

**Anritsu** Advancing beyond

# Signal Quality Analyzer-R

MP1900A

 SQA-R



# Signal Quality Analyzer-R MP1900A

Due to the explosive growth of data traffic resulting from the popularity of smartphones and mobile terminals, network interfaces are transitioning to faster 200/400 GbE standards, and PCI bus interface speeds now exceed 10G. In addition, the equipment and chipsets using these interfaces support multi-channels and multi-protocols. The MP1900A series is a high-performance BERT with excellent expandability for supporting Physical layer evaluations of these high-speed interfaces. The all-in-one design is ideal for early stage R&D evaluations of all interfaces covering next-generation Ethernet networks to bus interconnects

## Model/Order Number, Name, Option

| Model/Order No. | Name   |
|-----------------|--|
| MP1900A         | Signal Quality Analyzer-R*1                        |
| MP1900A-110     | Windows10 Upgrade Retrofit*2                       |
| MP1900A-ES310   | Three Years Extended Warranty Service              |
| MP1900A-ES510   | Five Years Extended Warranty Service               |
| MU195020A       | 21G/32G bit/s SI PPG                               |
| MU195020A-001   | 32 Gbit/s Extension                                |
| MU195020A-010   | 1ch Data Output                                    |
| MU195020A-020   | 2ch Data Output                                    |
| MU195020A-011   | 1ch 10Tap Emphasis                                 |
| MU195020A-021   | 2ch 10Tap Emphasis                                 |
| MU195020A-030   | 1ch Data Delay                                     |
| MU195020A-031   | 2ch Data Delay                                     |
| MU195020A-040   | 1ch Variable ISI                                   |
| MU195020A-041   | 2ch Variable ISI                                   |
| MU195020A-050   | Sequence Editor Function                           |
| MU195020A-051   | Sequence Editor Function PCIe 5 Extension          |
| MU195020A-101   | 32 Gbit/s Extension Retrofit                       |
| MU195020A-120   | 2ch Data Output Retrofit                           |
| MU195020A-111   | 1ch 10Tap Emphasis Retrofit                        |
| MU195020A-121   | 2ch 10Tap Emphasis Retrofit                        |
| MU195020A-130   | 1ch Data Delay Retrofit                            |
| MU195020A-131   | 2ch Data Delay Retrofit                            |
| MU195020A-140   | 1ch Variable ISI Retrofit                          |
| MU195020A-141   | 2ch Variable ISI Retrofit                          |
| MU195020A-340   | 1ch Variable ISI Retrofit                          |
| MU195020A-341   | 2ch Variable ISI Retrofit                          |
| MU195020A-350   | Sequence Editor Function Retrofit                  |
| MU195020A-351   | Sequence Editor Function PCIe 5 Extension Retrofit |
| MU195020A-ES310 | Three Years Extended Warranty Service              |
| MU195020A-ES510 | Five Years Extended Warranty Service               |
| MU195040A       | 21G/32G bit/s SI ED                                |
| MU195040A-001   | 32 Gbit/s Extension                                |
| MU195040A-010   | 1ch ED   |
| MU195040A-020   | 2ch ED   |
| MU195040A-011   | 1ch CTLE   |
| MU195040A-021   | 2ch CTLE   |
| MU195040A-022   | Clock Recovery                                     |
| MU195040A-101   | 32 Gbit/s Extension Retrofit                       |
| MU195040A-120   | 2ch ED Retrofit                                    |
| MU195040A-111   | 1ch CTLE Retrofit                                  |
| MU195040A-121   | 2ch CTLE Retrofit                                  |
| MU195040A-122   | Clock Recovery Retrofit                            |
| MU195040A-ES310 | Three Years Extended Warranty Service              |
| MU195040A-ES510 | Five Years Extended Warranty Service               |
| MU196020A       | PAM4 PPG   |
| MU196020A-001   | 32G baud   |
| MU196020A-002   | 58G baud   |
| MU196020A-003   | 64G baud   |
| MU196020A-011   | 4Tap Emphasis                                      |
| MU196020A-030   | Data Delay   |
| MU196020A-040   | Adjustable ISI                                     |
| MU196020A-042   | FEC Pattern Generation                             |
| MU196020A-050   | Inter-Module Synchronization                       |
| MU196020A-112   | 32G to 58G baud Extension Retrofit                 |
| MU196020A-113   | 32G to 64G baud Extension Retrofit                 |
| MU196020A-123   | 58G to 64G baud Extension Retrofit                 |
| MU196020A-111   | 4Tap Emphasis Retrofit                             |
| MU196020A-130   | Data Delay Retrofit                                |
| MU196020A-140   | Adjustable ISI Retrofit                            |
| MU196020A-142   | FEC Pattern Generation Retrofit                    |
| MU196020A-150   | Inter-Module Synchronization Retrofit              |
| MU196020A-340   | Adjustable ISI Retrofit                            |
| MU196020A-342   | FEC Pattern Generation Retrofit                    |
| MU196020A-ES310 | Three Years Extended Warranty Service              |
| MU196020A-ES510 | Five Years Extended Warranty Service               |

| Model/Order No. | Name   |
|-----------------|--|
| MU196040B       | PAM4 ED  |
| MU196040B-001   | 32G baud (2.4G to 32.1G)   |
| MU196040B-002   | 58G baud (NRZ: 2.4G to 64.2G, PAM4: 2.4G to 58.2G)                           |
| MU196040B-011   | Equalizer  |
| MU196040B-021   | 29G baud Clock Recovery (2.4G to 29G)  |
| MU196040B-022   | 32G baud Clock Recovery (2.4G to 32.1G)                                      |
| MU196040B-023   | 58G baud Clock Recovery Extension (51G to 58.2G)                             |
| MU196040B-041   | SER Measurement  |
| MU196040B-042   | FEC Analysis   |
| MU196040B-111   | Equalizer Retrofit   |
| MU196040B-112   | 32G to 58G baud Extension Retrofit (NRZ: 2.4G to 64.2G, PAM4: 2.4G to 58.2G) |
| MU196040B-121   | 29G baud Clock Recovery Retrofit (2.4G to 29G)                               |
| MU196040B-122   | 32G baud Clock Recovery Retrofit (2.4G to 32.1G)                             |
| MU196040B-123   | 58G baud Clock Recovery Extension Retrofit (51G to 58.2G)                    |
| MU196040B-124   | 32G baud Clock Recovery Extension Retrofit (2.4G to 32.1G)                   |
| MU196040B-141   | SER Measurement Retrofit   |
| MU196040B-341   | SER Measurement Retrofit   |
| MU196040B-342   | FEC Analysis Retrofit  |
| MU196040B-ES310 | Three Years Extended Warranty Service  |
| MU196040B-ES510 | Five Years Extended Warranty Service   |
| MU196040A       | PAM4 ED  |
| MU196040A-001   | 32.1G baud Decoder   |
| MU196040A-022   | 25.5G to 32.1G baud Clock Recovery   |
| MU196040A-041   | SER Measurement  |
| MU196040A-122   | 25.5G to 32.1G baud Clock Recovery Retrofit                                  |
| MU196040A-141   | SER Measurement Retrofit   |
| MU196040A-ES310 | Three Years Extended Warranty Service  |
| MU196040A-ES510 | Five Years Extended Warranty Service   |
| MU195050A       | Noise Generator  |
| MU195050A-001   | White Noise  |
| MU195050A-101   | White Noise Retrofit   |
| MU195050A-ES310 | Three Years Extended Warranty Service  |
| MU195050A-ES510 | Five Years Extended Warranty Service   |
| MU181000B       | 12.5 GHz 4port Synthesizer   |
| MU181000B-001   | Jitter Modulation  |
| MU181000B-002   | SSC Extension  |
| MU181000B-101   | Jitter Modulation Retrofit   |
| MU181000B-102   | SSC Extension Retrofit   |
| MU181000B-ES310 | Three Years Extended Warranty Service  |
| MU181000B-ES510 | Five Years Extended Warranty Service   |
| MU181500B       | Jitter Modulation Source   |
| MU181500B-ES310 | Three Years Extended Warranty Service  |
| MU181500B-ES510 | Five Years Extended Warranty Service   |
| MX183000A       | High-Speed Serial Data Test Software   |
| MX183000A-PL001 | Jitter Tolerance Test  |
| MX183000A-PL021 | PCIe Link Training   |
| MX183000A-PL022 | USB Link Training  |
| MX183000A-PL023 | USB 3.2 x 2 Link Training  |
| MX183000A-PL025 | PCIe 5 Link Training   |
| MX183000A-PL031 | DUT Error Counts Import  |

