

**MU196020A
PAM4 PPG
MU196040A
PAM4 ED
MU196040B
PAM4 ED
Operation Manual**

Fifth Edition

- For safety and warning information, please read this manual before attempting to use the equipment.
- Additional safety and warning information is provided within the MP1900A Signal Quality Analyzer-R Operation Manual. Please also refer to it before using 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

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CAUTION

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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.



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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.

MU196020A PAM4 PPG

MU196040A PAM4 ED

MU196040B PAM4 ED

Operation Manual

1 December 2018 (First Edition)

29 June 2020 (Fifth Edition)

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Printed in Japan

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Revision History:

February 29th, 2020

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

Plug-in Units: MU196020A PAM4 PPG
MU196040A PAM4 ED
MU196040B PAM4 ED

2. Applied Directive and Standards

When the MU196020A PAM4 PPG, MU196040A PAM4 ED and MU196040B PAM4 ED are installed in the MP1900A, the applied directive and standards of this unit conform to those of the MP1900A main frame.

PS: About main frame

Please contact Anritsu for the latest information on the main frame types that MU196020A, MU196040A and MU196040B can be used with.

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

| | |
|----------------|--------------------|
| Plug-in Units: | MU196020A PAM4 PPG |
| | MU196040A PAM4 ED |
| | MU196040B PAM4 ED |

2. Applied Directive and Standards

When the MU196020A PAM4 PPG, MU196040A PAM4 ED and MU196040B PAM4 ED are installed in the MP1900A, the applied directive and standards of this unit conform to those of the MP1900A main frame.

PS: About main frame

Please contact Anritsu for the latest information on the main frame types that MU196020A, MU196040A and MU196040B can be used with.

About This Manual

A testing system combining an MP1900A Signal Quality Analyzer-R, module(s), and control software is called a Signal Quality Analyzer-R Series. The operation manuals of the Signal Quality Analyzer-R Series consist of separate documents for the MP1900A, module(s), and control software, as shown below.

Configuration of Signal Quality Analyzer-R Series Operation

☒ indicates this document.

MP1900A Signal Quality Analyzer-R Operation Manual

Describes the basic operations, panel details, and maintenance of the MP1900A, as well as the steps from module installation to the start of use.

Module Operation Manual

MU195020A 21G/32G bit/s SI PPG MU195040A 21G/32G bit/s SI ED
MU195050A Noise Generator Operation Manual

Describes the panel details, how to operate, performance test, maintenance, and troubleshooting of the module to be installed on the MP1900A.

MU196020A PAM4 PPG MU196040A PAM4 ED MU196040B PAM4 ED
Operation Manual

Describes the panel details, performance test, maintenance, and troubleshooting of the MU196020A, MU196040A, and MU196040B.

MU181000A 12.5GHz Synthesizer MU181000B 12.5GHz 4 port Synthesizer
Operation Manual

Describes the panel details, how to operate, performance test, maintenance, and troubleshooting of the MU181000A and MU181000B.

MU181500B Jitter Modulation Source Operation Manual

Describes the panel details, how to operate, performance test and maintenance of the MU181500B.

MU183020A 28G/32G bit/s PPG MU183021A 28G/32G bit/s 4ch PPG
Operation Manual

Describes the panel details, performance test, maintenance, and troubleshooting of the MU183020A and MU183021A.

MU183040A 28G/32G bit/s ED MU183041A 28G/32G bit/s 4ch ED
MU183040B 28G/32G bit/s High Sensitivity ED
MU183041B 28G/32G bit/s 4ch High Sensitivity ED Operation Manual

Describes the panel details, how to operate, performance test, maintenance, and troubleshooting of the MU183040A, MU183041A, MU183040B, and MU183041B.

Configuration of Signal Quality Analyzer-R Series Operation Manuals (Cont'd)

☐ indicates this document.

MX190000A Signal Quality Analyzer-R Control Software Operation Manual

Describes the operation of the software that controls the Signal Quality Analyzer-R Series.

Extended Application Operation Manual

Describes the operation of the extended application for the Signal Quality Analyzer-R Series.

MX183000A High-Speed Serial Data Test Software Operation Manual

Describes the setup and operating procedure of MX183000A.

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Chapter 1 Overview

This chapter describes the overview of the following modules.

- MU196020A PAM4 PPG (hereafter, MU196020A)
- MU196040A PAM4 ED (hereafter, MU196040A)
- MU196040B PAM4 ED (hereafter, MU196040B)

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1.1 Product Overview

The MU196020A, MU196040A, and MU196040B (hereinafter “MP1900A modules”) are plug-in modules that can be built into the MP1900A Signal Quality Analyzer-R. MP1900A supports error measurement with PRBS patterns, DATA patterns and various PAM4 test patterns at the following bit rates or baud rates:

- MU196020A: Max. 64.2 Gbit/s or 64.2 Gbaud
- MU196040A: Max. 32.1 Gbit/s or 32.1 Gbaud
- MU196040B: Max. 64.2 Gbit/s or 58.2 Gbaud

Combination of MU196020A and MU195050A Noise Generator (hereinafter, MU195050A) supports generation of data which common mode noise, differential mode noise and white noise are applied to and which is optimal for signal integrity evaluation of up to 32.1 Gbaud. Various option configurations are available for the MP1900A modules. This module is therefore useful for research, development, and production of various types of digital communication equipment, modules, and devices.

The features of the MP1900A modules are as follows:

MU196020A features

- Capable of generating one channel of NRZ or PAM4 signal at up to 64.2 Gbit/s or 64.2 Gbaud. (MU196020A-003)
- Capable of independently adjusting the amplitude of each eye of PAM4 signal.
- Capable of generating signals of PRBS pattern, DATA pattern and various PAM4 patterns.
- Capable of signal integrity evaluation using 4TAP Emphasis (MU196020A-x11)
- Capable of adding intersymbol interference (ISI) using 4TAP Emphasis. (MU196020A-x40)
- Capable of generating patterns and inserting errors, which support RS-FEC(544,514) and RS-FEC(528,514). (MU196020A-x42)
- Capable of synchronizing operations among channels using multiple MU196020As that are installed in MP1900A.

This function allows generating synchronous data supported by the application that requires Multi Channel. (MU196020A-x50)

MU196040A features

- Supporting symbol measurement of one channel of PAM4 signal at up to 32.1 Gbaud using the built-in PAM4 Decoder circuit.
- Capable of measuring signals of PRBS pattern, DATA pattern and various PAM4 patterns.
- Long user-programmable patterns (256 Mbits, 256 Msymbol)
- Capable of evaluating serial communication by selecting MU196040A-001 that has one data input channel each for NRZ (32.1 Gbit/s) and PAM4 (32.1 Gbaud).
- Having the input sensitivity (typical values) of NRZ 23 mV (32.1 Gbit/s, Eye Height) and PAM4 23 mV (32.1 Gbaud, Eye Height, per eye) and optimal for signal evaluation.
- Capable of clock recovery on 25.5 to 32.1 Gbaud signals by installing MU196040A-x22.
- Capable of evaluating PAM4 signals by Symbol Error Rate (SER) by installing MU196040A-x41.

MU196040B features

- Supporting symbol measurement of one channel of PAM4 signal at up to 58.2 Gbaud using the built-in PAM4 Decoder circuit.
- Capable of measuring signals of PRBS pattern, DATA pattern and various PAM4 patterns.
- Long user-programmable patterns (256 Mbits, 256 Msymbols)
- Capable of capturing the data pattern of up to 8 Mbits or 4 Msymbols.
- Capable of capturing the data pattern, in which RS-FEC Symbol Error(s) occurred, and counting FEC Symbol Errors.
- Capable of evaluating serial communication by selecting MU196040B-002 or x12 that has one data input channel each for NRZ (64.2 Gbit/s) and PAM4 (58.2 Gbaud).
- Having the input sensitivity (typical values) of NRZ 23 mV (32.1 Gbit/s, Eye Height) and PAM4 23 mV (32.1 Gbaud, Eye Height, per eye) and optimal for signal evaluation.
- Capable of using the Equalizer function by adding the MU196040B-x11.
- Capable of clock recovery on 2.4 to 29.0 Gbaud signals by installing MU196040B-x21.
- Capable of clock recovery on 2.4 to 32.1 Gbaud signals by installing MU196040B-x22.
- Capable of clock recovery on 51.0 to 58.2 Gbaud signals by installing MU196040B-x23.
- Capable of evaluating PAM4 signals by Symbol Error Rate (SER) by installing MU196040B-x41.

1.2 Product Configuration

1.2.1 Standard configuration

Table 1.2.1-1 and Table 1.2.1-2 below show the standard configurations of the three MP1900A modules respectively.

Table 1.2.1-1 Standard Configuration of MU196020A

| Item | Model Name | Product Name | Q'ty | Remarks |
|-------------|------------|--------------------------------|------|--|
| Mainframe | MU196020A | PAM4 PPG | 1 | |
| Accessories | J1632A | Terminator | 4 | Clock Output, Aux Output × 2, Gating Output |
| | V210 | Terminator | 2 | Data Output × 2 |
| | J1341A | Open | 2 | Ext Clock Input, AUX Input |
| | J1359A | Coaxial Adaptor (K-P.K-J, SMA) | 1 | Clock Output |
| | J1717A | Coaxial Adaptor (SMA-P, SAM-J) | 5 | Ext Clock Input, Aux Output × 2, Gating Output, AUX Input |

Table 1.2.1-2 Standard Configuration of MU196040A

| Item | Model Name | Product Name | Q'ty | Remarks |
|-------------|--------------------------------------|--------------------------------|------|-------------------------------|
| Mainframe | MU196040A | PAM4 ED | 1 | |
| Accessories | J1632A | Terminator | 2 | Aux Output × 2, |
| | J1341A | Open | 2 | Ext Clock Input, AUX Input |
| | J1359A | Coaxial Adaptor (K-P.K-J, SMA) | 1 | Ext Clock Input |
| | J1717A | Coaxial Adaptor (SMA-P, SAM-J) | 3 | Aux Output × 2, AUX Input |
| | When the MU196040A-001 is installed: | | | |
| | J1341A | Open | 2 | Data Input × 2 |
| | J1359A | Coaxial Adaptor (K-P.K-J, SMA) | 2 | Data Input × 2 |

Table 1.2.1-3 Standard Configuration of MU196040B

| Item | Model Name | Product Name | Q'ty | Remarks |
|-------------|------------|--------------------------------|------|-------------------------------|
| Mainframe | MU196040B | PAM4 ED | 1 | |
| Accessories | V210 | Terminator | 2 | Data Input × 2 |
| | J1341A | Open | 2 | Ext Clock Input, AUX Input |
| | J1359A | Coaxial Adaptor (K-P.K-J, SMA) | 1 | Ext Clock Input |
| | J1632A | Terminator | 2 | Aux Output × 2, |
| | J1717A | Coaxial Adaptor (SMA-P, SAM-J) | 3 | Aux Output × 2, AUX Input |
| | 41V-6 | Precision Fixed Attenuator | 2 | Data Input × 2 |

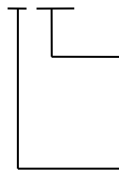
1.2.2 Options

Table 1.2.2-1 and Table 1.2.2-2 show the options for the MP1900A modules. All options are sold separately.

Note:

Option name format is as follows:

MU196020A-x x x



Indicates function.

This value is recognized by the MP1900A.

Anritsu management number.

This value is not recognized by the mainframe.

0: Factory-installed option

1: Retrofit option.

(Must be returned to Anritsu (Japan) when installing.)

2: Retrofit option.

(Must be returned to Anritsu Service and Sales office when installing.)

3: Software option.

License registration is required when installing

Table 1.2.2-1 Options of MU196020A

| Model Name | Product Name | Remarks |
|---------------|------------------------------------|---------|
| MU196020A-001 | 32G baud | *1 |
| MU196020A-002 | 58G baud | *1 |
| MU196020A-003 | 64G baud | *1 |
| MU196020A-y12 | 32G to 58G baud Extension Retrofit | *2,*3 |
| MU196020A-y13 | 32G to 64G baud Extension Retrofit | *2,*3 |
| MU196020A-y23 | 58G to 64G baud Extension Retrofit | *2,*4 |
| MU196020A-x11 | 4Tap Emphasis | *5 |
| MU196020A-x30 | Data Delay | *5 |
| MU196020A-x40 | Adjustable ISI | *5, *6 |
| MU196020A-x42 | FEC Pattern Generation | *5 |
| MU196020A-x50 | Inter-Module Synchronization | *5, *7 |

*1: Factory-installed hardware option. Select one from among them.

*2: Hardware retrofit options, which can be selected after shipping from our factory. (y = 1 or 2)

*3: It can be retrofitted when the Option 001 is installed.

*4: It can be retrofitted when the Option 002 is installed.

*5: Software option (x = 0, 1, or 2)

*6: It can be retrofitted when the Option x11 is installed.

*7: It can be retrofitted when the Option x30 is installed.

Table 1.2.2-2 Options of MU196040A

| Model Name | Product Name | Remarks |
|---------------|------------------------------------|---------|
| MU196040A-001 | 32.1G baud Decoder | *1 |
| MU196040A-x22 | 25.5G to 32.1G baud Clock Recovery | *2,*3 |
| MU196040A-x41 | SER Measurement | *2,*4 |

*1: Factory-installed hardware option

*2: x = 0, 1, or 2

*3: Hardware option

*4: Software option

Table 1.2.2-3 Options of MU196040B

| Model Name | Product Name | Remarks |
|---------------|-----------------------------------|-------------|
| MU196040B-001 | 32G baud | *1,*2 |
| MU196040B-002 | 58G baud | *1,*2 |
| MU196040B-z11 | Equalizer | *2,*11 |
| MU196040B-y12 | 32G to 58G baud Extension | *2,*5,*6 |
| MU196040B-x21 | 29G baud Clock Recovery | *3,*4,*7,*8 |
| MU196040B-x22 | 32G baud Clock Recovery | *3,*4,*7,*8 |
| MU196040B-x23 | 58G baud Clock Recovery Extension | *2,*4,*9 |
| MU196040B-y24 | 32G baud Clock Recovery Extension | *3,*5,*10 |
| MU196040B-z41 | SER Measurement | *2,*11 |

*1: Factory-installed

*2: Software option

*3: Hardware option

*4: x = 0, 1, or 2

*5: y = 1 or 2

*6: MU196040B-001 must be installed.

*7: This option can be installed together with MU196040B-x23.

*8: One of MU196040B-x21 and MU196040B-x22 can be installed.

*9: MU196040B-002 or MU196040B-y12 must be installed.
MU196040B-x21 or MU196040B-x22 must be installed.

*10: MU196040B-x21 must be installed.

*11: z = 0, 1, 2, or 3

1.2.3 Optional Accessories

Table 1.2.3-1 shows the optional accessories for the MP1900A modules.
All optional accessories are sold separately.

Table 1.2.3-1 Optional Accessories

| Model Name | Product Name | Remarks |
|------------|---|--------------------------------|
| 34VFK50 | Precision Adapter | Conversion connector (V-F K-M) |
| 34VKF50 | Precision Adapter | Conversion connector (V-M K-F) |
| 41KC-3 | Precision Fixed Attenuator 3 dB | K connector |
| 41KC-6 | Precision Fixed Attenuator 6 dB | K connector |
| 41KC-10 | Precision Fixed Attenuator 10 dB | K connector |
| 41KC-20 | Precision Fixed Attenuator 20 dB | K connector |
| 41V-3 | Precision Fixed Attenuator 3 dB | V connector |
| 41V-6 | Precision Fixed Attenuator 6 dB | V connector |
| 41V-10 | Precision Fixed Attenuator 10 dB | V connector |
| 41V-20 | Precision Fixed Attenuator 20 dB | V connector |
| J1342A | Coaxial Cable 0.8 m | APC3.5 connector |
| J1359A | Coaxial Adaptor (K-P.K-J, SMA) | |
| J1439A | Coaxial Cable 0.8 m (K connector) | |
| J1510A | Pick OFF Tee | K connector |
| J1624A | Coaxial Cable 0.3 m (SMA connector) | |
| J1625A | Coaxial Cable 1 m (SMA connector) | |
| J1632A | Terminator | SMA connector |
| J1678A | ESD Protection Adapter-K | K connector |
| J1679A | ESD Protection Adapter-V | V connector |
| J1728A | Electrical Length Specified Coaxial Cable (0.4 m, K connector) | |

Table 1.2.3-1 Optional Accessories (Cont'd)

| Model Name | Product Name | Remarks |
|-------------------|--|---|
| J1748A | Power Splitter (1.5G-18GHz) | |
| J1758A | ISI Board | |
| J1789A | Electrical Length Specified Coaxial Cable (0.4m, V connector) | |
| J1790A | Electrical Length Specified Coaxial Cable (0.8m, V connector) | |
| J1792A | Skew match pair semirigid cable (V-K connector, Data Input1) | For connecting to the Data Input1 connector of MU195050A |
| J1793A | Pick OFF Tee | V connector |
| J1800A | ISI Board V | V connector |
| K240C | Precision Power Divider | K connector |
| V210 | Terminator | V connector |
| V240C | Precision Power Divider | V connector |
| W3976AE | MU196020A/40A/40B Operation Manual | Printed version, English |
| Z0306A | Wrist strap | |
| Z1964A | Torque Wrench (Right Angle) | |

1.3 Specifications

1.3.1 Specifications for MU196020A

Table 1.3.1-1 Operating Baud/Bit Rate

| Item | Specifications |
|-------------------------|---|
| Operating Baud/Bit Rate | <p>When the Option 001 is installed. PAM4: 2.4 to 32.1 Gbaud NRZ: 2.4 to 32.1 Gbit/s</p> <p>When the Option 002 or y12 is installed. PAM4: 2.4 to 58.2 Gbaud NRZ: 2.4 to 58.2 Gbit/s</p> <p>When the Option 003, y13, or y23 is installed. PAM4: 2.4 to 64.2 Gbaud NRZ: 2.4 to 64.2 Gbit/s</p> <p>The setting range of the baud rate (PAM4 output) and bit rate (NRZ output) is common. Only the baud rate is described hereafter.</p> |
| Setting Range / Step | <p>The setting range of the baud rate is determined by the linking module (valid only when installing to the same frame as MU196020A) and the Frequency in Table 1.3.1-12 Clock Output.</p> <p>When linking with MU181000A/B *4</p> <p>2.400 000 to 25.000 000 Gbaud, 0.000 002 Gbaud step*1, *2, *3 25.000 004 to 32.100 000 Gbaud, 0.000 004 Gbaud step*1, *2, *3 25.000 004 to 50.000 000 Gbaud, 0.000 004 Gbaud step*2, *3 50.000 008 to 58.200 000 Gbaud, 0.000 008 Gbaud step*2 50.000 008 to 64.200 000 Gbaud, 0.000 008 Gbaud step*3</p> <p>When linking with MU181000A/B and MU181500B *4</p> <p>2.400 000 to 3.125 000 Gbaud, 0.000 002 Gbaud step*1, *2, *3 3.200 002 to 6.250 000 Gbaud, 0.000 002 Gbaud step*1, *2, *3 6.400 002 to 12.500 000 Gbaud, 0.000 002 Gbaud step*1, *2, *3 12.800 002 to 25.000 000 Gbaud, 0.000 002 Gbaud step*1, *2, *3 25.600 004 to 32.100 000 Gbaud, 0.000 004 Gbaud step*1, *2, *3 25.600 004 to 50.000 000 Gbaud, 0.000 004 Gbaud step*2, *3 51.200 008 to 58.200 000 Gbaud, 0.000 008 Gbaud step*2 51.200 008 to 64.200 000 Gbaud, 0.000 008 Gbaud step*3</p> |

*1: When the Option 001 is installed.

*2: When the Option 002 or y12 is installed.

*3: When the Option 003, y13, or y23 is installed.

*4: Linking is not available when **Unit Sync** is **ON**.

Table 1.3.1-1 Operating Baud/Bit Rate (Cont'd)

| Item | Specifications | | |
|---|----------------------------|-----------------------|--|
| When linking with MU181500B and using external clock Clock Output Rate Full Rate | | | |
| | Baud Rate Setting Range | Input Clock Frequency | Relationship Between Baud Rate and Input Clock Frequency |
| | 2.4 to 15.0 Gbaud*1,*2,*3 | 2.4 to 15.0 GHz | 1/1 Clock Input |
| | 15.0 to 30.0 Gbaud*1,*2,*3 | 7.5 to 15.0 GHz | 1/2 Clock Input |
| | 25.0 to 32.1 Gbaud*1,*2,*3 | 6.25 to 8.025 GHz | 1/4 Clock Input |
| | | | |
| | Baud Rate Setting Range | Input Clock Frequency | Relationship Between Baud Rate and Input Clock Frequency |
| | 2.4 to 30.0 Gbaud*1,*2,*3 | 1.2 to 15.0 GHz | 1/2 Clock Input |
| Clock Output Rate Half Rate, Quarter Rate | 30.0 to 32.1 Gbaud*1 | 7.5 to 8.025 GHz | 1/4 Clock Input |
| | 30.0 to 58.2 Gbaud*2 | 7.5 to 14.55 GHz | 1/4 Clock Input |
| | 30.0 to 60.0 Gbaud*3 | 7.5 to 15.0 GHz | 1/4 Clock Input |
| | 60.0 to 64.2 Gbaud*3 | 7.5 to 8.025 GHz | 1/8 Clock Input |
| | | | |
| | | | |

Table 1.3.1-1 Operating Baud/Bit Rate (Cont'd)

| Item | Specifications | | |
|--|---|-----------------------|--|
| External Clock When the Output Clock Rate is set to Full Rate When the Output Clock Rate is set to Half Rate, Quarter Rate | Baud Rate Setting Range | Input Clock Frequency | Relationship Between Baud Rate and Input Clock Frequency |
| | 2.4 to 16.05 Gbaud ^{*1,*2,*3} | 2.4 to 16.05 GHz | 1/1 Clock Input |
| | 16.05 to 32.1 Gbaud ^{*1,*2,*3} | 8.025 to 16.05 GHz | 1/2 Clock Input |
| | 25.0 to 32.1 Gbaud ^{*1,*2,*3} | 6.25 to 8.025 GHz | 1/4 Clock Input |
| | Baud Rate Setting Range | Input Clock Frequency | Relationship Between Baud Rate and Input Clock Frequency |
| | 2.4 to 32.1 Gbaud ^{*1,*2,*3} | 1.2 to 16.05 GHz | 1/2 Clock Input |
| | 25.0 to 32.1 Gbaud ^{*1} | 6.25 to 8.025 GHz | 1/4 Clock Input |
| | 25.0 to 50.0 Gbaud ^{*2,*3} | 6.25 to 12.50 GHz | 1/4 Clock Input |
| | 32.1 to 58.2 Gbaud ^{*2} | 8.025 to 14.55 GHz | 1/4 Clock Input |
| | 32.1 to 64.2 Gbaud ^{*3} | 8.025 to 16.05 GHz | 1/4 Clock Input |
| Offset Setting Range / Step | –1000 to +1000 ppm, 1 ppm step This is available only when linking with MU181000A/B. The setting range is, however, –1000 to 0 ppm when the bit rate is set as follows: Clock Output Rate Full Rate 12.500 000 Gbaud, 25.000 000 Gbaud Clock Output Rate Half Rate, Quarter Rate 25.000 000 Gbaud, 50.000 000 Gbaud | | |

Table 1.3.1-2 Jitter Setting Range

| Item | Specifications* ¹ | | | | | | | | | | | | | | | | | | | | |
|---|--|---------------------------|--------------------------|------------|-----------|--------------|----------|---------------|---------|----------------|--------|---------------------------|--------------------------|------------|-----------|--------------|----------|---------------|---------|----------------|--------|
| SJ1 Setting Range SJ1 Clock Output Rate At Full Rate | <p>When SJ2 switch is the built-in SJ2, the settable Jitter Amplitude is halved.</p> <p>30 < Baud rate ≤ 32.1 Gbaud, 15 < Baud rate ≤ 17 Gbaud</p> <table border="1"> <thead> <tr> <th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr> </thead> <tbody> <tr> <td>10 to 100k</td><td>0 to 2000</td></tr> <tr> <td>100.1k to 1M</td><td>0 to 200</td></tr> <tr> <td>1.001M to 10M</td><td>0 to 16</td></tr> <tr> <td>10.01M to 150M</td><td>0 to 1</td></tr> </tbody> </table> <p>17 < Baud rate ≤ 30 Gbaud</p> <table border="1"> <thead> <tr> <th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr> </thead> <tbody> <tr> <td>10 to 100k</td><td>0 to 2000</td></tr> <tr> <td>100.1k to 1M</td><td>0 to 200</td></tr> <tr> <td>1.001M to 10M</td><td>0 to 16</td></tr> <tr> <td>10.01M to 250M</td><td>0 to 1</td></tr> </tbody> </table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 100k | 0 to 2000 | 100.1k to 1M | 0 to 200 | 1.001M to 10M | 0 to 16 | 10.01M to 150M | 0 to 1 | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 100k | 0 to 2000 | 100.1k to 1M | 0 to 200 | 1.001M to 10M | 0 to 16 | 10.01M to 250M | 0 to 1 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | | | | | | | | | | | | |
| 10 to 100k | 0 to 2000 | | | | | | | | | | | | | | | | | | | | |
| 100.1k to 1M | 0 to 200 | | | | | | | | | | | | | | | | | | | | |
| 1.001M to 10M | 0 to 16 | | | | | | | | | | | | | | | | | | | | |
| 10.01M to 150M | 0 to 1 | | | | | | | | | | | | | | | | | | | | |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | | | | | | | | | | | | |
| 10 to 100k | 0 to 2000 | | | | | | | | | | | | | | | | | | | | |
| 100.1k to 1M | 0 to 200 | | | | | | | | | | | | | | | | | | | | |
| 1.001M to 10M | 0 to 16 | | | | | | | | | | | | | | | | | | | | |
| 10.01M to 250M | 0 to 1 | | | | | | | | | | | | | | | | | | | | |

*1: When linking with MU181000A/B and MU181500B

Table 1.3.1-2 Jitter Setting Range (Cont'd)

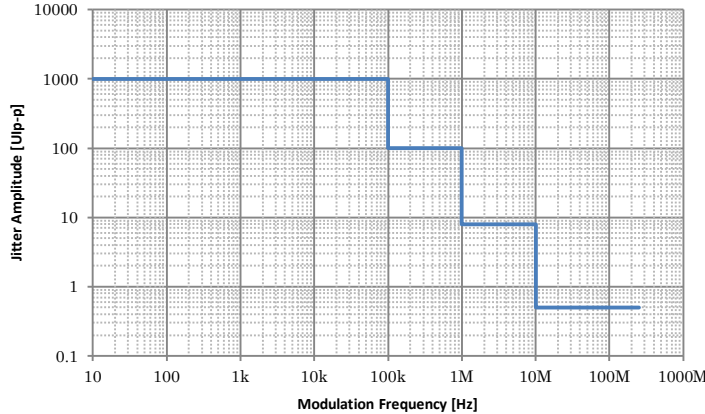
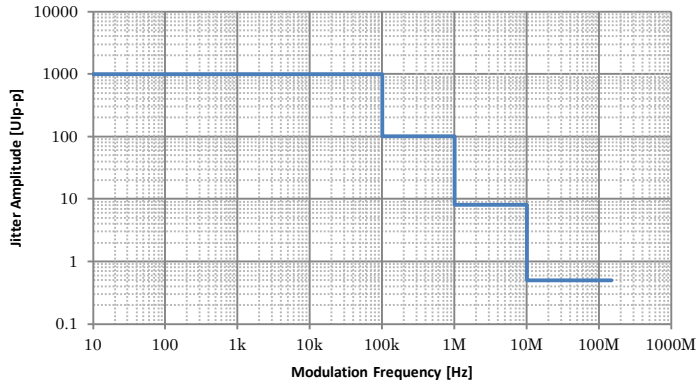
| Item | Specifications* ¹ | | | | | | | | | | |
|--|---|---------------------------|--------------------------|------------|-----------|--------------|----------|---------------|--------|----------------|----------|
| SJ1 Clock Output Rate At Full Rate (Cont'd) | 8.5 < Baud rate ≤ 15 Gbaud | | | | | | | | | | |
| |  | | | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 100k</td><td>0 to 1000</td></tr><tr><td>100.1k to 1M</td><td>0 to 100</td></tr><tr><td>1.001M to 10M</td><td>0 to 8</td></tr><tr><td>10.01M to 250M</td><td>0 to 0.5</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 100k | 0 to 1000 | 100.1k to 1M | 0 to 100 | 1.001M to 10M | 0 to 8 | 10.01M to 250M | 0 to 0.5 |
| | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | |
| 10 to 100k | 0 to 1000 | | | | | | | | | | |
| 100.1k to 1M | 0 to 100 | | | | | | | | | | |
| 1.001M to 10M | 0 to 8 | | | | | | | | | | |
| 10.01M to 250M | 0 to 0.5 | | | | | | | | | | |
| | | | | | | | | | | | |
| | 4 < Baud rate ≤ 8.5 Gbaud | | | | | | | | | | |
| |  | | | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 100k</td><td>0 to 1000</td></tr><tr><td>100.1k to 1M</td><td>0 to 100</td></tr><tr><td>1.001M to 10M</td><td>0 to 8</td></tr><tr><td>10.01M to 150M</td><td>0 to 0.5</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 100k | 0 to 1000 | 100.1k to 1M | 0 to 100 | 1.001M to 10M | 0 to 8 | 10.01M to 150M | 0 to 0.5 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | | |
| 10 to 100k | 0 to 1000 | | | | | | | | | | |
| 100.1k to 1M | 0 to 100 | | | | | | | | | | |
| 1.001M to 10M | 0 to 8 | | | | | | | | | | |
| 10.01M to 150M | 0 to 0.5 | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

Table 1.3.1-2 Jitter Setting Range (Cont'd)

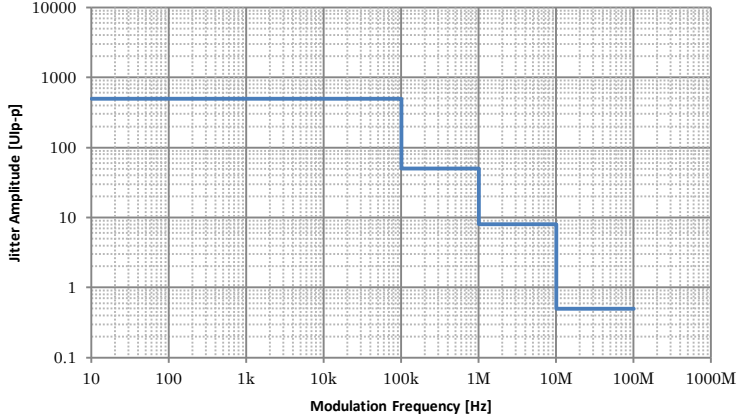
| Item | Specifications* ¹ | | | | | | | | | | |
|---|--|---------------------------|--------------------------|------------|----------|--------------|---------|---------------|--------|----------------|----------|
| SJ1 Clock Output Rate At Full Rate (Cont'd) | <div>2.4 ≤ Baud rate ≤ 4 Gbaud</div> <div></div> <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 100k</td><td>0 to 500</td></tr><tr><td>100.1k to 1M</td><td>0 to 50</td></tr><tr><td>1.001M to 10M</td><td>0 to 8</td></tr><tr><td>10.01M to 100M</td><td>0 to 0.5</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 100k | 0 to 500 | 100.1k to 1M | 0 to 50 | 1.001M to 10M | 0 to 8 | 10.01M to 100M | 0 to 0.5 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | | |
| 10 to 100k | 0 to 500 | | | | | | | | | | |
| 100.1k to 1M | 0 to 50 | | | | | | | | | | |
| 1.001M to 10M | 0 to 8 | | | | | | | | | | |
| 10.01M to 100M | 0 to 0.5 | | | | | | | | | | |

Table 1.3.1-2 Jitter Setting Range (Cont'd)

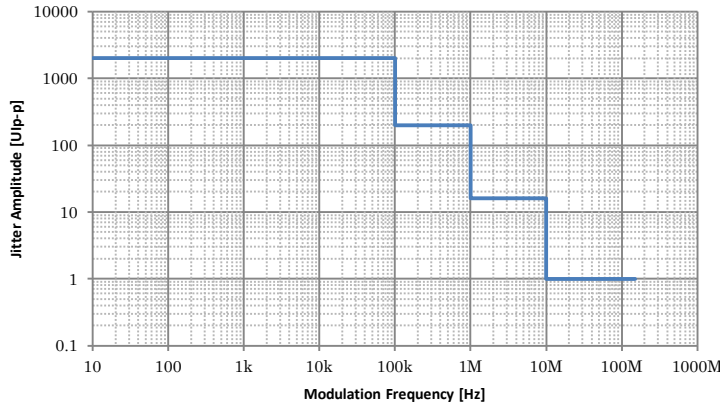
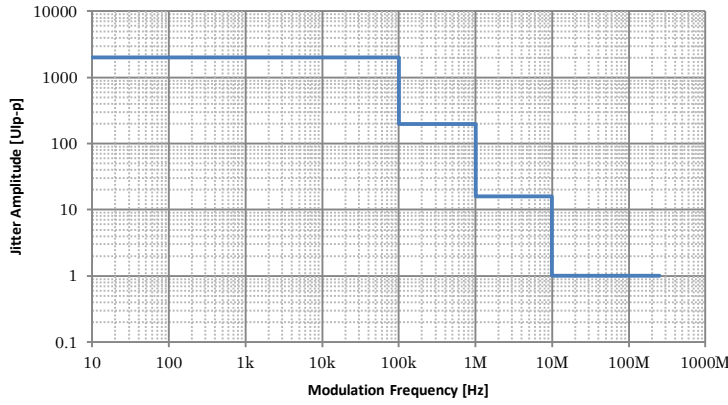
| Item | Specifications* ¹ | | | | | | | | | | |
|--|--|---------------------------|--------------------------|------------|-----------|--------------|----------|---------------|---------|----------------|--------|
| SJ1 Clock Output Rate At Half Rate, Quarter Rate | 60 < Baud rate ≤ 64.2 Gbaud, 30 < Baud rate ≤ 34 Gbaud, 8 < Baud rate ≤ 17 Gbaud | | | | | | | | | | |
| |  | | | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 100k</td><td>0 to 2000</td></tr><tr><td>100.1k to 1M</td><td>0 to 200</td></tr><tr><td>1.001M to 10M</td><td>0 to 16</td></tr><tr><td>10.01M to 150M</td><td>0 to 1</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 100k | 0 to 2000 | 100.1k to 1M | 0 to 200 | 1.001M to 10M | 0 to 16 | 10.01M to 150M | 0 to 1 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | | |
| 10 to 100k | 0 to 2000 | | | | | | | | | | |
| 100.1k to 1M | 0 to 200 | | | | | | | | | | |
| 1.001M to 10M | 0 to 16 | | | | | | | | | | |
| 10.01M to 150M | 0 to 1 | | | | | | | | | | |
| | 34 < Baud rate ≤ 60 Gbaud, 17 < Baud rate ≤ 30 Gbaud | | | | | | | | | | |
| |  | | | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 100k</td><td>0 to 2000</td></tr><tr><td>100.1k to 1M</td><td>0 to 200</td></tr><tr><td>1.001M to 10M</td><td>0 to 16</td></tr><tr><td>10.01M to 250M</td><td>0 to 1</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 100k | 0 to 2000 | 100.1k to 1M | 0 to 200 | 1.001M to 10M | 0 to 16 | 10.01M to 250M | 0 to 1 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | | |
| 10 to 100k | 0 to 2000 | | | | | | | | | | |
| 100.1k to 1M | 0 to 200 | | | | | | | | | | |
| 1.001M to 10M | 0 to 16 | | | | | | | | | | |
| 10.01M to 250M | 0 to 1 | | | | | | | | | | |

Table 1.3.1-2 Jitter Setting Range (Cont'd)

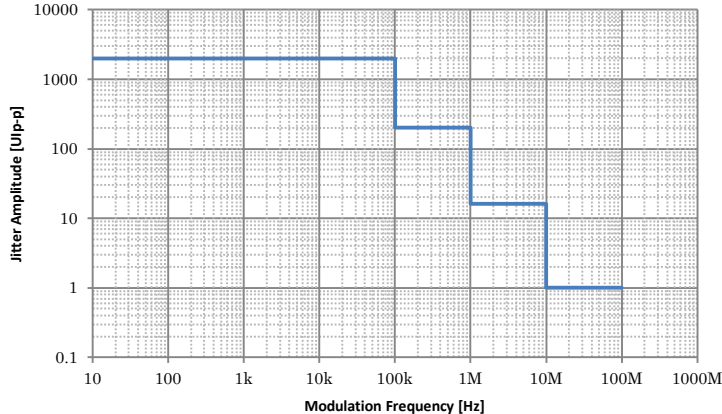
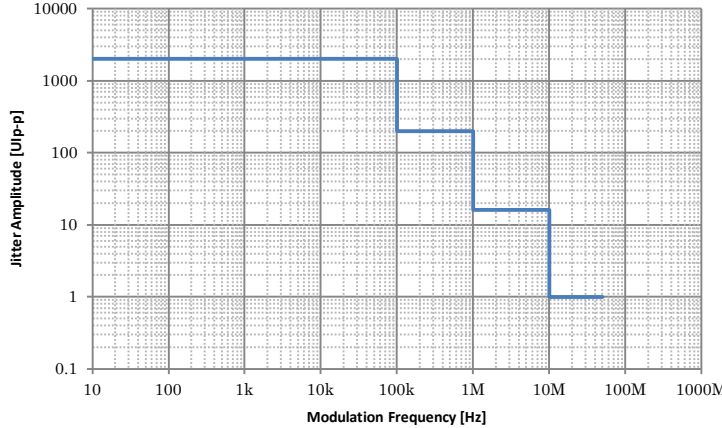
| Item | Specifications* ¹ | | | | | | | | | | |
|---|--|---------------------------|--------------------------|------------|-----------|--------------|----------|---------------|---------|----------------|--------|
| SJ1 Clock Output Rate At Half Rate, Quarter Rate (Cont'd) | 2.4 < Baud rate ≤ 8 Gbaud | | | | | | | | | | |
| |  | | | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 100k</td><td>0 to 2000</td></tr><tr><td>100.1k to 1M</td><td>0 to 200</td></tr><tr><td>1.001M to 10M</td><td>0 to 16</td></tr><tr><td>10.01M to 100M</td><td>0 to 1</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 100k | 0 to 2000 | 100.1k to 1M | 0 to 200 | 1.001M to 10M | 0 to 16 | 10.01M to 100M | 0 to 1 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | | |
| 10 to 100k | 0 to 2000 | | | | | | | | | | |
| 100.1k to 1M | 0 to 200 | | | | | | | | | | |
| 1.001M to 10M | 0 to 16 | | | | | | | | | | |
| 10.01M to 100M | 0 to 1 | | | | | | | | | | |
| | Baud rate 2.4 Gbaud | | | | | | | | | | |
| |  | | | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 100k</td><td>0 to 2000</td></tr><tr><td>100.1k to 1M</td><td>0 to 200</td></tr><tr><td>1.001M to 10M</td><td>0 to 16</td></tr><tr><td>10.01M to 50M</td><td>0 to 1</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 100k | 0 to 2000 | 100.1k to 1M | 0 to 200 | 1.001M to 10M | 0 to 16 | 10.01M to 50M | 0 to 1 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | | |
| 10 to 100k | 0 to 2000 | | | | | | | | | | |
| 100.1k to 1M | 0 to 200 | | | | | | | | | | |
| 1.001M to 10M | 0 to 16 | | | | | | | | | | |
| 10.01M to 50M | 0 to 1 | | | | | | | | | | |

Table 1.3.1-2 Jitter Setting Range (Cont'd)

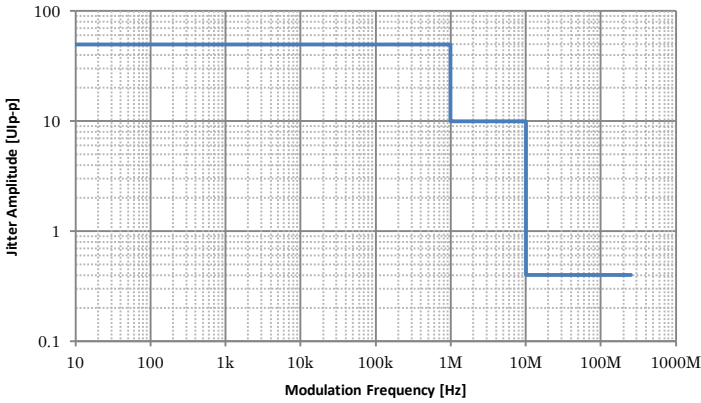
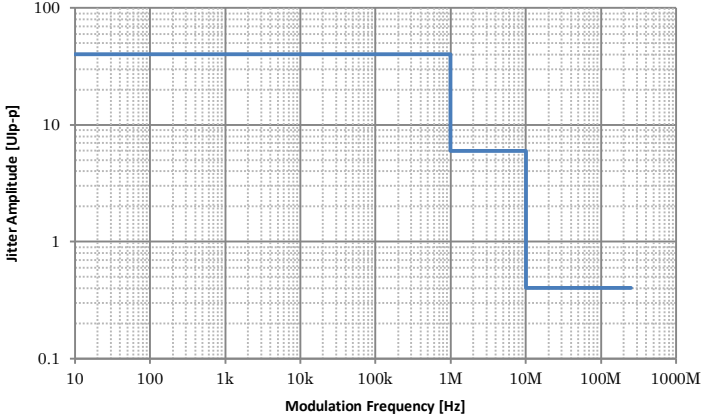
| Item | Specifications* ¹ | | | | | | | | |
|--|---|---------------------------|--------------------------|----------|---------|---------------|---------|----------------|----------|
| SJ2 Setting Range SJ2 via MU181000 Clock Output Rate At Full Rate | The SJ2 via MU181000 Clock and the Built-in SJ2 can be set exclusively. 15.000 001 ≤ Baud rate ≤ 32.1 Gbaud | | | | | | | | |
| |  | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 1M</td><td>0 to 50</td></tr><tr><td>1.001M to 10M</td><td>0 to 10</td></tr><tr><td>10.01M to 250M</td><td>0 to 0.4</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 1M | 0 to 50 | 1.001M to 10M | 0 to 10 | 10.01M to 250M | 0 to 0.4 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | |
| 10 to 1M | 0 to 50 | | | | | | | | |
| 1.001M to 10M | 0 to 10 | | | | | | | | |
| 10.01M to 250M | 0 to 0.4 | | | | | | | | |
| | 6.400 001 ≤ Baud rate ≤ 15 Gbaud | | | | | | | | |
| |  | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 1M</td><td>0 to 40</td></tr><tr><td>1.001M to 10M</td><td>0 to 6</td></tr><tr><td>10.01M to 250M</td><td>0 to 0.4</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 1M | 0 to 40 | 1.001M to 10M | 0 to 6 | 10.01M to 250M | 0 to 0.4 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | |
| 10 to 1M | 0 to 40 | | | | | | | | |
| 1.001M to 10M | 0 to 6 | | | | | | | | |
| 10.01M to 250M | 0 to 0.4 | | | | | | | | |

Table 1.3.1-2 Jitter Setting Range (Cont'd)

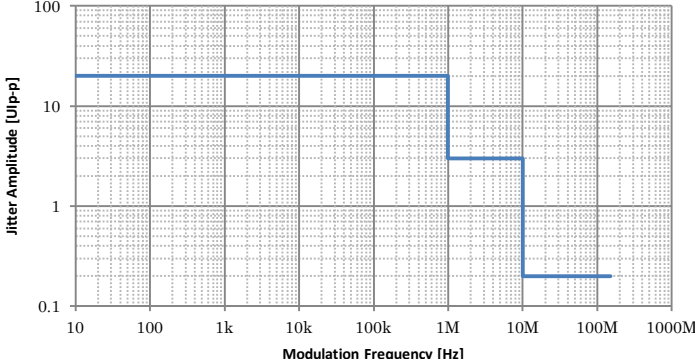
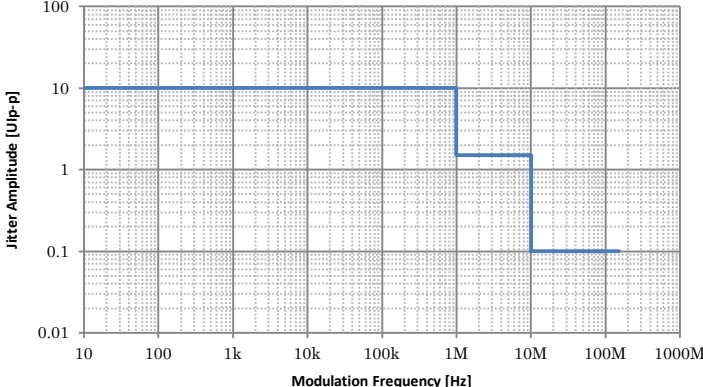
| Item | Specifications* ¹ | | | | | | | | |
|--|--|---------------------------|--------------------------|----------|---------|---------------|----------|----------------|----------|
| SJ2 via MU181000 Clock Output Rate At Full Rate (Cont'd) | 3.200 001 ≤ Baud rate ≤ 6.25 Gbaud | | | | | | | | |
| |  | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 1M</td><td>0 to 20</td></tr><tr><td>1.001M to 10M</td><td>0 to 3</td></tr><tr><td>10.01M to 150M</td><td>0 to 0.2</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 1M | 0 to 20 | 1.001M to 10M | 0 to 3 | 10.01M to 150M | 0 to 0.2 |
| | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | |
| 10 to 1M | 0 to 20 | | | | | | | | |
| 1.001M to 10M | 0 to 3 | | | | | | | | |
| 10.01M to 150M | 0 to 0.2 | | | | | | | | |
| 2.4 ≤ Baud rate ≤ 3.125 Gbaud | | | | | | | | | |
| |  | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 1M</td><td>0 to 10</td></tr><tr><td>1.001M to 10M</td><td>0 to 1.5</td></tr><tr><td>10.01M to 150M</td><td>0 to 0.1</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 1M | 0 to 10 | 1.001M to 10M | 0 to 1.5 | 10.01M to 150M | 0 to 0.1 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | |
| 10 to 1M | 0 to 10 | | | | | | | | |
| 1.001M to 10M | 0 to 1.5 | | | | | | | | |
| 10.01M to 150M | 0 to 0.1 | | | | | | | | |

