ±0.35 dB or less (−12 dBm or more, typical)

Table D.3-2   Accuracy of Optical Power Meter

Connector	Wavelength	Reading of Optical Power Meter	Average Power(dBm) Measurement Value	Minimum Value	Level Difference	Maximum Value
MMF	850 nm	dBm	dBm		dB	
SMF	1310 nm	dBm	dBm		dB	
SMF	1550 nm	dBm	dBm		dB	

CRU

Table D.3-3 CRU Output

Sensitivity			
Pass/Fail			
Additive jitter			
Operation Rate	**Jitter RMS*1**	**Jitter RMS*2**	**Calculated Value*3**
25.78125 Gbaud			
26.5625 Gbaud			
28.05 Gbaud			

*1: Result obtained by measuring PPG1 Data waveform

*2: Result obtained by measuring CRU Out waveform

*3: Calculate the value using the following formula.

$$J_{Add} = \sqrt{(J_{CRU})^2 - (J_{PPG})^2}$$

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