\*1: The Windows 10 OS will be installed in all orders from July 1, 2020.  
 \*2: MP1900A main units running Windows Embedded Standard 7 are retrofitted to Windows 10 using a hardware upgrade. Anritsu destroys the unnecessary, post-upgrade Windows Embedded Standard 7 parts. For details, contact our sales representative.

## Signal Quality Analyzer-R MP1900A Main Frame Specifications

|                             |   |
|-----------------------------|---|
| Functions                   |   |
| Input Device, Button        | Resistance film touch panel, Rotary encoder, Function button, Power button  |
| LED                         | Power, Power Stan dBy, Disk Access  |
| LCD                         | 12.1 inch WXGA (1280 × 800)   |
| Ethernet                    | 10/100/1000 Base-T RJ45 1 port (External: For remote control)<br>10/100/1000 Base-T RJ45 1 port (Internal: Reserved for future use) |
| External Display            | D-Sub 15 pin 1 port<br>HDMI Type A 1 port   |
| USB                         | Front panel USB Type A 4 port<br>Rear panel USB Type A 2 port   |
| Module Slot                 | 8 Slots   |
| Functional Earth Terminal   | Front panel: 2 Jacks<br>Rear panel: 1 Terminal  |
| OS                          | Windows 10  |
| Internal Storage Device     | SATA 2.5-inch HDD 1 Unit (tray loading)*1   |
| Remote Interface            | GPIB, Ethernet External (automatic switchover)  |
| Internal Reference Clock    | 10 MHz ± 1 ppm (Accuracy at initial shipment)   |
| Environmental Performance   |   |
| Power Supply*2              | 100 V(ac) to 120 V(ac), 200 V(ac) to 240 V(ac) (automatic switching between 100 and 200 V systems),<br>50 Hz to 60 Hz               |
| Power Consumption           | 1350 VA   |
| Operating Temperature Range | +5°C to +40°C   |
| Dimensions and Mass         | 340 (W) × 222.5 (H) × 451 (D) mm (Protrusions excluded)<br>20 kg (excluding modules, blank panels, protective cover, power cord)    |
| CE                          |   |
| EMC                         | 2014/30/EU, EN61326-1, EN61000-3-2  |
| LVD                         | 2014/35/EU, EN61010-1   |
| RoHS                        | 2011/65/EU, EN50581   |

\*1: Removing and replacing the HDD by Customer is outside the scope of warranty coverage.