Table 1.3.1-2 Jitter Setting Range (Cont'd)

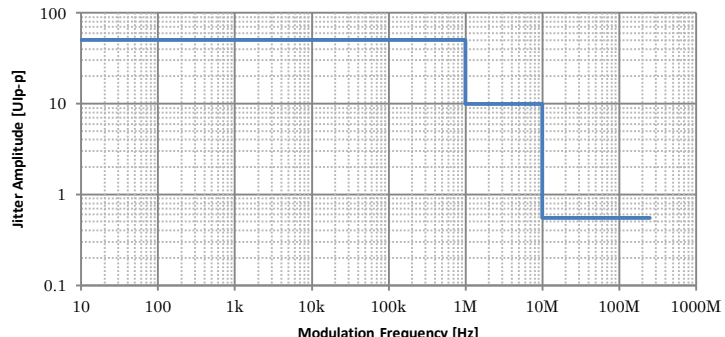
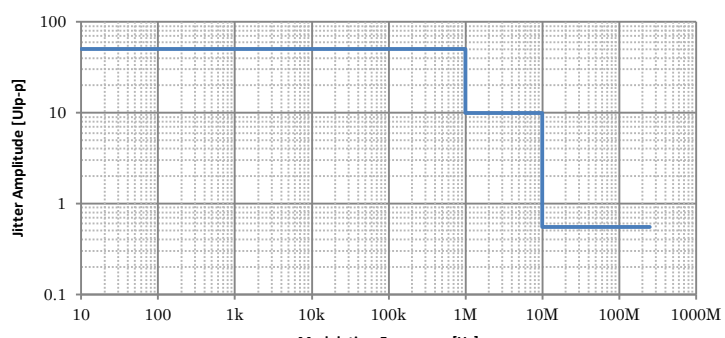
| Item | Specifications* ¹ | | | | | | | | |
|--|---|---------------------------|--------------------------|----------|---------|---------------|---------|----------------|------------|
| SJ2 via MU181000 Clock Output Rate At Half Rate, Quarter Rate | 60.000 001 ≤ Baud rate ≤ 64.2 Gbaud | | | | | | | | |
| |  | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 1M</td><td>0 to 50</td></tr><tr><td>1.001M to 10M</td><td>0 to 10</td></tr><tr><td>10.01M to 250M</td><td>0 to 0.544</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 1M | 0 to 50 | 1.001M to 10M | 0 to 10 | 10.01M to 250M | 0 to 0.544 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | |
| 10 to 1M | 0 to 50 | | | | | | | | |
| 1.001M to 10M | 0 to 10 | | | | | | | | |
| 10.01M to 250M | 0 to 0.544 | | | | | | | | |
| | 30.000 001 ≤ Baud rate ≤ 60.0 Gbaud | | | | | | | | |
| |  | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 1M</td><td>0 to 50</td></tr><tr><td>1.001M to 10M</td><td>0 to 10</td></tr><tr><td>10.01M to 250M</td><td>0 to 0.548</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 1M | 0 to 50 | 1.001M to 10M | 0 to 10 | 10.01M to 250M | 0 to 0.548 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | |
| 10 to 1M | 0 to 50 | | | | | | | | |
| 1.001M to 10M | 0 to 10 | | | | | | | | |
| 10.01M to 250M | 0 to 0.548 | | | | | | | | |

Table 1.3.1-2 Jitter Setting Range (Cont'd)

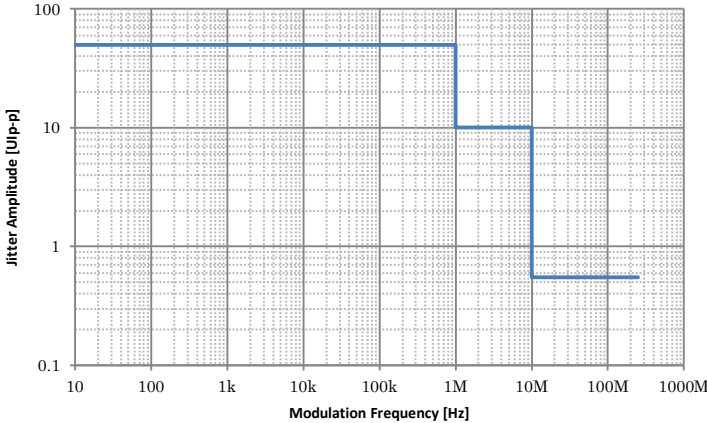
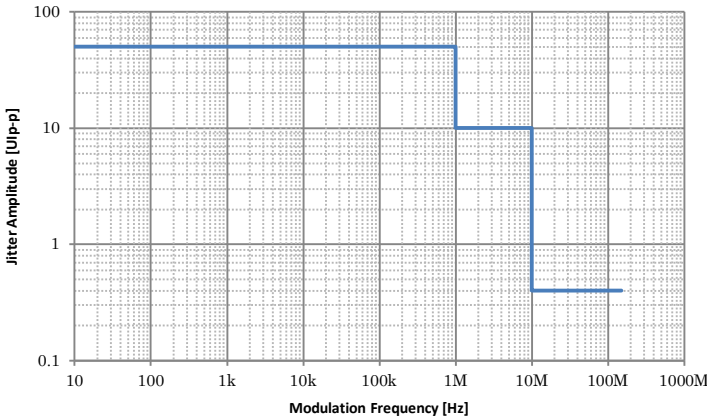
| Item | Specifications* ¹ | | | | | | | | |
|---|--|---------------------------|--------------------------|----------|---------|---------------|---------|----------------|-----------|
| SJ2 via MU181000 Clock Output Rate At Half Rate, Quarter Rate (Cont'd) | 12.800001 ≤ Baud rate ≤ 30.0 Gbaud | | | | | | | | |
| |  | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 1M</td><td>0 to 50</td></tr><tr><td>1.001M to 10M</td><td>0 to 10</td></tr><tr><td>10.01M to 250M</td><td>0 to 0.55</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 1M | 0 to 50 | 1.001M to 10M | 0 to 10 | 10.01M to 250M | 0 to 0.55 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | |
| 10 to 1M | 0 to 50 | | | | | | | | |
| 1.001M to 10M | 0 to 10 | | | | | | | | |
| 10.01M to 250M | 0 to 0.55 | | | | | | | | |
| | 6.400001 ≤ Baud rate ≤ 12.5 Gbaud | | | | | | | | |
| |  | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 1M</td><td>0 to 50</td></tr><tr><td>1.001M to 10M</td><td>0 to 10</td></tr><tr><td>10.01M to 150M</td><td>0 to 0.4</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 1M | 0 to 50 | 1.001M to 10M | 0 to 10 | 10.01M to 150M | 0 to 0.4 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | |
| 10 to 1M | 0 to 50 | | | | | | | | |
| 1.001M to 10M | 0 to 10 | | | | | | | | |
| 10.01M to 150M | 0 to 0.4 | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

Table 1.3.1-2 Jitter Setting Range (Cont'd)

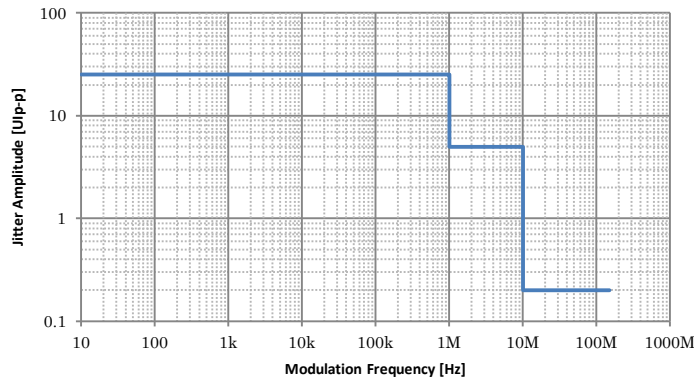
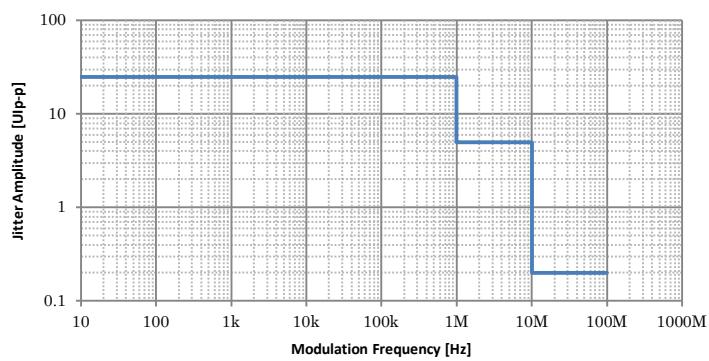
| Item | Specifications* ¹ | | | | | | | | |
|---|--|---------------------------|--------------------------|----------|---------|---------------|--------|----------------|----------|
| SJ2 via MU181000 Clock Output Rate At Half Rate, Quarter Rate (Cont'd) | 3.600001 ≤ Baud rate ≤ 6.25 Gbaud | | | | | | | | |
| |  | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 1M</td><td>0 to 25</td></tr><tr><td>1.001M to 10M</td><td>0 to 5</td></tr><tr><td>10.01M to 150M</td><td>0 to 0.2</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 1M | 0 to 25 | 1.001M to 10M | 0 to 5 | 10.01M to 150M | 0 to 0.2 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | |
| 10 to 1M | 0 to 25 | | | | | | | | |
| 1.001M to 10M | 0 to 5 | | | | | | | | |
| 10.01M to 150M | 0 to 0.2 | | | | | | | | |
| | 3.200001 < Baud rate ≤ 3.6 Gbaud | | | | | | | | |
| |  | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 1M</td><td>0 to 25</td></tr><tr><td>1.001M to 10M</td><td>0 to 5</td></tr><tr><td>10.01M to 100M</td><td>0 to 0.2</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 1M | 0 to 25 | 1.001M to 10M | 0 to 5 | 10.01M to 100M | 0 to 0.2 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | |
| 10 to 1M | 0 to 25 | | | | | | | | |
| 1.001M to 10M | 0 to 5 | | | | | | | | |
| 10.01M to 100M | 0 to 0.2 | | | | | | | | |

Table 1.3.1-2 Jitter Setting Range (Cont'd)

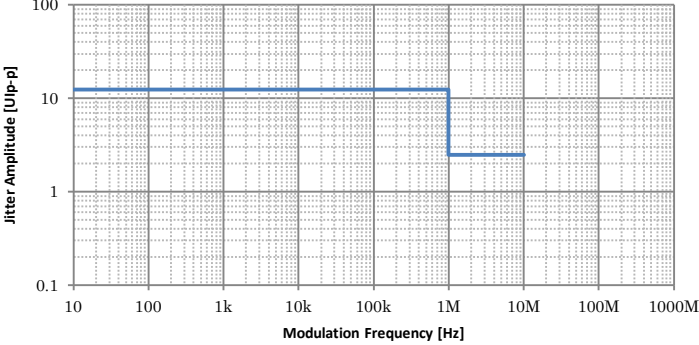
| Item | Specifications* ¹ | | | | | | |
|---|--|---------------------------|--------------------------|----------|-----------|---------------|----------|
| SJ2 via MU181000 Clock Output Rate At Half Rate, Quarter Rate (Cont'd) | <div>2.4 ≤ Baud rate ≤ 3.125 Gbaud</div> <div></div> <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>10 to 1M</td><td>0 to 12.4</td></tr><tr><td>1.001M to 10M</td><td>0 to 2.5</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 10 to 1M | 0 to 12.4 | 1.001M to 10M | 0 to 2.5 |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | |
| 10 to 1M | 0 to 12.4 | | | | | | |
| 1.001M to 10M | 0 to 2.5 | | | | | | |

Table 1.3.1-2 Jitter Setting Range (Cont'd)

| Item | Specifications* ¹ | | | | | | | | | | |
|--|---|---------------------------|--------------------------|----------|-----------|-----------|-----------|-----------|-----------|------|----------|
| Built-in SJ2 Clock Output Rate At Full Rate | 15 < Baud rate ≤ 32.1 Gbaud | | | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>33k</td><td>0 to 1000</td></tr><tr><td>87M</td><td>0 to 0.5</td></tr><tr><td>100M</td><td>0 to 0.5</td></tr><tr><td>210M</td><td>0 to 0.2</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 33k | 0 to 1000 | 87M | 0 to 0.5 | 100M | 0 to 0.5 | 210M | 0 to 0.2 |
| | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | |
| | 33k | 0 to 1000 | | | | | | | | | |
| | 87M | 0 to 0.5 | | | | | | | | | |
| | 100M | 0 to 0.5 | | | | | | | | | |
| | 210M | 0 to 0.2 | | | | | | | | | |
| | 4 < Baud rate ≤ 15 Gbaud | | | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>33k</td><td>0 to 500</td></tr><tr><td>87M</td><td>0 to 0.25</td></tr><tr><td>100M</td><td>0 to 0.25</td></tr><tr><td>210M</td><td>0 to 0.1</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 33k | 0 to 500 | 87M | 0 to 0.25 | 100M | 0 to 0.25 | 210M | 0 to 0.1 |
| | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | |
| | 33k | 0 to 500 | | | | | | | | | |
| | 87M | 0 to 0.25 | | | | | | | | | |
| | 100M | 0 to 0.25 | | | | | | | | | |
| | 210M | 0 to 0.1 | | | | | | | | | |
| | 2.4 ≤ Baud rate ≤ 4 Gbaud | | | | | | | | | | |
| <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>33k</td><td>0 to 500</td></tr><tr><td>87M</td><td>0 to 0.25</td></tr><tr><td>100M</td><td>0 to 0.25</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 33k | 0 to 500 | 87M | 0 to 0.25 | 100M | 0 to 0.25 | | | |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | | |
| 33k | 0 to 500 | | | | | | | | | | |
| 87M | 0 to 0.25 | | | | | | | | | | |
| 100M | 0 to 0.25 | | | | | | | | | | |
| Built-in SJ2 Clock Output Rate At Half Rate, Quarter Rate | 8 < Baud rate ≤ 64.2 Gbaud | | | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>33k</td><td>0 to 1000</td></tr><tr><td>87M</td><td>0 to 0.5</td></tr><tr><td>100M</td><td>0 to 0.5</td></tr><tr><td>210M</td><td>0 to 0.2</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 33k | 0 to 1000 | 87M | 0 to 0.5 | 100M | 0 to 0.5 | 210M | 0 to 0.2 |
| | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | |
| | 33k | 0 to 1000 | | | | | | | | | |
| | 87M | 0 to 0.5 | | | | | | | | | |
| | 100M | 0 to 0.5 | | | | | | | | | |
| | 210M | 0 to 0.2 | | | | | | | | | |
| | 2.4 < Baud rate ≤ 8 Gbaud | | | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>33k</td><td>0 to 1000</td></tr><tr><td>87M</td><td>0 to 0.5</td></tr><tr><td>100M</td><td>0 to 0.5</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 33k | 0 to 1000 | 87M | 0 to 0.5 | 100M | 0 to 0.5 | | |
| | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | |
| | 33k | 0 to 1000 | | | | | | | | | |
| | 87M | 0 to 0.5 | | | | | | | | | |
| | 100M | 0 to 0.5 | | | | | | | | | |
| | Baud rate 2.4 Gbaud | | | | | | | | | | |
| | <table><tr><th>Modulation Frequency (Hz)</th><th>Jitter Amplitude (Ulp-p)</th></tr><tr><td>33k</td><td>0 to 1000</td></tr></table> | Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | 33k | 0 to 1000 | | | | | | |
| Modulation Frequency (Hz) | Jitter Amplitude (Ulp-p) | | | | | | | | | | |
| 33k | 0 to 1000 | | | | | | | | | | |

Table 1.3.1-3 External Clock Input

| Item | Specifications |
|-----------------------|--|
| Number of Inputs | 1 (Single-Ended) |
| Input frequency range | 1.2 to 16.05 GHz |
| Input amplitude | 0.3 to 1.0 V _{p-p} (–6.5 to +4.0 dBm) |
| Termination | 50 Ω, AC Coupling |
| Connector | SMA connector (f.) |

Table 1.3.1-4 Aux Input

| Item | Specifications |
|---------------------|---|
| Number of Inputs | 1 (Single-Ended) |
| Variation | Error Injection, Burst, Unit Sync |
| Minimum Pulse Width | 1/256 of data rate |
| Input level | <ul style="list-style-type: none"> 0/–1 V (H: –0.25 to 0.05 V, L: –1.1 to –0.8 V) 0/–0.5 V (H: –0.05 to 0.05 V, L: –0.55 to –0.45 V) V_{th} 0 V (Input amplitude: 0.5 to 1.0 V_{p-p}) Select one of the above. |
| Termination | 50 Ω, GND |
| Connector | SMA connector (f.) |

Table 1.3.1-5 Aux Output

| Item | Specifications |
|--|---|
| Number of Outputs | 2 (Differential output) |
| Output control | ON/OFF switching |
| Variation | 1/n Clock (n = 8, 12, 16, 20...1020, 1024), Pattern Sync, Burst Out2 |
| Pattern Sync PRBS, PRGM | Position: 1 to {(Least common multiple of Pattern Length' and 256) – 263}, in 8 steps When the pattern length is 1023 bits or less, Pattern Length' is the length as an integer multiple so that it becomes 1024 bits or more. |
| Burst Out2 Burst Trigger Delay Pulse Width | 0 to (Burst Cycle – 256) bits, 8 bits step 16 to (Burst Cycle – 256) bits, 8 bits step |
| Output level | 0/–0.6 V (H: –0.25 to 0.05 V, L: –0.80 to –0.45 V) |
| Termination | 50 Ω, GND |
| Connector | SMA connector (f.) |

Table 1.3.1-6 Gating Output

| Item | Specifications |
|---------------------------|--|
| Number of Outputs | 1 (Single-Ended) |
| Output control | ON/OFF switching |
| Variation | Burst, Repeat |
| Burst | Burst Output |
| Burst Trigger Delay | 0 to (Burst Cycle – 256) bits, 8 bits step |
| Enable Pulse Width | 16 to (Burst Cycle – 256) bits, 8 bits step |
| Output Level | 0/–1 V (H: –0.25 to 0.05 V, L: –1.25 to –0.8 V)* |
| Repeat | Timing Signal Output |
| Timing Signal Cycle | $\text{INT} \left(\frac{\text{Pattern length}}{256} \right) \times 256$ |
| Timing Signal Delay | 0 to {(Least common multiple of Pattern Length' and 256) – 256} The maximum settable number is 68 719 476 480, in 8-bit steps When the pattern length is 1023 bits or less, Pattern Length' is the length as an integer multiple so that it becomes 1024 bits or more. |
| Timing Signal Pulse Width | 256 to {(Least common multiple of Pattern Length' and 256) – 256} The maximum settable number is 68 719 476 480, in 8-bit steps When the pattern length is 1023 bits or less, Pattern Length' is the length as an integer multiple so that it becomes 1024 bits or more. |
| Output Level | 0/–1 V (H: –0.25 to 0.05 V, L: –1.25 to –0.8 V)* |
| Unit Sync Output | Outputs the timing signal when Unit Sync is set to ON . |
| Termination | 50 Ω, GND |
| Connector | SMA connector (f.) |

*: L: Output Enable, H: Output Disable

Table 1.3.1-7 Generated Pattern

| Item | Specifications |
|---|---|
| PRBS Pattern Length Mark ratio PRBS generator polynomial PRBS Inversion | $2^n - 1$ ($n = 7, 9, 10, 11, 13, 15, 20, 23, 31$) $1/2$ ($1/2$ INV is supported by a logical inversion.) $n = 7: 1 + X^6 + X^7$ $n = 9: 1 + X^5 + X^9$ $n = 10: 1 + X^7 + X^{10}$ $n = 11: 1 + X^9 + X^{11}$ $n = 13: 1 + X + X^2 + X^{12} + X^{13}$ $n = 15: 1 + X^{14} + X^{15}$ $n = 20: 1 + X^3 + X^{20}$ $n = 23: 1 + X^{18} + X^{23}$ $n = 31: 1 + X^{28} + X^{31}$ This is available in PAM4 mode only. Logical inversion of PRBS can be set independently for MSB and LSB. |
| Zero-Substitution Additional bit Pattern Length Start position Length of Consecutive Zero Bits | This is available in NRZ mode only. 0 bit, 1 bit 2^n ($n = 7, 9, 10, 11, 15, 20, 23$) $2^n - 1$ ($n = 7, 9, 10, 11, 15, 20, 23$) Bit after the longest run of zero bits 1 to (Pattern Length – 1) bits If the bit coming after Zero-substitution is “0”, then it is replaced with “1”. |
| Data Data Length | NRZ: 2 to 268 435 456 bits, 1 bit step PAM4: 2 to 268 435 456 symbols, 1 symbol step |
| Bit Shift | This is available in PAM4 mode only. Bit shift of MSBs can be controlled in the range of ± 256 bits (in 1-bit steps). |
| PAM4 Standard Pattern CEI IEEE InfiniBand Fibre Channel RS-FEC | Standard-compliant PAM4-mode patterns QPRBS13-CEI, QPRBS31-CEI IEEE802.3bs/cd: PRBS13Q, PRBS31Q, SSPRQ, Square Wave IEEE802.3bj: QPRBS13, JP03A, JP03B, Transmitter Linearity PRBS13Q (InfiniBand), PRBS23Q, PRBS31Q (InfiniBand) PRBS31Q (Fibre Channel) When the MU196020A-x42 is installed. RS-FEC Scrambled Idle 50G 1Lane, RS-FEC Scrambled Idle 100G 1Lanes, RS-FEC Scrambled Idle 100G 2Lanes, RS-FEC Scrambled Idle 200G 4Lanes, RS-FEC Scrambled Idle 400G 4Lanes, RS-FEC Scrambled Idle 400G 8Lanes |
| NRZ Standard Pattern CEI RS-FEC | Standard-compliant NRZ-mode pattern SSPR When the MU196020A-x42 is installed. RS-FEC Scrambled Idle 25G 1Lane, RS-FEC Scrambled Idle 100G 4Lanes |

Table 1.3.1-8 Pattern Sequence

| Item | Specifications |
|---------------|--|
| Sequence | Repeat, Burst |
| Repeat | Continuous Pattern |
| Burst | This is available only when Coding is NRZ. |
| Source | Internal, External-Trigger (Aux Input), External-Enable (Aux Input) |
| Data Sequence | Restart, Consecutive, Continuous |
| Enable period | Internal: 12 800 to 2 147 483 136 bits, 256 bits step Ext Trigger/Enable: 12 800 to 2 147 483 648 bits, 256 bits step |
| Burst Cycle | 25 600 to 2 147 483 648 bits, 1 024 bits step |

Table 1.3.1-9 Coding

| Item | Specifications |
|--------------------------------------|----------------|
| Coding | NRZ, PAM4 |
| NRZ | Normal, Invert |
| PAM4 Gray Coding | ON, OFF |
| PAM4 Precoding (1/(1 + D) mod 4)* | ON, OFF |

*: $(1/(1+D) \bmod 4)$ is a generator polynomial defined in the IEEE802.3.

Table 1.3.1-10 Error Addition

| Item | Specifications |
|---------------------------|--|
| Type | Bit, Error on MSB, Error on LSB, Error on LSB&MSB, RS-FEC Symbol Error* |
| Bit | This is available only when Coding is NRZ. |
| Source | Internal, External-Trigger (Rise edge trigger), External-Disable (L: Disable) |
| Error Variation | Repeat, Single (Cannot be selected when Source is External-Trigger.) |
| Error Rate | *E-n (* = 1 to 9, n = 3 to 12), Upper limit: 3.0E-3 |
| Error Route | Select 1 to 32, Scan |
| Bit/Burst | Switching between Bit and Burst |
| Burst Length | 1 to 256, 1 step |
| RS-FEC Symbol Error* | This is available whether Coding is NRZ or PAM4. When Coding is PAM4, an error is inserted to make the PAM4 signal change by one level only. NRZ: An error is inserted every 10 bits. PAM4: An error is inserted every 10 or 20 PAM4 symbols. |
| Source | Internal, External-Trigger (Rise edge trigger), External-Disable (L: Disable) |
| Error Variation | Repeat, Single (Cannot be selected when Source is External-Trigger.) |
| Symbol error per codeword | 1 to 20 (When Coding is NRZ and PAM4.) |

*: When the MU196020A-x42 is installed.

Table 1.3.1-10 Error Addition (Cont'd)

| Item | Specifications |
|--|--|
| RS-FEC Symbol Error* (Cont'd) Error Rate Error Addition Method | $*E-n$ (* = 1 to 9, n = 3 to 12), Upper limit: $3.0E-3$ Type1: Level 0 → Level 1, Level 1 → Level 2, Level 2 → Level 3, Level 3 → Level 2 Type2: Level 0 → Level 1, Level 1 → Level 2, Level 2 → Level 1, Level 3 → Level 2 Type3: Level 0 → Level 1, Level 1 → Level 0, Level 2 → Level 1, Level 3 → Level 2 MSB Only: Level 0 → Level 2, Level 1 → Level 3, Level 2 → Level 0, Level 3 → Level 1 LSB Only: Level 0 → Level 1, Level 1 → Level 0, Level 2 → Level 3, Level 3 → Level 2 |
| Error on MSB Source Error Variation Symbol Error Rate Symbol/Burst Burst Length | Adds the specified symbol error. This is available only when Coding is PAM4. The set error is added to MSB only. Internal, External-Trigger (Rise edge trigger), External-Disable (L: Disable) Repeat, Single (Cannot be selected when Source is External-Trigger.) $*E-n$ (* = 1 to 9, n = 3 to 12), Upper limit: $3.0E-3$ Switching between Symbol and Burst 1 to 256, 1 step |
| Error on LSB Source Error Variation Symbol Error Rate Symbol/Burst Burst Length | Adds the specified symbol error. This is available only when Coding is PAM4. The set error is added to LSB only. Internal, External-Trigger (Rise edge trigger), External-Disable (L: Disable) Repeat, Single (Cannot be selected when Source is External-Trigger.) $*E-n$ (* = 1 to 9, n = 3 to 12), Upper limit: $3.0E-3$ Switching between Symbol and Burst 1 to 256, 1 step |

Table 1.3.1-10 Error Addition (Cont'd)

| Item | Specifications |
|-----------------------|---|
| Error on LSB&MSB | Adds the specified symbol error. This is available only when Coding is PAM4. An error is inserted to make the PAM4 signal change by one level only. |
| Source | Internal, External-Trigger (Rise edge trigger), External-Disable (L: Disable) |
| Error Variation | Repeat, Single (Cannot be selected when Source is External-Trigger.) |
| Symbol Error Rate | *E-n (* = 1 to 9, n = 3 to 12), Upper limit: 3.0E-3 |
| Symbol/Burst | Switching between Symbol and Burst |
| Burst Length | 1 to 256, 1 step |
| Error Addition Method | Type1: Level 0 → Level 1, Level 1 → Level 2, Level 2 → Level 3, Level 3 → Level 2 Type2: Level 0 → Level 1, Level 1 → Level 2, Level 2 → Level 1, Level 3 → Level 2 Type3: Level 0 → Level 1, Level 1 → Level 0, Level 2 → Level 1, Level 3 → Level 2 |
| FEC Standard | When Coding is NRZ: RS-FEC Scrambled Idle 25G 1Lane, RS-FEC Scrambled Idle 100G 4Lanes When Coding is PAM4: RS-FEC Scrambled Idle 50G 1Lane, RS-FEC Scrambled Idle 100G 1Lanes, RS-FEC Scrambled Idle 100G 2Lanes, RS-FEC Scrambled Idle 200G 4Lanes, RS-FEC Scrambled Idle 400G 4Lanes, RS-FEC Scrambled Idle 400G 8Lanes |

Table 1.3.1-11 Data Output

| Item | Specifications* ¹ |
|---|---|
| Number of Outputs Waveform | 2 (Data, XData) Cannot be varied independently NRZ, PAM4 |
| NRZ Eye Amplitude Setting Range Accuracy | NRZ: 70 to 800 mVp-p, 2 mV step (Single-Ended) When using the J1789A: $\pm 35 \text{ mV} \pm 12\%$ (Single-Ended)* ² When using the J1790A: $\pm 35 \text{ mV} \pm 12\%$ (Single-Ended)* ^{3, *4, *5} |
| PAM4 Eye Amplitude PAM4 (0/3 Level) Setting Range PAM4 (0/3 Level) Accuracy PAM4 (0/1, 1/2, 2/3 Level) Independently variable PAM4 (0/1, 1/2, 2/3 Level) Setting Range PAM4 (0/1, 1/2, 2/3 Level) Accuracy | PAM4(0/3 Level): 70 to 800 mVp-p, 1 mV step (Single-Ended)* ⁶ When using the J1789A: $\pm 35 \text{ mV} \pm 12\%$ of Amplitude* ^{2, *7} When using the J1790A: $\pm 35 \text{ mV} \pm 12\%$ of Amplitude* ^{3, *4, *5, *7} Provided, 20% to 50%, 1 mV Step (Eye amplitude conversion) (PAM4 Amplitude 0/3 level is assumed to be 100%.) PAM4(0/1 Level): 23 to 266 mVp-p, 1 mV step (Single-Ended) PAM4(1/2 Level): 24 to 268 mVp-p, 1 mV step (Single-Ended) PAM4(2/3 Level): 23 to 266 mVp-p, 1 mV step (Single-Ended) When using the J1789A: $\pm 35 \text{ mV} \pm 12\%$ of Amplitude* ⁸ When using the J1790A: $\pm 35 \text{ mV} \pm 12\%$ of Amplitude* ^{9, *10, *11} |
| Offset Setting Range Accuracy | -2.0–Eye Amplitude/2 to +3.3–Eye Amplitude/2 Vth, 1 mV step (Single-Ended) $\pm 65 \text{ mV} \pm 10\%$ of offset (Vth) \pm (Eye Amplitude Accuracy / 2) (Except when Emphasis is turned On with the MU196020A-x11 installed.) (For PAM4, when setting each of PAM4 Amplitude (3/2, 2/1 and 1/0) equally to 33%.) |
| Cross Point | Typ. 50% (fixed) |
| Tr/Tf | When using the J1789A: Typ. 9 ps (20-80%)* ¹² Typ. 8.5 ps (20-80%)* ¹³ When using the J1790A: Typ. 9.5 ps (20-80%)* ¹² Typ. 8.8 ps (20-80%)* ¹³ |

*1: Unless otherwise specified, these are specified with the conditions of PRBS2³¹–1, Mark ratio 1/2, and Cross Point 50%.

The values shall be observed by using an optional accessory, J1789A or J1790A, and a 70-GHz bandwidth sampling oscilloscope.

*2: Setting Range $\leq 700 \text{ mVp-p}$

*3: Setting Range $\leq 700 \text{ mVp-p}$
($\leq 32.1 \text{ Gbit/s}$, when the Options 001, 002, y12, 003, y13 and y23 are installed)

*4: Setting Range $\leq 600 \text{ mVp-p}$
($\leq 58.2 \text{ Gbit/s}$, when the Options 002, y12, 003, y13 and y23 are installed)

- *5: Setting Range ≤ 550 mVp-p
(≤ 64.2 Gbit/s, when the Options 003, y13 and y23 are installed)
- *6: When PAM4 output signal is directly input to the ED, the lower limit for the error-free amplitude depends on the performance of the ED used.

When using MP1862A as ED, the lower limit for the error-free amplitude (reference data) is as follows:
125 mV (0/3 Level, ≤ 32.1 Gbaud, when the Option 001 is installed)
250 mV (0/3 Level, ≤ 58.2 Gbaud, when the Options 002, y12, 003, y13 and y23 are installed)
Pattern: PRBS15, at a constant temperature between 20 and 30°C
- *7: Single-Ended, PAM4 0/3 Level, and when setting each of PAM4 Amplitude (3/2, 2/1 and 1/0) equally to 33%
- *8: Setting Range ≤ 234 mVp-p, Single-Ended, at each amplitude level (Upper, Middle, Lower)
- *9: Setting Range ≤ 234 mVp-p, Single-Ended, at each amplitude level (Upper, Middle, Lower)
(≤ 32.1 Gbit/s, when the Options 001, 002, y12, 003, y13 and y23 are installed)
- *10: Setting Range ≤ 200 mVp-p, Single-Ended, at each amplitude level (Upper, Middle, Lower)
(≤ 58.2 Gbit/s, when the Options 002, y12, 003, y13 and y23 are installed)
- *11: Setting Range ≤ 184 mVp-p, Single-Ended, at each amplitude level (Upper, Middle, Lower), when using the J1790A coaxial cable (0.8m)
(≤ 64.2 Gbit/s, when the Options 003, y13 and y23 are installed)
- *12: NRZ, 32.1 Gbit/s, Eye Amplitude 0.5 Vp-p (Single-Ended), only when Coding is NRZ and Emphasis is Off.
- *13: NRZ, 58.2 Gbit/s (when the Options 002 and y12 are installed), 64.2 Gbit/s (when the Options 003, y13 and y23 are installed), Eye Amplitude 0.5 Vp-p (Single-Ended), only when Coding is NRZ and Emphasis is Off.

Table 1.3.1-11 Data Output (Cont'd)

| Item | Specifications* ¹ |
|--|---|
| Half Period Jitter Setting Range Accuracy | –20 to +20, 1 step Typ. ± 0.04 UI* ¹⁴ |
| Jitter Measurement conditions Peak-to-Peak Jitter Jitter RMS Intrinsic RJ (RMS) | NRZ, Bit rate 32.1 Gbit/s (When the Option 001 is installed), 58.2 Gbit/s (When the Options 002 and y12 are installed), 64.2 Gbit/s (When the Options 003, y13 and y23 are installed) Eye Amplitude 0.5 Vp-p (Single-Ended) At a constant temperature between 20 and 30°C, measure with a 70-GHz bandwidth sampling oscilloscope with residual jitter of less than 200 fs (RMS). Typ. 6 ps p-p (Count of measured jitters: 30) Typ. 600 fs rms (Count of measured jitters: 30) Typ. 170 fs (Repeating pattern of 1,0) * ¹⁵ |
| Waveform Distortion (0-peak) | Typ. ± 110 mV* ¹⁶ |
| PAM4 Level Separation Mismatch Ratio (R_{LM}) | 0.95 (min.) * ¹⁷ |

*14: 2.4, 8, 16, 26.562 5, 32.1 Gbit/s (When the Option 001 is installed),
2.4, 8, 16, 26.562 5, 32.1, 40, 53.125, 58.2 Gbit/s (When the Options
002 and y12 are installed)
2.4, 8, 16, 26.562 5, 32.1, 40, 53.125 ,58.2 ,64.2 Gbit/s (When the
Options 003, y13 and y23 are installed), Eye Amplitude 0.5 Vp-p
(Single-Ended)

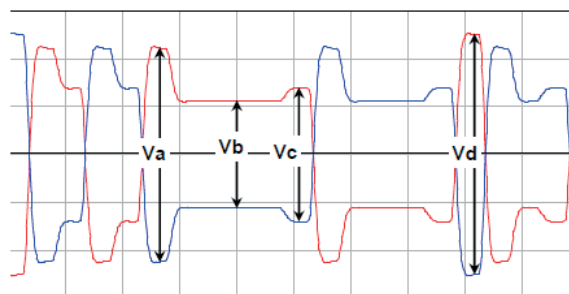
*15: NRZ, Bit rate 58.2 Gbit/s (When the Options 002 and y12 are
installed),
64.2 Gbit/s (When the Options 003, y13 and y23 are installed)

*16: NRZ, Bit rate 32.1 Gbit/s (When the Option 001 is installed),
58.2 Gbit/s (When the Options 002 and y12 are installed),
64.2 Gbit/s (When the Options 003, y13 and y23 are installed)
Eye Amplitude 0.5 Vp-p (Single-Ended)

*17: PAM4, 26.5625 Gbaud (When the Option 001 is installed),
53.125 Gbaud (When the Options 002, y12, 003, y13 and y23 are
installed),
1.0 Vp-p (Differential), refer to the IEEE P802.3bs for equation to
calculate.

Table 1.3.1-11 Data Output (Cont'd)

| Item | Specifications* ¹ |
|---|--|
| PAM4 Signal to noise and distortion ratio (SNDR) | 33 dB (min.) * ¹⁸ , * ¹⁹ |
| Electrical TDECQ | 0.9 dB* ²⁰ |
| Output ON/OFF | ON/OFF switching available |
| Data / XData Skew | ±1 ps Cable error not included. |
| Termination | AC, DC switching For DC: GND, -2V, +1.3V, +3.3V, Open (LVDS), 50 Ω |
| Connector | V connector (f.) |
| Offset Reference | V _{th} |
| Level Guard | Amplitude, V _{oh} and V _{ol} can be set. |
| External ATT Factor | -40 to 0 dB, 0.1 dB step When the fixed attenuator is connected, the amplitude and offset of the signal output via the fixed attenuator are displayed. |
| Emphasis Emphasis Tap Cursor Setting Range / Step | When the Option x11 is installed 4 (1post-cursor, 2pre-cursor) 4 Tap parameter values for all eyes (Upper, Middle and Lower) become identical. This means that 4 Tap parameters for Upper, Middle and Lower Eyes cannot be controlled independently. -20 to +20 dB, 0.01 dB step (Post-Cursor: $20\log_{10}V_a/V_b$, Pre-Cursor: $20\log_{10}V_c/V_b$) |
| Accuracy | Typ. ±1 dB (16 Gbaud, Amplitude 0.5 V _{p-p} (Single-Ended), De-Emphasis, Pre-Cursor1 = 6 dB, Post Cursor1 = 3.5 dB) |
| Setting Range of Emphasis Peak Voltage | 70 to 800 mV _{p-p} (Single-Ended) |
| Emphasis ON/OFF | ON/OFF switching |



Provided that the maximum amplitude is restricted by the setting range of emphasis peak voltage.

*¹⁸: PAM4, 26.5625 Gbaud (When the Option 001 is installed),
53.125 Gbaud (When the Options 002, y12, 003, y13 and y23 are installed),
1.0 V_{p-p} (Differential), refer to the IEEE P802.3cd for equation to calculate.

*¹⁹: 60-GHz bandwidth sampling oscilloscope

*20: 26.5625 Gbaud (When the Option 001 is installed),
53.125 Gbaud (When the Options 002, y12, 003, y13 and y23 are installed),
Using an equalizer, Single, Pattern: SSPRQ

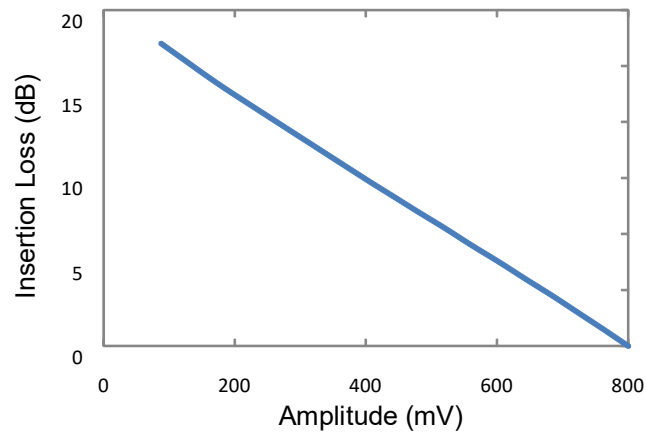
Table 1.3.1-11 Data Output (Cont'd)

| Item | Specifications* ¹ |
|---|--|
| Channel Emulator* ²¹ , * ²² Response S-Parameter file Channel Emulator ON/OFF Gain Adjust | Normal: Outputs the PPG Data signal whose waveform emulates the connected transmission line with the loaded S parameter. Inverse: Outputs the PPG Data signal whose inverse characteristics emulate the transmission line with the loaded S parameter. Normal, Inverse S2P file (Extension: "*.s2p"), S4P file (Extension: "*.s4p") Supports output files from the MS4640B Series Vector Network Analyzer. ON/OFF switching Adjusts the loss to emulate and loss of the loaded S parameter at the specified frequency, when Response is Normal. 0GHz, 1GHz, Nyquist Frequency switching |
| Adjustable ISI* ²¹ Loss Channel Frequency Insertion Loss Tuning Insertion Loss Insertion Loss Accuracy Adjustable ISI ON/OFF | Sets the loss of the channel which generates ISI and outputs the PPG data signal whose waveform emulates the setting. This is available for MU196020A in combination with the following. Not Specified: an external loss channel board J1800A×1 Short Channel: one J1800A (optional accessory) J1800A×2 Middle Channel: two J1800As (optional accessory) J1800A×3 Long Channel: three J1800As (optional accessory) J1758A: a J1758A (optional accessory) MU195050A Noise: an MU195050A Noise Module Insertion Loss can be set at Nyquist or 1/2 Nyquist Frequency. Displays the absolute loss that is sum of the loss selected for Loss Channel and the setting value of Tuning Insertion Loss at Nyquist Frequency and 1/2 Nyquist Frequency. The relative loss from the loss value of Loss Channel can be set. –8.00 to 8.00 dB, 0.01 dB step, Nyquist Frequency –8.00 to 8.00 dB, 0.01 dB step, 1/2 Nyquist Frequency ±1.0 dB Nominal @Nyquist Frequency 6 dB, Repeating pattern of "1,0" * ²³ , * ²⁵ , * ²⁶ ±1.5 dB Nominal @Nyquist Frequency 6 dB, Repeating pattern of "1,0" * ²⁴ , * ²⁵ , * ²⁶ ±1.0 dB Nominal @1/2Nyquist Frequency 3 dB, Repeating pattern of "1,1,0,0" * ²³ , * ²⁵ , * ²⁶ ±1.5 dB Nominal @1/2Nyquist Frequency 3 dB, Repeating pattern of "1,1,0,0" * ²⁴ , * ²⁵ , * ²⁶ ON/OFF switching |

*21: When the Option x40 is installed.

*22: It is assumed to use for the purpose of compensating the loss of the transmission line.

The following graph shows typical limits for adjustable insertion loss. However, it does not mean that all the responses emulated from the S-Parameter file are compensated as the graph shows.



*23: Baud Rate 26.6 Gbaud (when Option 001, 002, y12, 003, y13, and y23 installed)

*24: Baud Rate 53.1 Gbaud (when Option 002, y12, Option 003, y13, and y23 installed)

*25: Eye Amplitude 0.5 Vp-p, at each spectrum, at a constant temperature between 20 and 30°C

*26: The frequency characteristics of Insertion Loss Accuracy when setting 6 dB@Nyquist Frequency and 3 dB@1/2 Nyquist Frequency are shown below.

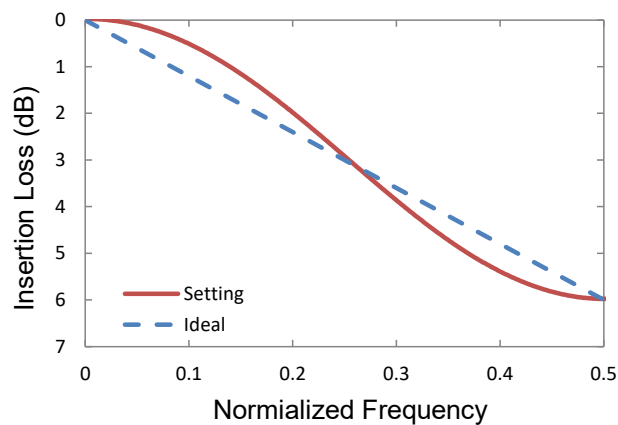


Table 1.3.1-12 Clock Output

| Item | Specifications* |
|-------------------|--|
| Frequency | |
| Full Rate | Operation Baud Rate = Clock Output Frequency 2.4 to 32.1 GHz (Option 001) |
| Half Rate | Operation Baud Rate = (Clock Output Frequency) × 2 1.2 to 16.05 GHz (Option 001) 1.2 to 29.1 GHz (When the Options 002 and y12 are installed) 1.2 to 32.1 GHz (When the Options 003, y13 and y23 are installed) |
| Quarter Rate | Operation Baud Rate = (Clock Output Frequency) × 4 0.6 to 8.025 GHz (Option 001) 0.6 to 14.55 GHz (When the Options 002 and y12 are installed) 0.6 to 16.05 GHz (When the Options 003, y13 and y23 are installed) |
| Number of Outputs | 1 |
| Amplitude | Min. 0.3 V _{p-p} , Max. 1.0 V _{p-p} (Output Frequency ≤ 16.05 GHz) Min. 0.4 V _{p-p} , Max. 1.0 V _{p-p} (Output Frequency > 16.05 GHz) |
| Output control | ON, OFF switching |
| Termination | 50 Ω, AC Coupling |
| Connector | K connector (f.) |

*: These values are monitored using an optional accessory (J1439A) at a sampling oscilloscope bandwidth of 70 GHz.