\*2: Operating voltage is -10% to +10% of rated voltage

# SI PPG MU195020A Specifications

## Operating Bit Rate

| Bit Rate Setting Range<br>(MU181000B synchronized operation)                            | 2.400 000 Gbit/s to 21.000 000 Gbit/s, 0.000 002 Gbit/s step*1<br>2.400 000 Gbit/s to 25.000 000 Gbit/s, 0.000 002 Gbit/s step*2<br>25.000 004 Gbit/s to 32.100 000 Gbit/s, 0.000 004 Gbit/s step*2<br>Offset<br>-1000 to +1000 ppm, 1 ppm step*3   |   |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
|---|---|---|--|--------------------------|-----------------------|---|---------------------------|---------------------|----------------------|------------------------------|---------------------|----------------------|------------------------------|----------------------|----------------------|------------------------------|---------------------|----------------------|------------------------------|-----------------------|----------------------|------------------------------|-----------------------|----------------------|--------------------------|-----------------------|---|-----------------------------|----------------------|----------------------|-----------------------------|----------------------|----------------------|------------------------------|-----------------------|----------------------|
| Bit Rate Setting Range<br>(MU181500B synchronized operation)                            | 2.400 000 Gbit/s to 3.125 000 Gbit/s, 0.000 002 Gbit/s step<br>3.200 002 Gbit/s to 6.250 000 Gbit/s, 0.000 002 Gbit/s step<br>6.400 002 Gbit/s to 12.500 000 Gbit/s, 0.000 002 Gbit/s step<br>12.800 002 Gbit/s to 21.000 000 Gbit/s, 0.000 002 Gbit/s step*1<br>12.800 002 Gbit/s to 25.000 000 Gbit/s, 0.000 002 Gbit/s step*2<br>25.600 004 Gbit/s to 32.100 000 Gbit/s, 0.000 004 Gbit/s step*2<br>Offset<br>-1000 to +1000 ppm, 1 ppm step*3   |   |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| Bit Rate Setting Range<br>(with external clock source)                                  | <p>When the Output Clock Rate is set to Full Rate</p> <table border="1"> <thead> <tr> <th>Operating Bit Rate Range</th> <th>Input Clock Frequency</th> <th>Relationship between Bit Rate and Clock Frequency</th> </tr> </thead> <tbody> <tr> <td>2.4 Gbit/s to 16.0 Gbit/s</td> <td>2.4 GHz to 16.0 GHz</td> <td>Operate at 1/1 clock</td> </tr> <tr> <td>16.0 Gbit/s to 20.0 Gbit/s*1</td> <td>8.0 GHz to 10.0 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>20.0 Gbit/s to 21.0 Gbit/s*1</td> <td>10.0 GHz to 10.5 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>16.0 Gbit/s to 21.0 Gbit/s*2</td> <td>8.0 GHz to 10.0 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>20.0 Gbit/s to 32.1 Gbit/s*2</td> <td>10.0 GHz to 16.05 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>25.0 Gbit/s to 32.1 Gbit/s*2</td> <td>6.25 GHz to 8.025 GHz</td> <td>Operate at 1/4 clock</td> </tr> </tbody> </table> <p>When the Output Clock Rate is set to Half Rate</p> <table border="1"> <thead> <tr> <th>Operating Bit Rate Range</th> <th>Input Clock Frequency</th> <th>Relationship between Bit Rate and Clock Frequency</th> </tr> </thead> <tbody> <tr> <td>2.4 Gbit/s to 28.1 Gbit/s*1</td> <td>1.2 GHz to 14.05 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>2.4 Gbit/s to 32.1 Gbit/s*2</td> <td>1.2 GHz to 16.05 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>25.0 Gbit/s to 32.1 Gbit/s*2</td> <td>6.25 GHz to 8.025 GHz</td> <td>Operate at 1/4 clock</td> </tr> </tbody> </table> |   |  | Operating Bit Rate Range | Input Clock Frequency | Relationship between Bit Rate and Clock Frequency | 2.4 Gbit/s to 16.0 Gbit/s | 2.4 GHz to 16.0 GHz | Operate at 1/1 clock | 16.0 Gbit/s to 20.0 Gbit/s*1 | 8.0 GHz to 10.0 GHz | Operate at 1/2 clock | 20.0 Gbit/s to 21.0 Gbit/s*1 | 10.0 GHz to 10.5 GHz | Operate at 1/2 clock | 16.0 Gbit/s to 21.0 Gbit/s*2 | 8.0 GHz to 10.0 GHz | Operate at 1/2 clock | 20.0 Gbit/s to 32.1 Gbit/s*2 | 10.0 GHz to 16.05 GHz | Operate at 1/2 clock | 25.0 Gbit/s to 32.1 Gbit/s*2 | 6.25 GHz to 8.025 GHz | Operate at 1/4 clock | Operating Bit Rate Range | Input Clock Frequency | Relationship between Bit Rate and Clock Frequency | 2.4 Gbit/s to 28.1 Gbit/s*1 | 1.2 GHz to 14.05 GHz | Operate at 1/2 clock | 2.4 Gbit/s to 32.1 Gbit/s*2 | 1.2 GHz to 16.05 GHz | Operate at 1/2 clock | 25.0 Gbit/s to 32.1 Gbit/s*2 | 6.25 GHz to 8.025 GHz | Operate at 1/4 clock |
| Operating Bit Rate Range  | Input Clock Frequency   | Relationship between Bit Rate and Clock Frequency |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 2.4 Gbit/s to 16.0 Gbit/s   | 2.4 GHz to 16.0 GHz   | Operate at 1/1 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 16.0 Gbit/s to 20.0 Gbit/s*1  | 8.0 GHz to 10.0 GHz   | Operate at 1/2 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 20.0 Gbit/s to 21.0 Gbit/s*1  | 10.0 GHz to 10.5 GHz  | Operate at 1/2 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 16.0 Gbit/s to 21.0 Gbit/s*2  | 8.0 GHz to 10.0 GHz   | Operate at 1/2 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 20.0 Gbit/s to 32.1 Gbit/s*2  | 10.0 GHz to 16.05 GHz   | Operate at 1/2 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 25.0 Gbit/s to 32.1 Gbit/s*2  | 6.25 GHz to 8.025 GHz   | Operate at 1/4 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| Operating Bit Rate Range  | Input Clock Frequency   | Relationship between Bit Rate and Clock Frequency |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 2.4 Gbit/s to 28.1 Gbit/s*1   | 1.2 GHz to 14.05 GHz  | Operate at 1/2 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 2.4 Gbit/s to 32.1 Gbit/s*2   | 1.2 GHz to 16.05 GHz  | Operate at 1/2 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 25.0 Gbit/s to 32.1 Gbit/s*2  | 6.25 GHz to 8.025 GHz   | Operate at 1/4 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| Bit Rate Setting Range<br>(MU181500B synchronized operation with external clock source) | <p>When the Output Clock Rate is set to Full Rate</p> <table border="1"> <thead> <tr> <th>Operating Bit Rate Range</th> <th>Input Clock Frequency</th> <th>Relationship between Bit Rate and Clock Frequency</th> </tr> </thead> <tbody> <tr> <td>2.4 Gbit/s to 15.0 Gbit/s</td> <td>2.4 GHz to 15.0 GHz</td> <td>Operate at 1/1 clock</td> </tr> <tr> <td>15.0 Gbit/s to 20.0 Gbit/s*1</td> <td>7.5 GHz to 10.0 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>20.0 Gbit/s to 21.0 Gbit/s*1</td> <td>10.0 GHz to 10.5 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>15.0 Gbit/s to 20.0 Gbit/s*2</td> <td>7.5 GHz to 10.0 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>20.0 Gbit/s to 30.0 Gbit/s*2</td> <td>10.0 GHz to 15.0 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>25.0 Gbit/s to 32.1 Gbit/s*2</td> <td>6.25 GHz to 8.025 GHz</td> <td>Operate at 1/4 clock</td> </tr> </tbody> </table> <p>When the Output Clock Rate is set to Half Rate</p> <table border="1"> <thead> <tr> <th>Operating Bit Rate Range</th> <th>Input Clock Frequency</th> <th>Relationship between Bit Rate and Clock Frequency</th> </tr> </thead> <tbody> <tr> <td>2.4 Gbit/s to 21.0 Gbit/s*1</td> <td>1.2 GHz to 10.5 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>2.4 Gbit/s to 30.0 Gbit/s*2</td> <td>1.2 GHz to 15.0 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>25.0 Gbit/s to 32.1 Gbit/s*2</td> <td>6.25 GHz to 8.025 GHz</td> <td>Operate at 1/4 clock</td> </tr> </tbody> </table>    |   |  | Operating Bit Rate Range | Input Clock Frequency | Relationship between Bit Rate and Clock Frequency | 2.4 Gbit/s to 15.0 Gbit/s | 2.4 GHz to 15.0 GHz | Operate at 1/1 clock | 15.0 Gbit/s to 20.0 Gbit/s*1 | 7.5 GHz to 10.0 GHz | Operate at 1/2 clock | 20.0 Gbit/s to 21.0 Gbit/s*1 | 10.0 GHz to 10.5 GHz | Operate at 1/2 clock | 15.0 Gbit/s to 20.0 Gbit/s*2 | 7.5 GHz to 10.0 GHz | Operate at 1/2 clock | 20.0 Gbit/s to 30.0 Gbit/s*2 | 10.0 GHz to 15.0 GHz  | Operate at 1/2 clock | 25.0 Gbit/s to 32.1 Gbit/s*2 | 6.25 GHz to 8.025 GHz | Operate at 1/4 clock | Operating Bit Rate Range | Input Clock Frequency | Relationship between Bit Rate and Clock Frequency | 2.4 Gbit/s to 21.0 Gbit/s*1 | 1.2 GHz to 10.5 GHz  | Operate at 1/2 clock | 2.4 Gbit/s to 30.0 Gbit/s*2 | 1.2 GHz to 15.0 GHz  | Operate at 1/2 clock | 25.0 Gbit/s to 32.1 Gbit/s*2 | 6.25 GHz to 8.025 GHz | Operate at 1/4 clock |
| Operating Bit Rate Range  | Input Clock Frequency   | Relationship between Bit Rate and Clock Frequency |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 2.4 Gbit/s to 15.0 Gbit/s   | 2.4 GHz to 15.0 GHz   | Operate at 1/1 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 15.0 Gbit/s to 20.0 Gbit/s*1  | 7.5 GHz to 10.0 GHz   | Operate at 1/2 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 20.0 Gbit/s to 21.0 Gbit/s*1  | 10.0 GHz to 10.5 GHz  | Operate at 1/2 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 15.0 Gbit/s to 20.0 Gbit/s*2  | 7.5 GHz to 10.0 GHz   | Operate at 1/2 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 20.0 Gbit/s to 30.0 Gbit/s*2  | 10.0 GHz to 15.0 GHz  | Operate at 1/2 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 25.0 Gbit/s to 32.1 Gbit/s*2  | 6.25 GHz to 8.025 GHz   | Operate at 1/4 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| Operating Bit Rate Range  | Input Clock Frequency   | Relationship between Bit Rate and Clock Frequency |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 2.4 Gbit/s to 21.0 Gbit/s*1   | 1.2 GHz to 10.5 GHz   | Operate at 1/2 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 2.4 Gbit/s to 30.0 Gbit/s*2   | 1.2 GHz to 15.0 GHz   | Operate at 1/2 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |
| 25.0 Gbit/s to 32.1 Gbit/s*2  | 6.25 GHz to 8.025 GHz   | Operate at 1/4 clock                              |  |                          |                       |   |                           |                     |                      |                              |                     |                      |                              |                      |                      |                              |                     |                      |                              |                       |                      |                              |                       |                      |                          |                       |   |                             |                      |                      |                             |                      |                      |                              |                       |                      |

\*1: Not available Option x01

\*2: Available Option x01

\*3: Offset setting range depends on the bit rate. The range is -1000 to 0 ppm at the following bit rate.