Table 1.3.1-13 Data Delay*¹

| Item | Specifications |
|-----------------------|---|
| Phase variable range | −1000 to +1000 mUI, 2 mUI step |
| Accuracy | ±50 mUIp-p* ^{2,*3,*4} ±100 mUIp-p* ^{2,*3,*5} |
| mUI – ps switching | Available (internally converted into ps) |
| Calibration | Available (when jitter modulation is off) |
| Calibration indicator | This is displayed when one of the following conditions is met: <ul style="list-style-type: none"> 1/1 Clock frequency change by ±250 kHz. Ambient temperature change by ±5°C. |

*1: When the Option x30 is installed.

*2: Measured with a sampling oscilloscope with residual jitter of less than 200 fs (RMS), at a constant amplitude setting.

*3: Typical value

*4: Baud rate ≤ 32.1 Gbaud

*5: Baud rate > 32.1 Gbaud

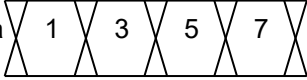
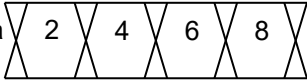
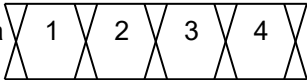
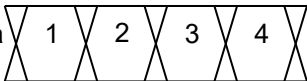
Table 1.3.1-14 Jitter tolerance

| Item | Specifications | | | | | | | | | | | | | | | | | | | | | |
|---------------------------|---|---------------------------|-----------------------------------|-----------------------|----|-------|-------|-------|-------|-------|---------|-------|-----|-----------|-----|----|------------|----|---|-------------|---|---|
| Jitter tolerance | <p>For NRZ output,</p> <p>Bit rate: 32.1 Gbit/s (Option 001) 58.2 Gbit/s (When the Options 002 and y12 are installed) 64.2 Gbit/s (When the Options 003, y13 and y23 are installed)</p> <p>Pattern: PRBS2³¹−1</p> <p>With MU181500B, SSC with frequency of 33 kHz and deviation of 5300 ppm can be applied simultaneously with RJ with amplitude of 0.3 UI. These specifications are defined assuming the following conditions: Loopback connection to MU196040A (32.1 Gbit/s) or MP1862A + MU183040B (58.2 Gbit/s, 64.2 Gbit/s), at a constant temperature between 20 and 30°C .</p> <p>When RJ + BUJ is bigger than 0.5 UIp-p or SJ1 + Built-in SJ2 + RJ + BUJ is bigger than the standard value + 0.3 UIp-p, “Overload” is displayed on the MU181500B screen.</p> <p>For details on the maximum modulation jitter that depends on the bit rate, refer to “Table 1.3.1-2 Jitter Setting Range”.</p> <p>32.1 Gbit/s</p> <div><table><thead><tr><th>Modulation frequency [Hz]</th><th>Max. modulation amplitude [UIp-p]</th><th>Specification [UIp-p]</th></tr></thead><tbody><tr><td>10</td><td>2 000</td><td>2 000</td></tr><tr><td>7 500</td><td>2 000</td><td>2 000</td></tr><tr><td>100 000</td><td>2 000</td><td>150</td></tr><tr><td>1 000 000</td><td>200</td><td>15</td></tr><tr><td>10 000 000</td><td>16</td><td>1</td></tr><tr><td>250 000 000</td><td>1</td><td>1</td></tr></tbody></table></div> | Modulation frequency [Hz] | Max. modulation amplitude [UIp-p] | Specification [UIp-p] | 10 | 2 000 | 2 000 | 7 500 | 2 000 | 2 000 | 100 000 | 2 000 | 150 | 1 000 000 | 200 | 15 | 10 000 000 | 16 | 1 | 250 000 000 | 1 | 1 |
| Modulation frequency [Hz] | Max. modulation amplitude [UIp-p] | Specification [UIp-p] | | | | | | | | | | | | | | | | | | | | |
| 10 | 2 000 | 2 000 | | | | | | | | | | | | | | | | | | | | |
| 7 500 | 2 000 | 2 000 | | | | | | | | | | | | | | | | | | | | |
| 100 000 | 2 000 | 150 | | | | | | | | | | | | | | | | | | | | |
| 1 000 000 | 200 | 15 | | | | | | | | | | | | | | | | | | | | |
| 10 000 000 | 16 | 1 | | | | | | | | | | | | | | | | | | | | |
| 250 000 000 | 1 | 1 | | | | | | | | | | | | | | | | | | | | |

Table 1.3.1-14 Jitter tolerance (Cont'd)

| Item | Specifications | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-----------------------------------|--|---------------------------|-----------------------------------|-----------------------|----|-------|-------|-------|-------|-------|---------|-------|----|-----------|-----|-----|------------|----|-----|-------------|---|-----|---------------------------|-----------------------------------|-----------------------|----|-------|-------|-------|-------|-------|---------|-------|----|-----------|-----|-----|------------|----|-----|-------------|---|-----|
| Jitter tolerance mask (Cont'd) | <div>58.2 Gbit/s, 64.2 Gbit/s</div> <div><table><tr><th>Modulation frequency [Hz]</th><th>Max. modulation amplitude [Ulp-p]</th><th>Specification [Ulp-p]</th></tr><tr><td>10</td><td>2 000</td><td>1 000</td></tr><tr><td>7 500</td><td>2 000</td><td>1 000</td></tr><tr><td>100 000</td><td>2 000</td><td>75</td></tr><tr><td>1 000 000</td><td>200</td><td>7.5</td></tr><tr><td>10 000 000</td><td>16</td><td>0.5</td></tr><tr><td>250 000 000</td><td>1</td><td>0.5</td></tr></table></div> <table><tr><th>Modulation frequency [Hz]</th><th>Max. modulation amplitude [Ulp-p]</th><th>Specification [Ulp-p]</th></tr><tr><td>10</td><td>2 000</td><td>1 000</td></tr><tr><td>7 500</td><td>2 000</td><td>1 000</td></tr><tr><td>100 000</td><td>2 000</td><td>75</td></tr><tr><td>1 000 000</td><td>200</td><td>7.5</td></tr><tr><td>10 000 000</td><td>16</td><td>0.5</td></tr><tr><td>250 000 000</td><td>1</td><td>0.5</td></tr></table> | Modulation frequency [Hz] | Max. modulation amplitude [Ulp-p] | Specification [Ulp-p] | 10 | 2 000 | 1 000 | 7 500 | 2 000 | 1 000 | 100 000 | 2 000 | 75 | 1 000 000 | 200 | 7.5 | 10 000 000 | 16 | 0.5 | 250 000 000 | 1 | 0.5 | Modulation frequency [Hz] | Max. modulation amplitude [Ulp-p] | Specification [Ulp-p] | 10 | 2 000 | 1 000 | 7 500 | 2 000 | 1 000 | 100 000 | 2 000 | 75 | 1 000 000 | 200 | 7.5 | 10 000 000 | 16 | 0.5 | 250 000 000 | 1 | 0.5 |
| Modulation frequency [Hz] | Max. modulation amplitude [Ulp-p] | Specification [Ulp-p] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 2 000 | 1 000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 500 | 2 000 | 1 000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 100 000 | 2 000 | 75 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 000 000 | 200 | 7.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 000 000 | 16 | 0.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 250 000 000 | 1 | 0.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Modulation frequency [Hz] | Max. modulation amplitude [Ulp-p] | Specification [Ulp-p] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 2 000 | 1 000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 500 | 2 000 | 1 000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 100 000 | 2 000 | 75 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 000 000 | 200 | 7.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 000 000 | 16 | 0.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 250 000 000 | 1 | 0.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 1.3.1-15 Multichannel Operation*¹

| Item | Specifications |
|---------------------------------|---|
| Multi-Module Synchronization | <p>A function to synchronize timing of generating patterns among multiple modules*², *³, *⁴, *⁵, *⁶</p> <p>Baud Rate ≤ 32.1 Gbaud: Capable of synchronizing bit generation timing with an accuracy of less than 1 UI</p> <p>Baud Rate > 32.1 Gbaud: Capable of synchronizing bit generation timing with an accuracy of less than 5 UI</p> |
| Inter-Module 2ch Combination | <p>This is available only for NRZ.</p> <p>Generates signals of which the first bit generation timing is synchronized between modules.</p> <p>And,</p> <p>generates signals with the bit-interleaved generation bit patterns between modules.</p> <p>Slot1</p> <p>Data </p> <p>Slot2</p> <p>Data </p> |
| Inter-Module CH Synchronization | <p>Generates signals of which the first bit generation timing is synchronized between modules.</p> <p>Slot1</p> <p>Data </p> <p>Slot2, 3, 4</p> <p>Data </p> |

*1: When the Option x30 and x50 are installed.

*2: The following options must be the same among the modules to be synchronized.

Option 001

Option 002 or y12

Option 003, y13, or y23

*3: Slot 1 to 2: Inter-Module 2ch Combination (only for NRZ)

*4: Slot 1 to 4: Inter-Module CH Synchronization

*5: The modules to be synchronized must be installed successively from Slot 1.

*6: In the range of $\pm 3^{\circ}\text{C}$ from the temperature when performing the Multi Channel Calibration function, the bit generation timing is guaranteed.

Table 1.3.1-15 Multichannel Operation*¹ (Cont'd)

| Item | Specifications |
|---------------------------------------|--|
| Output | Only the items to be changed when Multi-Module Synchronization is set are described. |
| Phase setting range | –64 000 to +64 000 mUI* ⁷ |
| Phase setting resolution | 2 mUI* ⁷ |
| Pattern | |
| Data length | When CH Combination is set: 4 to 536,870,912 bits, 2 bits step When CH Synchronization is set: same as Sync OFF |
| Unit Sync* ^{8, 9} | ON/OFF switching available |
| Number of Units | Synchronous control available between up to two MP1900As. Synchronous control of up to 8 channels is available with two MP1900As each installed with four MU196020As. |
| Unit Sync Output* ¹⁰ | To output a timing signal from the Gating Out connector when Unit Sync is touched Provided with an inter-unit synchronization status indicator. The status indicator at Unit Sync turns orange when it requires to be timed to the other. |
| Unit Sync Input* ¹⁰ | To input a timing signal from the AUX In connector |
| Bit phase difference between MP1900As | <p>Within ± 1024 UI</p> <p>Timing difference between bit generations that occurs when Unit Sync is touched</p> <p>MP1900A (Master)</p> <p>Slot 1 X 1 X 2 X 3 X 4 X</p> <p>Slot 2 X 1' X 2' X 3' X 4' X</p> <p>Slot 3 X 1'' X 2'' X 3'' X 4'' X</p> <p>Slot 4 X 1''' X 2''' X 3''' X 4''' X</p> <p>MP1900A (Slave)</p> <p>Slot 1 X 1 X 2 X 3 X 4 X</p> <p>Slot 2 X 1' X 2' X 3' X 4' X</p> <p>Slot 3 X 1'' X 2'' X 3'' X 4'' X</p> <p>Slot 4 X 1''' X 2''' X 3''' X 4''' X</p> <p>→ ← $-1024 \text{ UI} < \text{difference} < +1024 \text{ UI}$</p> <p>The pattern generating position is synchronized using the Channel Synchronization function.</p> <p>The pattern generating position between the MP1900As is synchronized using the Unit Sync function. MP1900A: two units MU196020A: four modules (The 8ch pattern is synchronized.)</p> |

*⁷: Each channel can be set independently.*⁸: Available on MX190000A version 3.02.00 or later.*⁹: Available only when using inter-module synchronization.*¹⁰: Available only when **Unit Sync** is ON.

Table 1.3.1-16 General

| Item | Specifications |
|-----------------------|---|
| Dimensions | 21 mm (H), 234 mm (W), 175 mm (D) Excluding protrusions |
| Mass | 2.5 kg max. |
| Operating Temperature | 15 to 30°C MP1900A's ambient temperature. MU196020A shall operate when installed. |
| Storage Temperature | −20 to 60°C MU196020A installed to MP1900A shall comply with MIL-T-28800E Class 5. |

1.3.2 Specifications for MU196040A

Table 1.3.2-1 Operating Baud Rate

| Item | Specifications |
|---------------------|---|
| Operating Baud Rate | When the Option 001 is installed. PAM4 input: 2.4 to 32.1 Gbaud NRZ input: 2.4 to 32.1 Gbit/s |

Table 1.3.2-2 System Clock

| Item | Specifications |
|--------------|--|
| System Clock | External, Recovered Clock (When the Option 022 is installed) External: Clock input from the Ext Clock Input connector Recovered Clock: Clock recovered from the data input from the Data Input connector |

Table 1.3.2-3 Data Input

| Item | Specifications |
|------------------------------------|---|
| Number of inputs | 2 (Data, XData) (Differential) |
| Input Condition | Single-Ended, Differential 50 Ohm, Differential 100 Ohm When set to Differential 50 Ohm or Differential 100 Ohm: Independent, Tracking, Alternate* ¹ When set to Alternate: Data-XData, XData-Data* ² When set to Single-Ended: Data, XData* ³ |
| Signal Type LSB/MSB Diagnostics | NRZ, PAM4 When set to PAM4, the PAM4 mode can be switched between as follows: Diagnostics Mode OFF: Treats signals as symbols by receiving LSB and MSB while synchronizing them with each other. Diagnostics Mode ON: Asynchronously receives LSB and MSB. |
| Amplitude | NRZ: The range in which the Auto Adjust function operates. PAM4: The range in which the Auto Search PAM4 Fine function operates. NRZ: 0.05 to 1.0 V _{p-p} * ⁴ PAM4: 0.3 to 1.0 V _{p-p} * ⁵ |
| Threshold | NRZ, PAM4 Middle Eye Threshold: -3.5 to +3.3 V, 1 mV step * ² , * ⁶ PAM4 Upper Eye Threshold: -3.9 to +3.7 V, 1 mV step * ⁷ PAM4 Lower Eye Threshold: -3.9 to +3.7 V, 1 mV step * ⁷ |

*1: Tracking is available only for NRZ.

*2: The absolute value of the difference between Data and XData
Threshold values shall be 1.5 V or less.

*3: PAM4 Upper Eye and Lower Eye can be set by relative values to
Middle Eye in the range of -0.4 V to +0.4 V.

*4: Single-Ended, Differential

*5: 0/3 Level, PRBS31, Single-Ended, Differential, when connecting
directly to the MU196020A.

*6: Data and XData can be set independently.

*7: Data and XData cannot be set independently, and can be set in the
range of ±0.4 V from Middle Eye Threshold.

Table 1.3.2-3 Data Input (Cont'd)

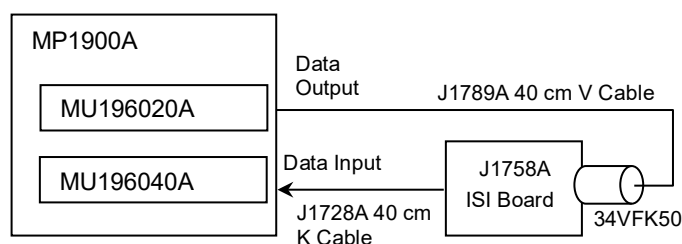
| Item | Specifications |
|---------------|--|
| Sensitivity | Single-Ended , Mark Ratio1/2, when connecting directly to the MU196020A with J1789A. When the Option-001 is installed, 34VKF50 shall be included. At a constant temperature between 20 and 30°C |
| Eye Amplitude | NRZ, PRBS31 Typ. 32 mVp-p, ≤ 50 mVp-p*8 (26.5625 Gbit/s, 32.1 Gbit/s) |
| Eye Height | NRZ, PRBS31 Typ. 23 mV*8 (26.5625 Gbit/s, 32.1 Gbit/s) PAM4 0/1 1/2 2/3 Level, PRBS31, Eye Height where BER is 1E-06, when using External Clock Typ. 23 mV, ≤ 50 mV*8 (26.5625 Gbaud, 32.1 Gbaud) |
| Phase Margin | When connecting directly to the MU196020A with J1789A. When the Option-001 is installed, 34VKF50 shall be included. At a constant temperature between 20 and 30°C, when using External Clock NRZ, PRBS31, Differential, Mark Ratio 1/2, when inputting 1.0 Vp-p Typ. 25.8 ps*8 (26.5625 Gbit/s) Typ. 18.0 ps*8 (32.1 Gbit/s) PAM4 0/3 Level, Eye Width where BER is 1E-06, PRBS31, Single-Ended, Mark Ratio1/2, when inputting 0.5 Vp-p, Emphasis ON (Best values in the range of 1Pre ≤ 5 dB and 1Post ≤ 5 dB) Typ. 5.3 ps*8 (26.5625 Gbaud) Typ. 4.5 ps*8 (32.1 Gbaud) |

*8: When the Option 001 is installed.

Table 1.3.2-3 Data Input (Cont'd)

| Item | Specifications |
|-------------------------------|--|
| Stressed Margin* ⁹ | |
| Stressed Eye Height | PAM4 0/1 1/2 2/3 Level, QPRBS13-CEI, Eye Height where BER is 1E-06, when using External Clock ≥ 32 mV* ¹⁰ |
| Stressed Eye Width | PAM4 0/1 1/2 2/3 Level, QPRBS13-CEI, Eye Width where BER is 1E-06, when using External Clock ≥ 7.15 ps* ¹⁰ |
| Termination | 50 Ω, GND, Variable |
| Termination Voltage | When set to Variable: -2.5 to +3.5 V, 10 mV step |
| Connector | K connector (f.) (When the Option 001 is installed) |

*9: Differential, Mark Ratio 1/2, when connecting J1758A and MU196020A by using J1789A, 34VKF50 and J1728A.



At a constant temperature between 20 and 30°C, measure with a 70-GHz bandwidth sampling oscilloscope with residual jitter of less than 200 fs (RMS).

Adjust De-Emphasis (2 Pre Cursors and 1 Post Cursor) of MU196020A so that the product of Eye Height (1E-06) and Eye Width (1E-06) can be maximized in the differential waveform.

Calculate the 4th-order Bessel Filter (Cutoff Frequency 50 GHz) + CTLE (+1 dB Peaking at 14 GHz) and calibrate it to a PAM4 waveform with Eye Amplitude of 0.88 V_{p-p} (Diff) or less and Eye Linearity RLM 0.85 or more.

*10: 28 Gbaud, when the Option 001 is installed, BER 1E-12

Table 1.3.2-4 Clock Input

| Item | Specifications |
|----------------------|--|
| External Clock Input | Operation Baud Rate = Clock Input Frequency (When the Option 001 is installed) |
| Number of inputs | 1 (Single-Ended) |
| Frequency range | When the Option 001 is installed: 2.4 to 32.1 GHz |
| Amplitude | 0.3 to 1.0 V _{p-p} (–6.5 to +4.0 dBm) (Input Frequency ≤ 16.05 GHz) 0.4 to 1.0 V _{p-p} (–3.9 to +4.0 dBm) (Input Frequency > 16.05 GHz) |
| Termination | 50 Ω, AC Coupling |
| Connector | K connector (f.) |

Table 1.3.2-5 Aux Input

| Item | Specifications |
|---------------------|--|
| Number of inputs | 1 (Single-Ended) |
| Variation | External Mask, Burst |
| Minimum pulse width | 1/256 of Data rate |
| Input level | <ul style="list-style-type: none"> 0/–1 V (H: –0.25 to 0.05 V, L: –1.1 to –0.8 V) 0/–0.5 V (H: –0.05 to 0.05 V, L: –0.55 to –0.45 V) V_{th} 0 V (Input amplitude 0.5 to 1.0 V_{p-p}) Select one of the above. |
| Termination | 50 Ω, GND |
| Connector | SMA connector (f.) |

Table 1.3.2-6 Aux Output

| Item | Specifications |
|----------------------------|--|
| Number of outputs | 2 (Differential) |
| Variation | 1/n Clock (n = 8, 12, 16, 20...1020, 1024), Pattern Sync, Sync Gain, Error Output |
| Pattern Sync PRBS, PRGM | Position: 1 to {(Least common multiple of Pattern Length' and 128) – 135}, 8 step (When the Option 001 is installed) Pattern Length' shall be the value obtained by multiplying Pattern Length setting until it becomes 1024 or more if it is 1023 or less. |
| Output level | 0/–0.6 V (H: –0.25 to 0.05V, L: –0.80 to –0.45 V) |
| Termination | 50 Ω, GND |
| Connector | SMA connector (f.) |

Table 1.3.2-7 Pattern Detection

| Item | Specifications |
|--|--|
| PRBS | |
| Pattern length | $2^n - 1$ ($n = 7, 9, 10, 11, 13, 15, 20, 23, 31$) |
| Mark ratio | 1/2, 1/2 _{inv} |
| PRBS generator polynomial | $n=7: 1 + X^6 + X^7$ $n=9: 1 + X^5 + X^9$ $n=10: 1 + X^7 + X^{10}$ $n=11: 1 + X^9 + X^{11}$ $n=13: 1 + X + X^2 + X^{12} + X^{13}$ $n=15: 1 + X^{14} + X^{15}$ $n=20: 1 + X^3 + X^{20}$ $n=23: 1 + X^{18} + X^{23}$ $n=31: 1 + X^{28} + X^{31}$ |
| PRBS Inversion | This is available in PAM4 mode only. Logically inverted PRBS can be set independently for MSB and LSB. |
| Zero-Substitution | This is available in NRZ mode only. |
| Additional Bit | 0 bit, 1 bit |
| Pattern length | 2^n or $2^n - 1$ ($n = 7, 9, 10, 11, 15, 20, 23$) |
| Start position | Substitutes the bit coming after the maximum “0” successive bits. |
| Zero-Length | 1 to (Pattern Length–1) bits If the bit coming after Zero-substitution is “0,” then it is replaced with “1.” |
| Data | |
| Data length | NRZ: 2 to 268 435 456 bits, 1 bit step PAM4: 2 to 268 435 456 symbols, 1 symbol step |
| Coding | NRZ, PAM4 |
| NRZ | Normal, Invert |
| PAM4 Gray Coding | ON, OFF |
| PAM4 Precoding ($1/(1 + D) \bmod 4$)* | ON, OFF |
| PAM4 Standard Pattern | Standard-compliant PAM4-mode patterns |
| CEI | QPRBS13-CEI, QPRBS31-CEI |
| IEEE | IEEE802.3bs/cd: PRBS13Q, PRBS31Q, SSPRQ, Square Wave IEEE802.3bj: QPRBS13, JP03A, JP03B, Transmitter Linearity |
| InfiniBand | PRBS13Q (InfiniBand), PRBS23Q, PRBS31Q (InfiniBand) |
| Fibre Channel | PRBS31Q (Fibre Channel) |
| NRZ Standard Pattern | Standard-compliant NRZ-mode pattern |
| CEI | SSPR |

*: $(1/(1+D) \bmod 4)$ is a generator polynomial defined in the IEEE802.3.

Table 1.3.2-8 Pattern Sequence

| Item | Specifications |
|---------------|--|
| Sequence | Repeat, Burst |
| Repeat | Continuous Pattern |
| Burst | This is available only when Coding is NRZ. |
| Source | Internal, External-Enable (Aux Input), External-Trigger (Aux Input) |
| Delay | Internal: 0 to 2 147 483 640 bits, 8 bits step Ext Trigger, Enable: 0 to 2 147 483 520 bits, 8 bits step Adjust Method: Auto, Manual |
| Enable Period | Internal: 12 800 to 2 147 482 624 bits, 256 bits step Ext Trigger: 12 800 to 2 147 483 136 bits, 256 bits step |
| Burst Cycle | 25 600 to 2 147 483 648 bits, 1024 bits step |

Table 1.3.2-9 Measurement

| Item | Specifications |
|---------|--|
| Counter | Error Rate (ER) Total: 0.000 1E–18 to 1.000 0E00 Error Count (EC) Total: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Error Interval: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 %Error Free Interval: 0.000 0 to 100.000 0 Error Rate (ER) Insertion (INS): 0.000 1E–18 to 1.000 0E00 Error Count (EC) Insertion (INS): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Error Rate (ER) Omission (OMI): 0.000 1E–18 to 1.000 0E00 Error Count (EC) Omission (OMI): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Frequency: 2 400.000 to 58 200.000 MHz Frequency measurement accuracy: $\pm 1 \text{ ppm } \pm 1 \text{ kHz}^*$ Clock Count: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Sync Loss Interval: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Clock Loss Interval: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Expressions enclosed in parentheses are abbreviations. |
| | The following are available only for PAM4 (Diagnostics Mode ON) measurement. MSB Error Rate (ER) Total: 0.000 1E–18 to 1.000 0E00 MSB Error Count (EC) Total: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 MSB Error Interval: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 MSB %Error Free Interval: 0.000 0 to 100.000 0 MSB Error Rate (ER) Insertion (INS): 0.000 1E–18 to 1.000 0E00 MSB Error Count (EC) Insertion (INS): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 MSB Error Rate (ER) Omission (OMI): 0.000 1E–18 to 1.000 0E00 MSB Error Count (EC) Omission (OMI): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 LSB Error Rate (ER) Total: 0.000 1E–18 to 1.000 0E00 LSB Error Count (EC) Total: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 LSB Error Interval: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 LSB %Error Free Interval: 0.000 0 to 100.000 0 LSB Error Rate (ER) Insertion (INS): 0.000 1E–18 to 1.000 0E00 LSB Error Count (EC) Insertion (INS): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 LSB Error Rate (ER) Omission (OMI): 0.000 1E–18 to 1.000 0E00 LSB Error Count (EC) Omission (OMI): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Expressions enclosed in parentheses are abbreviations. |

*: With a gating system and with MP1900A's reference clock (10 MHz) calibrated

Table 1.3.2-9 Measurement (Cont'd)

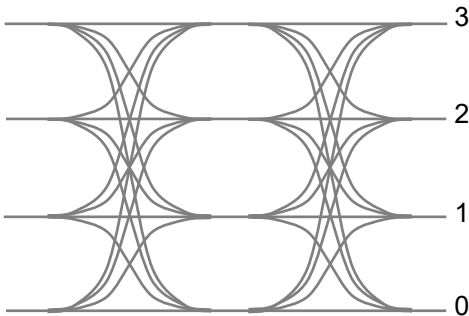
| Item | Specifications |
|------------------|---|
| Counter (Cont'd) | <p>The following are available when the Option x41 SER Measurement is installed.</p> <p>The following are available only for PAM4 (Diagnostics Mode OFF) measurement.</p>  <p>Symbol Error Rate (SER): 0.000 1E-18 to 1.000 0E00 Symbol Error Count (SEC): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Symbol Error Interval: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Symbol %Error Free Interval: 0.000 0 to 100.000 0</p> <p>Level 0 → 3 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 0 → 2 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 0 → 1 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 0 → 3 ER: 0.000 1E-18 to 1.000 0E00 Level 0 → 2 ER: 0.000 1E-18 to 1.000 0E00 Level 0 → 1 ER: 0.000 1E-18 to 1.000 0E00 Level 0 EC Total: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 0 ER Total: 0.000 1E-18 to 1.000 0E00</p> <p>Level 1 → 3 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 1 → 2 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 1 → 0 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 1 → 3 ER: 0.000 1E-18 to 1.000 0E00 Level 1 → 2 ER: 0.000 1E-18 to 1.000 0E00 Level 1 → 0 ER: 0.000 1E-18 to 1.000 0E00 Level 1 EC Total: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 1 ER Total: 0.000 1E-18 to 1.000 0E00</p> |

Table 1.3.2-9 Measurement (Cont'd)

| Item | Specifications |
|------------------------|---|
| Counter (Cont'd) | <p>Level 2 → 3 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17</p> <p>Level 2 → 1 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17</p> <p>Level 2 → 0 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17</p> <p>Level 2 → 3 ER: 0.000 1E-18 to 1.000 0E00</p> <p>Level 2 → 1 ER: 0.000 1E-18 to 1.000 0E00</p> <p>Level 2 → 0 ER: 0.000 1E-18 to 1.000 0E00</p> <p>Level 2 EC Total: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17</p> <p>Level 2 ER Total: 0.0001E-18 to 1.000 0E00</p> <p>Level 3 → 2 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17</p> <p>Level 3 → 1 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17</p> <p>Level 3 → 0 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17</p> <p>Level 3 → 2 ER: 0.000 1E-18 to 1.000 0E00</p> <p>Level 3 → 1 ER: 0.000 1E-18 to 1.000 0E00</p> <p>Level 3 → 0 ER: 0.000 1E-18 to 1.000 0E00</p> <p>Level 3 EC Total: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17</p> <p>Level 3 ER Total: 0.000 1E-18 to 1.000 0E00</p> <p>Expressions enclosed in parentheses are abbreviations.</p> |
| Gating | Time, Clock Count, Error Count |
| Gating Unit | Time: 1 second to 99 days 23 hours 59 minute 59 seconds |
| | Clock Count: >E+4 to >E+16 |
| | Error Count: >E+4 to >E+16 |
| Cycle | Single, Repeat, Untimed |
| Current | On, Off can be set. |
| | Calculation: Progressive, Immediate |
| | Interval: 100 ms, 200 ms |
| Auto Sync | On, Off can be set. |
| | Synchronization threshold: INT, E-2 to E-8 |
| Sync Control | PRBS: Automatic Synchronization |
| | Data: Frame On |
| Frame Length | NRZ: 4 to 64 bits, 4 bits step |
| | PAM4: 4 to 64 symbols, 4 symbol step |
| Frame Mask | Available |
| Frame Position | NRZ: 1 to (Pattern Length – Frame Length +1) bits, 1 bit step |
| | PAM4: 1 to (Pattern Length – Frame Length +1) symbols, 1 symbol step |
| Error/Alarm Conditions | |
| Error Detection | NRZ: Insertion/Omission, Transition/Non Transition |
| | PAM4: Not available |
| EI/EFI Interval | 1 ms, 10 ms, 100 ms, 1 s |

Table 1.3.2-10 Error Analysis

| Item | Specifications | | | | | | | | | | | | | | | | | | |
|------------------------------------|---|-----------------------|-------------|----------------|---|------------------------|---|------------------------|---|-------------------------|---|--------------------------|----|--------------------------|----|---------------------------|----|----------------------------|-----|
| Block Window Setting resolution | Excludes the specified data pattern from measurement. <table> <tr> <th>Pattern length (bits)</th><th>Step (bits)</th></tr> <tr> <td>2 to 2 097 152</td><td>1</td></tr> <tr> <td>2 097 153 to 4 194 304</td><td>2</td></tr> <tr> <td>4 194 305 to 8 388 608</td><td>4</td></tr> <tr> <td>8 388 609 to 16 777 216</td><td>8</td></tr> <tr> <td>16 777 217 to 33 554 432</td><td>16</td></tr> <tr> <td>33 554 433 to 67 108 864</td><td>32</td></tr> <tr> <td>67 108 865 to 134 217 728</td><td>64</td></tr> <tr> <td>134 217 729 to 268 435 456</td><td>128</td></tr> </table> | Pattern length (bits) | Step (bits) | 2 to 2 097 152 | 1 | 2 097 153 to 4 194 304 | 2 | 4 194 305 to 8 388 608 | 4 | 8 388 609 to 16 777 216 | 8 | 16 777 217 to 33 554 432 | 16 | 33 554 433 to 67 108 864 | 32 | 67 108 865 to 134 217 728 | 64 | 134 217 729 to 268 435 456 | 128 |
| Pattern length (bits) | Step (bits) | | | | | | | | | | | | | | | | | | |
| 2 to 2 097 152 | 1 | | | | | | | | | | | | | | | | | | |
| 2 097 153 to 4 194 304 | 2 | | | | | | | | | | | | | | | | | | |
| 4 194 305 to 8 388 608 | 4 | | | | | | | | | | | | | | | | | | |
| 8 388 609 to 16 777 216 | 8 | | | | | | | | | | | | | | | | | | |
| 16 777 217 to 33 554 432 | 16 | | | | | | | | | | | | | | | | | | |
| 33 554 433 to 67 108 864 | 32 | | | | | | | | | | | | | | | | | | |
| 67 108 865 to 134 217 728 | 64 | | | | | | | | | | | | | | | | | | |
| 134 217 729 to 268 435 456 | 128 | | | | | | | | | | | | | | | | | | |
| Bit Window | Excludes any channels among internal 32 channels from measurement. (Available only in NRZ mode.) | | | | | | | | | | | | | | | | | | |
| External Mask | H: Measurement L: Mask | | | | | | | | | | | | | | | | | | |

Table 1.3.2-11 Auto Measurement

| Item | Specifications |
|-------------|--|
| Auto Adjust | NRZ: Vth direction only (Phase direction not supported.)* ¹ PAM4: MSB Vth direction only (Phase direction not supported.)* ¹ , * ² |
| Auto Search | NRZ: Available* ¹ PAM4 (LSB/MSB Diagnostics OFF/ON): Available* ¹ , * ² |

*1: PRBS Pattern, Mark Ratio 1/2

*2: Each of amplitudes shall be equal.

Table 1.3.2-12 Variable Clock Delay

| Item | Specifications |
|-----------------------|---|
| Phase variable range | –1000 to +1000 mUI, 2 mUI step |
| Accuracy | $\pm 50 \text{ mUIp-p}^{*1,*2}$ |
| mUI – ps switching | Available (internally converted into ps) |
| Calibration | Available (when jitter modulation is off) |
| Calibration indicator | This indicator is on when Calibration is required due to: <ul style="list-style-type: none"> • Change in 1/1Clock frequency by $\pm 250 \text{ kHz}$. • Change in the ambient temperature by $\pm 5^\circ\text{C}$. |

*1: Measure using an oscilloscope with residual jitter of less than 200 fs (RMS).

*2: Typical value

Table 1.3.2-13 Jitter Tolerance

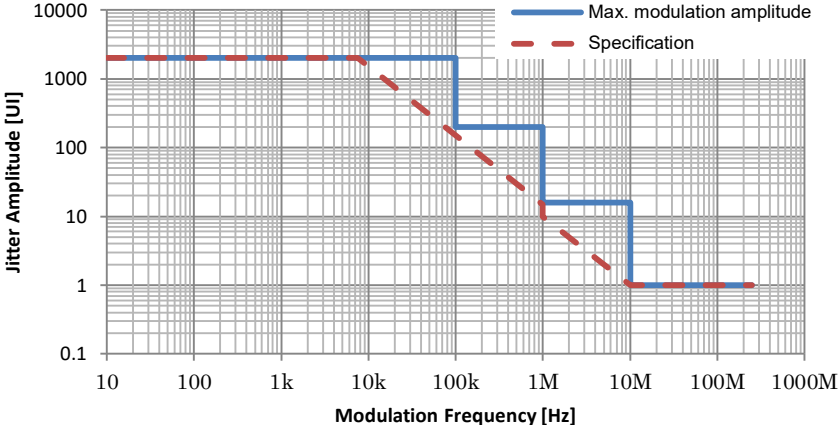
| Item | Specifications | | | | | | | | | | | | | | | | | | | | | |
|---------------------------|--|---------------------------|-----------------------------------|-----------------------|----|-------|-------|-------|-------|-------|---------|-------|-----|-----------|-----|----|------------|----|---|-------------|---|---|
| Jitter tolerance | <p>For NRZ output</p> <p>Bit rate: 32.1 Gbit/s</p> <p>Pattern: PRBS2³¹−1</p> <p>With MU181500B, SSC with frequency of 33 kHz and deviation of 5300 ppm can be applied simultaneously with RJ with amplitude of 0.3 UI.</p> <p>These specifications are defined assuming the following conditions: Loopback connection to the MU196020A, at a constant temperature between 20 and 30°C.</p> <p>When RJ+BUJ is bigger than 0.5 UIp-p or SJ + RJ + BUJ is bigger than the standard value + 0.3 UIp-p, “Overload” is displayed on the MU181500B screen.</p> <div></div> <table><thead><tr><th>Modulation frequency [Hz]</th><th>Max. modulation amplitude [Ulp-p]</th><th>Specification [Ulp-p]</th></tr></thead><tbody><tr><td>10</td><td>2 000</td><td>2 000</td></tr><tr><td>7 500</td><td>2 000</td><td>2 000</td></tr><tr><td>100 000</td><td>2 000</td><td>150</td></tr><tr><td>1 000 000</td><td>200</td><td>15</td></tr><tr><td>10 000 000</td><td>16</td><td>1</td></tr><tr><td>250 000 000</td><td>1</td><td>1</td></tr></tbody></table> | Modulation frequency [Hz] | Max. modulation amplitude [Ulp-p] | Specification [Ulp-p] | 10 | 2 000 | 2 000 | 7 500 | 2 000 | 2 000 | 100 000 | 2 000 | 150 | 1 000 000 | 200 | 15 | 10 000 000 | 16 | 1 | 250 000 000 | 1 | 1 |
| Modulation frequency [Hz] | Max. modulation amplitude [Ulp-p] | Specification [Ulp-p] | | | | | | | | | | | | | | | | | | | | |
| 10 | 2 000 | 2 000 | | | | | | | | | | | | | | | | | | | | |
| 7 500 | 2 000 | 2 000 | | | | | | | | | | | | | | | | | | | | |
| 100 000 | 2 000 | 150 | | | | | | | | | | | | | | | | | | | | |
| 1 000 000 | 200 | 15 | | | | | | | | | | | | | | | | | | | | |
| 10 000 000 | 16 | 1 | | | | | | | | | | | | | | | | | | | | |
| 250 000 000 | 1 | 1 | | | | | | | | | | | | | | | | | | | | |

Table 1.3.2-14 Clock Recovery

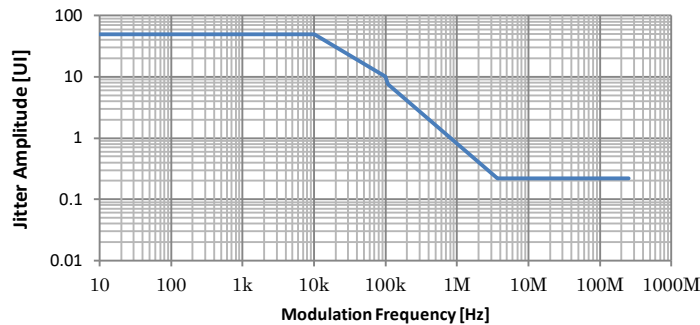
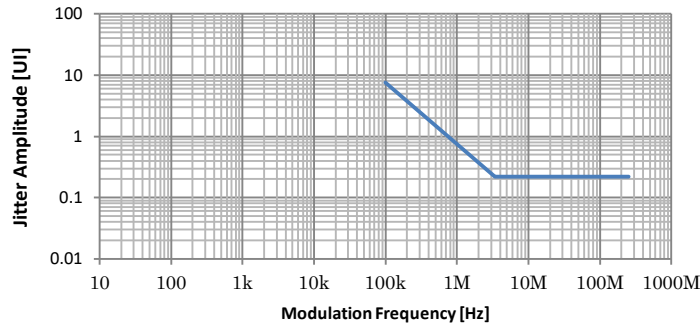
| Item | Specifications* ¹ | | | | | | | | | | | | | | | | | | | | | |
|---|--|-------------------|-------------------|---------|----------|------------|--|---------|------------|--|------------------|------------|--|----------------|------------|--|-------------------|------------|--|----------------|------------|--|
| Operating bit rate | NRZ: 25.5 to 32.1 Gbit/s PAM4: 25.5 to 32.1 Gbaud | | | | | | | | | | | | | | | | | | | | | |
| Setting range | 25.500 000 to 32.100 000 Gbaud, 0.000 001 Gbaud step | | | | | | | | | | | | | | | | | | | | | |
| Supported standard and baud rate | For NRZ mode | | | | | | | | | | | | | | | | | | | | | |
| | <table><tr><th>Standard</th><th>Bit Rate [Gbit/s]</th><th>Remarks</th></tr><tr><td>100G ULH</td><td>32.100 000</td><td></td></tr><tr><td>32G FC</td><td>28.050 000</td><td></td></tr><tr><td>CEI-28G</td><td>28.000 000</td><td></td></tr><tr><td>100G OTU4</td><td>27.952 496</td><td></td></tr><tr><td>100GbE(25.78 × 4)</td><td>25.781 250</td><td></td></tr><tr><td>InfiniBand EDR</td><td>25.781 250</td><td></td></tr></table> | Standard | Bit Rate [Gbit/s] | Remarks | 100G ULH | 32.100 000 | | 32G FC | 28.050 000 | | CEI-28G | 28.000 000 | | 100G OTU4 | 27.952 496 | | 100GbE(25.78 × 4) | 25.781 250 | | InfiniBand EDR | 25.781 250 | |
| | Standard | Bit Rate [Gbit/s] | Remarks | | | | | | | | | | | | | | | | | | | |
| | 100G ULH | 32.100 000 | | | | | | | | | | | | | | | | | | | | |
| | 32G FC | 28.050 000 | | | | | | | | | | | | | | | | | | | | |
| | CEI-28G | 28.000 000 | | | | | | | | | | | | | | | | | | | | |
| | 100G OTU4 | 27.952 496 | | | | | | | | | | | | | | | | | | | | |
| | 100GbE(25.78 × 4) | 25.781 250 | | | | | | | | | | | | | | | | | | | | |
| | InfiniBand EDR | 25.781 250 | | | | | | | | | | | | | | | | | | | | |
| | For PAM4 mode | | | | | | | | | | | | | | | | | | | | | |
| | <table><tr><th>Standard</th><th>Baud Rate [Gbaud]</th><th>Remarks</th></tr><tr><td>64G FC</td><td>28.900 000</td><td></td></tr><tr><td>CEI-56G</td><td>28.000 000</td><td></td></tr><tr><td>200GbE(26.6 × 4)</td><td>26.562 500</td><td></td></tr><tr><td>InfiniBand HDR</td><td>26.562 500</td><td></td></tr></table> | Standard | Baud Rate [Gbaud] | Remarks | 64G FC | 28.900 000 | | CEI-56G | 28.000 000 | | 200GbE(26.6 × 4) | 26.562 500 | | InfiniBand HDR | 26.562 500 | | | | | | | |
| | Standard | Baud Rate [Gbaud] | Remarks | | | | | | | | | | | | | | | | | | | |
| | 64G FC | 28.900 000 | | | | | | | | | | | | | | | | | | | | |
| | CEI-56G | 28.000 000 | | | | | | | | | | | | | | | | | | | | |
| | 200GbE(26.6 × 4) | 26.562 500 | | | | | | | | | | | | | | | | | | | | |
| InfiniBand HDR | 26.562 500 | | | | | | | | | | | | | | | | | | | | | |
| Operating bit rate tracking | Tracks the operating bit rate of the PPG selected from the PPGs installed in the same MP1900A. | | | | | | | | | | | | | | | | | | | | | |
| Maximum number of consecutive zeros* ² | 72 bit (Zero Substitution 2 ¹⁵) | | | | | | | | | | | | | | | | | | | | | |
| Lock range* ² | ±100 ppm | | | | | | | | | | | | | | | | | | | | | |
| Target loop band* ³ | Baud rate / 1667, Baud rate / 2578, Baud rate / 6640, Jitter Tolerance | | | | | | | | | | | | | | | | | | | | | |

*1: When the Option x22 is installed, these are specified with the conditions of PRBS Pattern and Mark Ratio 1/2 (in PAM4 mode, MSB Mark Ratio 1/2) unless otherwise specified.

*2: The target loop band is specified by 1/1667, 1/2578, 1/6640.

*3: The SSPRQ pattern supports Baud rate / 6640 only. When set to Jitter Tolerance, Baud rate / 1667 or higher.