Full Rate: 12.500000 Gbit/s, 25.000000 Gbit/s

Half Rate: 25.000000 Gbit/s

## External Clock Input

|                       |   |
|-----------------------|---|
| Number of Input       | 1 (Single-end)                          |
| Input Frequency Range | 1.2 GHz to 16.05 GHz                    |
| Input Amplitude       | 0.3 Vp-p to 1.0 Vp-p (-6.5 to +4.0 dBm) |
| Termination           | AC, 50Ω                                 |
| Connector             | SMA (f)                                 |

# SI PPG MU195020A Specifications

## Aux Input and Output

|                     |   |
|---------------------|---|
| Aux Input           |   |
| Number of Input     | 1 (Single-end)  |
| Signal Type         | Error Injection, Burst, Sequence Trigger*   |
| Minimum Pulse Width | 1/128 of data rate  |
| Input Level         | <ul style="list-style-type: none"> <li>• 0/-1 V (H: -0.25 V to 0.05 V, L: -1.1 V to -0.8 V)</li> <li>• 0/-0.5 V (H: -0.05 V to 0.05 V, L: -0.55 V to -0.45 V)</li> </ul> Select one of the above. |
| Termination         | GND, 50Ω  |
| Connector           | SMA (f)   |
| Aux Output          |   |
| Number of Output    | 2 (Differential)  |
| Signal Type         | 1/n Clock (n = 4, 6, 8, 10 ... 510, 512), Pattern Sync, Burst Out2, LTSSM Trigger*  |
| Output Level        | 0/-0.6 V (H: -0.25 V to 0.05 V, L: -0.80 V to -0.45 V)  |
| Terminator          | GND, 50Ω  |
| Connector           | SMA (f)   |

\*: Sequence Trigger and LTSSM Trigger can be selected only when Test Pattern is Sequence.

## Gating Output

|                  |   |
|------------------|---|
| Number of Output | 2 (Differential)                                      |
| Signal Type      | Burst, Repeat, LFPS*1                                 |
| Output Level     | 0/-1 V (H: -0.25 V to 0.05 V, L: -1.25 V to -0.8 V)*2 |
| Terminator       | GND, 50Ω  |
| Connector        | SMA (f)   |

\*1: Can be set when Test Pattern is Sequence and Specification is USB3.0 or USB3.1 Gen2.

\*2: L: Output Enable, H: Output Disable

## Generated Pattern\*1

|                                 |  |          |            |            |              |                |  |             |              |             |                    |
|---------------------------------|--|----------|------------|------------|--------------|----------------|--|-------------|--------------|-------------|--------------------|
| PRBS                            |  |          |            |            |              |                |  |             |              |             |                    |
| Pattern Length                  | 2 <sup>n</sup> - 1 (n = 7, 9, 10, 11, 15, 20, 23, 31)  |          |            |            |              |                |  |             |              |             |                    |
| Mark Ratio                      | 1/2 (1/2INV is supported by a logical inversion.)  |          |            |            |              |                |  |             |              |             |                    |
| Zero-Substitution               |  |          |            |            |              |                |  |             |              |             |                    |
| Additional Bit                  | 0 bit, 1 bit   |          |            |            |              |                |  |             |              |             |                    |
| Pattern Length                  | 2 <sup>n</sup> or 2 <sup>n</sup> - 1 (n = 7, 9, 10, 11, 15, 20, 23)  |          |            |            |              |                |  |             |              |             |                    |
| Start Position                  | Substitutes the bit coming after the maximum "0" successive bits.  |          |            |            |              |                |  |             |              |             |                    |
| Length of Consecutive Zero Bits | 1 to (Pattern Length - 1) bits<br>If the bit coming after Zero-substitution is "0", then it is replaced with "1".  |          |            |            |              |                |  |             |              |             |                    |
| Data                            |  |          |            |            |              |                |  |             |              |             |                    |
| Data Length                     | 2 bits to 268435456 bits, 1 bit step   |          |            |            |              |                |  |             |              |             |                    |
| Current Outputting Pattern      | 1 to 10, 1 step<br>Outputs the pattern of the selected number. Patterns can be switched glitch-free.   |          |            |            |              |                |  |             |              |             |                    |
| Mixed Pattern                   |  |          |            |            |              |                |  |             |              |             |                    |
| Pattern                         | Data   |          |            |            |              |                |  |             |              |             |                    |
| Mixed Block                     | To the smaller of the following values:<br>1 to 511 Block, 1 Block step<br>$\text{INT} \left( \frac{268435456}{\text{ROW count}} \times \text{Data length} \right) \text{ bits}$<br>$\text{INT} \left( \frac{268435456 + 2^{31}}{\text{ROW length}} \times \text{ROW count} \right) \text{ bits}$  |          |            |            |              |                |  |             |              |             |                    |
| Mixed Row Length                | 2048 to 268435456 + 2 <sup>31</sup> bits, 1024 bits step (Data + PRBS Length)  |          |            |            |              |                |  |             |              |             |                    |
| Data Length                     | 1024 bits to 268435456 bits, 1 bit step  |          |            |            |              |                |  |             |              |             |                    |
| Number of Rows                  | 1 to 16, 1 step  |          |            |            |              |                |  |             |              |             |                    |
| Number of Blocks                | 1 to 511, 1 step   |          |            |            |              |                |  |             |              |             |                    |
| PRBS Pattern Length, Mark Ratio | Same as PRBS.  |          |            |            |              |                |  |             |              |             |                    |
| PRBS Sequence                   | Restart, Consecutive   |          |            |            |              |                |  |             |              |             |                    |
| Scramble                        | Can be set per PRBS and Data for each Block (except the Data area for Block 1)   |          |            |            |              |                |  |             |              |             |                    |
| PAM4*2                          |  |          |            |            |              |                |  |             |              |             |                    |
| Pattern Type                    | Square Wave, JP03A, JP03B, PRQS10, SSPR, QPRBS13, QPRBS13-CEI, SSPRQ, Transmitter Linearity, PRBS13Q, PRBS31Q, User Define   |          |            |            |              |                |  |             |              |             |                    |
| User Define in detail           | <table border="1"> <tr> <td>Raw Data</td> <td>PRBS, Data</td> </tr> <tr> <td>PRBS Stage</td> <td>Same as PRBS</td> </tr> <tr> <td>PRBS Inversion</td> <td>Logic Inversion/Non-Inversion of PRBS part</td> </tr> <tr> <td>Data Length</td> <td>Same as Data</td> </tr> <tr> <td>Gray Coding</td> <td>Gray Coding ON/OFF</td> </tr> </table> | Raw Data | PRBS, Data | PRBS Stage | Same as PRBS | PRBS Inversion | Logic Inversion/Non-Inversion of PRBS part | Data Length | Same as Data | Gray Coding | Gray Coding ON/OFF |
| Raw Data                        | PRBS, Data   |          |            |            |              |                |  |             |              |             |                    |
| PRBS Stage                      | Same as PRBS   |          |            |            |              |                |  |             |              |             |                    |
| PRBS Inversion                  | Logic Inversion/Non-Inversion of PRBS part   |          |            |            |              |                |  |             |              |             |                    |
| Data Length                     | Same as Data   |          |            |            |              |                |  |             |              |             |                    |
| Gray Coding                     | Gray Coding ON/OFF   |          |            |            |              |                |  |             |              |             |                    |
| Sequence*3                      |  |          |            |            |              |                |  |             |              |             |                    |
| Specification                   | PCIe1, PCIe2, PCIe3, PCIe4, PCIe5*4, USB3.0, USB3.1 Gen2   |          |            |            |              |                |  |             |              |             |                    |
| Transmit                        | Starts transmitting the sequence pattern.  |          |            |            |              |                |  |             |              |             |                    |
| Manual                          | Enabled when Manual Trigger is set.  |          |            |            |              |                |  |             |              |             |                    |
| Trigger Block No.               | Sets the block number of the sequence to output an LTSSM Trigger signal from AUX Output connector.<br>1 to 128 Block No., 1 step   |          |            |            |              |                |  |             |              |             |                    |