Table 1.3.2-14 Clock Recovery (Cont'd)

| Item | Specifications | | | | | | | | | | | | | | | | | | | | | | |
|---|--|---------------------------|-------------------------------|----|----|--------|----|---------|----|---------|-----|-----------|------|-------------|------|---------------------------|-------------------------------|---------|-----|-----------|------|-------------|------|
| Jitter Tolerance Clock Recovery*4,*5 | <p>At the bit rate of 28.05 Gbaud, conforming to Jitter Tolerance Mask defined by the “32G FC standard”. The following masks are taken as typical values:</p>  <table border="1"> <thead> <tr> <th>Modulation Frequency (Hz)</th><th>Jitter Tolerance Mask (UIp-p)</th></tr> </thead> <tbody> <tr><td>10</td><td>50</td></tr> <tr><td>10 000</td><td>50</td></tr> <tr><td>100 000</td><td>10</td></tr> <tr><td>108 805</td><td>7.5</td></tr> <tr><td>3 709 271</td><td>0.22</td></tr> <tr><td>250 000 000</td><td>0.22</td></tr> </tbody> </table> <p>At the bit rate of 25.78125 Gbaud, conforming to Jitter Tolerance Mask defined by the “100GbE (25.78G × 4) standard”. The following masks are taken as typical values:</p>  <table border="1"> <thead> <tr> <th>Modulation Frequency (Hz)</th><th>Jitter Tolerance Mask (UIp-p)</th></tr> </thead> <tbody> <tr><td>100 000</td><td>7.5</td></tr> <tr><td>3 409 256</td><td>0.22</td></tr> <tr><td>250 000 000</td><td>0.22</td></tr> </tbody> </table> | Modulation Frequency (Hz) | Jitter Tolerance Mask (UIp-p) | 10 | 50 | 10 000 | 50 | 100 000 | 10 | 108 805 | 7.5 | 3 709 271 | 0.22 | 250 000 000 | 0.22 | Modulation Frequency (Hz) | Jitter Tolerance Mask (UIp-p) | 100 000 | 7.5 | 3 409 256 | 0.22 | 250 000 000 | 0.22 |
| Modulation Frequency (Hz) | Jitter Tolerance Mask (UIp-p) | | | | | | | | | | | | | | | | | | | | | | |
| 10 | 50 | | | | | | | | | | | | | | | | | | | | | | |
| 10 000 | 50 | | | | | | | | | | | | | | | | | | | | | | |
| 100 000 | 10 | | | | | | | | | | | | | | | | | | | | | | |
| 108 805 | 7.5 | | | | | | | | | | | | | | | | | | | | | | |
| 3 709 271 | 0.22 | | | | | | | | | | | | | | | | | | | | | | |
| 250 000 000 | 0.22 | | | | | | | | | | | | | | | | | | | | | | |
| Modulation Frequency (Hz) | Jitter Tolerance Mask (UIp-p) | | | | | | | | | | | | | | | | | | | | | | |
| 100 000 | 7.5 | | | | | | | | | | | | | | | | | | | | | | |
| 3 409 256 | 0.22 | | | | | | | | | | | | | | | | | | | | | | |
| 250 000 000 | 0.22 | | | | | | | | | | | | | | | | | | | | | | |

*4: Defined assuming the following conditions:

- Loop-back connection to MU196020A
- NRZ input
- Test Pattern (Length): PRBS2³¹−1
- Data input amplitude: 0.1 Vp-p

*5: Typical value, specified at a constant temperature between 20 and 30°C.

Table 1.3.2-15 Mechanical Performance

| Item | Specifications |
|-----------------------|---|
| Dimensions | 21 mm (H), 234 mm (W), 175 mm (D), Excluding protrusions |
| Mass | 2.5 kg max. |
| Operating temperature | 15 to 30°C MP1900A's ambient temperature. MU196040A shall operate when installed. |
| Storage temperature | −20 to 60°C MU196040A installed to MP1900A shall comply with MIL-T-28800E Class 5. |

1.3.3 Specifications for MU196040B

Table 1.3.3-1 Operating Baud Rate

| Item | Specifications |
|---------------------|---|
| Operating Baud Rate | When the Option 001 is installed. PAM4 input: 2.4 to 32.1 Gbaud NRZ input: 2.4 to 32.1 Gbit/s When the Option 002 or y12 is installed. PAM4 input: 2.4 to 58.2 Gbaud NRZ input: 2.4 to 64.2 Gbit/s |

Table 1.3.3-2 System Clock

| Item | Specifications |
|--------------|---|
| System Clock | External, Recovered Clock (When the Option x21, x22, x23, or y24 is installed) External: Clock input from the Ext Clock Input connector For PAM4, select from 2.4 to 32.1 Gbaud, 32.1 to 58.2 Gbaud and Auto. For NRZ, select from 2.4 to 32.1 Gbit/s, 32.1 to 64.2 Gbit/s and Auto. Recovered Clock: Clock recovered from the data input from the Data Input connector |

Table 1.3.3-3 Data Input

| Item | Specifications |
|------------------------------------|--|
| Number of inputs | 2 (Data, XData) (Differential) |
| Input Condition | Single-Ended, Differential 50 Ohm, Differential 100 Ohm When set to Differential 50 Ohm or Differential 100 Ohm: Independent, Tracking, Alternate* ¹ When set to Alternate: Data-XData, XData-Data* ² When set to Single-Ended: Data, XData* ³ |
| Signal Type LSB/MSB Diagnostics | NRZ, PAM4 When set to PAM4, the PAM4 mode can be switched between as follows: Diagnostics Mode OFF: Treats signals as symbols by receiving LSB and MSB while synchronizing them with each other. Diagnostics Mode ON: Asynchronously receives LSB and MSB. |
| Amplitude | NRZ: The range in which the Auto Adjust function and the Auto Search function operate. 0.05 to 1.0 Vp-p* ^{4,5} 0.1 to 1.0 Vp-p* ^{4,6} PAM4: The range in which the Auto Search PAM4 Fine function operates. 0.3 to 1.0 Vp-p* ^{7,8} 0.4 to 1.0 Vp-p* ^{7,9} |
| Threshold | NRZ, PAM4 Middle Eye Threshold: -3.5 to +3.3 V, 1 mV step * ^{2,10} PAM4 Upper Eye Threshold: -3.9 to +3.7 V, 1 mV step * ¹¹ PAM4 Lower Eye Threshold: -3.9 to +3.7 V, 1 mV step * ¹¹ |

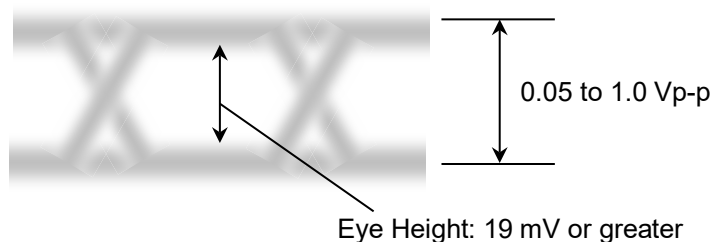
*1: Tracking is available only for NRZ.

*2: The absolute value of the difference between Data and XData Threshold values shall be 1.5 V or less.

*3: PAM4 Upper Eye and Lower Eye can be set by relative values to Middle Eye in the range of -0.4 V to +0.4 V.

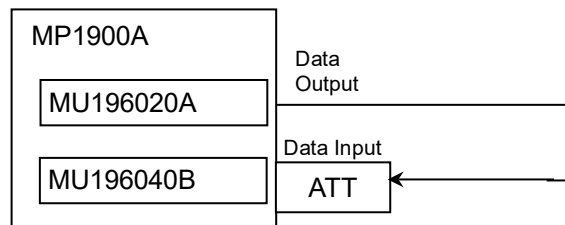
*4: Single-Ended, Differential, Mark Ratio1/2, the Eye Height shall meet the specification.

Example of waveform input to MU196040B when bit rate is 32.1 Gbit/s

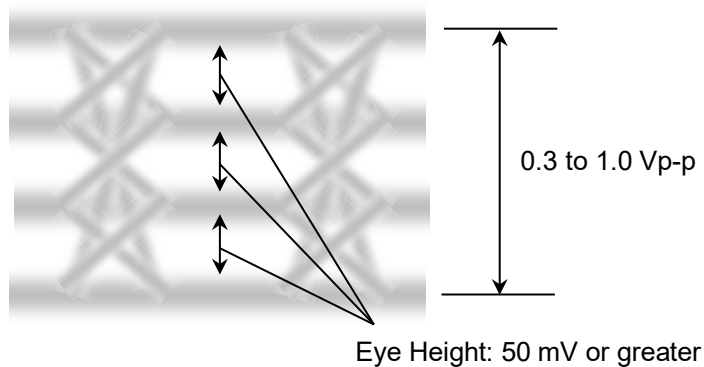


*5: Bit rate ≤ 32.1 Gbit/s

- *6: Bit rate >32.1 Gbit/s
- *7: 0/3 Level, PRBS31, Mark Ratio1/2, with connected to the MU196020A using an attenuator, with Emphasis adjusted so that the Eye Height meets the specification



Example of waveform input to MU196040B when baud rate is 32.1 Gbaud



- *8: Single-Ended, Differential, Baud rate \leq 32.1 Gbaud
- *9: Differential, Baud rate >32.1 Gbaud
- *10: Data and XData can be set independently.
- *11: Data and XData cannot be set independently, and can be set in the range of ± 0.4 V from Middle Eye Threshold.

Table 1.3.3-3 Data Input (Cont'd)

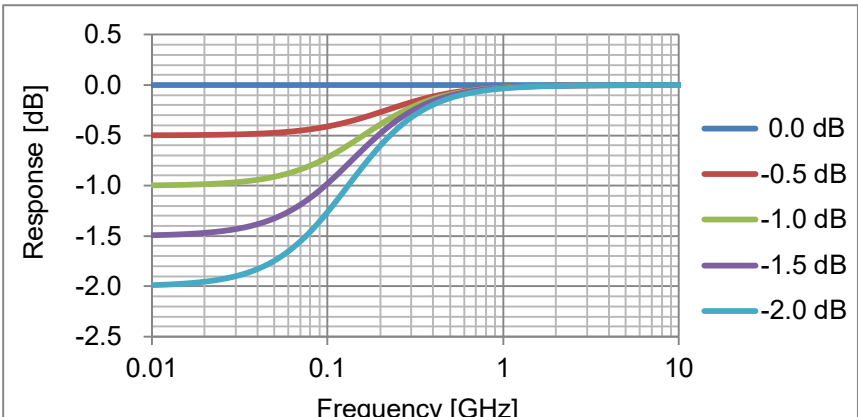
| Item | Specifications |
|---------------|---|
| Sensitivity | Single-Ended, Mark Ratio 1/2, PRBS31, when connecting directly to the MU196020A using J1789A and an attenuator, Emphasis ON, unused connectors on the MU196020A and MU196040B are terminated, At a constant temperature between 20 and 30°C |
| Eye Amplitude | NRZ Typ. 25 mVp-p, ≤ 50 mVp-p* ¹² (26.5625 Gbit/s, 32.1 Gbit/s) Typ. 31 mVp-p, ≤ 55 mVp-p* ¹³ (53.125 Gbit/s) Typ. 43 mVp-p, ≤ 60 mVp-p* ¹³ (64.2 Gbit/s) |
| Eye Height | NRZ Typ. 19 mV* ¹² (26.5625 Gbit/s, 32.1 Gbit/s) Typ. 21 mV* ¹³ (53.125 Gbit/s) Typ. 32 mV* ¹³ (64.2 Gbit/s) PAM4 0/1 1/2 2/3 Level, PRBS31, when using External Clock Typ. 23 mV, ≤ 50 mV* ¹² (26.5625 Gbaud, 32.1 Gbaud) Typ. 36 mV, ≤ 60 mV* ¹³ (53.125 Gbaud) Typ. 49 mV, ≤ 70 mV* ¹³ (58.2 Gbaud) Note that 53.125 Gbaud and 58.2 Gbaud are defined by the Eye Height value that results in a differential waveform having BER of 1E-06 by changing the test pattern to QPRBS13-CEI after setting the test pattern to PRBS31 and setting the amplitude value. |
| Phase Margin | Differential, Mark Ratio 1/2, PRBS31, when inputting 0.5 Vp-p, when connecting directly to the MU196020A using J1789A and an attenuator. At a constant temperature between 20 and 30°C, when using External Clock NRZ* ¹⁴ Typ. 25.8 ps* ¹² (26.5625 Gbit/s) Typ. 18.0 ps* ¹² (32.1 Gbit/s) Typ. 10.5 ps* ¹³ (53.125 Gbit/s) Typ. 8.7 ps* ¹³ (64.2 Gbit/s) PAM4 Typ. 5.3 ps* ¹² (26.5625 Gbaud) Typ. 4.5 ps* ¹² (32.1 Gbaud) Typ. 4.1 ps* ^{13,*14} (53.125 Gbaud) Typ. 2.5 ps* ^{13,*14} (58.2 Gbaud) |

*12: When the Option 001, 002, or y12 is installed.

*13: When the Option 002 or y12 is installed.

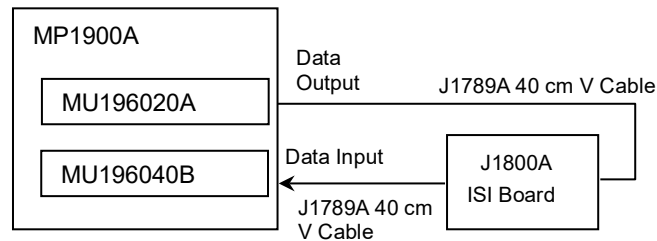
*14: Value including RJ equivalent to BER 1E-12 of input signal

Table 1.3.3-3 Data Input (Cont'd)

| Item | Specifications |
|--|--|
| Stressed Margin Stressed Eye Height | PAM4 0/1 1/2 2/3 Level, QPRBS13-CEI, Eye Height where BER is 1E-06, when using External Clock $\geq 32 \text{ mV}^{*15,*16}$ $\geq 37 \text{ mV}^{*17,*18}$ |
| Stressed Eye Width | PAM4 0/1 1/2 2/3 Level, QPRBS13-CEI, Eye Width where BER is 1E-06, when using External Clock $\geq 7.53 \text{ ps}^{*15,*16}$ $\geq 3.76 \text{ ps}^{*17,*18}$ |
| Termination Termination Voltage | 50 Ω , GND, Variable When set to Variable: -2.5 to +3.5 V, 10 mV step |
| Connector | V connector (f.) |
| Decision Feedback Equalizer Tap Coefficient Setting Range Loss Compensation | With a built-in Decision Feedback Equalizer (DFE) ^{*19} 1 0 to 30, 1 step Nom. 1.4 dB ^{*20} |
| Low Frequency Equalizer Gain Setting Range Accuracy Ideal Frequency Response | With a built-in Low Frequency Equalizer ^{*19} -2.0 to 0 dB, 0.5 dB step Typ. $\pm 1.0 \text{ dB}$  |

*15: 26.5625 Gbaud, when installed with the Option 001, 002 or y12 and the Option z11, BER 1E-12

*16: 26.5625 Gbaud, Differential, Mark Ratio 1/2, when J1789A is used to connect J1800A (1 pc) and MU196020A



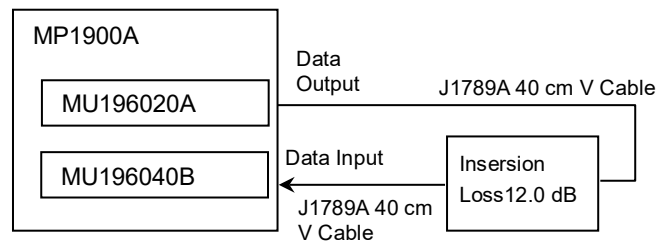
At a constant temperature between 20 and 30°C, measure with a 70-GHz bandwidth sampling oscilloscope with residual jitter of less than 200 fs (RMS).

Adjust De-Emphasis (2 Pre Cursors and 1 Post Cursor) of MU196020A so that the product of Eye Height (1E-06) and Eye Width (1E-06) can be maximized in the differential waveform.

Calculate the 4th-order Bessel Filter (Cutoff Frequency 40 GHz) + CTLE (+1 dB Peaking at 14 GHz) and calibrate it to a PAM4 waveform with Eye Amplitude of 0.88 Vp-p (Diff) or less and Eye Linearity R_{LM} 0.85 or more.

Activate the DFE and Low Frequency Equalizer in the MU196040B, and perform adjustment.

- *17: 53.125 Gbaud, when the Option 002, y12 and z11 are installed, BER 1E-8 nom.
- *18: 53.125 Gbaud, Differential, Mark Ratio1/2, when connecting a device with 12.0 dB insertion loss and MU196020A.



At a constant temperature between 20 and 30°C, measure with a 70-GHz bandwidth sampling oscilloscope with residual jitter of less than 200 fs (RMS).

Adjust De-Emphasis (2 Pre Cursors and 1 Post Cursor) of MU196020A so that the product of Eye Height (1E-06) and Eye Width (1E-06) can be maximized in the differential waveform.

Calculate the 4th-order Bessel Filter (Cutoff Frequency 43 GHz) + CTLE (+1 dB Peaking at 28 GHz) and calibrate it to a PAM4 waveform with Eye Amplitude of 0.88 Vp-p (Diff) or less and Eye Linearity R_{LM} 0.85 or more.

Activate the DFE and Low Frequency Equalizer in the MU196040B, and perform adjustment.

*19: When the Option z11 is installed.

*20: 53.125 Gbaud, Calculated from the following three:

- The BER result obtained when DFE is OFF under the condition of *18.
- The BER result obtained when DFE is OFF under the condition of *18 and 1.8 dB additional loss.
- The best BER result obtained when DFE is ON under the condition of *18 and 1.8 dB additional loss.

Table 1.3.3-4 Clock Input

| Item | Specifications |
|----------------------|--|
| External Clock Input | Operation Baud Rate = Clock Input Frequency × 2 |
| Number of inputs | 1 (Single-Ended) |
| Frequency range | 1.2 to 32.1 GHz |
| Amplitude | 0.3 to 1.0 V _{p-p} (–6.5 to +4.0 dBm) (Input Frequency ≤ 16.05 GHz) 0.4 to 1.0 V _{p-p} (–3.9 to +4.0 dBm) (Input Frequency > 16.05 GHz) |
| Termination | 50 Ω, AC Coupling |
| Connector | K connector (f.) |

Table 1.3.3-5 Aux Input

| Item | Specifications |
|---------------------|--|
| Number of inputs | 1 (Single-Ended) |
| Variation | External Mask, Burst, Capture External Trigger |
| Minimum pulse width | 1/256 of Data rate |
| Input level | <ul style="list-style-type: none"> • 0/–1 V (H: –0.25 to 0.05 V, L: –1.1 to –0.8 V) • 0/–0.5 V (H: –0.05 to 0.05 V, L: –0.55 to –0.45 V) • V_{th} 0 V (Input amplitude 0.5 to 1.0 V_{p-p}) Select one of the above. |
| Termination | 50 Ω, GND |
| Connector | SMA connector (f.) |

Table 1.3.3-6 Aux Output

| Item | Specifications |
|----------------------------|---|
| Number of outputs | 2 (Differential) |
| Variation | 1/n Clock (n = 8, 12, 16, 20...1020, 1024), Pattern Sync, Sync Gain, Error Output, Capture Trigger |
| Pattern Sync PRBS, PRGM | Position: 1 to {(Least common multiple of Pattern Length' and 256) – 263}, 8 steps (When the Option 001 is installed) Pattern Length' shall be the value obtained by multiplying Pattern Length setting until it becomes 1024 or more if it is 1023 or less. |
| Output level | 0/–0.6 V (H: –0.25 to 0.05V, L: –0.80 to –0.45 V) |
| Termination | 50 Ω, GND |
| Connector | SMA connector (f.) |

Table 1.3.3-7 Pattern Detection

| Item | Specifications |
|--|--|
| PRBS | |
| Pattern length | $2^n - 1$ ($n = 7, 9, 10, 11, 13, 15, 20, 23, 31$) |
| Mark ratio | 1/2, 1/2 _{inv} |
| PRBS generator polynomial | $n=7: 1 + X^6 + X^7$ $n=9: 1 + X^5 + X^9$ $n=10: 1 + X^7 + X^{10}$ $n=11: 1 + X^9 + X^{11}$ $n=13: 1 + X + X^2 + X^{12} + X^{13}$ $n=15: 1 + X^{14} + X^{15}$ $n=20: 1 + X^3 + X^{20}$ $n=23: 1 + X^{18} + X^{23}$ $n=31: 1 + X^{28} + X^{31}$ |
| PRBS Inversion | This is available in PAM4 mode only. Logically inverted PRBS can be set independently for MSB and LSB. |
| Zero-Substitution | This is available in NRZ mode only. |
| Additional Bit | 0 bit, 1 bit |
| Pattern length | 2^n or $2^n - 1$ ($n = 7, 9, 10, 11, 15, 20, 23$) |
| Start position | Substitutes the bit coming after the maximum “0” successive bits. |
| Zero-Length | 1 to (Pattern Length–1) bits If the bit coming after Zero-substitution is “0,” then it is replaced with “1.” |
| Data | |
| Data length | NRZ: 2 to 268 435 456 bits, 1 bit step PAM4: 2 to 268 435 456 symbols, 1 symbol step |
| Coding | NRZ, PAM4 |
| NRZ | Normal, Invert |
| PAM4 Gray Coding | ON, OFF |
| PAM4 Precoding ($1/(1 + D) \bmod 4$)* | ON, OFF |
| PAM4 Standard Pattern | Standard-compliant PAM4-mode patterns |
| CEI | QPRBS13-CEI, QPRBS31-CEI |
| IEEE | IEEE802.3bs/cd: PRBS13Q, PRBS31Q, SSPRQ, Square Wave IEEE802.3bj: QPRBS13, JP03A, JP03B, Transmitter Linearity |
| InfiniBand | PRBS13Q (InfiniBand), PRBS23Q, PRBS31Q (InfiniBand) |
| Fibre Channel | PRBS31Q (Fibre Channel) |
| NRZ Standard Pattern | Standard-compliant NRZ-mode pattern |
| CEI | SSPR |

*: $(1/(1+D) \bmod 4)$ is a generator polynomial defined in the IEEE802.3.

Table 1.3.3-8 Pattern Sequence

| Item | Specifications |
|---------------|--|
| Sequence | Repeat, Burst |
| Repeat | Continuous Pattern |
| Burst | This is available only when Coding is NRZ. |
| Source | Internal, External-Enable (Aux Input), External-Trigger (Aux Input) |
| Delay | Internal: 0 to 2 147 483 640 bits, 8 bits step Ext Trigger, Enable: 0 to 2 147 483 520 bits, 8 bits step Adjust Method: Auto, Manual |
| Enable Period | Internal: 12 800 to 2 147 482 624 bits, 256 bits step Ext Trigger: 12 800 to 2 147 483 136 bits, 256 bits step |
| Burst Cycle | 25 600 to 2 147 483 648 bits, 1024 bits step |

Table 1.3.3-9 Measurement

| Item | Specifications |
|---------|--|
| Counter | Error Rate (ER) Total: 0.000 1E–18 to 1.000 0E00 Error Count (EC) Total: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Error Interval: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 %Error Free Interval: 0.000 0 to 100.000 0 Error Rate (ER) Insertion (INS): 0.000 1E–18 to 1.000 0E00 Error Count (EC) Insertion (INS): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Error Rate (ER) Omission (OMI): 0.000 1E–18 to 1.000 0E00 Error Count (EC) Omission (OMI): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Frequency: 2 400.000 to 58 200.000 MHz Frequency measurement accuracy: ± 1 ppm ± 1 kHz* Clock Count: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Sync Loss Interval: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Clock Loss Interval: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Expressions enclosed in parentheses are abbreviations. |
| | The following are available only for PAM4 (Diagnostics Mode ON) measurement. MSB Error Rate (ER) Total: 0.000 1E–18 to 1.000 0E00 MSB Error Count (EC) Total: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 MSB Error Interval: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 MSB %Error Free Interval: 0.000 0 to 100.000 0 MSB Error Rate (ER) Insertion (INS): 0.000 1E–18 to 1.000 0E00 MSB Error Count (EC) Insertion (INS): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 MSB Error Rate (ER) Omission (OMI): 0.000 1E–18 to 1.000 0E00 MSB Error Count (EC) Omission (OMI): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 LSB Error Rate (ER) Total: 0.000 1E–18 to 1.000 0E00 LSB Error Count (EC) Total: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 LSB Error Interval: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 LSB %Error Free Interval: 0.000 0 to 100.000 0 LSB Error Rate (ER) Insertion (INS): 0.000 1E–18 to 1.000 0E00 LSB Error Count (EC) Insertion (INS): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 LSB Error Rate (ER) Omission (OMI): 0.000 1E–18 to 1.000 0E00 LSB Error Count (EC) Omission (OMI): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Expressions enclosed in parentheses are abbreviations. |

*: With a gating system and with MP1900A's reference clock (10 MHz) calibrated

Table 1.3.3-9 Measurement (Cont'd)

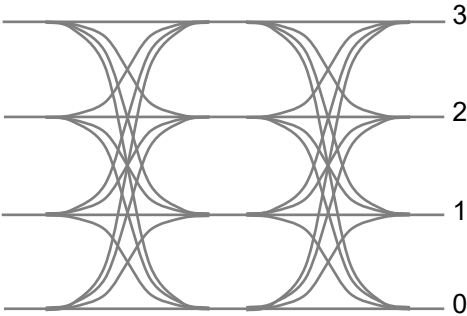
| Item | Specifications | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------------|--|-----------------|--|-----------------|--|-----------------|--|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-------------------|--|-------------------|---------------------------|-----------------|--|-----------------|--|-----------------|--|-----------------|---------------------------|-----------------|---------------------------|-----------------|---------------------------|-------------------|--|-------------------|---------------------------|
| Counter (Cont'd) | <p>The following are available when the Option z41 SER Measurement is installed.</p> <p>The following are available only for PAM4 (Diagnostics Mode OFF) measurement.</p>  <p>Symbol Error Rate (SER): 0.000 1E-18 to 1.000 0E00 Symbol Error Count (SEC): 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Symbol Error Interval: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Symbol %Error Free Interval: 0.000 0 to 100.000 0</p> <p>Details-Display1</p> <table> <tr> <td>Level 0 → 3 EC:</td><td>0 to 9 999 999, 1.000 0E07 to 9.999 9E17</td></tr> <tr> <td>Level 0 → 2 EC:</td><td>0 to 9 999 999, 1.000 0E07 to 9.999 9E17</td></tr> <tr> <td>Level 0 → 1 EC:</td><td>0 to 9 999 999, 1.000 0E07 to 9.999 9E17</td></tr> <tr> <td>Level 0 → 3 ER:</td><td>0.000 1E-18 to 1.000 0E00</td></tr> <tr> <td>Level 0 → 2 ER:</td><td>0.000 1E-18 to 1.000 0E00</td></tr> <tr> <td>Level 0 → 1 ER:</td><td>0.000 1E-18 to 1.000 0E00</td></tr> <tr> <td>Level 0 EC Total:</td><td>0 to 9 999 999, 1.000 0E07 to 9.999 9E17</td></tr> <tr> <td>Level 0 ER Total:</td><td>0.000 1E-18 to 1.000 0E00</td></tr> <tr> <td>Level 1 → 3 EC:</td><td>0 to 9 999 999, 1.000 0E07 to 9.999 9E17</td></tr> <tr> <td>Level 1 → 2 EC:</td><td>0 to 9 999 999, 1.000 0E07 to 9.999 9E17</td></tr> <tr> <td>Level 1 → 0 EC:</td><td>0 to 9 999 999, 1.000 0E07 to 9.999 9E17</td></tr> <tr> <td>Level 1 → 3 ER:</td><td>0.000 1E-18 to 1.000 0E00</td></tr> <tr> <td>Level 1 → 2 ER:</td><td>0.000 1E-18 to 1.000 0E00</td></tr> <tr> <td>Level 1 → 0 ER:</td><td>0.000 1E-18 to 1.000 0E00</td></tr> <tr> <td>Level 1 EC Total:</td><td>0 to 9 999 999, 1.000 0E07 to 9.999 9E17</td></tr> <tr> <td>Level 1 ER Total:</td><td>0.000 1E-18 to 1.000 0E00</td></tr> </table> | Level 0 → 3 EC: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | Level 0 → 2 EC: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | Level 0 → 1 EC: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | Level 0 → 3 ER: | 0.000 1E-18 to 1.000 0E00 | Level 0 → 2 ER: | 0.000 1E-18 to 1.000 0E00 | Level 0 → 1 ER: | 0.000 1E-18 to 1.000 0E00 | Level 0 EC Total: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | Level 0 ER Total: | 0.000 1E-18 to 1.000 0E00 | Level 1 → 3 EC: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | Level 1 → 2 EC: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | Level 1 → 0 EC: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | Level 1 → 3 ER: | 0.000 1E-18 to 1.000 0E00 | Level 1 → 2 ER: | 0.000 1E-18 to 1.000 0E00 | Level 1 → 0 ER: | 0.000 1E-18 to 1.000 0E00 | Level 1 EC Total: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | Level 1 ER Total: | 0.000 1E-18 to 1.000 0E00 |
| Level 0 → 3 EC: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 0 → 2 EC: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 0 → 1 EC: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 0 → 3 ER: | 0.000 1E-18 to 1.000 0E00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 0 → 2 ER: | 0.000 1E-18 to 1.000 0E00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 0 → 1 ER: | 0.000 1E-18 to 1.000 0E00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 0 EC Total: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 0 ER Total: | 0.000 1E-18 to 1.000 0E00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 1 → 3 EC: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 1 → 2 EC: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 1 → 0 EC: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 1 → 3 ER: | 0.000 1E-18 to 1.000 0E00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 1 → 2 ER: | 0.000 1E-18 to 1.000 0E00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 1 → 0 ER: | 0.000 1E-18 to 1.000 0E00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 1 EC Total: | 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Level 1 ER Total: | 0.000 1E-18 to 1.000 0E00 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 1.3.3-9 Measurement (Cont'd)

| Item | Specifications |
|------------------|--|
| Counter (Cont'd) | <p> Level 2 → 3 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 2 → 1 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 2 → 0 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 2 → 3 ER: 0.000 1E-18 to 1.000 0E00 Level 2 → 1 ER: 0.000 1E-18 to 1.000 0E00 Level 2 → 0 ER: 0.000 1E-18 to 1.000 0E00 Level 2 EC Total: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 2 ER Total: 0.0001E-18 to 1.000 0E00 </p> <p> Level 3 → 2 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 3 → 1 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 3 → 0 EC: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 3 → 2 ER: 0.000 1E-18 to 1.000 0E00 Level 3 → 1 ER: 0.000 1E-18 to 1.000 0E00 Level 3 → 0 ER: 0.000 1E-18 to 1.000 0E00 Level 3 EC Total: 0 to 9 999 999, 1.000 0E07 to 9.999 9E17 Level 3 ER Total: 0.000 1E-18 to 1.000 0E00 </p> <p> Details-Display2 Transition 1level Level 0 → 1 and Level 1 → 0 SEC: 0 to 9,999,999, 1.000 0E07 to 9.999 9E17 Level 1 → 2 and Level 2 → 1 SEC: 0 to 9,999,999, 1.000 0E07 to 9.999 9E17 Level 2 → 3 and Level 3 → 2 SEC: 0 to 9,999,999, 1.000 0E07 to 9.999 9E17 </p> <p> Transition 2level Level 0 → 2 and Level 2 → 0 SEC: 0 to 9,999,999, 1.000 0E07 to 9.999 9E17 Level 1 → 3 and Level 3 → 1 SEC: 0 to 9,999,999, 1.000 0E07 to 9.999 9E17 </p> <p> Transition 3level Level 0 → 3 and Level 3 → 0 SEC: 0 to 9,999,999, 1.000 0E07 to 9.999 9E17 </p> <p> Upper Eye Total SEC: 0 to 9,999,999, 1.000 0E07 to 9.999 9E17 Middle Eye Total SEC: 0 to 9,999,999, 1.000 0E07 to 9.999 9E17 Lower Eye Total SEC: 0 to 9,999,999, 1.000 0E07 to 9.999 9E17 Upper Eye Total SER: 0.000 1E-18 to 1.000 0E00 Middle Eye Total SER: 0.000 1E-18 to 1.000 0E00 Lower Eye Total SER: 0.000 1E-18 to 1.000 0E00 </p> <p>Expressions enclosed in parentheses are abbreviations.</p> |

Table 1.3.3-9 Measurement (Cont'd)

| Item | Specifications |
|------------------------|--|
| Gating | Time, Clock Count, Error Count |
| Gating Unit | Time: 1 second to 99 days 23 hours 59 minute 59 seconds |
| | Clock Count: $>E+4$ to $>E+16$ |
| | Error Count: $>E+4$ to $>E+16$ |
| Cycle | Single, Repeat, Untimed |
| Current | On, Off can be set. |
| | Calculation: Progressive, Immediate |
| | Interval: 100 ms, 200 ms |
| Auto Sync | On, Off can be set. |
| | Synchronization threshold: INT, $E-2$ to $E-8$ |
| Sync Control | PRBS: Automatic Synchronization |
| | Data: Frame On |
| Frame Length | NRZ: 4 to 64 bits, 4 bits step |
| | PAM4: 4 to 64 symbols, 4 symbols step |
| Frame Mask | Available |
| Frame Position | NRZ: 1 to (Pattern Length – Frame Length +1) bits, 1 bit step |
| | PAM4: 1 to (Pattern Length – Frame Length +1) symbols, 1 symbol step |
| Error/Alarm Conditions | |
| Error Detection | NRZ: Insertion/Omission, Transition/Non Transition |
| | PAM4: Not available |
| EI/EFI Interval | 1 ms, 10 ms, 100 ms, 1 s |

Table 1.3.3-10 Error Analysis

| Item | Specifications | | | | | | | | | | | | | | | | | | |
|--|--|-----------------------|-------------|----------------|---|------------------------|---|------------------------|---|-------------------------|---|--------------------------|----|--------------------------|----|---------------------------|----|----------------------------|-----|
| Block Window Setting resolution | Excludes the specified data pattern from measurement. <table> <tr> <th>Pattern length (bits)</th><th>Step (bits)</th></tr> <tr> <td>2 to 2 097 152</td><td>1</td></tr> <tr> <td>2 097 153 to 4 194 304</td><td>2</td></tr> <tr> <td>4 194 305 to 8 388 608</td><td>4</td></tr> <tr> <td>8 388 609 to 16 777 216</td><td>8</td></tr> <tr> <td>16 777 217 to 33 554 432</td><td>16</td></tr> <tr> <td>33 554 433 to 67 108 864</td><td>32</td></tr> <tr> <td>67 108 865 to 134 217 728</td><td>64</td></tr> <tr> <td>134 217 729 to 268 435 456</td><td>128</td></tr> </table> | Pattern length (bits) | Step (bits) | 2 to 2 097 152 | 1 | 2 097 153 to 4 194 304 | 2 | 4 194 305 to 8 388 608 | 4 | 8 388 609 to 16 777 216 | 8 | 16 777 217 to 33 554 432 | 16 | 33 554 433 to 67 108 864 | 32 | 67 108 865 to 134 217 728 | 64 | 134 217 729 to 268 435 456 | 128 |
| Pattern length (bits) | Step (bits) | | | | | | | | | | | | | | | | | | |
| 2 to 2 097 152 | 1 | | | | | | | | | | | | | | | | | | |
| 2 097 153 to 4 194 304 | 2 | | | | | | | | | | | | | | | | | | |
| 4 194 305 to 8 388 608 | 4 | | | | | | | | | | | | | | | | | | |
| 8 388 609 to 16 777 216 | 8 | | | | | | | | | | | | | | | | | | |
| 16 777 217 to 33 554 432 | 16 | | | | | | | | | | | | | | | | | | |
| 33 554 433 to 67 108 864 | 32 | | | | | | | | | | | | | | | | | | |
| 67 108 865 to 134 217 728 | 64 | | | | | | | | | | | | | | | | | | |
| 134 217 729 to 268 435 456 | 128 | | | | | | | | | | | | | | | | | | |
| Bit Window | Excludes any channels among internal 32 channels from measurement. (Available only in NRZ mode.) | | | | | | | | | | | | | | | | | | |
| External Mask | H: Measurement L: Mask | | | | | | | | | | | | | | | | | | |
| Capture Capture Mode Auto Launch Number of Blocks Block Length | NRZ, PAM4 (Only FEC Symbol Capture is available when LSB/MSB Diagnostics is set to ON.) PAM4 is available when the Option z41 SER Measurement is installed. Sync Mode Capture Performs error judgment. Synchronization is required between input data and pattern setting. Raw Data Capture Does not perform error judgment. Synchronization is not required between input data and pattern setting. FEC Symbol Capture*1, *2 Performs FEC Symbol error judgment. Synchronization is required between input data and pattern setting. Judgement is made on whether the number of FEC Symbol errors exceeds the threshold. Select the result screen you want to display automatically when data is captured. <ul style="list-style-type: none"> • Capture Data Displays the captured pattern data numerically or by a string (Bin, Hex, Symbol). • Error Mapping Displays the captured error data as a map. This cannot be selected when Capture Mode is Raw Data Capture or FEC Symbol Capture. • Disable Does not automatically display the result screen. 1, 2, 4, 8, 16, 32, 64, 128 NRZ: 8 Mbits / n (n=Number of blocks) PAM4: 4 Msymbols / n (n=Number of blocks) | | | | | | | | | | | | | | | | | | |

*1: Each FEC Symbol consists of data of 10 or 20 bits.

*2: Occurrence of one or more bit errors in one FEC Symbol is counted as one FEC Symbol error.

Table 1.3.3-10 Error Analysis (Cont'd)

| Item | Specifications | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|---|------------------|--------------------|------------------|--------------------|--------------|---|---|---|---------------|---|---|---|----------------|---|---|---|------------------|---|---|---|--|---|---|---|---|---|---|---|
| Capture (Cont'd) Trigger | <p>Error Detect, Match Pattern, Manual Trigger, External Trigger (Rising Edge), Consecutive Error Detect, Intermittent Error Detect Error Detect cannot be selected when Capture Mode is Raw Data Capture. For the relationship between Capture Modes and selectable Triggers, refer to the table below.</p> <table><tr><th>Trigger</th><th>Sync Mode Capture</th><th>Raw Data Capture</th><th>FEC Symbol Capture</th></tr><tr><td>Error Detect</td><td>√</td><td>—</td><td>—</td></tr><tr><td>Match Pattern</td><td>√</td><td>√</td><td>—</td></tr><tr><td>Manual Trigger</td><td>√</td><td>√</td><td>√</td></tr><tr><td>External Trigger</td><td>√</td><td>√</td><td>—</td></tr><tr><td>Consecutive Error Detect*³</td><td>—</td><td>—</td><td>√</td></tr><tr><td>Intermittent Error Detect*⁴</td><td>—</td><td>—</td><td>√</td></tr></table> | Trigger | Sync Mode Capture | Raw Data Capture | FEC Symbol Capture | Error Detect | √ | — | — | Match Pattern | √ | √ | — | Manual Trigger | √ | √ | √ | External Trigger | √ | √ | — | Consecutive Error Detect* ³ | — | — | √ | Intermittent Error Detect* ⁴ | — | — | √ |
| Trigger | Sync Mode Capture | Raw Data Capture | FEC Symbol Capture | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Error Detect | √ | — | — | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Match Pattern | √ | √ | — | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Manual Trigger | √ | √ | √ | | | | | | | | | | | | | | | | | | | | | | | | | | |
| External Trigger | √ | √ | — | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Consecutive Error Detect* ³ | — | — | √ | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Intermittent Error Detect* ⁴ | — | — | √ | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Trigger Position | After the Trigger, Around the Trigger, Before the Trigger After the Trigger and Before the Trigger cannot be selected when Capture Mode is FEC Symbol Capture. | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Match Pattern Length | NRZ: 4 to 64 bits, 1 bit step PAM4: 4 to 64 symbols, 1 symbol step | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Match Pattern Mask | NRZ: 4 to 64 bits, 1 bit step PAM4: 4 to 64 symbols, 1 symbol step | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| FEC Symbol Capture Setting Preset | NRZ: Variable, 25G NRZ 1Lane, 100G NRZ 4Lane PAM4: Variable, 50G PAM4 1Lane, 100G PAM4 1Lane, 100G PAM4 2Lane, 200G PAM4 4Lane, 400G PAM4 4Lane, 400G PAM4 8Lane | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Number of FEC Symbols per Lane in a Codeword | 68, 132, 136, 272, 528, 544 FEC Symbols, 1 FEC Symbol step | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Bit Length in a FEC Symbol | 10. 20 bits | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

*3: Consecutive Error Detect: Starts capturing when the number of consecutive FEC Symbol Errors equals to or exceeds the threshold regardless of codeword.

*4: Intermittent Error Detect: Starts capturing when the number of FEC Symbol Errors that occurred within one codeword exceeds the threshold.

Table 1.3.3-10 Error Analysis (Cont'd)

| Item | Specifications |
|---------------------------------|--|
| Capture (Cont'd) | |
| FEC Symbol Errors in a Codeword | When Trigger is Consecutive Error Detect: 1 to 32 FEC Symbols, 1 FEC Symbol step When Trigger is Intermittent Error Detect: 1 to n, 1 FEC Symbol step (n = Number of FEC Symbols in a Codeword) |
| Comparison | Greater than or equal to, Equal to |
| Capture Result | |
| Capture Data | Displays captured results by bit or symbol sequence in NRZ or PAM4 mode. When Capture Mode is Sync Mode Capture or FEC Symbol Capture, error bits and symbols are displayed with background color. |
| Viewer Mode | Sets the view mode of the captured result pattern. NRZ: BIN, HEX PAM4: Symbol, BIN(MSB/LSB) |
| Error display | Waveform display can be turned on and off. NRZ: Insertion Error, Omission Error PAM4(Symbol): Lower Eye Error, Middle Eye Error, Upper Eye Error, Middle/Lower Eye Error, Upper/Middle Eye Error, Upper/Middle/Lower Eye Error PAM4(MSB/LSB): Insertion Error, Omission Error |
| Error Search | This is available only when Capture Mode is Sync Mode Capture or FEC Symbol Capture. First: First error Pre: Previous error Next: Next error Last: Last error In PAM4 mode only, a search target can be selected from All, Upper Eye, Middle Eye and Lower Eye. |
| Continuous Error | This is available only when Capture Mode is Sync Mode Capture or FEC Symbol Capture. Searches for continuous error bits / symbols. NRZ: 1 to 256 bits PAM4(Symbol): 1 to 256 symbols PAM4(MSB/LSB) : 1 to 256 bits This is available only when Capture Mode is Sync Mode Capture or FEC Symbol Capture. |

Table 1.3.3-10 Error Analysis (Cont'd)

| Item | Specifications |
|------------------|---|
| Capture (Cont'd) | |
| File Save | <p>Saves the captured results and pattern to a file.</p> <p>NRZ:</p> <p>BIN/HEX Text: Captured result file (It can be opened in the Capture Data screen.)</p> <p>BIN/HEX Text(export): Pattern file including error information (It can be opened in Pattern Editor.)</p> <p>PAM4:</p> <p>Symbol Text: Captured result file (It can be opened in the Capture Data screen.)</p> <p>Symbol Text(export): Pattern file including error information (It can be opened in Pattern Editor.)</p> |
| File Open | <p>Redisplays the captured results.</p> <p>NRZ:</p> <p>BIN/HEX Text: Captured result file</p> <p>PAM4:</p> <p>Symbol Text: Captured result file</p> |
| Error Mapping | <p>Visually maps errors using bits with colored-background in NRZ or PAM4 mode.</p> <p>This is available only when Capture Mode is Sync Mode Capture.</p> |
| Error display | <p>NRZ: Insertion Error, Omission Error</p> <p>PAM4: Lower Eye Error, Middle Eye Error, Upper Eye Error, Middle/Lower Eye Error, Upper/Middle Eye Error, Upper/Middle/Lower Eye Error</p> |
| File Open | <p>Remaps the captured results (errors).</p> <p>NRZ:</p> <p>BIN/HEX Text: Captured result file</p> <p>PAM4:</p> <p>Symbol Text: Captured result file</p> |

Table 1.3.3-11 Auto Measurement

| Item | Specifications |
|-----------------|---|
| Bath-Tub | NRZ/PAM4: Available* ¹ |
| Auto Adjust | NRZ: Vth direction only* ² PAM4: MSB Vth direction only* ² , * ³ |
| Auto Search | NRZ: Available* ³ PAM4 (LSB/MSB Diagnostics OFF/ON): Available* ² , * ⁴ |
| BER/SER Logging | NRZ: With BER Logging PAM4: With SER Logging |

*1: When PAM4 is selected, measurement can be performed by selecting one from Upper, Middle, and Lower Eyes, and SER.

*2: PRBS Pattern, Mark Ratio 1/2

*3: Each of amplitudes shall be equal.

*4: Each of 0/1, 1/2 and 2/3 levels is equal.

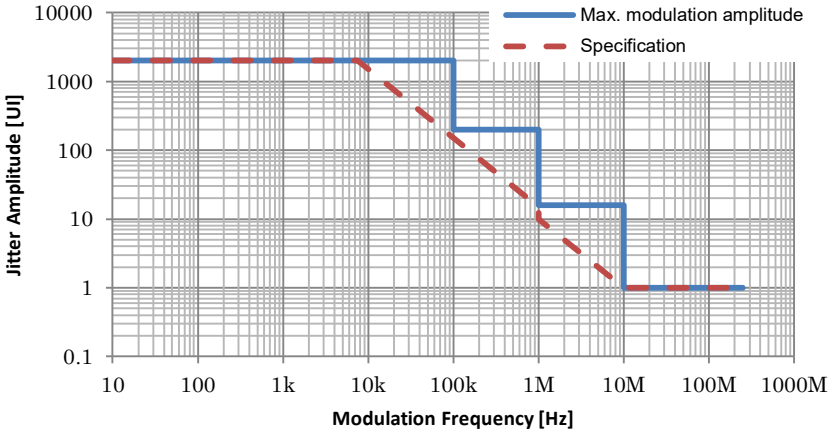
Table 1.3.3-12 Variable Clock Delay

| Item | Specifications |
|-----------------------|---|
| Phase variable range | –1000 to +1000 mUI, 2 mUI step |
| Accuracy | ±50 mUIp-p* ¹ , * ² (Baud rate ≤32.1 Gbaud) ±100 mUIp-p* ¹ , * ² (Baud rate >32.1 Gbaud) |
| mUI – ps switching | Available (internally converted into ps) |
| Calibration | Available (when jitter modulation is off) |
| Calibration indicator | This indicator is on when Calibration is required due to: <ul style="list-style-type: none"> • Change in 1/1Clock frequency by ±250 kHz. • Change in the ambient temperature by ±5°C. |

*1: Measure using an oscilloscope with residual jitter of less than 200 fs (RMS).

*2: Typical value

Table 1.3.3-13 Jitter Tolerance

| Item | Specifications | | | | | | | | | | | | | | | | | | | | | |
|---------------------------|--|---------------------------|-----------------------------------|-----------------------|----|-------|-------|-------|-------|-------|---------|-------|-----|-----------|-----|----|------------|----|---|-------------|---|---|
| For NRZ input | <p>Bit rate: 32.1 Gbit/s, 64.2 Gbit/s*1</p> <p>Pattern: PRBS2³¹−1</p> <p>32.1 Gbits: With MU181500B, SSC with frequency of 33 kHz and deviation of 5300 ppm can be applied simultaneously with RJ with amplitude of 0.3 UI.</p> <p>64.2 Gbits: With MU181500B, SSC with frequency of 33 kHz and deviation of 3300 ppm can be applied simultaneously with RJ with amplitude of 0.3 UI.</p> <p>These specifications are defined assuming the following conditions: Loopback connection to the MU196020A, at a constant temperature between 20 and 30°C.</p> <p>When RJ+BUJ is bigger than 0.5 UIp-p or SJ + RJ + BUJ is bigger than the standard value + 0.3 UIp-p, “Overload” is displayed on the MU181500B screen.</p> <p>32.1 Gbit/s</p> <div></div> <table><thead><tr><th>Modulation frequency [Hz]</th><th>Max. modulation amplitude [UIp-p]</th><th>Specification [UIp-p]</th></tr></thead><tbody><tr><td>10</td><td>2 000</td><td>2 000</td></tr><tr><td>7 500</td><td>2 000</td><td>2 000</td></tr><tr><td>100 000</td><td>2 000</td><td>150</td></tr><tr><td>1 000 000</td><td>200</td><td>15</td></tr><tr><td>10 000 000</td><td>16</td><td>1</td></tr><tr><td>150 000 000</td><td>1</td><td>1</td></tr></tbody></table> | Modulation frequency [Hz] | Max. modulation amplitude [UIp-p] | Specification [UIp-p] | 10 | 2 000 | 2 000 | 7 500 | 2 000 | 2 000 | 100 000 | 2 000 | 150 | 1 000 000 | 200 | 15 | 10 000 000 | 16 | 1 | 150 000 000 | 1 | 1 |
| Modulation frequency [Hz] | Max. modulation amplitude [UIp-p] | Specification [UIp-p] | | | | | | | | | | | | | | | | | | | | |
| 10 | 2 000 | 2 000 | | | | | | | | | | | | | | | | | | | | |
| 7 500 | 2 000 | 2 000 | | | | | | | | | | | | | | | | | | | | |
| 100 000 | 2 000 | 150 | | | | | | | | | | | | | | | | | | | | |
| 1 000 000 | 200 | 15 | | | | | | | | | | | | | | | | | | | | |
| 10 000 000 | 16 | 1 | | | | | | | | | | | | | | | | | | | | |
| 150 000 000 | 1 | 1 | | | | | | | | | | | | | | | | | | | | |

*1: When the Option 002 or x12 is installed.

Table 1.3.3-13 Jitter Tolerance (Cont'd)

1

Overview

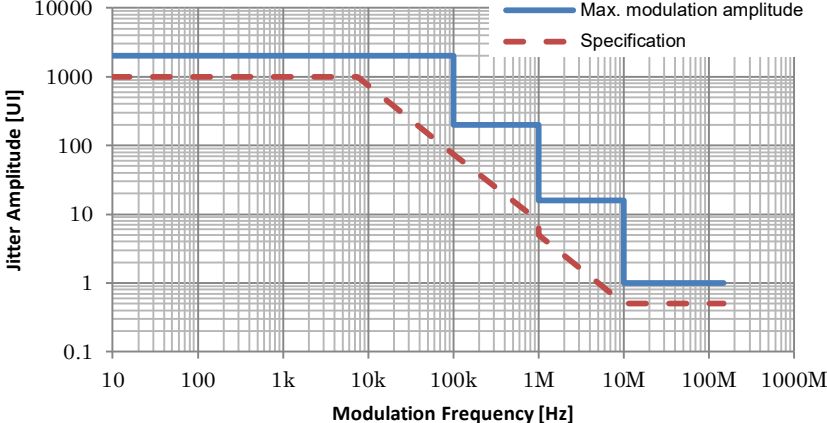
| Item | Specifications | | | | | | | | | | | | | | | | | | | | | |
|---------------------------|---|---------------------------|-----------------------------------|-----------------------|----|-------|-------|-------|-------|-------|---------|-------|----|-----------|-----|---|------------|----|-----|-------------|---|-----|
| For NRZ input (Cont'd) | <div>64.2 Gbit/s</div> <div></div> <table><thead><tr><th>Modulation frequency [Hz]</th><th>Max. modulation amplitude [Ulp-p]</th><th>Specification [Ulp-p]</th></tr></thead><tbody><tr><td>10</td><td>2 000</td><td>1 000</td></tr><tr><td>7 500</td><td>2 000</td><td>1 000</td></tr><tr><td>100 000</td><td>2 000</td><td>75</td></tr><tr><td>1 000 000</td><td>200</td><td>8</td></tr><tr><td>10 000 000</td><td>16</td><td>0.5</td></tr><tr><td>150 000 000</td><td>1</td><td>0.5</td></tr></tbody></table> | Modulation frequency [Hz] | Max. modulation amplitude [Ulp-p] | Specification [Ulp-p] | 10 | 2 000 | 1 000 | 7 500 | 2 000 | 1 000 | 100 000 | 2 000 | 75 | 1 000 000 | 200 | 8 | 10 000 000 | 16 | 0.5 | 150 000 000 | 1 | 0.5 |
| Modulation frequency [Hz] | Max. modulation amplitude [Ulp-p] | Specification [Ulp-p] | | | | | | | | | | | | | | | | | | | | |
| 10 | 2 000 | 1 000 | | | | | | | | | | | | | | | | | | | | |
| 7 500 | 2 000 | 1 000 | | | | | | | | | | | | | | | | | | | | |
| 100 000 | 2 000 | 75 | | | | | | | | | | | | | | | | | | | | |
| 1 000 000 | 200 | 8 | | | | | | | | | | | | | | | | | | | | |
| 10 000 000 | 16 | 0.5 | | | | | | | | | | | | | | | | | | | | |
| 150 000 000 | 1 | 0.5 | | | | | | | | | | | | | | | | | | | | |

Table 1.3.3-13 Jitter Tolerance (Cont'd)

| Item | Specifications | | | | | | | | | | | | | | | | | | | | | |
|---------------------------|--|---------------------------|-----------------------------------|-----------------------|----|-------|-------|-------|-------|-------|---------|-------|-----|-----------|-----|----|------------|----|---|-------------|---|---|
| For PAM4 input | Baud rate: 32.1 Gbaud* ² , 58.2 Gbaud* ¹ | | | | | | | | | | | | | | | | | | | | | |
| | Pattern: PRBS31Q | | | | | | | | | | | | | | | | | | | | | |
| | 32.1 Gbaud: With MU181500B, SSC with frequency of 33 kHz and deviation of 5300 ppm can be applied simultaneously with RJ with amplitude of 0.3 UI. | | | | | | | | | | | | | | | | | | | | | |
| | 58.2 Gbaud: With MU181500B, SSC with frequency of 33 kHz and deviation of 3300 ppm can be applied simultaneously with RJ with amplitude of 0.3 UI. | | | | | | | | | | | | | | | | | | | | | |
| | These specifications are defined assuming the following conditions: Loopback connection to the MU196020A, at a constant temperature between 20 and 30°C. When RJ+BUJ is bigger than 0.5 UIp-p or SJ + RJ + BUJ is bigger than the standard value + 0.3 UIp-p, “Overload” is displayed on the MU181500B screen. | | | | | | | | | | | | | | | | | | | | | |
| 32.1 Gbaud | <table><tr><th>Modulation frequency [Hz]</th><th>Max. modulation amplitude [UIp-p]</th><th>Specification [UIp-p]</th></tr><tr><td>10</td><td>2 000</td><td>2 000</td></tr><tr><td>7 500</td><td>2 000</td><td>2 000</td></tr><tr><td>100 000</td><td>2 000</td><td>150</td></tr><tr><td>1 000 000</td><td>200</td><td>15</td></tr><tr><td>10 000 000</td><td>16</td><td>1</td></tr><tr><td>150 000 000</td><td>1</td><td>1</td></tr></table> | Modulation frequency [Hz] | Max. modulation amplitude [UIp-p] | Specification [UIp-p] | 10 | 2 000 | 2 000 | 7 500 | 2 000 | 2 000 | 100 000 | 2 000 | 150 | 1 000 000 | 200 | 15 | 10 000 000 | 16 | 1 | 150 000 000 | 1 | 1 |
| Modulation frequency [Hz] | Max. modulation amplitude [UIp-p] | Specification [UIp-p] | | | | | | | | | | | | | | | | | | | | |
| 10 | 2 000 | 2 000 | | | | | | | | | | | | | | | | | | | | |
| 7 500 | 2 000 | 2 000 | | | | | | | | | | | | | | | | | | | | |
| 100 000 | 2 000 | 150 | | | | | | | | | | | | | | | | | | | | |
| 1 000 000 | 200 | 15 | | | | | | | | | | | | | | | | | | | | |
| 10 000 000 | 16 | 1 | | | | | | | | | | | | | | | | | | | | |
| 150 000 000 | 1 | 1 | | | | | | | | | | | | | | | | | | | | |

*2: When the Option 001 is installed.

Table 1.3.3-13 Jitter Tolerance (Cont'd)

1

Overview

| Item | Specifications | | | | | | | | | | | | | | | | | | | | | |
|---------------------------|---|---------------------------|-----------------------------------|-----------------------|----|-------|-------|-------|-------|-------|---------|-------|----|-----------|-----|---|------------|----|-----|-------------|---|-----|
| For PAM4 input (Cont'd) | <div>58.2 Gbaud</div> <div><table><thead><tr><th>Modulation frequency [Hz]</th><th>Max. modulation amplitude [Ulp-p]</th><th>Specification [Ulp-p]</th></tr></thead><tbody><tr><td>10</td><td>2 000</td><td>1 000</td></tr><tr><td>7 500</td><td>2 000</td><td>1 000</td></tr><tr><td>100 000</td><td>2 000</td><td>75</td></tr><tr><td>1 000 000</td><td>200</td><td>8</td></tr><tr><td>10 000 000</td><td>16</td><td>0.5</td></tr><tr><td>150 000 000</td><td>1</td><td>0.5</td></tr></tbody></table></div> | Modulation frequency [Hz] | Max. modulation amplitude [Ulp-p] | Specification [Ulp-p] | 10 | 2 000 | 1 000 | 7 500 | 2 000 | 1 000 | 100 000 | 2 000 | 75 | 1 000 000 | 200 | 8 | 10 000 000 | 16 | 0.5 | 150 000 000 | 1 | 0.5 |
| Modulation frequency [Hz] | Max. modulation amplitude [Ulp-p] | Specification [Ulp-p] | | | | | | | | | | | | | | | | | | | | |
| 10 | 2 000 | 1 000 | | | | | | | | | | | | | | | | | | | | |
| 7 500 | 2 000 | 1 000 | | | | | | | | | | | | | | | | | | | | |
| 100 000 | 2 000 | 75 | | | | | | | | | | | | | | | | | | | | |
| 1 000 000 | 200 | 8 | | | | | | | | | | | | | | | | | | | | |
| 10 000 000 | 16 | 0.5 | | | | | | | | | | | | | | | | | | | | |
| 150 000 000 | 1 | 0.5 | | | | | | | | | | | | | | | | | | | | |

Table 1.3.3-14 Clock Recovery

| Item | Specifications* ¹ |
|-----------------------------|---|
| Operating Baud rate | <p>When the Option x21 is installed.</p> <p>NRZ: 2.4 to 29.0 Gbit/s</p> <p>PAM4: 2.4 to 29.0 Gbaud</p> <p>When the Option x22, or x21 + y24 is installed.</p> <p>NRZ: 2.4 to 32.1 Gbit/s</p> <p>PAM4: 2.4 to 32.1 Gbaud</p> <p>When the Option x23 is installed.</p> <p>NRZ: 51.0 to 58.2 Gbit/s</p> <p>PAM4: 51.0 to 58.2 Gbaud</p> |
| Setting range* ² | <p>When the Option x21 is installed.</p> <p>NRZ: 2.400 000 to 29.000 000 Gbit/s, 0.000 001 Gbit/s step</p> <p>PAM4: 2.400 000 to 29.000 000 Gbaud, 0.000 001 Gbaud step</p> <p>When the Option x22, or x21 + y24 is installed.</p> <p>NRZ: 2.400 000 to 32.100 000 Gbit/s, 0.000 001 Gbit/s step</p> <p>PAM4: 2.400 000 to 32.100 000 Gbaud, 0.000 001 Gbaud step</p> <p>When the Option x23 is installed.</p> <p>NRZ: 51.000 000 to 58.200 000 Gbit/s, 0.000 001 Gbit/s step</p> <p>PAM4: 51.000 000 to 58.200 000 Gbaud, 0.000 001 Gbaud step</p> |

*1: When the Option x21, x22, x23, or y24 is installed.

The Options x22 and x23 can be installed together.

The Option x23 requires one of the Options x21, x22, 002 and y12.

The Options x21 and x22 cannot be installed together.

The Options x21 and x23 can be installed together.

The Option y24 requires the Option x21.

These are specified with the conditions of PRBS Pattern and Mark Ratio 1/2 (in PAM4 mode, MSB Mark Ratio 1/2) unless otherwise specified.

*2: When the ED is tracking the PPG linked with MU181000A/B and MU181500B, it operates in the same ranges of bit rate and baud rate as the PPG if a recovered clock is used as a system clock.

Table 1.3.3-14 Clock Recovery (Cont'd)

| Item | Specifications* ¹ | | |
|----------------------------------|------------------------------|-------------------|----------------|
| Supported standard and baud rate | For NRZ mode | | |
| | Standard | Bit Rate [Gbit/s] | Remarks |
| | CEI-56G | 56.000 000 | * ₃ |
| | 100G ULH | 32.100 000 | * ₄ |
| | 32G FC | 28.050 000 | * ₅ |
| | CEI-28G | 28.000 000 | * ₅ |
| | 100G OTU4 | 27.952 496 | * ₅ |
| | 100GbE(25.78 × 4) | 25.781 250 | * ₅ |
| | InfiniBand EDR | 25.781 250 | * ₅ |
| | InfiniBand FDR | 14.062 500 | * ₅ |
| | 16G FC | 14.025 000 | * ₅ |
| | 10G FC Over FEC | 11.316 800 | * ₅ |
| | 10GbE Over FEC | 11.095 700 | * ₅ |
| | OTU2 | 10.709 225 | * ₅ |
| | G975 FEC | 10.664 228 | * ₅ |
| | 10G FC | 10.518 750 | * ₅ |
| | 10GbE | 10.312 500 | * ₅ |
| | InfiniBand QDR | 10.000 000 | * ₅ |
| | OC-192/STM-64 | 9.953 280 | * ₅ |
| | 8G FC | 8.500 000 | * ₅ |
| | HSBI | 6.250 000 | * ₅ |
| | InfiniBand DDR | 5.000 000 | * ₅ |
| | 4G FC | 4.250 000 | * ₅ |
| | XAUI | 3.125 000 | * ₅ |
| | OTU1 | 2.666 060 | * ₅ |
| | InfiniBand SDR | 2.500 000 | * ₅ |
| | OC-48/STM-16 | 2.488 320 | * ₅ |

*₃: When the Option x23 is installed.*₄: When the Option x22, or x21 + y24 is installed.*₅: When the Option x21, x22, or x21 + y24 is installed.

Table 1.3.3-14 Clock Recovery (Cont'd)

| Item | Specifications* ¹ | | | | | | | | | | | | | | | | | | | | | |
|---|---|----------|-------------------|---------|----------|------------|----|------------------|------------|----|--------|------------|----|---------|------------|----|------------------|------------|----|----------------|------------|----|
| Supported standard and baud rate (Cont'd) | <div>For PAM4 mode</div> <table><tr><th>Standard</th><th>Baud Rate [Gbaud]</th><th>Remarks</th></tr><tr><td>CEI 112G</td><td>56.000 000</td><td>*3</td></tr><tr><td>400GbE(53.1 × 4)</td><td>53.125 000</td><td>*3</td></tr><tr><td>64G FC</td><td>28.900 000</td><td>*5</td></tr><tr><td>CEI 56G</td><td>28.000 000</td><td>*5</td></tr><tr><td>200GbE(26.6 × 4)</td><td>26.562 500</td><td>*5</td></tr><tr><td>InfiniBand HDR</td><td>26.562 500</td><td>*5</td></tr></table> | Standard | Baud Rate [Gbaud] | Remarks | CEI 112G | 56.000 000 | *3 | 400GbE(53.1 × 4) | 53.125 000 | *3 | 64G FC | 28.900 000 | *5 | CEI 56G | 28.000 000 | *5 | 200GbE(26.6 × 4) | 26.562 500 | *5 | InfiniBand HDR | 26.562 500 | *5 |
| Standard | Baud Rate [Gbaud] | Remarks | | | | | | | | | | | | | | | | | | | | |
| CEI 112G | 56.000 000 | *3 | | | | | | | | | | | | | | | | | | | | |
| 400GbE(53.1 × 4) | 53.125 000 | *3 | | | | | | | | | | | | | | | | | | | | |
| 64G FC | 28.900 000 | *5 | | | | | | | | | | | | | | | | | | | | |
| CEI 56G | 28.000 000 | *5 | | | | | | | | | | | | | | | | | | | | |
| 200GbE(26.6 × 4) | 26.562 500 | *5 | | | | | | | | | | | | | | | | | | | | |
| InfiniBand HDR | 26.562 500 | *5 | | | | | | | | | | | | | | | | | | | | |
| PPG Operating baud rate tracking | Tracks the operating baud rate of the PPG selected from the PPGs installed in the same MP1900A. It is provided with an indicator that turns on when the PPG's operating baud rate is out of the tracking range. | | | | | | | | | | | | | | | | | | | | | |
| Maximum number of consecutive zeros | <div>When the Option x21, x22, or x21 + y24 is installed.</div> <div>72 bit</div> <div>Zero Substitution 2¹⁵,</div> <div>Target loop band: 1/1667, 1/2578 at 2.4 to 25.499 999 G,</div> <div>1/1667, 1/2578, 1/6640 at 25.5 to 32.1 G</div> <div>When the Option x23 is installed.</div> <div>72 bit</div> <div>Zero Substitution 2¹⁵,</div> <div>Target loop band: 1/6640, 1/13280 at 51.0 to 58.2G</div> | | | | | | | | | | | | | | | | | | | | | |
| Lock range | <div>When the Option x21, x22, or x21 + y24 is installed.</div> <div>±200 ppm</div> <div>2.4 to 25.499 999 G, The target loop band is specified by 1/1667, 1/2578.</div> <div>±100 ppm</div> <div>25.5 to 32.1 G, The target loop band is specified by 1/1667, 1/2578,</div> <div>1/6640.</div> <div>When the Option x23 is installed.</div> <div>±100 ppm</div> <div>51.0 to 58.2 G, The target loop band is specified by 1/6640, 1/13280.</div> | | | | | | | | | | | | | | | | | | | | | |

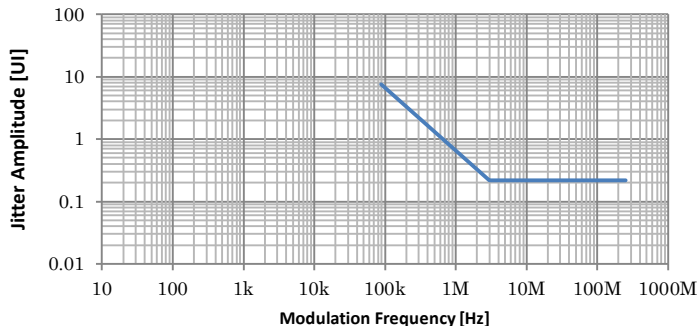
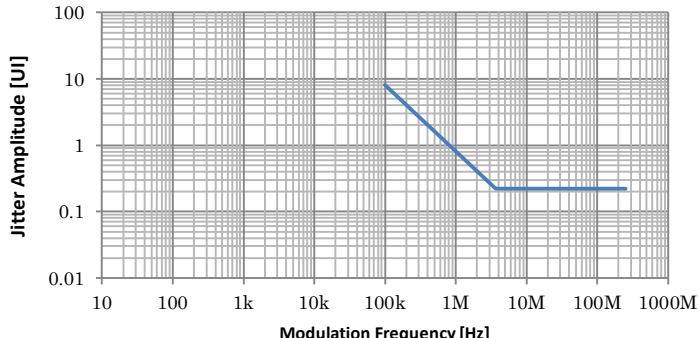
Table 1.3.3-14 Clock Recovery (Cont'd)

| Item | Specifications* ¹ |
|------------------------------|---|
| Target loop band | When the Option x21, x22, or x21 + y24 is installed. |
| | 25.5 to 32.1 G* ⁶ |
| | Baud rate / 1667 |
| | Baud rate / 2578 |
| | Baud rate / 6640 |
| | Jitter Tolerance |
| | 2.4 to 25.499 999 G |
| | Baud rate / 1667 |
| | Baud rate / 2578 |
| | Jitter Tolerance |
| | Variable |
| | When Variable is selected, the ranges are as follows: |
| | Baud rate [Gbaud] Range [MHz] Step [MHz] |
| | 2.400 000 to 5.500 000 3 - |
| | 5.500 001 to 7.500 000 3 to 4 1 |
| | 7.500 001 to 9.500 000 3 to 5 1 |
| | 9.500 001 to 10.500 000 3 to 6 1 |
| | 10.500 001 to 12.500 000 3 to 7 1 |
| | 12.500 001 to 14.500 000 3 to 8 1 |
| | 14.500 001 to 15.500 000 3 to 9 1 |
| | 15.500 001 to 17.500 000 3 to 10 1 |
| | 17.500 001 to 19.500 000 3 to 11 1 |
| | 19.500 001 to 20.500 000 3 to 12 1 |
| | 20.500 001 to 22.500 000 3 to 13 1 |
| | 22.500 001 to 24.500 000 3 to 14 1 |
| | 24.500 001 to 25.499 999 3 to 15 1 |
| | When the Option x23 is installed. |
| 51.0 to 58.2 G* ⁷ | |
| Baud rate / 6640 | |
| Baud rate / 13280 | |
| Jitter Tolerance | |

*6: The SSPRQ pattern supports Baud rate / 6640 only. When set to Jitter Tolerance, Baud rate / 1667 or higher.

*7: The SSPRQ pattern supports Baud rate / 6640 only. When set to Jitter Tolerance, Baud rate / 6640 or higher.

Table 1.3.3-14 Clock Recovery (Cont'd)

| Item | Specifications | | | | | | | | | | | | | | | | |
|---|---|---------------------------|-------------------------------|--------|-----|-----------|------|-------------|------|---------------------------|-------------------------------|---------|------|-----------|------|-------------|------|
| Jitter Tolerance* ⁸ NRZ input | <p>At the bit rate of 58.0 Gbit/s, conforming to Jitter Tolerance Mask defined by the “CEI 56G Jitter Tolerance Mask”. The following masks are taken as nominal values:</p>  <table border="1"> <thead> <tr> <th>Modulation Frequency (Hz)</th><th>Jitter Tolerance Mask (Ulp-p)</th></tr> </thead> <tbody> <tr> <td>87 349</td><td>7.5</td></tr> <tr> <td>2 977 820</td><td>0.22</td></tr> <tr> <td>250 000 000</td><td>0.22</td></tr> </tbody> </table> <p>At the bit rate of 28.05 Gbit/s, conforming to Jitter Tolerance Mask defined by the “32G FC Jitter Tolerance Mask”. The following masks are taken as typical values:</p>  <table border="1"> <thead> <tr> <th>Modulation Frequency (Hz)</th><th>Jitter Tolerance Mask (Ulp-p)</th></tr> </thead> <tbody> <tr> <td>100 000</td><td>8.16</td></tr> <tr> <td>3 709 271</td><td>0.22</td></tr> <tr> <td>250 000 000</td><td>0.22</td></tr> </tbody> </table> | Modulation Frequency (Hz) | Jitter Tolerance Mask (Ulp-p) | 87 349 | 7.5 | 2 977 820 | 0.22 | 250 000 000 | 0.22 | Modulation Frequency (Hz) | Jitter Tolerance Mask (Ulp-p) | 100 000 | 8.16 | 3 709 271 | 0.22 | 250 000 000 | 0.22 |
| Modulation Frequency (Hz) | Jitter Tolerance Mask (Ulp-p) | | | | | | | | | | | | | | | | |
| 87 349 | 7.5 | | | | | | | | | | | | | | | | |
| 2 977 820 | 0.22 | | | | | | | | | | | | | | | | |
| 250 000 000 | 0.22 | | | | | | | | | | | | | | | | |
| Modulation Frequency (Hz) | Jitter Tolerance Mask (Ulp-p) | | | | | | | | | | | | | | | | |
| 100 000 | 8.16 | | | | | | | | | | | | | | | | |
| 3 709 271 | 0.22 | | | | | | | | | | | | | | | | |
| 250 000 000 | 0.22 | | | | | | | | | | | | | | | | |

*8: Specified at a constant temperature between 20 and 30°C.

Table 1.3.3-14 Clock Recovery (Cont'd)

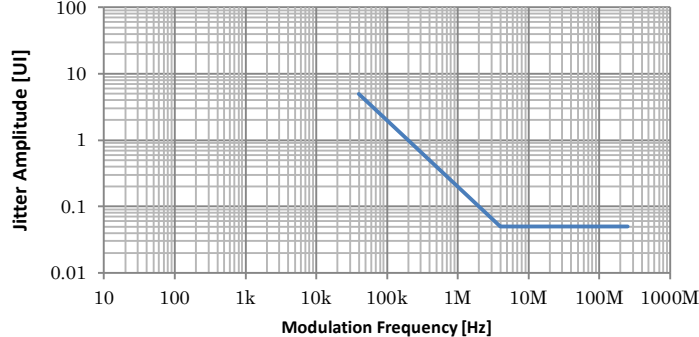
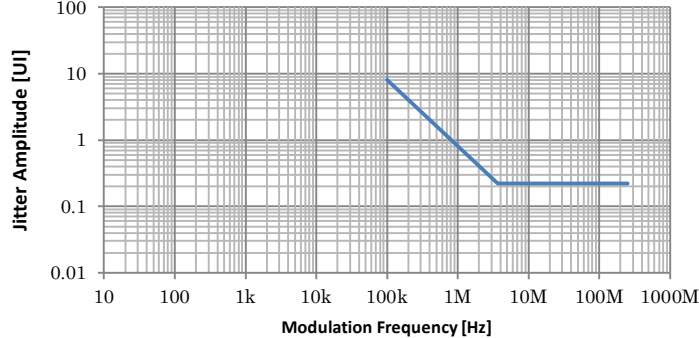
| Item | Specifications | | | | | | | | | | | | | | | | |
|---|--|---------------------------|-------------------------------|--------|---|-----------|------|-------------|------|---------------------------|-------------------------------|--------|----|-----------|------|-------------|------|
| Jitter Tolerance (Cont'd)*8 PAM4 input | <p>At the bit rate of 53.125 Gbaud, conforming to Jitter Tolerance Mask defined by the “CEI-112G-VSR Jitter Tolerance Mask”. The following masks are taken as nominal values:</p>  <table border="1"> <thead> <tr> <th>Modulation Frequency (Hz)</th><th>Jitter Tolerance Mask (Ulp-p)</th></tr> </thead> <tbody> <tr> <td>40 004</td><td>5</td></tr> <tr> <td>4 000 377</td><td>0.05</td></tr> <tr> <td>250 000 000</td><td>0.05</td></tr> </tbody> </table> <p>At the bit rate of 26.5625 Gbaud, conforming to Jitter Tolerance Mask defined by the “IEEE802.3bs Jitter Tolerance Mask”. The following masks are taken as typical values:</p>  <table border="1"> <thead> <tr> <th>Modulation Frequency (Hz)</th><th>Jitter Tolerance Mask (Ulp-p)</th></tr> </thead> <tbody> <tr> <td>40 000</td><td>22</td></tr> <tr> <td>4 000 000</td><td>0.22</td></tr> <tr> <td>250 000 000</td><td>0.22</td></tr> </tbody> </table> | Modulation Frequency (Hz) | Jitter Tolerance Mask (Ulp-p) | 40 004 | 5 | 4 000 377 | 0.05 | 250 000 000 | 0.05 | Modulation Frequency (Hz) | Jitter Tolerance Mask (Ulp-p) | 40 000 | 22 | 4 000 000 | 0.22 | 250 000 000 | 0.22 |
| Modulation Frequency (Hz) | Jitter Tolerance Mask (Ulp-p) | | | | | | | | | | | | | | | | |
| 40 004 | 5 | | | | | | | | | | | | | | | | |
| 4 000 377 | 0.05 | | | | | | | | | | | | | | | | |
| 250 000 000 | 0.05 | | | | | | | | | | | | | | | | |
| Modulation Frequency (Hz) | Jitter Tolerance Mask (Ulp-p) | | | | | | | | | | | | | | | | |
| 40 000 | 22 | | | | | | | | | | | | | | | | |
| 4 000 000 | 0.22 | | | | | | | | | | | | | | | | |
| 250 000 000 | 0.22 | | | | | | | | | | | | | | | | |

Table 1.3.3-15 Mechanical Performance

| Item | Specifications |
|-----------------------|---|
| Dimensions | 21 mm (H), 234 mm (W), 175 mm (D), Excluding protrusions |
| Mass | 2.5 kg max. |
| Operating temperature | 15 to 30°C MP1900A's ambient temperature. MU196040B shall operate when installed. |
| Storage temperature | −20 to 60°C MU196040B installed to MP1900A shall comply with MIL-T-28800E Class 5. |

Chapter 2 Before Use

This chapter describes preparations required before using the MP1900A modules.

| | | |
|-----|---------------------------------|-----|
| 2.1 | Installation to MP1900A | 2-2 |
| 2.2 | How to Operate Application..... | 2-2 |
| 2.3 | Preventing Damage | 2-3 |



2.1 Installation to MP1900A

For information on how to install the MP1900A modules to the MP1900A and how to turn on the power, refer to Chapter 3 “Preparation before Use” in the *MP1900A Signal Quality Analyzer-R Operation Manual*.

2.2 How to Operate Application

The modules connected to the MP1900A are controlled by operating the MX190000A Signal Quality Analyzer-R Control Software (hereinafter, referred to as “MX190000A”).

For information on how to start up, shut down, and operate the MX190000A, refer to the *MX190000A Signal Quality Analyzer-R Control Software Operation Manual*.

2.3 Preventing Damage

Always observe the ratings when connecting to the input and output connectors of the MP1900A modules. If an out-of-range signal is input, the MP1900A modules may be damaged.



CAUTION

- When signals are input to the MP1900A modules, 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.
- As a countermeasure against static electricity, ground other devices to be connected (including experimental circuits) with ground wires before connecting the I/O connector.
- 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.
- Never open the MP1900A modules. If you open it and MP1900A modules have failed or sufficient performance cannot be obtained, we may decline to repair the MP1900A modules.
- The MP1900A modules have many important circuits and parts including hybrid ICs. These parts are extremely sensitive to static electric charges, so never open the case of the MP1900A modules.
- The hybrid ICs used in the MP1900A modules are sealed in airtight containers; never open them. If you open it and the MP1900A modules have failed or sufficient performance cannot be obtained, we may decline to repair the MP1900A.

CAUTION

- To protect the MP1900A modules from electrostatic discharge failure, a conductive sheet should be placed onto the workbench, and the operator should wear an electrostatic discharge wrist strap. Always ground the wrist strap to the workbench antistatic mat or the frame ground of the MP1900A modules.
- When connecting an external device such as a Bias-T to the output connectors of MP1900A modules, 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.
 - 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.

<Recommended procedure>

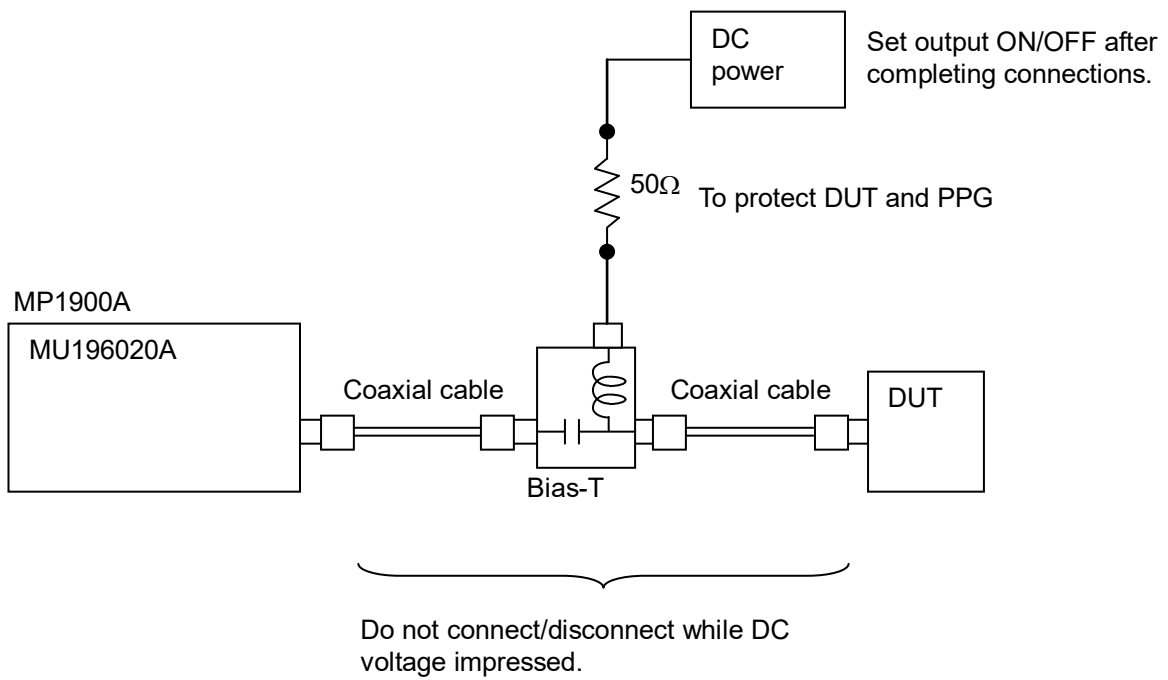
Measurement Preparation 1:

1. Connect all equipment.
2. Set the DC power supply output to ON.
3. Set the MP1900A modules output to ON and complete measurement.

Measurement Preparation 2

1. Set the equipment output to OFF.
2. Set the DC power supply output to OFF.
3. Disconnect the MP1900A modules, or change the DUT connections.

Since even unforeseen fluctuations in DC voltage and load (open or short circuits at the MP1900A modules output side and changes caused by using a high-frequency probe, etc.,) can damage the DUT and equipment, we recommend connecting a 50-ohm resistance in series with the DC terminal of the Bias-T to prevent risk of damage.

**Figure 2.3-1 Bias-T Connection Example**

Chapter 3 Panel Layout and Connectors

This chapter describes the panel and connectors of the MP1900A modules.

| | | |
|-------|---|------|
| 3.1 | Panel Layout..... | 3-2 |
| 3.1.1 | MU196020A..... | 3-2 |
| 3.1.2 | MU196040A..... | 3-3 |
| 3.1.3 | MU196040B..... | 3-4 |
| 3.2 | Inter-Module Connection..... | 3-5 |
| 3.2.1 | Measuring Errors..... | 3-7 |
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| 3.2.3 | Adding Jitter to Output Signal..... | 3-10 |
| 3.2.4 | Synchronizing Multiple Channels of PPG..... | 3-11 |

3.1 Panel Layout

3.1.1 MU196020A

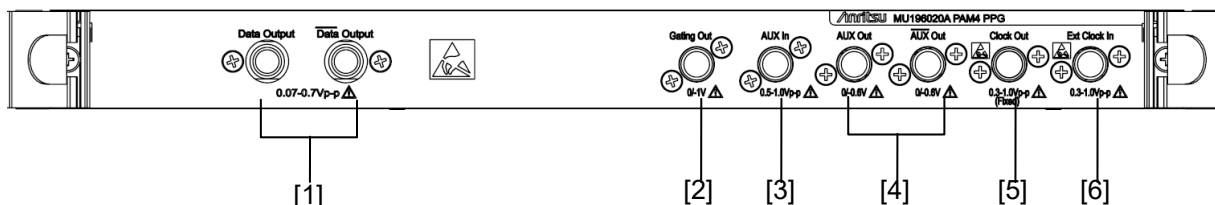


Figure 3.1.1-1 Panel layout (MU196020A-x10)

Table 3.1.1-1 Connectors on panel

| No. | Name | Description |
|-----|-----------------------------|---|
| [1] | Data Output, Data Output | Outputs differential Data and $\overline{\text{Data}}$ signals. Various interface signals can be output, depending on the installed option (s). Because of differential output, be sure to terminate the unused connector with the coaxial terminator (V210). |
| [2] | Gating Out | In case of Repeat: Outputs the timing signals. In case of Burst: Outputs the timing signals for Burst. |
| [3] | AUX In | Inputs auxiliary signals. Variation: Error Injection, Burst |
| [4] | AUX Out, AUX Out | Outputs auxiliary signals. Variation: 1/N Clock, Pattern Sync, Burst Output2 Because of differential output, be sure to terminate the unused connector with the coaxial terminator (J1632A). |
| [5] | Clock Out | Outputs clock signals. |
| [6] | Ext Clock In | Inputs clock signals from these units: MU181000A 12.5GHz Synthesizer MU181000B 12.5GHz 4 Port Synthesizer MU181500B Jitter Modulation Source External Synthesizer* |

*: We recommend using the MG3690C series as an external synthesizer.

For details about the MG3690C series, contact Anritsu or our sales representative.

3.1.2 MU196040A



Figure 3.1.2-1 Panel layout (MU196040A)

Table 3.1.2-1 Connectors on panel

| No. | Name | Description |
|-----|---------------------------|---|
| [1] | Data Input, Data Input | Input Data, $\overline{\text{Data}}$ data signals. Support both differential and single-ended input signals. |
| [2] | AUX In | Inputs auxiliary signals. Variation: External Mask, Burst |
| [3] | AUX Out, AUX Out | Outputs auxiliary signals. Variation: 1/N Clock, Pattern Sync, Sync Gain, Error Output Because of differential output, be sure to connect the coaxial terminator (J1632A) to unused side connector. |
| [4] | Ext Clock In | Inputs clock signals. Mainly connected to the Clock Out connector of the PAM4 PPG. |

3.1.3 MU196040B

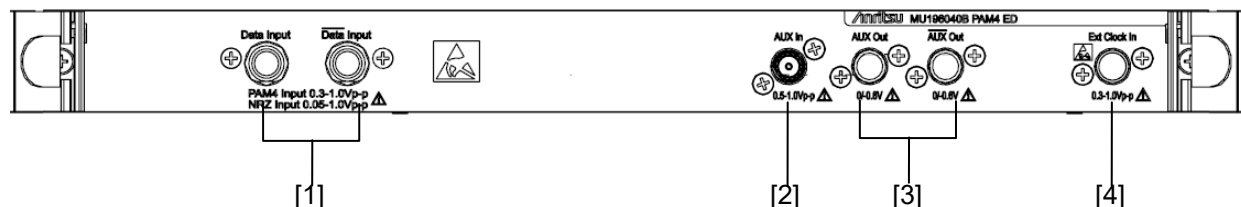


Figure 3.1.3-1 Panel layout (MU196040B)

Table 3.1.3-1 Connectors on panel

| No. | Name | Description |
|-----|---------------------------|---|
| [1] | Data Input, Data Input | Input Data, $\overline{\text{Data}}$ data signals. Support both differential and single-ended input signals. Be sure to terminate the unused connector with the coaxial terminator (V210). |
| [2] | AUX In | Inputs auxiliary signals. Variation: External Mask, Burst, Capture External Trigger |
| [3] | AUX Out, AUX Out | Outputs auxiliary signals. Variation: 1/N Clock, Pattern Sync, Sync Gain, Error Output Because of differential output, be sure to connect the coaxial terminator (J1632A) to unused side connector. |
| [4] | Ext Clock In | Inputs clock signals. Mainly connected to the Clock Out connector of the PAM4 PPG. |

3.2 Inter-Module Connection

Avoid static electricity when handling the devices.



WARNING

- When signals are input to this MP1900A modules, avoid excessive voltage beyond the rating. Otherwise, the circuit may be damaged.
- As a countermeasure against static electricity, ground other devices to be connected (including experimental circuits) with ground wires before connecting the I/O connector.
- 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 power supply voltage rating for the MP1900A is shown on the rear panel. Be sure to operate the MP1900A within the rated voltage range. The MP1900A may be damaged if a voltage out of the rating range is applied.
- To protect the MP1900A modules from electrostatic discharge failure, a conductive sheet should be placed onto the workbench, and the operator should wear an electrostatic discharge wrist strap. Always ground the wrist strap to the workbench antistatic mat or the frame ground of the MP1900A.
- When removing a cable from a connector on the front panel of the MP1900A modules, be careful not to add excessive stress to the connector.
Addition of excessive stress to a connector may result in characteristic degradation or a failure. Use a torque wrench (recommended torque: 0.9 N-M) when attaching or removing a cable.



CAUTION

The maximum data input level of MU196040A/B is 1.00 Vp-p.

When connecting the Data Output connector of MU195020A/MU183020A directly to the Data Input connector of MU196040A/B to verify operation, make sure that the data output level of MU195020A/MU183020A is 1.00 Vp-p or under.

Avoid inputting the signal exceeding the maximum input level to the Data Input connector of MU196040A/B. Failure to do so can cause damage.

3.2.1 Measuring Errors

This section describes a connection example of MU196020A, MU181000B 12.5GHz 4 ports synthesizer (hereafter MU181000B), and MU196040A/B that are installed to an MP1900A.

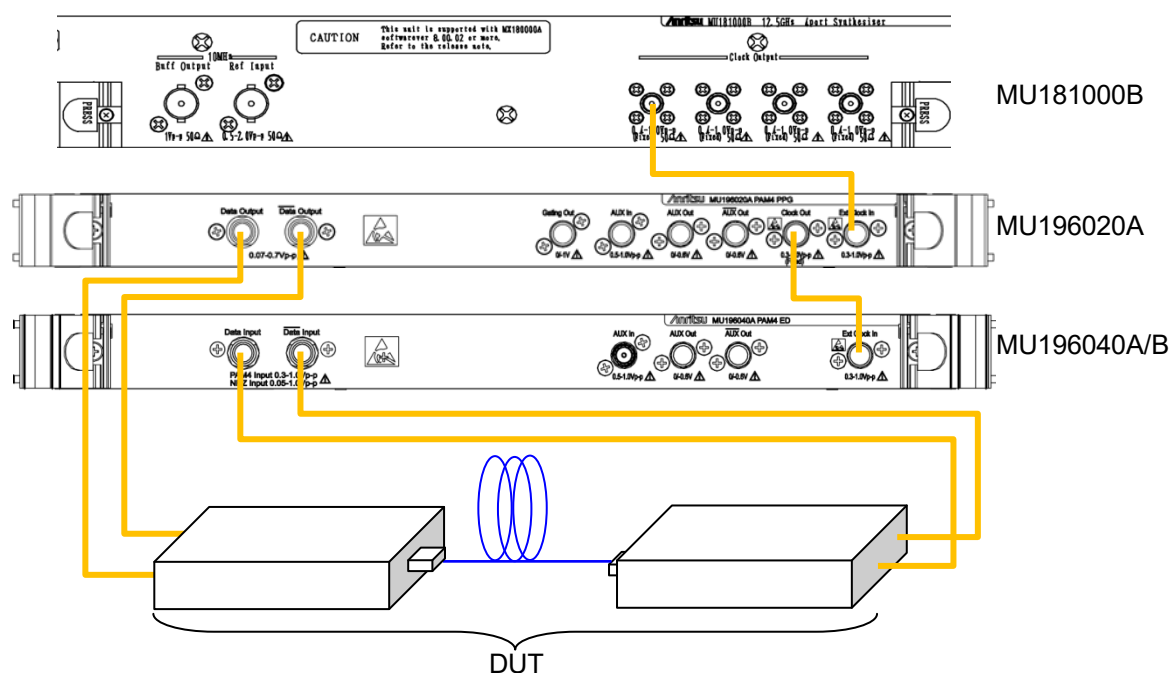


Figure 3.2.1-1 Inter-module connection example

1. Using a coaxial cable, connect the Clock Output connector of the MU181000B and the Ext Clock Input connector of the MU196020A.
2. Using a coaxial cable, connect the Clock Output connector of the MU196020A and the Ext Clock Input connector of the MU196040A/B.
3. Using a coaxial cable, connect the Data Output connector of the MU196020A and the Data Input connector of the device under test (DUT). Also, using a coaxial cable, connect the $\overline{\text{Data}}$ Output connector of the MU196020A and the $\overline{\text{Data}}$ Input connector of the DUT.
4. Using a coaxial cable, connect the Data Output connector of the DUT and the Data Input connector of the MU196040A/B. Also, using a coaxial cable, connect the $\overline{\text{Data}}$ Output connector of the DUT and the $\overline{\text{Data}}$ Input connector of the MU196040A/B.
5. Launch MX190000A, and touch **Standard BERT for PAM4** in the Application Selector screen.