\*1: Since the output circuit is DC-terminated using the AC-coupled Bias Tee method, the same symbol pattern has a 50% change in output level over a continuous period of about 5 μs.

\*2: Configurable when 2ch Combination or 64G × 2ch Combination is set.

\*3: The MU195020A-z50 is required. This can be set only when Module Combination is set to Independent.

If either Ch1 or Ch2 is set to Sequence, the other is also set to Sequence.

\*4: Requires both MU195020A-050/350 and MU195020A-051/351 options.

# SI PPG MU195020A Specifications

## Pattern Sequence

|               |   |
|---------------|---|
| Repeat        | Continuous Pattern  |
| Burst         |   |
| Burst Cycle   | 25600 bits to 2147483648 bits, 1024 bits step   |
| Enable period | Internal: 12800 bits to 2147483392 bits, 256 bits step<br>Ext Trigger: 12800 bits to 2147483648 bits, 256 bits step |

## Pre-Code

The function is available only when Pattern Sequence is Repeat.

|                 |                        |
|-----------------|------------------------|
| Modulation Type | 2ch Combination: DQPSK |
| Initial Data    | Choose 0 or 1.         |

## Error addition

|                   |   |
|-------------------|---|
| Area              | ALL, Specific Block (Can be selected only for Mixed.)               |
| Internal Trigger  |   |
| Error Variation   | Repeat, Single  |
| Error Ratio       | *E – n (*= 1 to 9, n = 3 to 12), Upper limit is 5E–3                |
| External Trigger* |   |
| Control Method    | External-Trigger (Rise edge trigger), External-Disable (L: Disable) |
| Bit/Burst         | Selects Bit Error or Burst Error                                    |
| Burst Length      | 1 to 127, 1 step  |

\*: Can be set when Test Pattern is other than Sequence.

## Data Output

Unless otherwise specified, these are defined with the conditions of PRBS<sup>231</sup> – 1, Mark ratio 1/2, and Cross Point 50%.

These values are monitored using an applicable part (Coaxial Cable J1439A, 0.8 m, K connector) at a sampling oscilloscope bandwidth of 70 GHz.

|                                     |   |
|-------------------------------------|---|
| Number of Outputs                   | Option x10: 2 (Data, $\overline{\text{Data}}$ )<br>Option x20: 4 (Data1, $\overline{\text{Data1}}$ , Data2, $\overline{\text{Data2}}$ )   |
| Output Amplitude                    |   |
| Setting Range                       | 0.1 Vp-p to 1.3 Vp-p, 2 mV step   |
| Setting Error                       | ±50 mV ±17%   |
| Offset                              |   |
| Setting Range                       | $-2.0 - \frac{\text{Amp.}}{2}$ to $+3.3 - \frac{\text{Amp.}}{2} - V_{th}$ , 1 mV step   |
| Setting Error                       | ±65 mV ±10% of offset (Vth) ± (Eye Amp. Accuracy/2)*1   |
| Defined Interface                   | NECL, SCFL, NCML, PCML, LVPECL  |
| Cross Point                         | 50% Fixed   |
| Rising/Falling Time                 | 12 ps (20 to 80%) (typ.)*1, *2, ≤15 ps (20 to 80%)*1, *2  |
| Half Period Jitter                  |   |
| Setting Range                       | –20 to 20, 1 step   |
| Setting Error                       | ±0.02 UI (typ.)*3   |
| Jitter                              | Peak-to-Peak Jitter (p-p): 6 ps p-p (Measurement count 30) (typ.)*2, *4<br>Random Jitter (RMS): 300 fs rms (1,0 repeat pattern) (typ.)*2, *4<br>Random Jitter (RMS): 115 fs rms (28 Gbit/s 1,0 repeat pattern) (typ.)*2, *5<br>Total Jitter (Total): 6 ps (Measurement count 30) (typ.)*2, *4, *6 |
| Waveform Distortion (0-peak)        | ±25 mV ±15% (typ.)*2  |
| Data/ $\overline{\text{Data}}$ Skew | ±1 ps (typ.)*7, *8  |
| Skew Between Channels*9             | ±0.25 UI*8  |
| Termination                         | AC, DC switching, 50Ω<br>For DC*10: GND, –2 V, +1.3 V, +3.3 V, Open (LVDS)  |
| Connector                           | K (f)   |

\*1: Option x11 or Option x21 is installed and that Emphasis is not set.

\*2: If Option x01 is not available, then this is at 21 Gbit/s.

If Option x01 is available, then this is at 32.1 Gbit/s.

Amplitude: 1.0 Vp-p

\*3: When the value is set to 0.

\*4: Using oscilloscope with residual jitter of less than 200 fs rms.

\*5: Using oscilloscope with residual jitter of less than 70 fs rms.

\*6: Defined by PRBS 2<sup>15</sup> – 1, BER 10<sup>–12</sup>.

\*7: Cable error is not included.

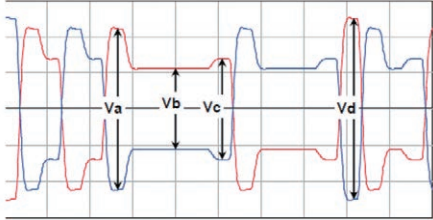
\*8: Includes standard accessory Coaxial Adapter J1359A (K-P-K-J to SMA).

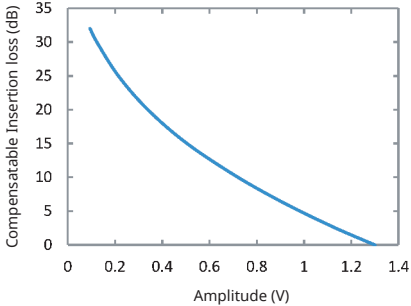
\*9: When Option x20 is available.