Configure the module settings including bit rate, pattern and amplitude.

3.2.2 Measuring Errors with Noise Added

This section describes a connection example of MU196020A, MU181000B, MU181500B Jitter Modulation Source (hereafter MU181500B), MU195050A, and MU196040A/B that are installed to an MP1900A. To connect MU196020A and the Data1 connector of MU195050A, use J1792A (optional accessory).

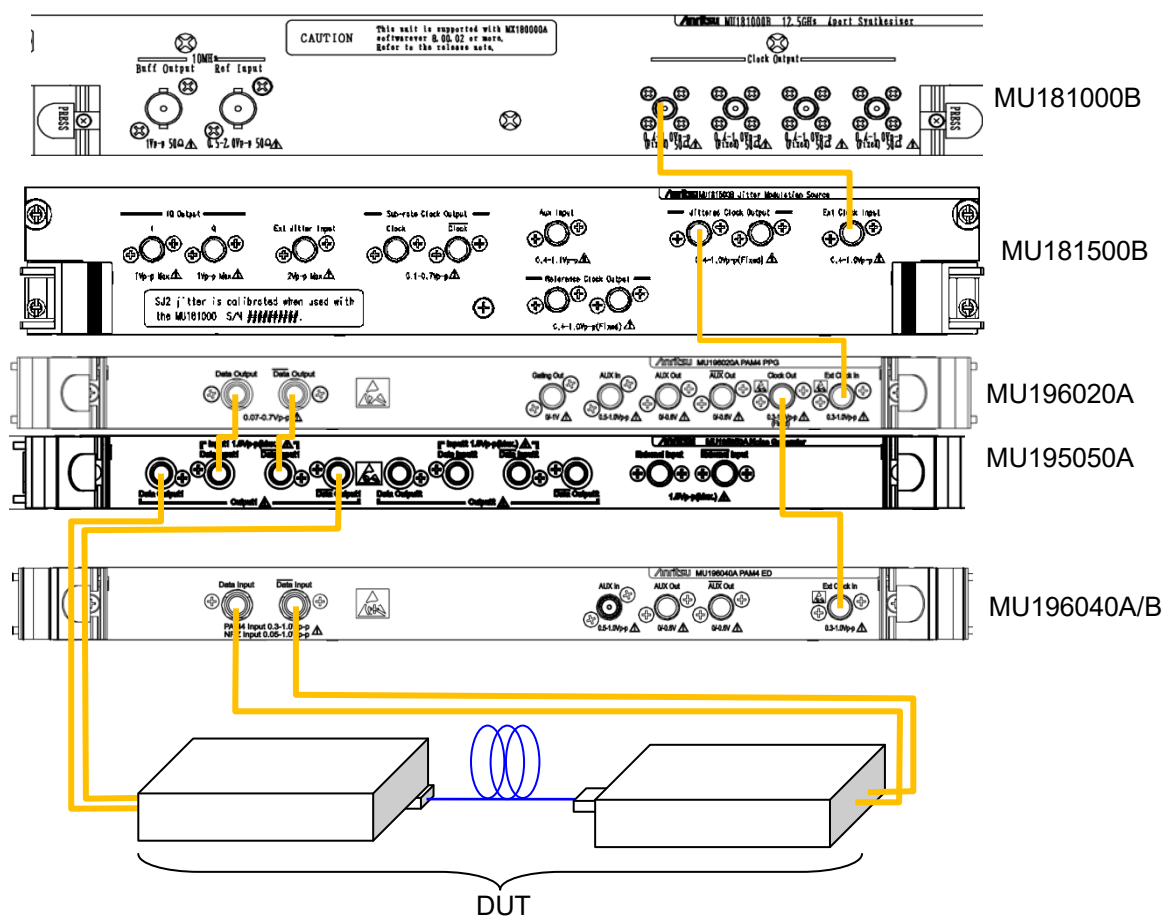


Figure 3.2.2-1 Inter-module connection example

1. Using a coaxial cable, connect the Clock Output connector of the MU181000B and the Ext Clock Input connector of the MU196020A.
2. Using the J1792A skew match pair semirigid cables (V-K connector, Data Input1), connect the Data Output and $\overline{\text{Data}}$ Output connectors of the MU196020A to the Data Input and $\overline{\text{Data}}$ Input connectors of the MU195050A.
3. Using a coaxial cable, connect the Data Output connector of the MU195050A and the Data Input connector of the device under test (DUT). Also, using a coaxial cable, connect the $\overline{\text{Data}}$ Output

connector of the MU195050A and the $\overline{\text{Data}}$ Input connector of the DUT.

4. Using a coaxial cable, connect the Data Output connector of the DUT and the Data Input connector of the MU196040A/B. Also, using a coaxial cable, connect the $\overline{\text{Data}}$ Output connector of the DUT and the $\overline{\text{Data}}$ Input connector of the MU196040A/B.
5. Launch MX190000A, and touch **Standard BERT for PAM4** in the Application Selector screen.
Configure the module settings including bit rate, pattern and amplitude.
6. On the **Output** tab of the MU196020A, set **Ext ATT Factor** to 3.3 dB (typ.) as the loss of the MU195050A.

3.2.3 Adding Jitter to Output Signal

To add jitter to signals output from PAM4 PPG, use MU181000B and MU181500B.

Figure 3.2.3-1 shows a connection example of MU181000B, MU181500B, MU196020A, and MU196040A/B. MU196040A/B-001 supports up to 32.1 Gbit/s and 32.1 Gbaud.

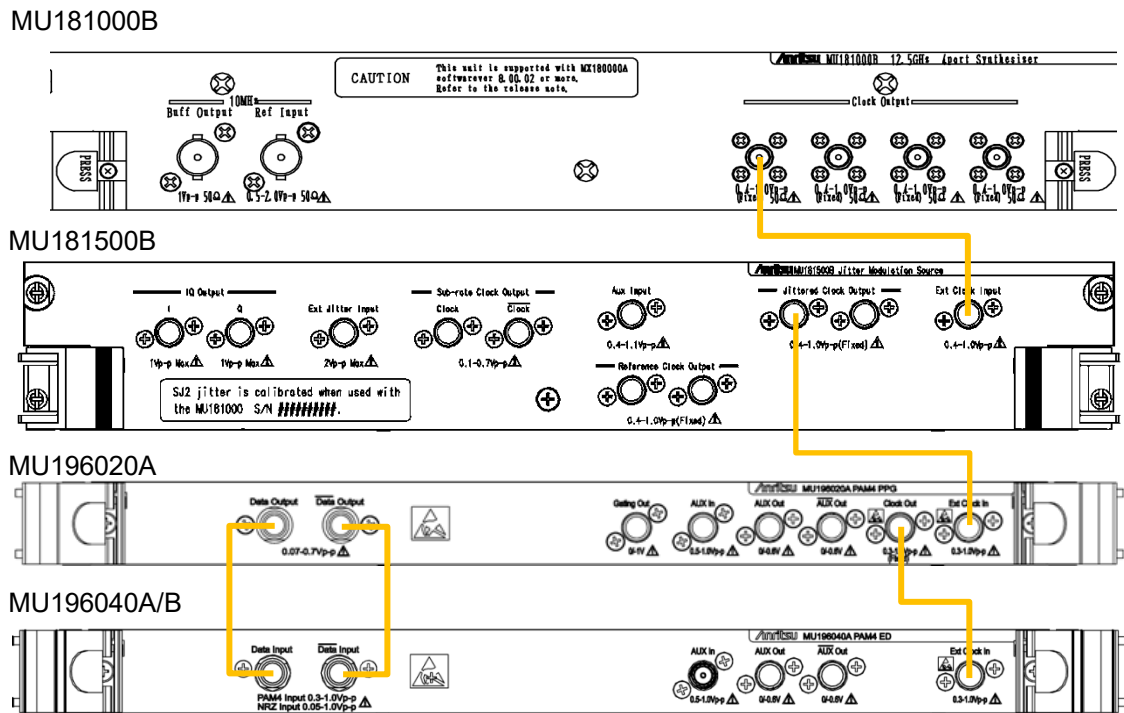


Figure 3.2.3-1 Connection example when adding jitter to output signal

1. Using a coaxial cable, connect the Clock Output connector of the MU181000B and the Ext Clock Input connector of the MU181500B.
2. Using a coaxial cable, connect the Jittered Clock Output connector of the MU181500B and the Ext Clock Input connector of the MU196020A.
3. Using a coaxial cable, connect the Clock Output connector of the MU196020A and the Ext Clock Input connector of the MU196040A/B.
4. Using coaxial cables, connect Data Output and $\overline{\text{Data}}$ Output connectors of the MU196020A with Data Input and $\overline{\text{Data}}$ Input connectors of the MU196040A/B (2 connections).
5. Launch MX190000A, and touch **Standard BERT for PAM4** in the Application Selector screen.

Configure the module settings including bit rate, pattern and amplitude.

3.2.4 Synchronizing Multiple Channels of PPG

To synchronize multiple MU196020As installed to MP1900A, use MU181000A/B or external clock.

The following figure shows a connection example when synchronizing two units of MU196020A using MU181000B.

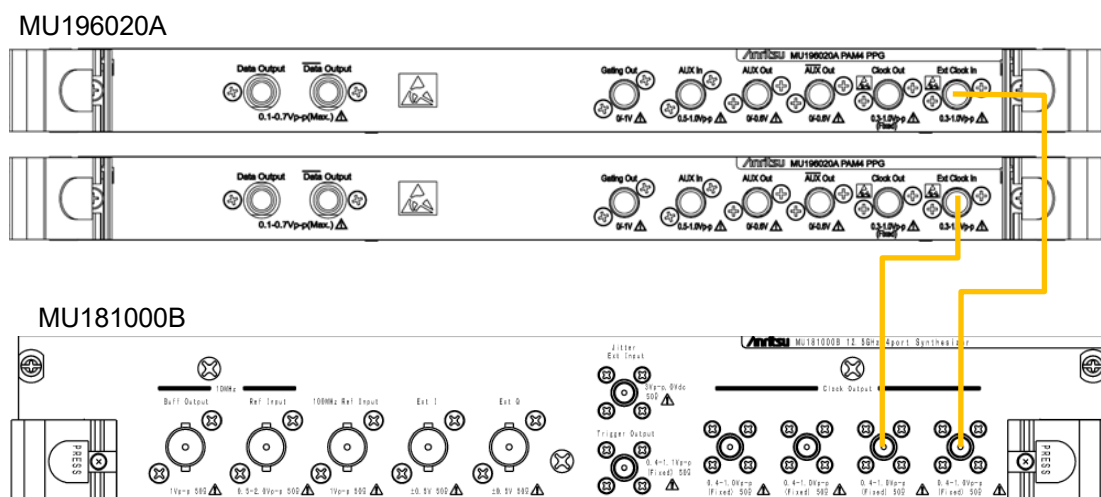


Figure 3.2.4-1 Connection Example When Synchronizing Two Units of PPGs

1. Connect two Clock Output connectors on MU181000B to the Ext Clock In connector on each MU196020A with two coaxial cables.
2. Start MX190000A and select **Menu** → **Combination Setting** on the menu bar. Set Sync ON/OFF of Inter module Combination to **Channel Synchronization**.

Notes:

- Insert units of MU196020A into slots in order from Slot 1.
- Make sure that the cable phase difference is 10 ps or under.

The following figure shows a connection example when synchronizing four units of MU196020A using MU181000B and MU181500B.

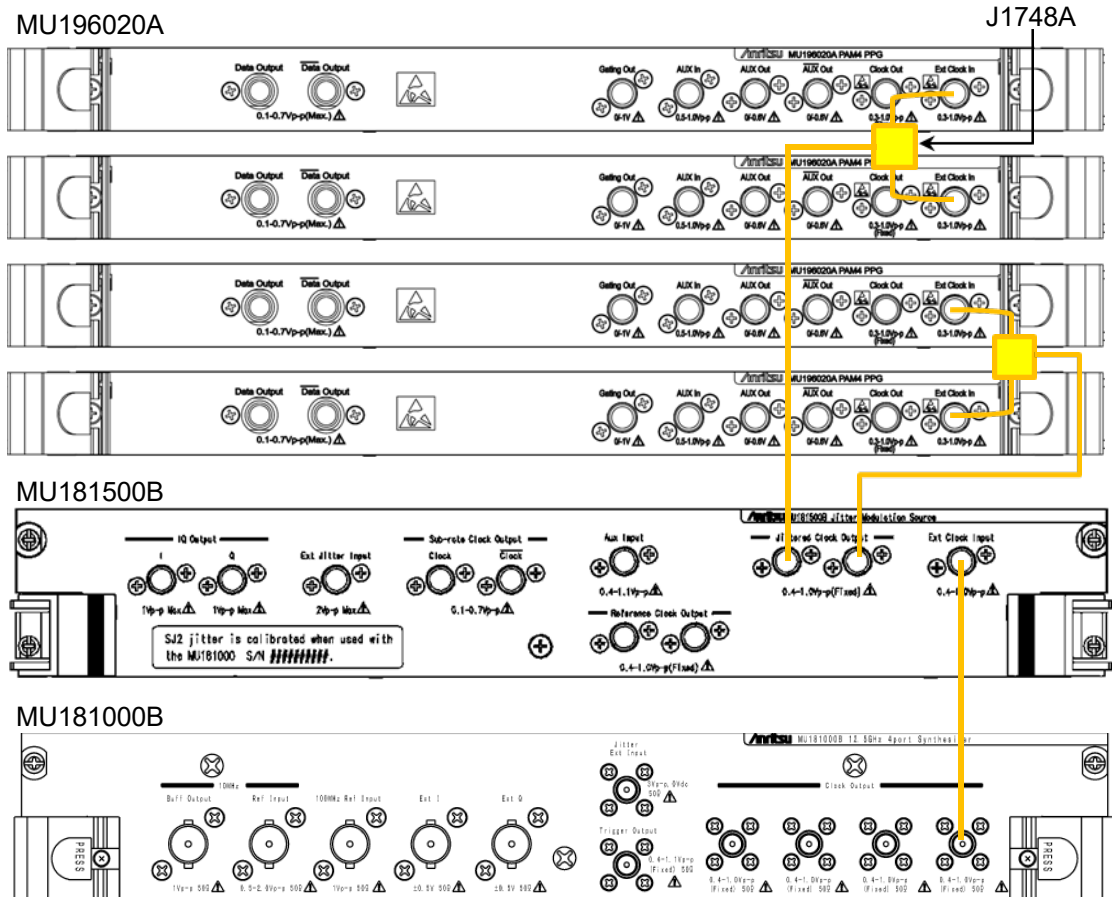


Figure 3.2.4-2 Connection Example When Synchronizing Four Units of PPGs

1. Connect the Clock Output connector of MU181000B and the Ext Clock Input connector of MU181500B with a coaxial cable.
2. Connect one Jittered Clock Output connector on MU181500B to the J1748A Power Splitter (1.5G-18GHz), which is an optional accessory, and the other Jittered Clock Output connector on MU181500B to other J1748A, using two coaxial cables.
3. Connect two J1748As to the Ext Clock In connector on four MU196020As using four coaxial cables.
4. Start MX190000A and select **Menu** → **Combination Setting** on the menu bar. Set Sync ON/OFF of Inter module Combination to **Channel Synchronization**.

Notes:

- Insert units of MU196020A into slots in order from Slot 1.
- Make sure that the cable phase difference is 10 ps or under.

Chapter 4 Usage Examples

This chapter describes usage examples of measurement using the MP1900A modules.

| | | |
|-----|--|-----|
| 4.1 | Evaluating Optical Components in 400GbE Transceiver | 4-2 |
| 4.2 | Evaluating Devices for 400GbE Transceiver..... | 4-5 |

4.1 Evaluating Optical Components in 400GbE Transceiver

This section explains how to evaluate optical components used in a 400GbE optical transceiver by using MU196020A and MU196040A.

The optical components are as follows:

- TOSA (transmitter optical subassembly) consisting of a laser diode, driver amp, EML and other parts
- ROSA (receiver optical subassembly) consisting of a photodiode, TIA (transimpedance amplifier) and other parts

The following is the block diagram of this test that uses MP1900A, MU181000B, MU196020A and MU196040A.

If a DUT has four optical channels (lanes) as shown below, the lanes are evaluated one by one.

If four MU196020As or MU196040As are used, the four lanes can be evaluated at a time. Up to four MU196020As or MU196040As can be installed on an MP1900A. For details on the connections, refer to 3.2.4 “Synchronizing Multiple Channels of PPG”.

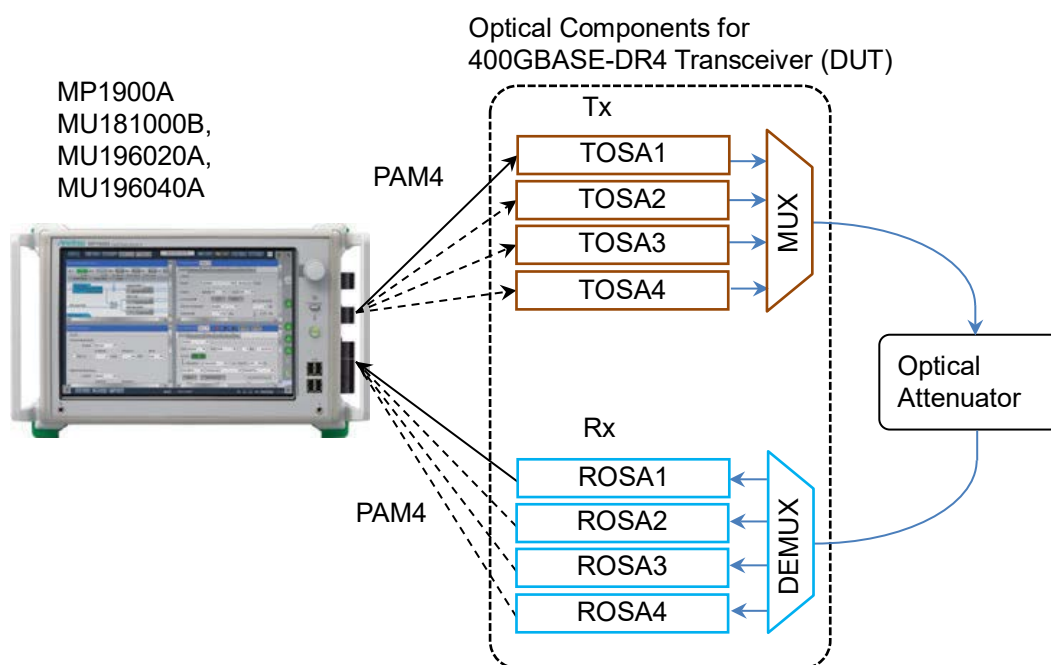


Figure 4.1-1 Block Diagram for Optical Component Evaluation

Measurement

1. Connect the MP1900A and DUT to GND.
2. Use a coaxial connector to connect the Clock Output connector of the MU181000B and the Ext. Clock In connector of the MU196020A.
3. Use a coaxial connector to connect the Clock Out connector of the MU196020A and the Ext. Clock In connector of the MU196040A.
4. Use coaxial cables to connect the Data Output connector and $\overline{\text{Data}}$ Output connector of the MU196020A to the Data Input connectors of the DUT (TOSA) (two connections).

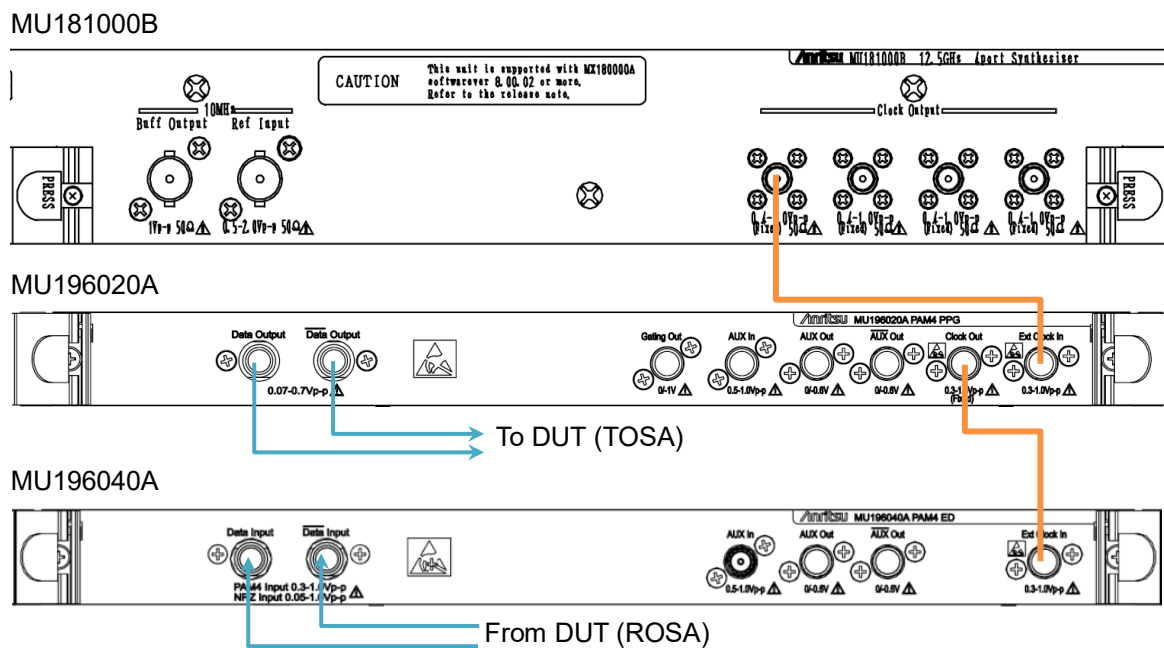


Figure 4.1-2 Module Connection Diagram

5. Use coaxial cables to connect the Data Input connector and $\overline{\text{Data}}$ Input connector of the MU196040A to the Data Output connectors of the DUT (ROSA) (two connections).
6. Connect the DUT and the optical attenuator. Minimize the attenuation.


Test method

1. Connect the power cord of the MP1900A.
2. Turn on the MP1900A.
3. Turn **OFF** data output. Match MU196020A data output interface to DUT's input by adjusting the amplitude and offset on the **Output** tab.
4. On the **Pattern** tab of the MU196020A and MP196040A, set the pattern by selecting a test pattern.
5. On the **Output** tab of the MU196020A, set the operation bit rate.
6. Adjust the data input interface of the MU196040A to the output interface of the DUT.
On the **Input** tab of the MU196040A, select a terminal condition at the Input Condition. Since the DUT is connected by the differential interface, select **Differential 100 Ohm**, and then **Tracking**.
7. Turn on the DUT.
Be sure to turn on the MP1900A first, and then the DUT.



CAUTION

The DUT may be damaged if a signal line is connected or disconnected while the output is ON. Be sure to turn off the MP1900A before changing the cable connection.

8. On the **Output** tab of the MU196020A, set Data/XData to **ON**, and then touch the Output button at the top of the screen to turn it from grey to green ().
9. Adjust the threshold voltage of the MU196040A.
Touch the **Auto Search** module function button. Select the module and mode, and start. If the input level is low, manually adjust it.
10. On the **Result** tab of the MU196040A, start the measurement and check the BER measurement result.
11. Check that the DUT is operating normally, and then adjust the attenuation of the optical attenuator to measure the sensitivity of the DUT (ROSA).
12. Change the connection of TOSA and ROSA, and then repeat steps 3 to 11.

4.2 Evaluating Devices for 400GbE Transceiver

In the evaluation of SERDES for 400GbE transceiver, the jitter tolerance of the CDR (Clock Data Recovery) is measured. This test requires the emphasis settings to be configured in order to compensate the frequency characteristics of the transmission channel and devices.

This section provides a test example with the configuration where MU196020A is installed to MP1900A.

If four MU196020As or MU196040As are used, the four lanes can be evaluated at a time. Up to four MU196020As or MU196040As can be installed on an MP1900A. For details on the connections, refer to 3.2.4 “Synchronizing Multiple Channels of PPG”.

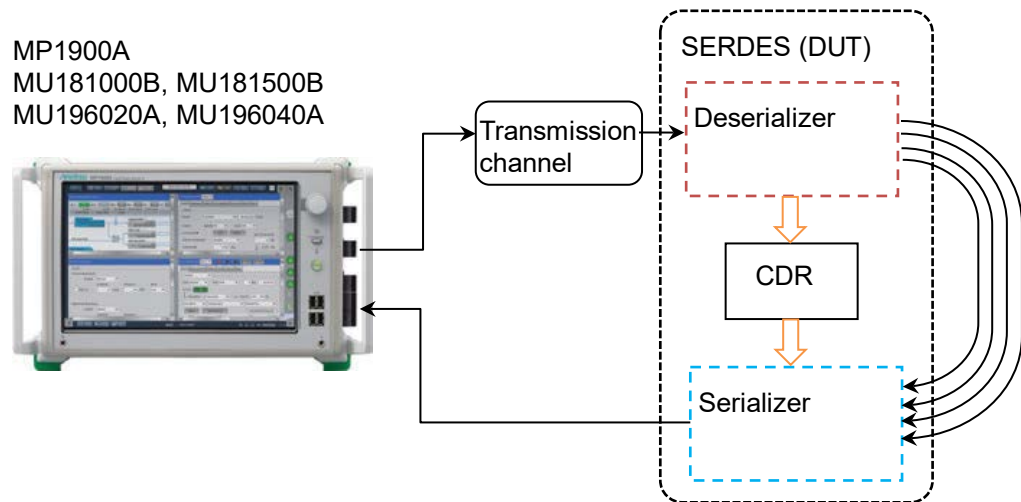


Figure 4.2-1 Block Diagram of SERDES Evaluation

Measurement

1. Connect the MP1900A and DUT to GND.
2. Use a coaxial connector to connect the Clock Output connector of the MU181000B and the Ext. Clock Input connector of the MU181500B.
3. Use a coaxial connector to connect the Jittered Clock Output connector of the MU181500B and the Ext. Clock In connector of the MU196020A.
4. Use coaxial cables to connect the Clock Out connector of the MU196020A to the Ext. Clock In connectors of the MU196040A.
5. Use coaxial cables to connect the Data Output connector and $\overline{\text{Data}}$ Output connector of the MU196020A to the Data Input connectors of the DUT (two connections).

6. Use coaxial cables to connect the Data Input connector and Data Input connector of the MU196040A to the Data Output connectors of the DUT (two connections).
7. To input the reference clock to the DUT, connect the Sub-rate Clock Output connector of MU181500B and the Clock Input connector of the DUT with a coaxial cable.

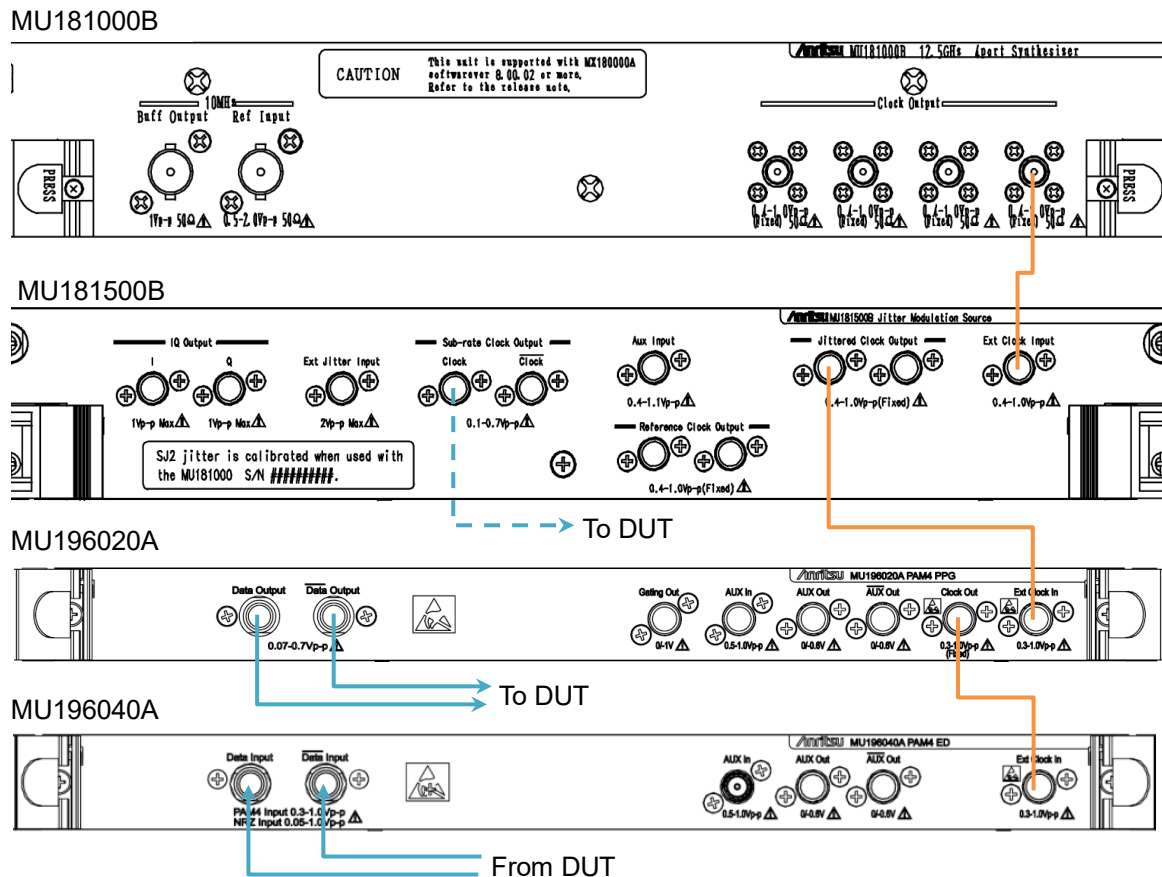



Figure 4.2-2 Module Connection Diagram

Test method

1. Connect the power cord of the MP1900A.
2. Turn on the MP1900A.
3. Set the frequency and amplitude of the jitter to be added by MU181500B.
To input the reference clock to the DUT, set the amplitude and division ratio of the Sub-rate Clock Output.
4. Turn **OFF** data output. Match MU196020A data output interface to DUT's input by adjusting the amplitude and offset on the **Output** tab.
5. On the **Output** tab of the MU196020A, set the operation bit rate to **28 Gbit/s**.
6. On the **Pattern** tab of the MU196020A, select a test pattern.

7. On the **Output** tab of the MU196020A, set Data Output to **ON**, and then touch the Output button on the top of the screen to turn it from grey to green ().
8. Adjust the threshold voltage of the MU196040A.
Touch the **Auto Search** module function button. Select the module and mode, and start. If the input level is low, manually adjust it.
9. On the **Result** tab of the MU196040A, start the measurement, and check the BER measurement result.
10. On the **Emphasis** tab of the MU196020A, configure the emphasis settings.
11. While checking the BER measurement results of the MU196040A, edit the emphasis settings for the MU196020A so that the BER can be optimal.
12. While checking the BER measurement results of the MU196040A, adjust the frequency and amplitude of the jitter to be added by MU181500B so that the BER can be optimal.

Chapter 5 Performance Test

This chapter describes the performance testing of the MP1900A modules.

- 5.1 Timing of Performance Tests5-2
- 5.2 Devices Required for Performance Tests5-3
- 5.3 Performance Test Items.....5-5
 - 5.3.1 Operating Frequency Range5-5
 - 5.3.2 Waveform Evaluation Test5-7
 - 5.3.3 Input Level5-11
 - 5.3.4 Pattern.....5-14
 - 5.3.5 Error Detection.....5-15

5.1 Timing of Performance Tests

Performance test is conducted to check that the major performance of the MP1900A modules meets the required specifications.

Conduct performance tests at acceptance inspection, operation check after repair, and periodic testing (once every six months).

5.2 Devices Required for Performance Tests

Before starting performance test, warm up the MP1900A and the measuring instruments for at least 30 minutes. Table 5.2-1 shows the required devices for performance test.

Table 5.2-1 Devices Required for Performance Tests

| Device Name | Model | Required Performance |
|---|---|--|
| Error detector | MP1900A + MU196040A-001 or MP1900A + MU196040B | Operating frequency: 2.4 to 32.1 GHz NRZ Data input sensitivity: 50 mVp-p or less*1 PAM4 Data input sensitivity: 300 mVp-p or less*2 |
| Sampling oscilloscope | | Electrical channel: 70 GHz or more band |
| Signal generator | MP1900A + MU196020A + MU181000A/B or MG3690 series | When using Ext Clock: Operating frequency: 1.2 to 16.05 GHz Output level: 300 to 1000 mVp-p Waveform: Rectangular wave or sine wave |
| Electrical Length Specified Coaxial Cable (0.4m, V connector) | J1789A | Bandwidth: 65 GHz, For connecting data signals |
| Electrical Length Specified Coaxial Cable (0.8m, V connector) | J1790A | Bandwidth: 65 GHz, For connecting data signals |
| Coaxial Cable 0.3 m (SMA connector) | J1624A | Bandwidth: 18 GHz, For connecting clock signals |
| Coaxial cable 1 m | J1625A | Bandwidth: 18GHz, For connecting trigger signals |
| Coaxial Attenuator | J0541E | Attenuation: 6 dB |
| Precision Fixed Attenuator 20 dB | 41V-20 | Attenuation: 20 dB |
| Precision Adaptor | 34VFK50 | For the Data Input connector of MU196040A-001 |
| Power Meter | ML2437A or ML2438A | |
| Power Sensor + cable | MA2444D | |

*1: PRBS31, 26.5625 Gbit/s, 32.1 Gbit/s, when MU196040A-001 is installed.

*2: PAM4 0/1 1/2 2/3 Level, PRBS31, Eye height where BER is 1E-06, when using External Clock, 26.5625 Gbaud, when MU196040A-001 is installed.

Note:

Before starting the performance test, warm up the device under test and the measuring instruments for at least 30 minutes, and wait until they become sufficiently stabilized unless otherwise specified.

Maximum measurement accuracy is assured under the following

conditions:

- Measurement is performed at room temperature.
- Fluctuations of AC power supply voltage are small.
- Noise, vibration, dust, and humidity are insignificant.

5.3 Performance Test Items

This section describes the following test items.

- Operating Frequency Range
- Waveform Evaluation Test
- Input Level
- Pattern
- Error Detection

5.3.1 Operating Frequency Range

(1) Specifications

Table 5.3.1-1 Specifications

| Option | Specifications |
|-------------------------------|---|
| MU196020A-001 | 2.4 to 32.1 Gbit/s (Gbaud) |
| MU196020A-002, y12 | 2.4 to 58.2 Gbit/s (Gbaud) |
| MU196020A-003, y23 | 2.4 to 64.2 Gbit/s (Gbaud) |
| MU196040A or MU196040B-001 | 2.4 to 32.1 Gbit/s (Gbaud) |
| MU196040B-002, y12 | 2.4 to 58.2 Gbaud 2.4 to 64.2 Gbit/s |

(2) Device connection

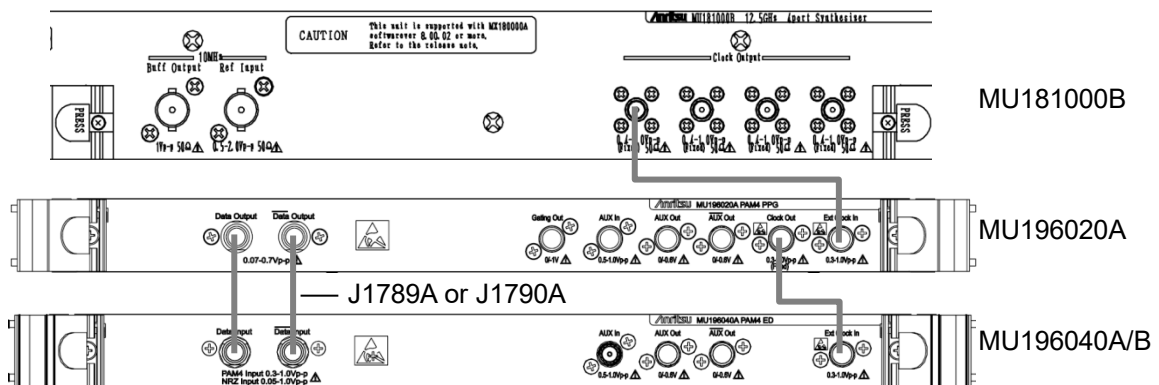
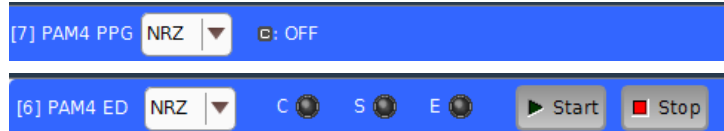


Figure 5.3.1-1 Connection Diagram for Operating Frequency Range Test

When using the MU181000A instead of MU181000B, attach the 6 dB Coaxial Attenuator to the Clock Output connector.

(3) Procedure

1. Mount the MU196020A onto the MP1900A, and turn on the MP1900A with the cables unconnected.
2. Set the modulation mode of MU196020A and MU196040A/B to **NRZ**.



3. On the **Output** tab of the MU196020A, set **Amplitude** to 0.500 V_{p-p}, and **Offset** to 0.000 V and V_{th}.
4. On the **Pattern** tab of the MU196020A, set **Test Pattern** to **PRBS** and **Length** to $2^{31}-1$.
5. Turn off the MP1900A when setting the parameters completely.
6. Connect the measuring instrument cables as shown in Figure 5.3.1-1.
7. Turn on the MP1900A and the measuring instruments, and warm them up.
8. Enable the MP1900A signal output (ON) to output signals from the MU196020A. The signals can be tested in the range of 2.4 to 32.1 Gbit/s (Gbaud).
9. Adjust the phase and threshold voltage of the MU196040A/B to the optimum values.
10. Check that no error is detected by the MU196040A/B.
11. While varying the operating frequency in the following range different by model and option, check that no error has occurred in the range.

MU196040A and MU196040B-001: 2.4 to 32.1 Gbit/s (Gbaud)

MU196040B-002: 2.4 to 64.2 Gbit/s (Gbaud)

MU196040A and MU196040B-001 do not support the test of the operating frequency exceeding 32.1 Gbit/s (Gbaud).

To check the MU196020A's performance at more than 32.1 Gbit/s when using the MU196040A and MU196040B-001, refer to 5.3.2, "Waveform Evaluation Test".

5.3.2 Waveform Evaluation Test

(1) Specifications

Table 5.3.2-1 Specifications for MU196020A

| Item | Conditions | Specification |
|---------------------------------|---|--|
| Amplitude | 0.07 to 0.70 Vp-p ^{*1, *2, *3, *4} 0.07 to 0.60 Vp-p ^{*5} 0.07 to 0.55 Vp-p ^{*6} | ±35 mV ±12% of amplitude |
| Offset (Vth) | $-2.0 - \frac{\text{Amp}}{2}$ to $+3.3 - \frac{\text{Amp}}{2}$ V | ±65 mV ±10% of offset (Vth) ±(Eye Amplitude Accuracy / 2) ^{*7, *8} |
| Cross point ^{*11} | Amplitude: 0.50 Vp-p | Fixed at 50% |
| Tr/Tf ^{*11} | Amplitude: 0.50 Vp-p | 9.0 ps (20 to 80%) ^{*1, *7, *9} 8.5 ps (20 to 80%) ^{*2, *3, *7, *9} 9.5 ps (20 to 80%) ^{*4, *7, *9} 8.8 ps (20 to 80%) ^{*5, *6, *7, *9} |
| Jitter ^{*10, *11, *12} | Amplitude: 0.50 Vp-p | 6.0 ps p-p ^{*1, *2, *3, *4, *5, *6, *9} 600 fs rms ^{*1, *2, *3, *4, *5, *6, *9} |

*1: When using the J1789A cable with MU196020A-001, at 32.1 Gbit/s

*2: When using the J1789A cable with MU196020A-002, at 58.2 Gbit/s

*3: When using the J1789A cable with MU196020A-003, at 64.2 Gbit/s

*4: When using the J1790A cable with MU196020A-001, at 32.1 Gbit/s

*5: When using the J1790A cable with MU196020A-002, at 58.2 Gbit/s

*6: When using the J1790A cable with MU196020A-003, at 64.2 Gbit/s

*7: Except when **Emphasis** is turned **On** with the MU196020A-x11 installed.

*8: For PAM4, when setting each of PAM4 Amplitude (3/2, 2/1 and 1/0) equally to 33%.

*9: Typical value

*10: The jitter specification value is defined assuming that the oscilloscope with residual jitter less than 200 fs (RMS) is used.

*11: NRZ

*12: Count of measured jitters: 30, at a constant temperature between 20 and 30°C

(2) Device connection

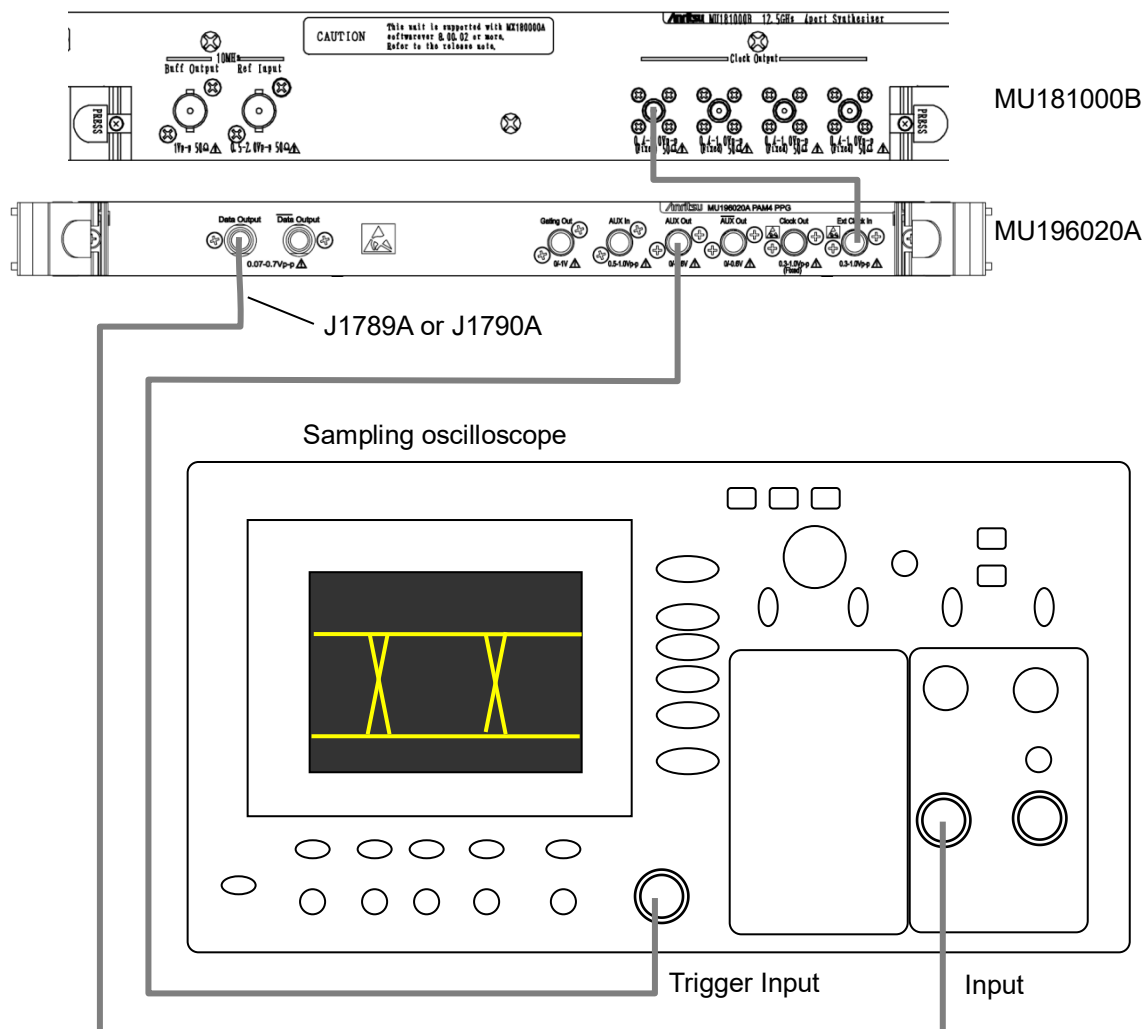


Figure 5.3.2-1 Connection Diagram for Waveform Test

When using the MU181000A instead of MU181000B, attach the 6 dB Coaxial Attenuator to the Clock Output connector.