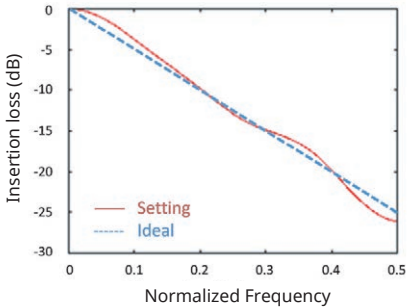
\*10: The output circuit is DC-terminated using the AC-coupled Bias Tee.

# SI PPG MU195020A Specifications

## 10Tap Emphasis (Option 011 or 021)

|                                     |   |
|-------------------------------------|---|
| Emphasis Tap                        | 10 (6 post-cursor, 3 pre-cursor)  |
| Cursor Setting Range                | -20 to +20 dB, 0.1 dB step<br>Post-Cursor: $20\log_{10}\left(\frac{V_a}{V_b}\right)$ , Pre-Cursor: $20\log_{10}\left(\frac{V_c}{V_d}\right)$<br> |
| Accuracy                            | ±1 dB (typ., Defined for the preset of 8, 16, and 25 Gbit/s for PCIe 3 and PCIe 4 respectively)   |
| Emphasis Peak Voltage Setting Range | 0.1 Vp-p to 1.5 Vp-p (Single-end)   |
| Transition Time from Idle State     | ≤8 ns (Maximum time to transition to valid diff signaling after leaving Electrical Idle)  |

|                                      |  |
|--------------------------------------|--|
| Channel Emulator (Option 040 or 041) | <p>Normal: Outputs signal emulating transmission channel equivalent to read S-parameter at PPG Data Output</p> <p>Inverse: Outputs signal with set De-Emphasis for compensating for transmission channel loss equivalent to read S-parameter at PPG Data Output</p> <p>The following graph indicates the maximum transmission channel loss that can be compensated for using the Channel Emulator function without causing a decrease in Amplitude.</p>  |
| Response                             | Normal, Inverse  |
| S-Parameter file                     | S2P File (extension *.s2p),<br>S4P File (Input ports 1 and 3; Output ports 3 and 4, extension *.s4p)<br>Supports Vector Network Analyzer MS4640B Series output files   |

|                                  |  |
|----------------------------------|--|
| Variable ISI (Option 040 or 041) | Sets ISI-generated channel loss and outputs this emulated waveform at PPG output Data signal (Output waveform amplitude standardized as set amplitude)<br>Used in combination with Channel Board, such as J1758 (Optional Accessory)   |
| Frequency Setting                | Can set Insertion Loss at Nyquist or 1/2 Nyquist frequency   |
| Insertion Loss Setting           | 1.5 to 25 dB 0.01 dB step @Nyquist Frequency<br>0 to 25 dB 0.01 dB step @1/2Nyquist Frequency  |
| Insertion Loss Accuracy          | <p>±1 dB nominal (design guarantee) at Nyquist frequency, 10 dB, with 1,0 pattern repetition</p> <p>±1 dB nominal (design guarantee) at 1/2 Nyquist frequency 5 dB, with 1, 1, 0, 0 pattern repetition</p> <p>Bit rates of 16 Gbit/s, 25 Gbit/s (Option 01 installed), Eye Amplitude of 1.0 Vp-p, each spectrum</p> <p>The Insertion Loss Accuracy is shown by the following graph of the frequency characteristics when 25 dB and 12.5 dB is set at the Nyquist frequency and 1/2 Nyquist frequency, respectively. (ISI Nominal Data)</p>  |
| Emulator On/Off                  | Can be composed of each Channel Emulator, Variable ISI, and Emphasis Tap   |

# SI PPG MU195020A Specifications

## Clock Output

These values are monitored using an applicable part (Coaxial Cable J1439A, 0.8 m, K connector) at a sampling oscilloscope bandwidth of 70 GHz.

|                  |  |
|------------------|--|
| Frequency        |  |
| Full Rate        | 2.4 GHz to 21.0 GHz* <sup>1</sup><br>2.4 GHz to 32.1 GHz* <sup>2</sup><br>Operation bit rate is same as clock output frequency.    |
| Half Rate        | 1.2 GHz to 10.5 GHz* <sup>1</sup><br>1.2 GHz to 16.05 GHz* <sup>2</sup><br>Operation bit rate is double of output clock frequency. |
| Number of Output | 1  |
| Amplitude        | 0.3 Vp-p to 1.0 Vp-p   |
| Termination      | AC, 50Ω  |
| Connector        | K (f)  |

\*1: Option x01 not available.

\*2: Option x01 available.

## Data Delay

When Option x30 or Option x31 is available.

|                       |   |
|-----------------------|---|
| Phase Variable Range  | -1000 mUI to +1000 mUI, 2 mUI step  |
| Phase Setting Error   | ±50 m UIp-p (typ.)*   |
| Calibration Indicator | This indicator is on when Calibration is required due to: <ul style="list-style-type: none"> <li>• 1/1 Clock frequency change by ±250 kHz.</li> <li>• Ambient temperature change by ±5 degree.</li> </ul> |

\*: When using an item with an oscilloscope residual jitter of less than 200 fs rms.

## Jitter Tolerance

| <p>Jitter Tolerance Mask*</p> | <p>Bit rate: 16, 28.1*, 32.1 Gbit/s*</p> <p>Pattern: PRBS 2<sup>31</sup> - 1</p> <p>SSC with a 7000 ppm amplitude and RJ of 0.3 UI can be simultaneously applied by using MU181500B.</p> <p>These specifications are defined assuming the following conditions:<br/> Loopback connection to the MU195040A, defined by one specific temperature in the range of 20°C to 30°C.<br/> When RJ + BUJ is bigger than 0.5 UIp-p or SJ + RJ + BUJ is bigger than the standard value + 0.3 UIp-p,<br/> "Overload" is displayed on the MU181500B screen..</p> <div style="text-align: center;"> </div> <table border="1" style="margin-top: 10px;"> <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>200</td> <td>150</td> </tr> <tr> <td>1,000,000</td> <td>16</td> <td>15</td> </tr> <tr> <td>10,000,000</td> <td>1</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 [UIp-p] | Specification [UIp-p] | 10 | 2,000 | 2,000 | 7,500 | 2,000 | 2,000 | 100,000 | 200 | 150 | 1,000,000 | 16 | 15 | 10,000,000 | 1 | 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                       | 200  | 150                       |                                   |                       |    |       |       |       |       |       |         |     |     |           |    |    |            |   |   |             |   |   |
| 1,000,000                     | 16   | 15                        |                                   |                       |    |       |       |       |       |       |         |     |     |           |    |    |            |   |   |             |   |   |
| 10,000,000                    | 1  | 1                         |                                   |                       |    |       |       |       |       |       |         |     |     |           |    |    |            |   |   |             |   |   |
| 250,000,000                   | 1  | 1                         |                                   |                       |    |       |       |       |       |       |         |     |     |           |    |    |            |   |   |             |   |   |

\*: Option x01 available.



# SI PPG MU195020A Specifications

## Multichannel Operation

|                           |  |
|---------------------------|--|
| Combination Setting*1, *2 |  |
| 2ch Combination           | Alternately outputs each bit in pattern as 32/64 Gbit/s band signal source to two channels.  |
| Channel Synchronization*1 | Number of channels: 2  |
| Combination of Modules    | Slot 1 to 4: 2-channel combination, channel synchronization*3  |
| 2-channel synchronization |  |
| Output                    | Phase variable range<br>-64 000 mUI to +64 000 mUI*4<br>Phase variable step<br>2 mUI*4   |
| Pattern                   |  |
| Data                      | Data Length<br>2 × n to 268435456 × n bits, n bits step*5  |
| Mixed                     | Row Length<br>(2048 × n) to { (268435456 + 2 <sup>31</sup> ) × n }, (1024 × n) bits step*5<br>Data Length<br>(1024 × n) to 268435456 × n bits, n bits step*5 |

\*1: Option x31 is required for target channels. Multichannel operation cannot be set when Test Pattern is set to Sequence.

\*2: Combination extending over multiple slots cannot be set.

\*3: When the options in the modules are the same and they are installed sequentially from slot 1,

\*4: A separate value can be set for each channel. This value is common to both Channel Combination and Channel Synchronization.

\*5: Common to every channel specified by Combination Setting.

## Extension Function

|      |   |
|------|---|
| PAM4 | <p>Supports the following by combining MU195020A with MZ1834A/B and G0375A.</p> <p>PAM4 signal generation</p> <ul style="list-style-type: none"> <li>• Amplitude (Single-end) 0.048 to 0.310 Vp-p (MZ1834A)</li> <li>• Amplitude (Single-end) 0.048 to 0.489 Vp-p (MZ1834B)</li> <li>• Amplitude (Single-end) 0.3 to 1.95 Vp-p (G0375A)</li> </ul> <p>PAM4 Emphasis signal generation (when Option x11 or Option x21 is installed)</p> <ul style="list-style-type: none"> <li>• Emphasis Peak Voltage (Single-end) 0.048 to 0.357 Vp-p (MZ1834A)</li> <li>• Emphasis Peak Voltage (Single-end) 0.048 to 0.564 Vp-p (MZ1834B)</li> <li>• Emphasis Peak Voltage (Single-end) 0.3 to 2.25 Vp-p (G0375A)</li> </ul> |
|------|---|

# SI ED MU195040A Specifications

## Operating Bit Rate

|                    |  |
|--------------------|--|
| Operating Bit Rate | 2.4 Gbit/s to 21.0 Gbit/s*1<br>2.4 Gbit/s to 32.1 Gbit/s*2 |
|--------------------|--|

\*1: Option x01 not available

\*2: Option x01 available

## System Clock

|              |   |
|--------------|---|
| System Clock | External, Clock Recovery, Clock and Data Recovery are optional* |
|--------------|---|

\*: Available when Option x22 is installed. If it is not installed, only External is available.

Clock is recovered from the data input to the Data1 Input connector.

## Data Input

|                          |   |  |                                  |               |               |
|--------------------------|---|--|----------------------------------|---------------|---------------|
| Number of Inputs         | 2 (Data, $\overline{\text{Data}}$ ) (Differential)*1<br>4 (Data1, $\overline{\text{Data1}}$ , Data2, $\overline{\text{Data2}}$ ) (Differential)*2   |  |                                  |               |               |
| Amplifier                | Single-end 50 $\Omega$ , Differential 50 $\Omega$ , Differential 100 $\Omega$ can be set.<br>At Single-end 50 $\Omega$ : Data and $\overline{\text{Data}}$ can be set.<br>At differential 50/100 $\Omega$ : Tracking, Independent, Alternate can be set.<br>When Alternate is selected: Data- $\overline{\text{Data}}$ and $\overline{\text{Data}}$ -Data can be set.*3<br>CTLE: On/Off Switching*4 |  |                                  |               |               |
| Input Signal Format      | NRZ, PAM4   |  |                                  |               |               |
| Input Amplitude*5        | 0.05 Vp-p to 1.0 Vp-p (NRZ)<br>0.3 Vp-p to 1.0 Vp-p (PAM4, $\leq$ 28.1 Gbaud)<br>0.4 Vp-p to 1.0 Vp-p (PAM4, $>$ 28.1 Gbaud)  |  |                                  |               |               |
| Threshold Voltage        | -3.5 V to +3.3 V (1 mV step) (Can be set separately.)<br>(Absolute value of difference between Data and $\overline{\text{Data}}$ Threshold values shall be 3 V or less.)  |  |                                  |               |               |
| Input Sensitivity        | NRZ*5, *6, *7   |  |                                  |               |               |
|                          | Bit Rate  | 21.0 Gbit/s  | 28.1 Gbit/s*8                    |               |               |
|                          | Amplitude   | 19 mVp-p (typ.), $\leq$ 27 mVp-p                           | 22 mVp-p (typ.), $\leq$ 31 mVp-p |               |               |
|                          | Eye Height*9  | 13 mV (typ.)   | 15 mV (typ.)                     |               |               |
|                          | PAM4*5, *7, *11   |  |                                  |               |               |
|                          | Baud Rate   | 21.0 Gbaud   | 28.1 Gbaud*8                     |               |               |
|                          | Amplitude   | 120 mVp-p (typ.), 40 mV/Eye                                | 150 mVp-p (typ.), 50 mV/Eye      |               |               |
|                          | Eye Height*9  | 24 mV (typ.)   | 26 mV (typ.)                     |               |               |
|                          | Phase Margin  | NRZ*6, *10   |                                  |               |               |
|                          |   | Bit Rate   | 21.0 Gbit/s                      | 25.0 Gbit/s*8 | 28.1 Gbit/s*8 |
| Phase Margin             |   | 33 ps (typ.)   | 27 ps (typ.)                     | 20 ps (typ.)  | 18 ps (typ.)  |
| PAM4 Middle*11, *12      |   |  |                                  |               |               |
| Baud Rate                |   | 21.0 Gbaud   | 25.0 Gbaud*8                     | 28.1 Gbaud*8  | 32.1 Gbaud*8  |
| Phase Margin             |   | 13 ps (typ.)   | 8 ps (typ.)                      | 5 ps (typ.)   | 2 ps (typ.)   |
| Eye Width                |   | 26.5 ps (typ.)   | 20 ps (typ.)                     | 15 ps (typ.)  | 13 ps (typ.)  |
| PAM4 Upper/Lower*11, *12 |   |  |                                  |               |               |
| Baud Rate                |   | 21.0 Gbaud   | 25.0 Gbaud*8                     | 28.1 Gbaud*8  |               |
| Phase Margin             |   | 8 ps (typ.)  | 5 ps (typ.)                      | 3 ps (typ.)   |               |
| Eye Width                |   | 26.5 ps (typ.)   | 20 ps (typ.)                     | 15 ps (typ.)  |               |
| Termination              |   | GND, Termination Variable Selectable<br>50 $\Omega$        |                                  |               |               |
| Termination Voltage      |   | Termination Variable Setting: -2.5 V to +3.5 V, 10 mV step |                                  |               |               |
| Connector                | K (f)   |  |                                  |               |               |
| CTLE*1                   |   |  |                                  |               |               |
| Band                     | Off, 8 Gbit/s to 10 Gbit/s, 16 Gbit/s to 20 Gbit/s, 25 Gbit/s to 28 Gbit/s, PCIe3, PCIe4, PCIe5   |  |                                  |               |               |
| Amplitude                | 0.05 Vp-p to 0.4 Vp-p (Input range not saturated when CTbE On)  |  |                                  |               |               |
| CTLE Gain                | Setting range<br>0 to -12 dB, 0.1 dB step<br>Accuracy<br>$\pm$ 0.5 dB (typ.)  |  |                                  |               |               |

\*1: Option x10

\*2: Option x20

\*3: Absolute value of difference between Data and  $\overline{\text{Data}}$  Threshold values shall be 1.5 V or less.