For waveform test, use a sampling oscilloscope that has a 70 GHz band and that has a residual jitter of less than 200 fs (RMS).

(3) Procedure

1. Mount the MU196020A onto the MP1900A, and turn on the MP1900A with the cables unconnected.
2. Set the modulation mode of the MU196020A to **NRZ**.
3. On the **Output** tab of the MU196020A, set as follows:

Bit Rate

MU196020A-001 32.100 000

MU196020A-002 58.200 000

MU196020A-003 64.200 000

| | |
|--------------------|--------------------|
| Ext ATT Factor | 0.000 |
| Amplitude | 0.070 |
| Offset | AC OFF, 0.000, Vth |
| Half Period Jitter | 0 |
| Delay | 0 |

In the **Cable for Data Output** box, select the model name of the cable used for connection to the sampling oscilloscope.

4. On the **Output** tab of the MU196020A, set the Data output amplitude, offset, and cross point to be tested.
5. On the **Pattern** tab of the MU196020A, set the test pattern.
Since the specification parameters are evaluated by the eye pattern observation, set the test pattern to PRBS, $2^{31}-1$.
6. Select a trigger signal to input to the sampling oscilloscope.
Select 1/N Clock in the AUX Output dropdown list on the **Misc1** tab of the MU196020A, and set the division ratio according to the sampling oscilloscope used.
7. Turn off the MP1900A when setting the parameters completely.
8. Connect the measuring instrument cables as shown in Figure 5.3.2-1. Be sure to connect the V210 terminators (standard accessories) to the Output connectors to which cables are not connected.
9. Turn on the MP1900A and the measuring instruments, and warm them up.
10. Enable the MP1900A signal output (ON) and output signals.
11. Measure the amplitude with the sampling oscilloscope, and record it.
12. On the **Output** tab of the MU196020A, set the value for **Amplitude**.

| | |
|---|-------|
| When using MU19020A-002 and J1790A cable: | 0.600 |
| When using MU19020A-003 and J1790A cable: | 0.550 |
| Other than those above: | 0.700 |
13. Measure the amplitude with the sampling oscilloscope, and record it.
14. On the **Output** tab of the MU196020A, set the value for **Offset**.

| | |
|---|--------|
| When using MU19020A-002 and J1790A cable: | -2.300 |
| When using MU19020A-003 and J1790A cable: | -2.275 |
| Other than those above: | -2.350 |
15. Measure the middle level of the eye with the sampling oscilloscope, and record it.

16. On the **Output** tab of the MU196020A, set **Amplitude** to 0.070 and **Offset** to 3.265.
17. Measure the middle level of the eye with the sampling oscilloscope, and record it.
18. On the **Output** tab of the MU190020A, set **Amplitude** to 0.500 and **Offset** to 0.000.
19. Measure the cross point, Tr/Tf and jitter with the sampling oscilloscope, and record them.
20. Set the modulation mode of the MU196020A to **PAM4**.
21. On the **Output** tab of the MU196020A, set **Total Amplitude** to 0.070 and touch **Even**.
22. Measure the amplitude with the sampling oscilloscope, and record it.
23. On the **Output** tab of the MU196020A, set the value for **Total Amplitude**.

| | |
|---|-------|
| When using MU19020A-002 and J1790A cable: | 0.600 |
| When using MU19020A-003 and J1790A cable: | 0.550 |
| Other than those above: | 0.700 |
24. Measure the amplitude with the sampling oscilloscope, and record it.
25. On the **Output** tab of the MU196020A, set the value for **Offset**.

| | |
|---|--------|
| When using MU19020A-002 and J1790A cable: | -2.300 |
| When using MU19020A-003 and J1790A cable: | -2.275 |
| Other than those above: | -2.350 |
26. Measure the middle level of Level 2/1 with the sampling oscilloscope, and record it.
27. On the **Output** tab of the MU196020A, set **Total Amplitude** to 0.070 and **Offset** to 3.265.
28. Measure the middle level of Level 2/1 with the sampling oscilloscope, and record it.
29. Use a coaxial cable to connect the $\overline{\text{Data}}$ Output connector of the MU196020A and the Input connector of the sampling oscilloscope. Be sure to connect the V210 terminators (standard accessories) to the Output connectors to which cables are not connected. Repeat the procedure from steps 3 to 28.

5.3.3 Input Level

(1) Specifications

Table 5.3.3-1 Specifications

| Option | Specifications | |
|-------------------------------------|--|------------------|
| MU196040A-001 | NRZ Input amplitude: | 0.05 to 1.0 Vp-p |
| | PAM4 Input amplitude: | 0.3 to 1.0 Vp-p |
| | Threshold voltage: | -3.5 to +3.3 V |
| MU196040B-001 | NRZ Input amplitude: | 0.05 to 1.0 Vp-p |
| | PAM4 Input amplitude: | 0.3 to 1.0 Vp-p |
| | Threshold voltage: | -3.5 to +3.3 V |
| MU196040B-002, MU196040B-001+y12 | NRZ Input amplitude (≤ 32.1 Gbit/s): | 0.05 to 1.0 Vp-p |
| | NRZ Input amplitude (> 32.1 Gbit/s): | 0.1 to 1.0 Vp-p |
| | PAM4 Input amplitude (≤ 32.1 Gbaud): | 0.3 to 1.0 Vp-p |
| | PAM4 Input amplitude (> 32.1 Gbaud): | 0.4 to 1.0 Vp-p |
| | Threshold voltage: | -3.5 to +3.3 V |

(2) Connection

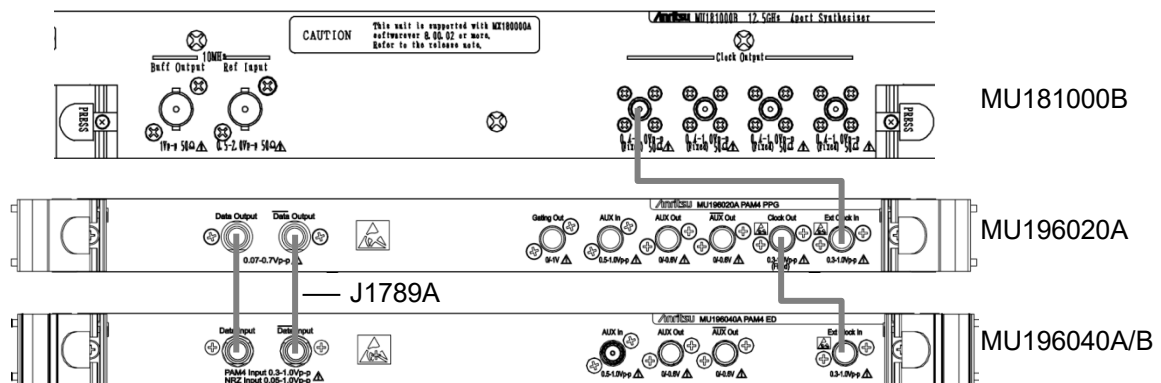


Figure 5.3.3-1 Connection Diagram for Input Level Test

(3) Procedure

1. Connect devices and configure the settings in the same manner as shown in steps 1 to 5 in Section 5.3.1.
2. Connect the measuring instrument cables as shown in Figure 5.3.3-1.
3. Turn on the MP1900A and the measuring instruments, and warm them up.
4. Configure the settings for the MU196020A and MU196040A/B as shown in items 1 to 4 of Table 5.3.3-2.

To perform a test at more than 32.1 Gbit/s when using the MU196040B, configure the settings as shown in items 1, 3, 5 and 6 of Table 5.3.3-2.

5. Set the output of the MU196020A to ON and touch **Start** of the MU196040A/B.

6. Touch **Auto Search**. In the **Mode** list, select **Fine**, and then touch **Start**. Check that the threshold voltage and phase are adjusted to optimum values and that no error occurs.
7. Set the modulation mode of MU196020A and MU196040A/B to **PAM4**.
8. Configure the settings for the MU196020A and MU196040A/B as shown in items 1 to 4 of Table 5.3.3-3.
To perform a test at more than 32.1 Gbaud when using the MU196040B, configure the settings as shown in items 1, 3, 5 and 6 of Table 5.3.3-3. Also, on the **Input** tab of the MU196040B, in the **Input Condition** box, select **Differential**.
9. Disconnect the cable from the Data Input connector, but leave the $\overline{\text{Data}}$ Input connector connected. Be sure to connect the V210 terminator (standard accessory) to the Output connector of MU196020A to which a cable is not connected.
10. On the **Input** tab of the MU196040A/B, set **Single-Ended** and **XData** for **Input Condition**. Repeat steps 4 to 8 to make sure that no errors have occurred.

Table 5.3.3-2 NRZ Input Level Test Setting (MU196040A/B)

| MU196020A | | | | MU196040A/B | |
|-----------|-------------|--------------------|----------------------|-------------|-------------------------------------|
| No. | Termination | Amplitude [Vp-p] | Offset (Vth) [V] | Termination | Threshold voltage [V] ^{*3} |
| 1 | GND | 0.7 | -2.35 | GND | -2.350 |
| 2 | | 0.05 ^{*1} | -0.225 ^{*1} | | -0.225 |
| 3 | | 0.7 | +2.95 | | +2.950 |
| 4 | | 0.05 ^{*2} | +0.305 ^{*2} | | +0.305 |
| 5 | | 0.1 | -2.05 | | -2.650 |
| 6 | | 0.1 | +3.25 | | +3.250 |

*1: To output a signal with an amplitude of 0.05 Vp-p and an offset of -0.225 V, connect the Precision Fixed Attenuator 20 dB (optional accessory: 41V-20) and the Precision Adaptor (optional accessory: 34VFK50) respectively to the Data Output and $\overline{\text{Data}}$ Output connectors of the MU196020A. And, set the MU196020A as follows:
Amplitude: 0.5 Vp-p
Offset: -2.25 V

*2: To output a signal with an amplitude of 0.05 Vp-p and an offset of +0.305 V, connect the Precision Fixed Attenuator 20 dB (optional accessory: 41V-20) and the Precision Adaptor (optional accessory: 34VFK50) respectively to the Data Output and $\overline{\text{Data}}$ Output connectors of the MU196020A. And, set the MU196020A as follows:

Amplitude: 0.5 V_{p-p}

Offset: +3.05 V

*3: In the **Mode** list, select **Fine (NRZ)**, and then start Auto Search to adjust the threshold voltage and phase to optimum values.

Table 5.3.3-3 PAM4 Input Level Test Setting (MU196040A/B)

| MU196020A | | | | MU196040A/B | |
|-----------|-------------|-------------------------------|-------------------------------|-------------|--|
| No. | Termination | Amplitude [V _{p-p}] | Offset (V _{th}) [V] | Termination | Threshold voltage [V]* |
| 1 | GND | 0.7 | -2.35 | GND | Upper: -2.350 + 0.233 (-2.117) Middle: -2.350 Lower: -2.350 - 0.233 (-2.583) |
| 2 | | 0.3 | -2.15 | | Upper: -2.150 + 0.100 (-2.050) Middle: -2.150 Lower: -2.150 - 0.100 (-2.250) |
| 3 | | 0.7 | +2.95 | | Upper: +2.950 + 0.233 (+3.183) Middle: +2.950 Lower: +2.950 - 0.233 (+2.717) |
| 4 | | 0.3 | +3.15 | | Upper: +3.150 + 0.100 (+3.250) Middle: +3.150 Lower: +3.150 - 0.100 (+3.050) |
| 5 | | 0.4 | -2.20 | | Upper: -2.20 + 0.133 (-2.067) Middle: -2.200 Lower: -2.200 - 0.133 (-2.333) |
| 6 | | 0.4 | +3.10 | | Upper: +3.100 + 0.133 (+3.333) Middle: +3.100 Lower: +3.100 - 0.133 (+2.967) |

*: In the **Mode** list, select **Fine (PAM4)**, and then start Auto Search to adjust the threshold voltage and phase to optimum values.

Note:

When changing the termination condition, configure the settings of the MU196020A and the MU196040A/B in the following order. The MU196020A and the MU196040A/B may be damaged if the settings are configured in an incorrect order or the termination condition is not set correctly.

- (1) Set the output of the MU196020A to OFF.
- (2) Set the termination condition for the MU196040A/B to GND.
- (3) Change the termination condition for the MU196020A.
- (4) Set the termination condition for the MU196040A/B to that for the MU196020A.

5.3.4 Pattern

(1) Specifications

- PRBS pattern (NRZ, PAM4)
- Zero Substitution pattern (NRZ)
- SSPRQ pattern (PAM4)

(2) Connection

Refer to Figure 5.3.3-1 for the device connection.

(3) Procedure

1. Configure the settings in the same manner as shown in steps 1 to 5 in Section 5.3.1.
2. Connect the measuring instrument cables as shown in Figure 5.3.3-1.
3. Turn on the MP1900A and the measuring instruments, and warm them up.
4. Set the modulation mode of MU196020A and MU196040A/B to **NRZ**.
5. Set the output of the MU196020A to ON and touch **Start** of the MU196040A/B. Adjust the phase as required, and check that no error occurs.
6. On the **Pattern** tab of both of the MU196040A/B and the MU196020A, switch the PRBS pattern length to the following values in order, and check that no error occurs.
 2^7-1 , 2^9-1 , $2^{10}-1$, $2^{11}-1$, $2^{13}-1$, $2^{15}-1$, $2^{20}-1$, $2^{23}-1$, $2^{31}-1$.
7. Set the PRBS pattern length of both MU196040A/B and MU196020A to $2^{31}-1$. Then, check that no error occurs for the following four modulation type and logic combinations:

Table 5.3.4-1 Modulation Type and Logic Settings

| | Modulation Type | Logic | Logic MSB | Logic LSB |
|---|-----------------|-------|-----------|-----------|
| 1 | NRZ | POS | — | — |
| 2 | NRZ | NEG | — | — |
| 3 | PAM4 | — | POS | POS |
| 4 | PAM4 | — | NEG | NEG |

8. Set the modulation mode of MU196020A and MU196040A/B to **NRZ**.
9. For both the MU196040A/B and the MU196020A, set the test pattern to Zero Substitution, then, switch the Length to the following values in order, and check that no error occurs.
 2^7 , 2^9 , 2^{10} , 2^{11} , 2^{15} , 2^{20} , 2^{23} , 2^7-1 , 2^9-1 , $2^{10}-1$, $2^{11}-1$, $2^{15}-1$, $2^{20}-1$, $2^{23}-1$.

10. Set the modulation mode of MU196020A and MU196040A/B to **PAM4**.
11. Change the test patterns of both MU196040A/B and MU196020A to SSPRQ, and check that no error occurs.

5.3.5 Error Detection

(1) Specifications

| | |
|----------------------------|------------------------------------|
| Error rate: | 0.0000×10^{-16} to 1.0000 |
| Error count: | 0 to 1×10^{16} |
| Error free interval (EFI): | 0.0000 to 100.0000% |
| Error interval (EI): | 0 to 1×10^{16} |
| Clock frequency: | |

MU196040A-001 2.4 to 32.1 GHz,

MU196040B-001 2.4 to 32.1 GHz,

MU196040B-002 2.4 to 64.2 GHz,

Accuracy $\pm(10 \text{ ppm} + 1 \text{ kHz})$

(2) Connection

Refer to Figure 5.3.3-1 for the device connection.

(3) Procedure

1. Configure the settings in the same manner as shown in steps 1 to 5 in Section 5.3.1.
2. Connect the measuring instrument cables as shown in Figure 5.3.3-1.
3. Turn on the MP1900A and the measuring instruments, and warm them up.
4. Set the frequency of the MU181000B to 10 GHz.
5. Set the modulation mode of MU196020A and MU196040A/B to **NRZ**.
6. Check that MU196020A is set to NRZ 20 Gbit/s, turn **ON** the Output, and then touch **Start** of the MU196040A/B. Adjust the phase as required, and check that no error occurs.
7. Turn On error insertion of the MU196020A, and make sure that the ER measurement results on the **Result** tab of the MU196040A/B match the values set on the **Error Addition** tab on the MU196020A.
8. Set "Single" for error insertion of the MU196020A (set Variation to **Single** on the MU196020A **Error Addition** tab).
9. In the Gating field of the **Measurement** tab of the MU196040A/B, set **Cycle** to **Single**, and set the measurement time to 10 seconds.

10. Touch the **Start** button of the MU196040A/B. While the measurement is running for 10 seconds, touch **Single** once on the **Error Addition** tab of the MU196020A.

When the measurement has finished, check that the measurement results are as follows.

| | |
|-----------------------------|------------|
| Error rate (ER): | 5.0000E-12 |
| Error count (EC): | 1.0000E-00 |
| Error free interval (%EFI): | 99.9900% |
| Error interval (EI): | 1 |

Chapter 6 Maintenance

This chapter describes maintenance of the MP1900A modules.

- 6.1 Daily Maintenance6-2
- 6.2 Cautions on Storage6-2
- 6.3 Transportation.....6-3
- 6.4 Calibration6-3

6.1 Daily Maintenance

- Wipe off any external stains with a cloth dampened with diluted mild detergent.
- Vacuum away any accumulated dust or dirt with a vacuum cleaner.
- Tighten any loose parts fixed with screws, using the specified tools.

6.2 Cautions on Storage

Wipe off any dust, soil, or stain on the MP1900A modules prior to storage. Install the supplied Opens or Terminators to the connectors on the panel.

Avoid storing the MP1900A modules in any of the following locations:

- In direct sunlight for extended periods
- Outdoors
- In excessively dusty locations
- Where condensation may occur
- In liquids, such as water, oil, or organic solvents, and medical fluids, or places where these liquids may adhere
- In salty air or in place chemically active gases (sulfur dioxide, hydrogen sulfide, chlorine, ammonia, nitrogen dioxide, 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 or mechanical shock, such as in cars, ships, or airplanes
- Under the following temperature and humidity conditions:
Temperature range of $\leq -20^{\circ}\text{C}$ or $\geq 60^{\circ}\text{C}$
Humidity range of $\geq 85\%$

Recommended storage conditions

In addition to the abovementioned storage cautions, the following environment conditions are recommended for long-term storage.

- Temperature range of 5 to 30°C
- Humidity range of 40 to 75%
- Slight daily fluctuation in temperature and humidity

6.3 Transportation

Use the original packing materials, if possible, when packing the MP1900A modules for transport. If you do not have the original packing materials, pack the MP1900A modules according to the following procedure. When handling the MP1900A modules, always wear clean gloves, and handle it gently so as not to damage it.

<Procedure>

1. Use a dry cloth to wipe off any stain or dust on the exterior of the MP1900A module.
2. Check for loose or missing screws.
3. Provide protection for structural protrusions and parts that can easily be deformed, and wrap the MP1900A module with a sheet of polyethylene. Finally, cover with moisture-proof paper.
4. Place the wrapped MP1900A module into a cardboard box, and tape the flaps with adhesive tape. Furthermore, store it in a wooden box as required by the transportation distance or method.
5. During transportation, place it under an environment that meets the conditions described in 6.2 “Cautions on Storage”.

6.4 Calibration

Regular maintenance such as periodic inspections and calibration is essential for the Signal Quality Analyzer-R series for long-term stable performance. Regular inspection and calibration are recommended for using the Signal Quality Analyzer Series in its prime condition at all times. The recommended calibration cycle after delivery of the Signal Quality Analyzer Series 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

Chapter 7 Troubleshooting

This chapter describes how to determine if a failure has occurred when a problem occurs during the MP1900A module operation.

| | | |
|-----|---|-----|
| 7.1 | Problems That Occur When Replacing Modules..... | 7-2 |
| 7.2 | Problems That Occur During Output Waveform Observation | 7-3 |
| 7.3 | Problems That Occur During Error Rate Measurement..... | 7-4 |
| 7.4 | Synchronization Failures | 7-5 |

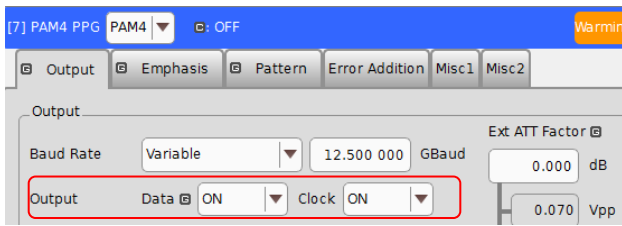
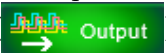
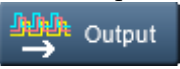
7.1 Problems That Occur When Replacing Modules

Table 7.1-1 Remedies for Problems That Occur When Replacing MP1900A Modules

| Symptom | Check Item | Remedy |
|----------------------------|--|--|
| Module recognition failed. | Is the module(s) installed properly? | Reinstall the module according to 3.3 “Installing and Removing Modules” in the <i>MP1900A Signal Quality Analyzer-R Operation Manual</i> . |
| | Are the appropriate modules installed? | Confirm the MP1900A software version and the supported modules by visiting the MP1900A Series Signal Quality Analyzers-R product information page in the Anritsu web site (https://www.anritsu.com). If the appropriate modulus are not recognized, it may have failed. 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. |

7.2 Problems That Occur During Output Waveform Observation

Table 7.2-1 Remedies for Problems That Occur During Waveform Observation

| Symptom | Check Item | Remedy |
|---|---|---|
| Output waveform cannot be monitored normally. | Is the Data or Clock on the Output tab set to ON ? | <p>On the Output tab, set Data or Clock to be output to ON.</p>  <p>When Output is OFF, turn it ON by touching the list box.</p> |
| | Is Output ON ()? | <p>On the top left corner of the screen, touch  to turn ON.</p> |
| | Is the operating clock supplied normally? | <p>When using the internal clock, check the bit rate setting.</p> <p>When the clock is supplied externally, check the connection interface. Refer to 3.1 “Panel Layout” for the interface.</p> |
| | Is the trigger clock set correctly? | <p>It is recommended to use the signal output from the AUX Output connector as the trigger clock. Check the AUX Output connector settings and interface with the sampling oscilloscope which measures the waveforms.</p> |
| | Is the electrical interface cable loose? | Tighten the connector. |
| | Do the cables used have good high-frequency characteristics? | <p>Use the cables and connectors that support 65 GHz or higher frequency band. If the bit rate is 32.1 Gbit/s (Gbaud) or less, use the cables and connectors that support 40 GHz or higher frequency band.</p> |

7.3 Problems That Occur During Error Rate Measurement

Table 7.3-1 Remedies for Problems That Occur During Error Rate Measurement

| Symptom | Check Item | Remedy |
|------------------|--|--|
| An error occurs. | Is the connection interface with the DUT correct? | Check that the data rate, level, offset and termination conditions match those of the DUT. |
| | Are the logical patterns correctly set on the MU196020A and the error detector (ED)? | Check if the patterns generated by the MU196020A are set such that they can be received by the DUT, and if the set patterns generated by the DUT and detected by the ED are the same. If the DUT outputs the patterns from the MU196020A as they are, connect the MU196020A and ED directly to check if an error is detected. Prevent the bit rate (baud rate) from exceeding 32.1 Gbit/s (Gbaud) when using MU196040A or MU196040B-001. |
| | Is the error addition function set to off? | On the Error Addition tab, check that the Error Addition switch is set to OFF . |
| | Is the electrical interface cable loose? | Tighten the connector. |
| | Do the cables used have good high-frequency characteristics? | Use the cables and connectors that support 65 GHz or higher frequency band. If the bit rate is 32.1 Gbit/s (Gbaud) or less, use the cables and connectors that support 40 GHz or higher frequency band. |
| | Are sufficient phase margin and threshold margin are secured? | Adjust the phase and offset to between the MU196020A and the DUT and between the DUT and ED, respectively so that they can be optimal. |

7.4 Synchronization Failures

Table 7.4-1 Remedies for Synchronization Failures

| Item | Check Item | Remedy |
|--------------------------|--|--|
| Input conditions | Do the quality, status and length of the connection cables comply with the specifications? | Replace the cables with appropriate ones in the following cases: <ul style="list-style-type: none"> • Frequency characteristics are not sufficient. • Loss is large. • Cables and connectors are damaged. • Connectors are contaminated. |
| | Is the cable connection correct and secure? | Confirm the destination and check if the connector is tightened securely. |
| | Are the single and differential (50/100 Ω) inputs set correctly? | Set the correct value. |
| | Is the input level correct? | Check the level by using an oscilloscope, etc. |
| | Are the input bit rate and clock frequency set correctly? | Set the bit rate and clock frequency correctly. Note: Use the frequency counter to check the current clock frequency. |
| | Is the frequency set near the bit rate when using clock recovery? | Set the frequency near the bit rate to be used. |
| | Has the clock loss display disappeared? | Check the data and clock signals to be input or clock recovery settings. |
| Termination conditions | Was the termination potential adjusted? | Set the termination potential correctly. Note: Incorrect setting may result in unit failure. |
| Clock setting conditions | Do the clock settings for PAM4 PPG and PAM4 ED match? | <p>PAM4 PPG: On the Misc2 tab, check the settings for Output Clock Rate and Operation Baud Rate (when Clock Source is External).</p> <p>On the Output tab, check the setting for Baud Rate.</p> <p>PAM4 ED: On the Input tab, check the setting for Operation Baud Rate in the Clock area (when Selection is set to External Clock).</p> <p>On the Result tab, check the Clock Count or Frequency value.</p> <p>Note: Without properly configured clock settings, expected measurement results cannot be obtained.</p> |

Table 7.4-1 Remedies for Synchronization Failures (Cont'd)

| Item | Check Item | Remedy |
|--|---|--|
| PAM4 symbol synchronization conditions | Has symbol synchronization been established between PAM4 MSB and LSB? | <p>In Diagnostics Mode, check that MSB/LSB Diff is 0. If it is 0, symbol synchronization has been established.</p> <p>If, on the Result tab of the PAM4 ED, either or both of Upper Eye Threshold and Lower Eye Threshold are set to a voltage within the range of Middle Eye Height, “-----” may be displayed in MSB/LSB Diff.</p> <p>Note: MSB/LSB Diff must be 0 when performing symbol measurement.</p> |
| PAM4 Auto Search conditions | Has the Auto Search function failed? | <p>In Diagnostics Mode, check that MSB/LSB Diff is within ± 48. Make sure the input level is sufficient.</p> <p>Note: MSB/LSB Diff must be within ± 48 when performing Auto Search.</p> |
| PAM4 pattern conditions | Is the pattern of PAM4 MSB and LSB different? | <p>In Diagnostics Mode, check that symbol synchronization can be established between MSB and LSB. As necessary, change the logic polarity and coding condition settings for MSB or LSB.</p> |

Appendix A Pseudo-Random Pattern

| | | |
|-----|---------------------------------|-----|
| A.1 | Pseudo-Random Pattern..... | A-2 |
| A.2 | Zero-Substitution Pattern | A-3 |

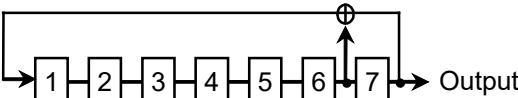
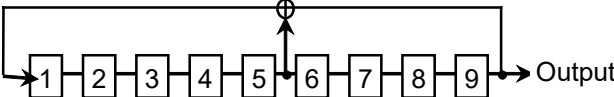
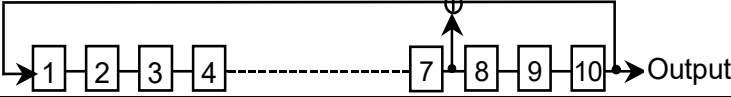
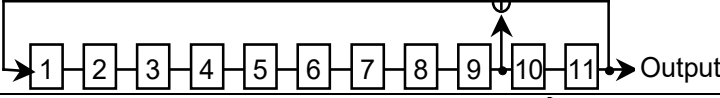
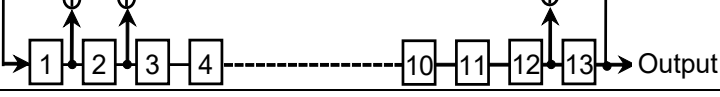

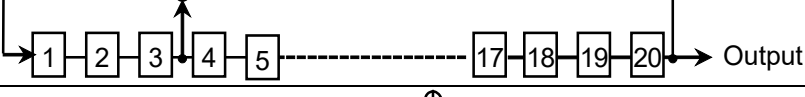
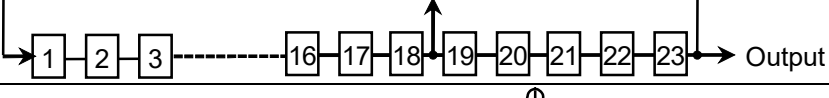
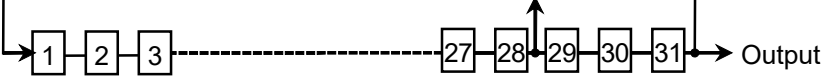
A.1 Pseudo-Random Pattern

Table A.1-1 shows the principle of pseudo-random pattern generation. A pseudo-random pattern is expressed in an N-th degree generating polynomial, with one cycle of $2^n - 1$. For a PRBS pattern with a cycle of $2^n - 1$, a pattern of successive “1s” for the number N is generated once in a cycle.


For the output level of the PRBS pattern, “1” indicates the low level and “0” indicates the high level when Logic is set to POS (positive).

The mark ratios of the PRBS pattern are generated as shown in the block diagrams of Table A.1-1.

Table A.1-1 Principle of pseudo-random pattern generation

| Cycle | Generating polynomial | Pattern generation block diagram |
|--------------|---------------------------------|--|
| $2^7 - 1$ | $1 + X^6 + X^7$ |  |
| $2^9 - 1$ | $1 + X^5 + X^9$ |  |
| $2^{10} - 1$ | $1 + X^7 + X^{10}$ |  |
| $2^{11} - 1$ | $1 + X^9 + X^{11}$ |  |
| $2^{13} - 1$ | $1 + X + X^2 + X^{12} + X^{13}$ |  |
| $2^{15} - 1$ | $1 + X^{14} + X^{15}$ |  |
| $2^{20} - 1$ | $1 + X^3 + X^{20}$ |  |
| $2^{23} - 1$ | $1 + X^{18} + X^{23}$ |  |
| $2^{31} - 1$ | $1 + X^{28} + X^{31}$ |  |

 : Shift register (N=1, 2, 3....)

 : Exclusive OR

A.2 Zero-Substitution Pattern

A string of successive “0s” for the number of set bits is made by substituting “0” for the pattern that follows the longest bit string of successive 0s in a PRBS pattern. In this event, if the bit immediately after the bit substituted to “0” is also “0”, it is inverted to “1”.

Example: For a PRBS pattern with a cycle of 2^7 , the largest number of successive 0s is 6 bits ($7 - 1$), and zero substitution starts from the following position:

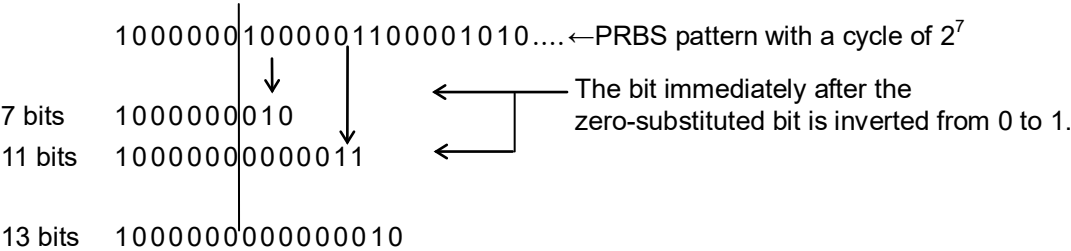


Figure A.2-1 Zero-Substitution Pattern

Appendix B List of Default Settings

Appendix B lists the factory default settings for MU196020A, MU196040A, and MU196040B.

To initialize all settings, select **Menu** → **Initialize**.

| | | |
|-----|-----------------|------|
| B.1 | MU196020A..... | B-2 |
| | B.1.1 PAM4..... | B-2 |
| | B.1.2 NRZ..... | B-7 |
| B.2 | MU196040A..... | B-10 |
| | B.2.1 PAM4..... | B-10 |
| | B.2.2 NRZ..... | B-15 |
| B.3 | MU196040B..... | B-20 |
| | B.3.1 PAM4..... | B-20 |
| | B.3.2 NRZ..... | B-25 |

B.1 MU196020A

B.1.1 PAM4

Table B.1.1-1 Output Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-------------------------|-------------------|---------------------|-------------------------------|
| Baud Rate | | | Variable |
| | Baud Rate | | 12.500 000 Gbaud |
| Output | Data | | ON |
| | Clock | | ON |
| Level Guard | | | OFF |
| | Level Guard Setup | Total Amplitude | 0.800 V |
| | | Offset Max(Voh) | 3.300 V |
| | | Offset Min(Vol) | −2.800 V |
| (PAM4 pattern settings) | | Offset switching | AC OFF |
| | | Total Amplitude | 0.500 Vp-p |
| | | Upper Eye Ratio | 33.400% |
| | | Level2 Voltage | 0.083 V |
| | | Offset | 0.000 V |
| | | Level1 Voltage | −0.083 V |
| | | Lower Eye Ratio | 33.400% |
| | | External ATT Factor | 0.000 dB |
| Half Period Jitter | | | 0 |
| Cable for Data Output | | | J1789A 0.4m Cable (Recommend) |
| Delay | | | 0 mUI |
| | | Calibration | – |
| | Jitter Input | | OFF |
| | Relative | | 0 mUI |

Table B.1.1-2 Emphasis Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|------------------|------------------------------|---------------|---------------|
| Manual Setting | Emphasis | | Off |
| | Standard/Preset | | USER |
| | | | De-Emphasis |
| | | | Preset0 |
| Graph | Total Amplitude | | 0.500 Vp-p |
| | Upper Eye | | 33.400% |
| | Lower Eye | | 33.400% |
| | Pre | Cursor2 | 0.000 dB |
| | | Cursor1 | 0.000 dB |
| | Post | Cursor1 | 0.000 dB |
| | Coefficient | C-2 | 0.000 000 |
| | | C-1 | 0.000 000 |
| | | C0 | 1.000 000 |
| | | C1 | 0.000 000 |
| Channel Emulator | Channel Emulator Function | | OFF |
| | Response | | Normal |
| | Graph Mode | | Freq. Domain |
| | Gain Adjust | | 1 GHz |
| ISI | ISI Function | | OFF |
| | Standard/Interface | | User |
| | Loss Channel | | Not Specified |
| | Graph Mode | | Freq. Domain |
| | Multi Point Mode | | 1point |
| | Tuning NF Insertion Loss | | 4.0 dB |
| | Tuning 1/2 NF Insertion Loss | | 2.0 dB |

Table B.1.1-3 Pattern Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|--------------|----------------|---------------|--------------------|
| Test Pattern | PRBS | | All List |
| | | Length | 2 ¹⁵ −1 |
| | | PRBS Inv MSB | ON |
| | | PRBS Inv LSB | ON |
| | | Gray Coder | ON |
| | | Pre Coder | OFF |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | | Bit Shift | 0 |
| | Data | Length | 4 bits |
| | | Gray Coder | ON |
| | | Pre Coder | OFF |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | | Bit Shift | 0 |
| | Data Editor | Data Length | 4 bits |
| | | Format | Hex(Byte) |
| | | Edit Mode | Overwrite |
| | | Cursor Addr | 0x00000000 |

Table B.1.1-3 Pattern Tab (Cont'd)

| Main Item | Secondary Item | Tertiary Item | Default |
|--------------|---|---------------|---------|
| Test Pattern | PRBS23Q, PRBS31Q, PRBS31Q (Infiniband), PRBS31Q (Fibre Channel) | PRBS Inv MSB | ON |
| | | PRBS Inv LSB | ON |
| | | Gray Coder | ON |
| | | Pre Coder | OFF |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | | Bit Shift | 0 |
| | PRBS13Q, QPRBS13-CEI, QPRBS31-CEI, PRBS13Q (Infiniband) | PRBS Inv MSB | OFF |
| | | PRBS Inv LSB | OFF |
| | | Gray Coder | ON |
| | | Pre Coder | OFF |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | | Bit Shift | 0 |
| | QPRBS13 | Seed | Lane 0 |
| | | Gray Coder | ON |
| | | Pre Coder | ON |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | | Bit Shift | 0 |
| | SSPRQ, JP03A, JP03B, Square Wave, Transmitter Linearity | Logic MSB | POS |
| | | Logic LSB | POS |
| | | Bit Shift | 0 |

Table B.1.1-4 Error Addition Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|----------------|---------------------|---------------|------------------|
| Error Addition | | | OFF |
| | Error Addition Mode | | Bit Error on MSB |
| | Bit Error on MSB | Symbol/Burst | Symbol |
| | | Source | Internal |
| | | Variation | Repeat |
| | | Rate | 1E-3 |
| | | Burst Length | 1 Symbols |

Table B.1.1-5 Misc1 Tab

| Main Item | Secondary Item | Tertiary Item | Default | | |
|------------------|----------------|---------------|-----------------|----------------|------------|
| Pattern Sequence | | | Repeat | | |
| | Gating Output | | ON | | |
| | Repeat | Pulse Width | 256 symbols | | |
| | | Delay | 0 symbols | | |
| AUX Input | | | Error Injection | | |
| | | | Vth | 0V | |
| AUX Output | | | 1/N Clock | | |
| | | | 1/N Clock | (Divide ratio) | 1/64 Clock |
| | | | Pattern Sync | Position | 1 symbols |

Table B.1.1-6 Misc2 Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|---------------|----------------------------------|----------------------|-------------------------------------|
| Clock Setting | Clock Source | | Unit1:Slot4:MU181500B* ¹ |
| | Baud Rate | | Variable* ¹ |
| | | Baud Rate | 12.500 000 GBaud* ¹ |
| | | Offset* ¹ | 0 ppm |
| | Output Clock Rate | | Halfrate |
| | Reference Clock* ¹ | | Internal |
| | Operation Bit Rate* ² | | 2.40 – 32.10 GBaud |

*1: When the MX190000A is started as Standard BERT for PAM4.

*2: When the MX190000A is started as Expert BERT.

B.1.2 NRZ

Table B.1.2-1 Output Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|------------------------|-------------------|---------------------|-------------------------------|
| Bitrate | | | Variable |
| | Bitrate | | 12.500 000 Gbit/s |
| Output | Data | | ON |
| | Clock | | ON |
| Level Guard | | | OFF |
| | Level Guard Setup | Amplitude | 0.800 V |
| | | Offset Max(Voh) | 3.300 V |
| | | Offset Min(Vol) | −2.800 V |
| (NRZ pattern settings) | | Amplitude | 0.500 Vp-p |
| | | Offset switching | AC OFF |
| | | Offset | 0.000 V |
| | | Offset Position | Vth |
| | | External ATT Factor | 0.000 dB |
| Half Period Jitter | | | 0 |
| Cable for Data Output | | | J1789A 0.4m Cable (Recommend) |
| Delay | | | 0 mUI |
| | | Calibration | – |
| | Jitter Input | | OFF |
| | Relative | | 0 mUI |

Table B.1.2-2 Emphasis Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|------------------|--------------------------------------|---------------|---------------|
| Manual Setting | Emphasis Function Standard/Preset | | Off |
| | | | USER |
| | | | De-Emphasis |
| | | | Preset0 |
| Graph | Amplitude | | 0.500 Vp-p |
| | Pre | Cursor2 | 0.000 dB |
| | | Cursor1 | 0.000 dB |
| | Post | Cursor1 | 0.000 dB |
| | Coefficient | C-2 | 0.000 000 |
| | | C-1 | 0.000 000 |
| | | C0 | 1.000 000 |
| | | C1 | 0.000 000 |
| Channel Emulator | Channel Emulator Function | | OFF |
| | Response | | Normal |
| | Graph Mode | | Freq. Domain |
| | Gain Adjust | | 1 GHz |
| ISI | ISI Function | | OFF |
| | Standard/Interface | | User |
| | Loss Channel | | Not Specified |
| | Graph Mode | | Freq. Domain |
| | Multi Point Mode | | 1point |
| | Tuning NF Insertion Loss | | 4.0 dB |
| | Tuning 1/2 NF Insertion Loss | | 2.0 dB |

Table B.1.2-3 Pattern Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|--------------|-------------------|--------------------------|--------------------|
| Test Pattern | | | All List |
| | PRBS | Length | 2 ¹⁵ −1 |
| | | Mark Ratio | 1/2 |
| | | Logic | POS |
| | Zero Substitution | Length | 2 ¹⁵ |
| | | Zero Substitution Length | 1 bits |
| | | Additional Bit | 1 |
| | | Logic | POS |
| | Data | Length | 2 |
| | | Logic | POS |
| | Data Editor | Data Length | 2 |
| | | Format | Hex(Byte) |
| | | Edit Mode | Overwrite |
| | | Cursor Addr | 0x00000000 |
| | SSPR | Logic | POS |

Table B.1.2-4 Error Addition Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|----------------|---------------------|---------------|-----------|
| Error Addition | | | OFF |
| | Error Addition Mode | | Bit Error |
| | Bit Error | Bit/Burst | Bit |
| | | Source | Internal |
| | | Variation | Repeat |
| | | Route | Select |
| | | Rate | 1E-3 |
| | | Burst Length | 1 bits |

Table B.1.2-5 Misc1 Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|------------------|----------------|-----------------|------------------|
| Pattern Sequence | | | Repeat |
| | Gating Output | | ON |
| | Repeat | Pulse Width | 256 bits |
| | | Delay | 0 bits |
| | Burst | Source | Internal |
| | | Data Sequence | Restart |
| | | Enable Period | 128 000 bits |
| | | Burst Cycle | 128 000 000 bits |
| | | Delay | 0 bits |
| | | Pulse Width | 128 000 bits |
| AUX Input | | Error Injection | |
| | Vth | 0V | |
| AUX Output | | 1/N Clock | |
| | 1/N Clock | (Divide ratio) | 1/64 Clock |
| | Pattern Sync | Position | 1 bits |

Table B.1.2-6 Misc2 Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|---------------|----------------------|---------------|-------------------------|
| Clock Setting | Clock Source | | Unit1:Slot4:MU181500B*1 |
| | Bit Rate | Variable*1 | |
| | | Baud Rate | 12.500 000 Gbit/s*1 |
| | | Offset*1 | 0 ppm |
| | Output Clock Rate | | Halfrate |
| | Reference Clock*1 | | Internal |
| | Operation Bit Rate*2 | | 2.40 – 32.10 Gbit/s |

*1: When the MX190000A is started as Standard BERT for PAM4.

*2: When the MX190000A is started as Expert BERT.

B.2 MU196040A

B.2.1 PAM4

Table B.2.1-1 Result Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-------------------------|------------------------|-------------------------|----------------|
| Switch of setting items | Setting display format | | Gating |
| | Input | Upper Eye Threshold | 0.095 V |
| | | Middle Eye Threshold | 0.000 V |
| | | Lower Eye Threshold | −0.095 V |
| | | UL Threshold | ON |
| | | Delay | 0 mUI |
| | Gating | Cycle | Repeat |
| | | Unit | Time |
| | | Time | 0 day 00:00:01 |
| | | Current | ON |
| | | Calculation | Progressive |
| | | Interval | 100 ms |
| | Condition | EI/EFI Interval | 100 ms |
| | | Bit Mask (Block Window) | OFF |
| | Auto Sync | Auto Sync | ON |
| | | Threshold | INT |
| | Sync Control | Frame Length | 64 symbols |
| | | Frame Position | 1 symbols |
| Time display format | | | Date&Time |
| Error/Alarm display | Details | | OFF |
| | Zoom | | OFF |

Table B.2.1-2 Measurement Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-----------------------|-----------------|---------------|----------------|
| Gating | Cycle | | Repeat |
| | Unit | | Time |
| | | Time | 0 day 00:00:01 |
| | | Clock Count | >E+10 |
| | | Error Count | >E+10 |
| | Current | | ON |
| | | Calculation | Progressive |
| | | Interval | 100 ms |
| Auto Sync | Auto Sync | | ON |
| | Threshold | | INT |
| Sync Control | Frame Length | | 64 symbols |
| | Frame Position | | 1 symbols |
| | Mask | | All 00 |
| Error/Alarm Condition | EI/EFI Interval | | 100 ms |

Table B.2.1-3 Pattern Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|--------------|----------------|---------------|--------------------|
| Test Pattern | PRBS | | All List |
| | | Length | 2 ¹⁵ −1 |
| | | PRBS Inv MSB | ON |
| | | PRBS Inv LSB | ON |
| | | Gray Coder | ON |
| | | Pre Coder | OFF |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | Data | Length | 4 |
| | | Gray Coder | ON |
| | | Pre Coder | OFF |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | Data Editor | Data Length | 4 |
| | | Format | Hex(Byte) |
| | | Edit Mode | Overwrite |
| | | Cursor Addr | 0x00000000 |

Table B.2.1-3 Pattern (Cont'd)

| Main Item | Secondary Item | Tertiary Item | Default |
|--------------|--|---------------|---------|
| Test Pattern | PRBS23Q, PRBS31Q, PRBS31Q (Infiniband), PRBS31Q (Fibre Channel) | PRBS Inv MSB | ON |
| | | PRBS Inv LSB | ON |
| | | Gray Coder | ON |
| | | Pre Coder | OFF |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | PRBS13Q, QPRBS13-CEI, QPRBS31-CEI, PRBS13Q (Infiniband) | PRBS Inv MSB | OFF |
| | | PRBS Inv LSB | OFF |
| | | Gray Coder | ON |
| | | Pre Coder | OFF |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | QPRBS13 | Seed | Lane 0 |
| | | Gray Coder | ON |
| | | Pre Coder | ON |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | SSPRQ, JP03A, JP03B, Square Wave, Transmitter Linearity | Logic MSB | POS |
| | | Logic LSB | POS |
| Mask | Bit Mask (Block Window) | | OFF |
| | External Mask | | OFF |

Table B.2.1-4 Input Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|---------------------|---------------------|------------------------|---------------------------------|
| Data | Input Condition | | Single-Ended |
| | | Single-Ended | Data |
| | | Differential 50Ohm | Independent |
| | | Differential 100Ohm | Independent |
| | Termination | | GND |
| | Data | Upper Eye Threshold | 0.165 V |
| | | Middle Eye Threshold | 0.000 V |
| | | Lower Eye Threshold | -0.165 V |
| | XData | Upper Eye Threshold | 0.165 V |
| | | Middle Eye Threshold | 0.000 V |
| | | Lower Eye Threshold | -0.165 V |
| | UL Threshold | | ON |
| | | Differential Selection | Data-XData |
| | | Threshold | 0.000 V |
| Clock | Selection | | External Clock |
| | Operation Baud Rate | | 2.40 – 16.05 GBaud |
| | Input Clock Freq. | | 2.40 – 16.05 GHz (1/1 Clock) |
| | Delay | | 0 mUI |
| | | Relative | 0 mUI |
| | | Jitter Input | OFF |
| Measurement Restart | Data Threshold | | OFF |
| | Clock Delay | | OFF |

Table B.2.1-5 Capture Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-------------|----------------------|---------------|---------------|
| Acquisition | | | Bit Pattern |
| Condition | Number of Block | | 128 |
| | Condition | Trigger | |
| | Trigger | | Match Pattern |
| | | Position | Top |
| | Match Pattern Length | | 4 bits |
| | Format | | HEX |
| | Math Pattern | | 0 |
| | Mask Pattern | | 0 |

Table B.2.1-6 Misc1 Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|------------------|----------------|----------------|-------------------|
| Pattern Sequence | | | Repeat |
| | Source | | External - Enable |
| AUX Input | | | External Mask |
| | | Vth | 0V |
| AUX Output | | | 1/N Clock |
| | 1/N Clock | (Divide ratio) | 1/64 Clock |
| | Pattern Sync | Position | 1 symbols |

B.2.2 NRZ

Table B.2.2-1 Result Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-------------------------|------------------------|-------------------------|--------------------|
| Switch of setting items | Setting display format | | Gating |
| | Input | Data Threshold | 0.000 V |
| | | XData Threshold | — |
| | | Differential Selection | Data-XData |
| | | Threshold | — |
| | | Delay | 0 mUI |
| | Gating | Cycle | Repeat |
| | | Unit | Time |
| | | Time | 0 day 00:00:01 |
| | | Current | ON |
| | | Calculation | Progressive |
| | Condition | Interval | 100 ms |
| | | Error Detection | Insertion/Omission |
| | | EI/EFI Interval | 100 ms |
| | | Bit Mask (Block Window) | OFF |
| | | Lane Mask (Bit Window) | OFF |
| | Auto Sync | Auto Sync | ON |
| | | Threshold | INT |
| | Sync Control | Frame Length | 64 bits |
| | | Frame Position | 1 bit |
| Result display format | | | Error/Alarm |
| Time display format | | | Date&Time |
| Error/Alarm display | Zoom | | OFF |
| | All Channel | | OFF |

Table B.2.2-2 Measurement Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-----------------------|-----------------|---------------|--------------------|
| Gating | Cycle | | Repeat |
| | Unit | | Time |
| | | Time | 0 day 00:00:01 |
| | | Clock Count | >E+10 |
| | | Error Count | >E+10 |
| | Current | | ON |
| | | Calculation | Progressive |
| | | Interval | 100 ms |
| Auto Sync | Auto Sync | | ON |
| | Threshold | | INT |
| Sync Control | Frame Length | | 64 bits |
| | Frame Position | | 1 bit |
| | Mask | | All 00 |
| Error/Alarm Condition | Error Detection | | Insertion/Omission |
| | EI/EFI Interval | | 100 ms |

Table B.2.2-3 Pattern Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|--------------|-------------------------|--------------------------|--------------------|
| Test Pattern | PRBS | Length | 2 ¹⁵ –1 |
| | | Mark Ratio | 1/2 |
| | | Logic | POS |
| | Zero Substitution | Length | 2 ¹⁵ |
| | | Zero Substitution Length | 1 bits |
| | | Additional Bit | 1 |
| | | Logic | POS |
| | Data | Length | 2 |
| | | Logic | POS |
| | Data Editor | Data Length | 2 |
| | | Format | Hex(Byte) |
| | | Edit Mode | Overwrite |
| | | Cursor Addr | 0x00000000 |
| | SSPR | Logic | POS |
| Mask | Bit Mask (Block Window) | | OFF |
| | Lane Mask (Bit Window) | | OFF |
| | External Mask | | OFF |

Table B.2.2-4 Input Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|---------------------|------------------------|---------------------|---------------------------------|
| Data | Input Condition | | Single-Ended |
| | | Single-Ended | Data |
| | | Differential 50Ohm | Independent |
| | | Differential 100Ohm | Independent |
| | Data Threshold | | 0.000 V |
| | Termination | | GND |
| | | Variable | 0.000 V |
| | XData Threshold | | 0.000 V |
| | Differential Selection | | Data-XData |
| | Threshold | | 0.000 V |
| Clock | Selection | | External Clock |
| | Operation Bitrate | | 2.40 – 16.05 GBit/s |
| | Input Clock Freq. | | 2.40 – 16.05 GHz (1/1 Clock) |
| | Delay | | 0 mUI |
| | | Relative | 0 mUI |
| | | Jitter Input | OFF |
| Measurement Restart | Data Threshold | | OFF |
| | Clock Delay | | OFF |

Table B.2.2-5 Capture Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-------------|----------------------|---------------|---------------|
| Acquisition | | | Bit Pattern |
| Condition | | | |
| | Number of Block | | 128 |
| | Condition | Trigger | |
| | Trigger | | Match Pattern |
| | | Position | Top |
| | Match Pattern Length | | 4 bits |
| | Format | | HEX |
| | Match Pattern | | 0 |
| | Mask Pattern | | 0 |

Table B.2.2-6 Misc1 Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|------------------|----------------|----------------|-------------------|
| Pattern Sequence | Burst | | Repeat |
| | | Source | External - Enable |
| | | Delay | 0 bits |
| | | Enable Period | 128 000 bits |
| | | Burst Cycle | 128 000 000 bits |
| | | Auto/Manual | Manual |
| AUX Input | | | External Mask |
| | | Vth | 0V |
| AUX Output | | | 1/N Clock |
| | 1/N Clock | (Divide ratio) | 1/64 Clock |
| | Pattern Sync | Position | 1 bits |

B.3 MU196040B

B.3.1 PAM4

Table B.3.1-1 Result Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-------------------------|------------------------|-------------------------|----------------|
| Switch of setting items | Setting display format | | Gating |
| | Input | Upper Eye Threshold | 0.095 V |
| | | Middle Eye Threshold | 0.000 V |
| | | Lower Eye Threshold | −0.095 V |
| | | U/L Threshold Sync | ON |
| | | Low Frequency Equalizer | OFF |
| | | | 0.000 dB |
| | | DFE | OFF |
| | | | 0 |
| | Delay | 0 mUI | |
| | Gating | Cycle | Repeat |
| | | Unit | Time |
| | | Time | 0 day 00:00:01 |
| | | Current | ON |
| | | Calculation | Progressive |
| | | Interval | 100 ms |
| | Condition | EI/EFI Interval | 100 ms |
| | | Bit Mask (Block Window) | OFF |
| | Auto Sync | Auto Sync | ON |
| | | Threshold | INT |
| | Sync Control | Frame Length | 64 symbols |
| | | Frame Position | 1 symbol |
| Time display format | | | Date&Time |
| Error/Alarm display | Details | | OFF |
| | Zoom | | OFF |

Table B.3.1-2 Measurement Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-----------------------|-----------------|---------------|-------------------------|
| Gating | Cycle | | Repeat |
| | Unit | | Time |
| | | Time | 0 day 00:00:01 |
| | | Clock Count | >E+10 |
| | | Error Count | >E+10 |
| | Current | | ON |
| | | Calculation | Progressive |
| | | Interval | 100 ms |
| Auto Sync | Auto Sync | | ON |
| | Threshold | | INT |
| Sync Control | Frame Length | | 64 symbols |
| | Frame Position | | 1 symbol |
| | Mask | | 00 00 00 00 00 00 00 00 |
| Error/Alarm Condition | EI/EFI Interval | | 100 ms |
| Measurement Restart | Data Threshold | | OFF |
| | Clock Delay | | OFF |

Table B.3.1-3 Pattern Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|--------------|----------------|---------------|--------------------|
| Test Pattern | | | All List |
| | PRBS | Length | 2 ¹⁵ −1 |
| | | PRBS Inv MSB | ON |
| | | PRBS Inv LSB | ON |
| | | Gray Coder | ON |
| | | Pre Coder | OFF |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | Data | Length | 4 |
| | | Gray Coder | ON |
| | | Pre Coder | OFF |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | Data Editor | Data Length | 4 |
| | | Format | Hex(Byte) |
| | | Edit Mode | Overwrite |
| | | Cursor Addr | 0x00000000 |

Table B.3.1-3 Pattern Tab (Cont'd)

| Main Item | Secondary Item | Tertiary Item | Default |
|-----------------------|--|---------------|---------|
| Test Pattern (Cont'd) | PRBS23Q, PRBS31Q, PRBS31Q (Infiniband), PRBS31Q (Fibre Channel) | PRBS Inv MSB | ON |
| | | PRBS Inv LSB | ON |
| | | Gray Coder | ON |
| | | Pre Coder | OFF |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | PRBS13Q, QPRBS13-CEI, QPRBS31-CEI, PRBS13Q (Infiniband) | PRBS Inv MSB | OFF |
| | | PRBS Inv LSB | OFF |
| | | Gray Coder | ON |
| | | Pre Coder | OFF |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | QPRBS13 | Seed | Lane 0 |
| | | Gray Coder | ON |
| | | Pre Coder | ON |
| | | Logic MSB | POS |
| | | Logic LSB | POS |
| | SSPRQ, JP03A, JP03B, Square Wave, Transmitter Linearity | Logic MSB | POS |
| | | Logic LSB | POS |
| Mask | Bit Mask (Block Window) | | OFF |
| | External Mask | | OFF |

Table B.3.1-4 Input Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-----------|-----------------------------|------------------------|---|
| Data | Input Condition | | Single-Ended |
| | | Single-Ended | Data |
| | | Differential 50Ohm | Independent |
| | | Differential 100Ohm | Independent |
| | Termination | | GND |
| | Data | Upper Eye Threshold | 0.095 V |
| | | Middle Eye Threshold | 0.000 V |
| | | Lower Eye Threshold | -0.095 V |
| | XData | Upper Eye Threshold | 0.095 V |
| | | Middle Eye Threshold | 0.000 V |
| | | Lower Eye Threshold | -0.095 V |
| | UL Threshold | | ON |
| | | Differential Selection | Data-XData |
| | | Threshold | 0.000 V |
| Equalizer | Low Frequency Equalizer | | OFF |
| | | Data | 0.000 dB |
| | Decision Feedback Equalizer | | OFF |
| | | Data | 0 |
| Clock | Selection | | External Clock |
| | Operation Baud Rate | | 2.40 – 32.10 Gaud* ¹ Auto* ² |
| | Input Clock Freq. | | 1.20 – 16.05 GHz (1/2 Clock)* ¹ 1.20 – 32.1 GHz (1/2 Clock)* ² |
| | Delay | | 0 mUI |
| | | Relative | 0 mUI |
| | | Jitter Input | OFF |

*1: When MU196040B-001 is installed.

*2: When MU196040B-002 or MU196040B-y12 is installed.

Table B.3.1-5 Capture Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|------------------------|----------------------|---------------|-------------------|
| Capture Mode | Capture Mode | | Sync Mode Capture |
| | | State | ---- |
| Capture Result Display | Auto Launch | | Capture Data |
| Condition | | | |
| | Number of Blocks | | 128 |
| | Capture Area | | After the Trigger |
| | Trigger | | Match Pattern |
| | Match Pattern Length | | 4 symbol |
| | Notation | | Symbol(PAM4) |
| | Match Pattern | | 00 00 |
| | Mask | | 00 00 |

Table B.3.1-6 Misc1 Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|------------------|----------------|----------------|-----------------|
| Pattern Sequence | | | Repeat |
| | Source | | External-Enable |
| AUX Input | | | External Mask |
| | Vth | | 0V |
| AUX Output | | | 1/N Clock |
| | 1/N Clock | (Divide ratio) | 1/64 Clock |
| | Pattern Sync | Position | 1 symbols |

Table B.3.1-7 Logging Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-----------------|----------------|---------------|----------|
| BER/SER Logging | Logging | | OFF |
| | Cycle | | 00:00:05 |
| | ER (Symbol) | | OFF |
| | ER (Bit) | | OFF |
| | ER (MSB) | | OFF |
| | ER (LSB) | | OFF |
| | EC (Symbol) | | OFF |
| | EC (Bit) | | OFF |
| | EC (MSB) | | OFF |
| | EC (LSB) | | OFF |
| | Clock Loss | | OFF |
| | Sync Loss | | OFF |

B.3.2 NRZ

Table B.3.2-1 Result Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-------------------------|------------------------|-------------------------|--------------------|
| Switch of setting items | Setting display format | | Gating |
| | Input | Data Threshold | 0.000 V |
| | | XData Threshold | — |
| | | Differential Selection | Data-XData |
| | | Threshold | — |
| | | Delay | 0 mUI |
| | | LFE | OFF |
| | | | 0.000 dB |
| | | DFE | OFF |
| | | | 0 |
| | Gating | Cycle | Repeat |
| | | Unit | Time |
| | | Time | 0 day 00:00:01 |
| | | Current | ON |
| | | Calculation | Progressive |
| | | Interval | 100 ms |
| | Condition | Error Detection | Insertion/Omission |
| | | EI/EFI Interval | 100 ms |
| | | Bit Mask (Block Window) | OFF |
| | | Lane Mask (Bit Window) | OFF |
| | Auto Sync | Auto Sync | ON |
| | | Threshold | INT |
| | Sync Control | Frame Length | 64 bits |
| | | Frame Position | 1 bit |
| Result display format | | | Error/Alarm |
| Time display format | | | Date&Time |
| Error/Alarm display | Zoom | | OFF |
| | Show in Window | | OFF |

Table B.3.2-2 Measurement Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-----------------------|-----------------|---------------|--------------------|
| Gating | Cycle | | Repeat |
| | Unit | | Time |
| | | Time | 0 day 00:00:01 |
| | | Clock Count | >E+10 |
| | | Error Count | >E+10 |
| | Current | | ON |
| | | Calculation | Progressive |
| | | Interval | 100 ms |
| Auto Sync | Auto Sync | | ON |
| | Threshold | | INT |
| Sync Control | Frame Length | | 64 bits |
| | Frame Position | | 1 bit |
| | Mask | | All 00 |
| Error/Alarm Condition | Error Detection | | Insertion/Omission |
| | EI/EFI Interval | | 100 ms |
| Measurement Restart | Data Threshold | | OFF |
| | Clock Delay | | OFF |

Table B.3.2-3 Pattern Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|--------------|-------------------------|--------------------------|--------------------|
| Test Pattern | | | All List |
| | PRBS | Length | 2 ¹⁵ –1 |
| | | Mark Ratio | 1/2 |
| | | Logic | POS |
| | Zero Substitution | Length | 2 ¹⁵ |
| | | Zero Substitution Length | 1 bits |
| | | Additional Bit | 1 |
| | | Logic | POS |
| | Data | Length | 2 |
| | | Logic | POS |
| | Data Editor | Data Length | 2 |
| | | Format | Hex(Byte) |
| | | Edit Mode | Overwrite |
| | | Cursor Addr | 0x00000000 |
| | SSPR | Logic | POS |
| Mask | Bit Mask (Block Window) | | OFF |
| | Lane Mask (Bit Window) | | OFF |
| | External Mask | | OFF |

Table B.3.2-4 Input Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-----------|-----------------------------|---------------------|---|
| Data | Input Condition | | Single-Ended |
| | | Single-Ended | Data |
| | | Differential 50Ohm | Independent |
| | | Differential 100Ohm | Independent |
| | Data Threshold | | 0.000 V |
| | Termination | | GND |
| | | Variable | 0.000 V |
| | XData Threshold | | 0.000 V |
| | Differential Selection | | Data-XData |
| | Threshold | | 0.000 V |
| Equalizer | Low Frequency Equalizer | | OFF |
| | | Data | 0.000 dB |
| | Decision Feedback Equalizer | | OFF |
| | | Data | 0 |
| Clock | Selection | | External Clock |
| | Operation Bitrate | | 2.40 – 32.10 Gbit/s* ¹ Auto* ² |
| | Input Clock Freq. | | 1.20–16.05 GHz (1/2 Clock)* ¹ 1.20–32.1 GHz (1/2 Clock)* ² |
| | Delay | | 0 mUI |
| | | Relative | 0 mUI |
| | | Jitter Input | OFF |

*1: When MU196040B-001 is installed.

*2: When MU196040B-002 or MU196040B-y12 is installed.

Table B.3.2-5 Capture Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|------------------------|----------------------|---------------|-------------------|
| Capture Mode | Capture Mode | | Sync Mode Capture |
| | | State | ---- |
| Capture Result Display | Auto Launch | | Capture Data |
| Condition | | | |
| | Number of Blocks | | 128 |
| | Capture Area | | After The Trigger |
| | Trigger | | Match Pattern |
| | Match Pattern Length | | 4 bit |
| | Notation | | Bin |
| | Match Pattern | | 0000 |
| | Mask | | 0000 |

Table B.3.2-6 Misc1 Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|------------------|----------------|----------------|------------------|
| Pattern Sequence | Burst | Source | External -Enable |
| | | Delay | 0 bits |
| | | Enable Period | 128 000 bits |
| | | Burst Cycle | 12 800 000 bits |
| | | Auto/Manual | Manual |
| | AUX Input | | External Mask |
| | | Vth | 0V |
| AUX Output | | | 1/N Clock |
| | 1/N Clock | (Divide ratio) | 1/64 Clock |
| | Pattern Sync | Position | 1 bits |

Table B.3.2-7 Logging Tab

| Main Item | Secondary Item | Tertiary Item | Default |
|-----------------|----------------|---------------|----------|
| BER/SER Logging | Logging | | OFF |
| | Cycle | | 00:00:05 |
| | ER (Total) | | OFF |
| | ER (INS) | | OFF |
| | ER (OMI) | | OFF |
| | EC (Total) | | OFF |
| | EC (INS) | | OFF |
| | EC (OMI) | | OFF |
| | Clock Loss | | OFF |
| | Sync Loss | | OFF |

Appendix C Performance Test Record Sheet

C.1 Performance Test Result Sheet

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

C.2 MU196020A

C.2.1 MU196020A-001

Table C.2.1-1 Operating Frequency Range

| Specification | Results | |
|--|---------|--------------------------|
| | Data | $\overline{\text{Data}}$ |
| No errors occur within the range from 2.4 to 32.1 Gbit/s.* | | |
| No errors occur within the range from 2.4 to 32.1 Gbaud.* | | |

*: Pattern PRBS, $2^{31}-1$

Table C.2.1-2 MU196020A-001 Waveform Evaluation Test- Amplitude (NRZ)

| Settings | | Specification | | Results | |
|-------------|------------------|--------------------|--------------------|---------|--------------------------|
| Bit rate | Amplitude (Vp-p) | Lower limit (Vp-p) | Upper limit (Vp-p) | Data | $\overline{\text{Data}}$ |
| 32.1 Gbit/s | 0.70 | 0.581 | 0.819 | | |
| | 0.07 | 0.027 | 0.113 | | |

Table C.2.1-3 MU196020A-001 Waveform Evaluation Test- 0/3 Level Amplitude (PAM4)

| Settings | | Specification | | Results | |
|------------|------------------|--------------------|--------------------|---------|--------------------------|
| Baud rate | Amplitude (Vp-p) | Lower limit (Vp-p) | Upper limit (Vp-p) | Data | $\overline{\text{Data}}$ |
| 32.1 Gbaud | 0.70 | 0.581 | 0.819 | | |
| | 0.07 | 0.027 | 0.113 | | |

Table C.2.1-4 MU196020A-001 Waveform Evaluation Test- Offset (NRZ)

| Settings | | Specification | | Results | |
|-------------|--------------|-----------------|-----------------|---------|--------------------------|
| Bit rate | Offset (Vth) | Lower limit (V) | Upper limit (V) | Data | $\overline{\text{Data}}$ |
| 32.1 Gbit/s | 3.265 | 2.817 | 3.713 | | |
| | -2.35 | -2.590 | -2.111 | | |

Table C.2.1-5 MU196020A-001 Waveform Evaluation Test- Offset (PAM4)

| Settings | | Specification | | Results | |
|------------|--------------|-----------------|-----------------|---------|--------------------------|
| Baud rate | Offset (Vth) | Lower limit (V) | Upper limit (V) | Data | $\overline{\text{Data}}$ |
| 32.1 Gbaud | 3.265 | 2.817 | 3.713 | | |
| | -2.35 | -2.590 | -2.111 | | |

Table C.2.1-6 MU196020A-001 Waveform Evaluation Test-Cross point (NRZ)

| Settings | | Specification | | Results | |
|-------------|------------------|-----------------|-----------------|---------|--------------------------|
| Bit rate | Amplitude (Vp-p) | Lower limit (%) | Upper limit (%) | Data | $\overline{\text{Data}}$ |
| 32.1 Gbit/s | 0.50 | 40 | 60 | | |

Table C.2.1-7 MU196020A-001 Waveform Evaluation Test- Tr/Tf (NRZ)

| Settings | | Specification | | Results | |
|-------------|------------------|------------------|-------------------|---------|--------------------------|
| Bit rate | Amplitude (Vp-p) | Lower limit (ps) | Upper limit (ps) | Data | $\overline{\text{Data}}$ |
| 32.1 Gbit/s | 0.50 | — | 9.0* ¹ | | |
| | | — | 9.5* ² | | |

*1: When J1789A cables are used.

*2: When J1790A cables are used.

Table C.2.1-8 MU196020A-001 Waveform Evaluation Test- Jitter (NRZ)

| Settings | | Specification | | Results | |
|-------------|------------------|------------------|----------------------|---------|--------------------------|
| Bit rate | Amplitude (Vp-p) | Lower limit (ps) | Upper limit (ps p-p) | Data | $\overline{\text{Data}}$ |
| 32.1 Gbit/s | 0.50 | — | 6.0 | | |

C.2.2 MU196020A-002

Table C.2.2-1 Operating Frequency Range

| Specification | Results | |
|--|---------|--------------------------|
| | Data | $\overline{\text{Data}}$ |
| No errors occur within the range from 2.4 to 32.1 Gbit/s.* | | |
| No errors occur within the range from 2.4 to 32.1 Gbaud.* | | |

*: Pattern PRBS, $2^{31}-1$

Table C.2.2-2 MU196020A-002 Waveform Evaluation Test- Amplitude (NRZ)

| Settings | | Specification | | Results | |
|-------------|--------------------|--------------------|--------------------|---------|--------------------------|
| Bit rate | Amplitude (Vp-p) | Lower limit (Vp-p) | Upper limit (Vp-p) | Data | $\overline{\text{Data}}$ |
| 58.2 Gbit/s | 0.70* ¹ | 0.581 | 0.819 | | |
| | 0.60* ² | 0.493 | 0.707 | | |
| | 0.07 | 0.027 | 0.113 | | |

*1: When J1789A cables are used.

*2: When J1790A cables are used.

Table C.2.2-3 MU196020A-002 Waveform Evaluation Test-0/3 Level Amplitude (PAM4)

| Settings | | Specification | | Results | |
|------------|--------------------|--------------------|--------------------|---------|--------------------------|
| Baud rate | Amplitude (Vp-p) | Lower limit (Vp-p) | Upper limit (Vp-p) | Data | $\overline{\text{Data}}$ |
| 58.2 Gbaud | 0.70* ¹ | 0.581 | 0.819 | | |
| | 0.60* ² | 0.493 | 0.707 | | |
| | 0.07 | 0.027 | 0.113 | | |

*1: When J1789A cables are used.

*2: When J1790A cables are used.

Table C.2.2-4 MU196020A-002 Waveform Evaluation Test- Offset (NRZ)

| Settings | | Specification | | Results | |
|-------------|---------------------|-----------------|-----------------|---------|--------------------------|
| Bit rate | Offset (Vth) | Lower limit (V) | Upper limit (V) | Data | $\overline{\text{Data}}$ |
| 58.2 Gbit/s | 3.265 | 2.817 | 3.713 | | |
| | -2.30* ¹ | -2.489 | -2.112 | | |
| | -2.35* ² | -2.590 | -2.111 | | |

*1: When J1790A cables are used, Amplitude 0.60 Vp-p

*2: When J1789A cables are used, Amplitude 0.70 Vp-p

Table C.2.2-5 MU196020A-002 Waveform Evaluation Test- Offset (PAM4)

| Settings | | Specification | | Results | |
|------------|---------------------|-----------------|-----------------|---------|--------------------------|
| Baud rate | Offset (Vth) | Lower limit (V) | Upper limit (V) | Data | $\overline{\text{Data}}$ |
| 58.2 Gbaud | 3.265 | 2.817 | 3.713 | | |
| | -2.30* ¹ | -2.489 | -2.112 | | |
| | -2.35* ² | -2.590 | -2.111 | | |

*1: When J1790A cables are used, Amplitude 0.60 Vp-p

*2: When J1789A cables are used, Amplitude 0.70 Vp-p

Table C.2.2-6 MU196020A-002 Waveform Evaluation Test- Cross point (NRZ)

| Settings | | Specification | | Results | |
|-------------|------------------|-----------------|-----------------|---------|--------------------------|
| Bit rate | Amplitude (Vp-p) | Lower limit (%) | Upper limit (%) | Data | $\overline{\text{Data}}$ |
| 58.2 Gbit/s | 0.50 | 40 | 60 | | |

Table C.2.2-7 MU196020A-002 Waveform Evaluation Test- Tr/Tf (NRZ)

| Settings | | Specification | | Results | |
|-------------|------------------|------------------|-------------------|---------|--------------------------|
| Bit rate | Amplitude (Vp-p) | Lower limit (ps) | Upper limit (ps) | Data | $\overline{\text{Data}}$ |
| 58.2 Gbit/s | 0.50 | — | 8.5* ¹ | | |
| | | — | 8.8* ² | | |

*1: When J1789A cables are used.

*2: When J1790A cables are used.

Table C.2.2-8 MU196020A-002 Waveform Evaluation Test- Jitter (NRZ)

| Settings | | Specification | | Results | |
|-------------|------------------|------------------|----------------------|---------|--------------------------|
| Bit rate | Amplitude (Vp-p) | Lower limit (ps) | Upper limit (ps p-p) | Data | $\overline{\text{Data}}$ |
| 58.2 Gbit/s | 0.50 | — | 6.0 | | |

C.2.3 MU196020A-003

Table C.2.3-1 Operating Frequency Range

| Specification | Results | |
|--|---------|--------------------------|
| | Data | $\overline{\text{Data}}$ |
| No errors occur within the range from 2.4 to 32.1 Gbit/s.* | | |
| No errors occur within the range from 2.4 to 32.1 Gbaud.* | | |

*: Pattern PRBS, $2^{31}-1$

Table C.2.3-2 MU196020A-003 Waveform Evaluation Test- Amplitude (NRZ)

| Settings | | Specification | | Results | |
|-------------|--------------------|--------------------|--------------------|---------|--------------------------|
| Bit rate | Amplitude (Vp-p) | Lower limit (Vp-p) | Upper limit (Vp-p) | Data | $\overline{\text{Data}}$ |
| 64.2 Gbit/s | 0.70* ¹ | 0.581 | 0.819 | | |
| | 0.55* ² | 0.405 | 0.595 | | |
| | 0.07 | 0.027 | 0.113 | | |

*1: When J1789A cables are used.

*2: When J1790A cables are used.

Table C.2.3-3 MU196020A-003 Waveform Evaluation Test-0/3 Level Amplitude (PAM4)

| Settings | | Specification | | Results | |
|------------|--------------------|--------------------|--------------------|---------|--------------------------|
| Baud rate | Amplitude (Vp-p) | Lower limit (Vp-p) | Upper limit (Vp-p) | Data | $\overline{\text{Data}}$ |
| 64.2 Gbaud | 0.70* ¹ | 0.581 | 0.819 | | |
| | 0.55* ² | 0.405 | 0.595 | | |
| | 0.07 | 0.027 | 0.113 | | |

*1: When J1789A cables are used.

*2: When J1790A cables are used.

Table C.2.3-4 MU196020A-003 Waveform Evaluation Test- Offset (NRZ)

| Settings | | Specification | | Results | |
|-------------|----------------------|-----------------|-----------------|---------|--------------------------|
| Bit rate | Offset (Vth) | Lower limit (V) | Upper limit (V) | Data | $\overline{\text{Data}}$ |
| 64.2 Gbit/s | 3.265 | 2.817 | 3.713 | | |
| | -2.275* ¹ | -2.438 | -2.112 | | |
| | -2.35* ² | -2.590 | -2.111 | | |

*1: When J1790A cables are used, Amplitude 0.55 Vp-p

*2: When J1789A cables are used, Amplitude 0.70 Vp-p

Table C.2.3-5 MU196020A-003 Waveform Evaluation Test- Offset (PAM4)

| Settings | | Specification | | Results | |
|------------|----------------------|-----------------|-----------------|---------|--------------------------|
| Baud rate | Offset (Vth) | Lower limit (V) | Upper limit (V) | Data | $\overline{\text{Data}}$ |
| 64.2 Gbaud | 3.265 | 2.817 | 3.713 | | |
| | -2.275* ¹ | -2.438 | -2.112 | | |
| | -2.35* ² | -2.590 | -2.111 | | |

*1: When J1790A cables are used, Amplitude 0.55 Vp-p

*2: When J1789A cables are used, Amplitude 0.70 Vp-p

Table C.2.3-6 MU196020A-003 Waveform Evaluation Test - Cross point (NRZ)

| Settings | | Specification | | Results | |
|-------------|------------------|-----------------|-----------------|---------|--------------------------|
| Bit rate | Amplitude (Vp-p) | Lower limit (%) | Upper limit (%) | Data | $\overline{\text{Data}}$ |
| 64.2 Gbit/s | 0.50 | 40 | 60 | | |

Table C.2.3-7 MU196020A-003 Waveform Evaluation Test - Tr/Tf (NRZ)

| Settings | | Specification | | Results | |
|-------------|------------------|------------------|-------------------|---------|--------------------------|
| Bit rate | Amplitude (Vp-p) | Lower limit (ps) | Upper limit (ps) | Data | $\overline{\text{Data}}$ |
| 64.2 Gbit/s | 0.50 | — | 8.5* ¹ | | |
| | | — | 8.8* ² | | |

*1: When J1789A cables are used.

*2: When J1790A cables are used.

Table C.2.3-8 MU196020A-003 Waveform Evaluation Test- Jitter (NRZ)

| Settings | | Specification | | Results | |
|-------------|------------------|------------------|----------------------|---------|--------------------------|
| Bit rate | Amplitude (Vp-p) | Lower limit (ps) | Upper limit (ps p-p) | Data | $\overline{\text{Data}}$ |
| 64.2 Gbit/s | 0.50 | — | 6.0 | | |

C.3 MU196040A

Table C.3-1 Input level range (NRZ)

| Settings | | | | | Specification | Results | |
|-------------|------------------|------------------|-------------|-----------------------|------------------|---------|------|
| MU196020A | | | MU196040A | | | Data | Data |
| Termination | Amplitude (Vp-p) | Offset (Vth) (V) | Termination | Threshold voltage (V) | | | |
| GND | 0.7 | −2.35 | GND | −2.350 | No errors occur. | | |
| | 0.05 | −0.225 | | −0.225 | | | |
| | 0.7 | +2.95 | | +2.950 | | | |
| | 0.05 | +0.305 | | +0.305 | | | |

Table C.3-2 Input level range (PAM4)

| Settings | | | | | Specification | Results | |
|-------------|------------------|------------------|-------------|--|------------------|---------|------|
| MU196020A | | | MU196040A | | | Data | Data |
| Termination | Amplitude (Vp-p) | Offset (Vth) (V) | Termination | Threshold voltage (V) | | | |
| GND | 0.7 | −2.35 | GND | Upper: −2.117 Middle: −2.350 Lower: −2.583 | No errors occur. | | |
| | 0.3 | −2.15 | | Upper: −2.050 Middle: −2.150 Lower: −2.250 | | | |
| | 0.7 | +2.95 | | Upper: 3.183 Middle: 2.950 Lower: 2.717 | | | |
| | 0.3 | +3.15 | | Upper: 3.250 Middle: 3.150 Lower: 3.050 | | | |

Table C.3-3 Test pattern (PRBS-NRZ)

| Settings | | | | Specification | Results | |
|-----------|-------|-----------|-------|------------------|---------|------|
| MU196020A | | MU196040A | | | Data | Data |
| Length | Logic | Length | Logic | | | |
| 2^7-1 | POS | 2^7-1 | POS | No errors occur. | | |
| 2^9-1 | POS | 2^9-1 | POS | | | |
| 2^11-1 | POS | 2^11-1 | POS | | | |
| 2^13-1 | POS | 2^13-1 | POS | | | |
| 2^15-1 | POS | 2^15-1 | POS | | | |
| 2^20-1 | POS | 2^20-1 | POS | | | |
| 2^23-1 | POS | 2^23-1 | POS | | | |
| 2^31-1 | POS | 2^31-1 | POS | | | |
| 2^31-1 | NEG | 2^31-1 | NEG | | | |

Table C.3-4 Test pattern (PRBS-PAM4)

| Settings | | | | | | Specification | Results | |
|--------------------|-----------|-----------|--------------------|-----------|-----------|------------------|---------|--------------------------|
| MU196020A | | | MU196040A | | | | Data | $\overline{\text{Data}}$ |
| Length | Logic MSB | Logic LSB | Length | Logic MSB | Logic LSB | | | |
| 2 ⁷ –1 | POS | POS | 2 ⁷ –1 | POS | POS | No errors occur. | | |
| 2 ⁹ –1 | POS | POS | 2 ⁹ –1 | POS | POS | | | |
| 2 ¹¹ –1 | POS | POS | 2 ¹¹ –1 | POS | POS | | | |
| 2 ¹⁵ –1 | POS | POS | 2 ¹⁵ –1 | POS | POS | | | |
| 2 ²⁰ –1 | POS | POS | 2 ²⁰ –1 | POS | POS | | | |
| 2 ²³ –1 | POS | POS | 2 ²³ –1 | POS | POS | | | |
| 2 ³¹ –1 | POS | POS | 2 ³¹ –1 | POS | POS | | | |
| 2 ³¹ –1 | NEG | NEG | 2 ³¹ –1 | NEG | NEG | | | |

Table C.3-5 Test pattern (Zero Substitution-NRZ)

| Settings | | | | Specification | Results | |
|-----------|-------|-----------|-------|------------------|---------|--------------------------|
| MU196020A | | MU196040A | | | Data | $\overline{\text{Data}}$ |
| Length | Logic | Length | Logic | No errors occur. | | |
| 2^7 | POS | 2^7 | POS | | | |
| 2^9 | POS | 2^9 | POS | | | |
| 2^10 | POS | 2^10 | POS | | | |
| 2^11 | POS | 2^11 | POS | | | |
| 2^15 | POS | 2^15 | POS | | | |
| 2^20 | POS | 2^20 | POS | | | |
| 2^23 | POS | 2^23 | POS | | | |
| 2^7-1 | POS | 2^7-1 | POS | | | |
| 2^9-1 | POS | 2^9-1 | POS | | | |
| 2^10-1 | POS | 2^10-1 | POS | | | |
| 2^11-1 | POS | 2^11-1 | POS | | | |
| 2^15-1 | POS | 2^15-1 | POS | | | |
| 2^20-1 | POS | 2^20-1 | POS | | | |
| 2^23-1 | POS | 2^23-1 | POS | | | |

Table C.3-6 Test pattern (SSPRQ-PAM4)

| Settings | | | | Specification | Results | |
|-----------|-------|-----------|-------|------------------|---------|--------------------------|
| MU196020A | | MU196040A | | | Data | $\overline{\text{Data}}$ |
| Pattern | Logic | Pattern | Logic | | | |
| SSPRQ | POS | SSPRQ | POS | No errors occur. | | |

Table C.3-7 Error detection

| Item | Specification | Results | |
|----------------------------|---------------|---------|--------------------------|
| | | Data | $\overline{\text{Data}}$ |
| Error rate (ER) | 5.0000E-12 | | |
| Error count (EC) | 1.0000E-00 | | |
| Error free interval (%EFI) | 99.9900% | | |
| Error interval (EI) | 1 | | |

C.4 MU196040B

Table C.4-1 Input level range (NRZ \leq 32.1 Gbit/s)

| Settings | | | | | Specification | Results | |
|-------------|------------------|------------------|-------------|-----------------------|------------------|---------|------|
| MU196020A | | | MU196040B | | | Data | Data |
| Termination | Amplitude (Vp-p) | Offset (Vth) (V) | Termination | Threshold voltage (V) | | | |
| GND | 0.7 | −2.35 | GND | −2.350 | No errors occur. | | |
| | 0.05 | −0.225 | | −0.225 | | | |
| | 0.7 | +2.95 | | +2.950 | | | |
| | 0.05 | +0.305 | | +0.305 | | | |

Table C.4-2 Input level range (NRZ $>$ 32.1 Gbit/s)

| Settings | | | | | Specification | Results | |
|-------------|------------------|------------------|-------------|-----------------------|------------------|---------|--------------------------|
| MU196020A | | | MU196040B | | | Data | $\overline{\text{Data}}$ |
| Termination | Amplitude (Vp-p) | Offset (Vth) (V) | Termination | Threshold voltage (V) | | | |
| GND | 0.7 | −2.35 | GND | −2.350 | No errors occur. | | |
| | 0.1 | −2.05 | | −2.050 | | | |
| | 0.7 | +2.95 | | +2.950 | | | |
| | 0.1 | +3.25 | | +3.250 | | | |

Table C.4-3 Input level range (PAM4 ≤ 32.1 Gbaud)

| Settings | | | | | Specification | Results | |
|-------------|------------------|------------------|-------------|--|------------------|---------|------|
| MU196020A | | | MU196040B | | | Data | Data |
| Termination | Amplitude (Vp-p) | Offset (Vth) (V) | Termination | Threshold voltage (V) | | | |
| GND | 0.7 | −2.35 | GND | Upper: −2.117 Middle: −2.350 Lower: −2.583 | No errors occur. | | |
| | 0.3 | −2.15 | | Upper: −2.050 Middle: −2.150 Lower: −2.250 | | | |
| | 0.7 | +2.95 | | Upper: 3.183 Middle: 2.950 Lower: 2.717 | | | |
| | 0.3 | +3.15 | | Upper: 3.250 Middle: 3.150 Lower: 3.050 | | | |

Table C.4-4 Input level range (PAM4 > 32.1 Gbaud)

| Settings | | | | | Specification | Results | |
|-------------|------------------|------------------|-------------|--|------------------|---------|------|
| MU196020A | | | MU196040B | | | Data | Data |
| Termination | Amplitude (Vp-p) | Offset (Vth) (V) | Termination | Threshold voltage (V) | | | |
| GND | 0.7 | −2.35 | GND | Upper: −2.117 Middle: −2.350 Lower: −2.583 | No errors occur. | | |
| | 0.4 | −2.20 | | Upper: −2.067 Middle: −2.200 Lower: −2.333 | | | |
| | 0.7 | +2.95 | | Upper: 3.183 Middle: 2.950 Lower: 2.717 | | | |
| | 0.4 | +3.10 | | Upper: 3.233 Middle: 3.100 Lower: 2.967 | | | |

Table C.4-5 Test pattern (PRBS-NRZ)

| Settings | | | | Specification | Results | |
|-----------|-------|-----------|-------|------------------|---------|------|
| MU196020A | | MU196040B | | | Data | Data |
| Length | Logic | Length | Logic | | | |
| 2^7-1 | POS | 2^7-1 | POS | No errors occur. | | |
| 2^9-1 | POS | 2^9-1 | POS | | | |
| 2^11-1 | POS | 2^11-1 | POS | | | |
| 2^13-1 | POS | 2^13-1 | POS | | | |
| 2^15-1 | POS | 2^15-1 | POS | | | |
| 2^20-1 | POS | 2^20-1 | POS | | | |
| 2^23-1 | POS | 2^23-1 | POS | | | |
| 2^31-1 | POS | 2^31-1 | POS | | | |
| 2^31-1 | NEG | 2^31-1 | NEG | | | |

Table C.4-6 Test pattern (PRBS-PAM4)

| Settings | | | | | | Specification | Results | |
|--------------------|-----------|-----------|--------------------|-----------|-----------|------------------|---------|--------------------------|
| MU196020A | | | MU196040B | | | | Data | $\overline{\text{Data}}$ |
| Length | Logic MSB | Logic LSB | Length | Logic MSB | Logic LSB | | | |
| 2 ⁷ −1 | POS | POS | 2 ⁷ −1 | POS | POS | No errors occur. | | |
| 2 ⁹ −1 | POS | POS | 2 ⁹ −1 | POS | POS | | | |
| 2 ¹¹ −1 | POS | POS | 2 ¹¹ −1 | POS | POS | | | |
| 2 ¹⁵ −1 | POS | POS | 2 ¹⁵ −1 | POS | POS | | | |
| 2 ²⁰ −1 | POS | POS | 2 ²⁰ −1 | POS | POS | | | |
| 2 ²³ −1 | POS | POS | 2 ²³ −1 | POS | POS | | | |
| 2 ³¹ −1 | POS | POS | 2 ³¹ −1 | POS | POS | | | |
| 2 ³¹ −1 | NEG | NEG | 2 ³¹ −1 | NEG | NEG | | | |

Table C.4-7 Test pattern (Zero Substitution -NRZ)

| Settings | | | | Specification | Results | |
|-----------|-------|-----------|-------|------------------|---------|------|
| MU196020A | | MU196040B | | | Data | Data |
| Length | Logic | Length | Logic | | | |
| 2^7 | POS | 2^7 | POS | No errors occur. | | |
| 2^9 | POS | 2^9 | POS | | | |
| 2^10 | POS | 2^10 | POS | | | |
| 2^11 | POS | 2^11 | POS | | | |
| 2^15 | POS | 2^15 | POS | | | |
| 2^20 | POS | 2^20 | POS | | | |
| 2^23 | POS | 2^23 | POS | | | |
| 2^7-1 | POS | 2^7-1 | POS | | | |
| 2^9-1 | POS | 2^9-1 | POS | | | |
| 2^10-1 | POS | 2^10-1 | POS | | | |
| 2^11-1 | POS | 2^11-1 | POS | | | |
| 2^15-1 | POS | 2^15-1 | POS | | | |
| 2^20-1 | POS | 2^20-1 | POS | | | |
| 2^23-1 | POS | 2^23-1 | POS | | | |

Table C.4-8 Test pattern (SSPRQ-PAM4)

| Settings | | | | Specification | Results | |
|-----------|-------|-----------|-------|------------------|---------|--------------------------|
| MU196020A | | MU196040B | | | Data | $\overline{\text{Data}}$ |
| Pattern | Logic | Pattern | Logic | | | |
| SSPRQ | POS | SSPRQ | POS | No errors occur. | | |

Table C.4-9 Error detection

| Item | Specification | Results | |
|----------------------------|---------------|---------|--------------------------|
| | | Data | $\overline{\text{Data}}$ |
| Error rate (ER) | 5.0000E-12 | | |
| Error count (EC) | 1.0000E-00 | | |
| Error free interval (%EFI) | 99.9900% | | |
| Error interval (EI) | 1 | | |

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