\*4: Option x11 or Option x21

\*5: The Amplitude at NRZ input is the Auto Adjust function operation range. The Amplitude at PAM4 input is the PAM4 Auto Search function operation range. Input sensitivity is the minimum input amplitude which becomes error-free.

\*6: PRBS 31, Single-end, Mark ratio 1/2, CTLE OFF

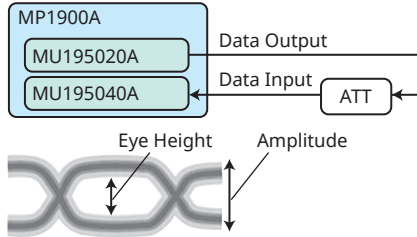
\*7: Defined by one specific temperature in the range of 20°C to 30°C.

\*8: Option x01

# SI ED MU195040A Specifications

\*9: Sensitivity of eye height.

Eye height is the minimum value that induces no bit error when MU195040A receives the output signal from MU195020A + ATT in the measurement system shown in the following figure (using a sampling oscilloscope of 70 GHz band or higher for measuring output amplitude)



\*10: When using 0.5 Vp-p Input and External Clock.

\*11: At PRBS15, Single-end, Mark Ratio 1/2 equivalent, and CTLE OFF, with MU195020A + G0375A

\*12: At Emphasis ON (best value within range of 1Pre ≤ 3 dB/1Post ≤ 1 dB) based on IEEE802.3bs measurement method

## Clock Input

|                  |   |
|------------------|---|
| Number of Inputs | 1 (Single-end)                          |
| Frequency Range  | 1.2 GHz to 16.05 GHz                    |
| Input Level      | 0.3 Vp-p to 1.0 Vp-p (-6.5 to +4.0 dBm) |
| Termination      | AC, 50Ω                                 |
| Connector        | SMA (f)                                 |

## Aux Input, Aux Output

|                         |   |
|-------------------------|---|
| Aux Input               |   |
| Number of Inputs        | 1 (Single-end)  |
| Input Signal            | External Mask, Burst, Capture External Trigger  |
| Minimum Pulse Width     | 1/128 of Data rate  |
| Input Level             | <ul style="list-style-type: none"> <li>0/-1 V (H: -0.25 V to 0.05 V, L: -1.1 V to -0.8 V)</li> <li>0/-0.5 V (H: -0.05 V to 0.05 V, L: -0.55 V to -0.45 V)</li> <li>V<sub>TH</sub> 0 V (Input amplitude 0.5 Vp-p to 1.0 Vp-p)</li> </ul> Select one of the above.  |
| Termination             | GND, 50Ω  |
| Connector               | SMA (f)   |
| Aux Output              |   |
| Number of Outputs       | 2 (Differential)  |
| Output Signal Selection | 1/n Clock (n = 4, 6, 8, 10...510, 512), Pattern Sync*, Sync Gain, Error Output  |
| Pattern Sync            | PRBS, PRGM<br>Position: 1 to (Least common multiple of Pattern Length' and 128) – 135, 8 step<br>Pattern Length' shall be the value obtained by multiplying Pattern Length setting until it becomes 512 or more if it is 511 or less.<br>Mixed Data<br>Block No. setting: 1 to the Block No. specified for Mixed Data, in single steps<br>Row No. setting: 1 to the Row No. specified for Mixed Data, in single steps |
| Output Level            | 0/-0.6 V (H: -0.25 V to 0.05 V, L: -0.80 V to -0.45 V)  |
| Termination             | GND, 50Ω  |
| Connector               | SMA (f)   |

\*: Cannot be selected when Test Pattern is HSSB Data.

## Pattern Detection

|                             |   |
|-----------------------------|---|
| PRBS                        |   |
| Pattern Length              | 2 <sup>n</sup> - 1 (n = 7, 9, 10, 11, 15, 20, 23, 31)   |
| Mark Ratio                  | 1/2 (1/2INV is supported by a logical inversion.)   |
| Zero-Substitution           |   |
| Additional Bit              | 0 bit, 1 bit  |
| Pattern Length              | 2 <sup>n</sup> or 2 <sup>n</sup> - 1 (n = 7, 9, 10, 11, 15, 20, 23)   |
| Start Position              | Substitutes the bit coming after the maximum "0" successive bits.   |
| Successive-zeros Bit Length | 1 to (Pattern Length - 1) bits<br>If the bit coming after Zero-substitution is "0," then it is replaced with "1." |
| Data                        |   |
| Pattern Length              | 2 bits to 268435456 bits, 1 bit step  |

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|                       |  |          |            |            |              |                |  |             |              |             |                    |
|-----------------------|--|----------|------------|------------|--------------|----------------|--|-------------|--------------|-------------|--------------------|
| Mixed Pattern         |  |          |            |            |              |                |  |             |              |             |                    |
| Pattern               | Data   |          |            |            |              |                |  |             |              |             |                    |
| Mixed Block           | To the smaller of the following values:<br>1 to 511 Block, 1 Block step<br>$\text{INT} \left( \frac{268435456}{\text{ROW count}} \times \text{Data length} \right)$ bits<br>$\text{INT} \left( \frac{268435456 + 2^{31}}{\text{ROW length}} \times \text{ROW count} \right)$ bits  |          |            |            |              |                |  |             |              |             |                    |
| Mixed Row Length      | 2048 to 268435456 + 2 <sup>31</sup> bits, 1024 bits step (Data + PRBS Length)  |          |            |            |              |                |  |             |              |             |                    |
| Pattern Length        | 1024 bits to 268435456 bits, 1 bit step  |          |            |            |              |                |  |             |              |             |                    |
| Number of Rows        | 1 to 16, 1 step  |          |            |            |              |                |  |             |              |             |                    |
| Number of Blocks      | 1 to 511, 1 step   |          |            |            |              |                |  |             |              |             |                    |
| PRBS Steps/Mark Ratio | Same as PRBS.  |          |            |            |              |                |  |             |              |             |                    |
| PRBS Sequence         | Restart, Consecutive   |          |            |            |              |                |  |             |              |             |                    |
| Descramble            | Can be set per PRBS and Data for each Block (except the Data area for Block 1).  |          |            |            |              |                |  |             |              |             |                    |
| PAM4*1                |  |          |            |            |              |                |  |             |              |             |                    |
| Pattern Type          | Square Wave, JP03A, JP03B, PRQS10, SSPR, QPRBS13, QPRBS13-CEI, SSPRQ, Transmitter Linearity, PRBS13Q, PRBS31Q, User Define   |          |            |            |              |                |  |             |              |             |                    |
| User Define in detail | <table border="1"> <tr> <td>Raw Data</td> <td>PRBS, Data</td> </tr> <tr> <td>PRBS Stage</td> <td>Same as PRBS</td> </tr> <tr> <td>PRBS Inversion</td> <td>Logic Inversion/Non-Inversion of PRBS part</td> </tr> <tr> <td>Data Length</td> <td>Same as Data</td> </tr> <tr> <td>Gray Coding</td> <td>Gray Coding ON/OFF</td> </tr> </table> | Raw Data | PRBS, Data | PRBS Stage | Same as PRBS | PRBS Inversion | Logic Inversion/Non-Inversion of PRBS part | Data Length | Same as Data | Gray Coding | Gray Coding ON/OFF |
| Raw Data              | PRBS, Data   |          |            |            |              |                |  |             |              |             |                    |
| PRBS Stage            | Same as PRBS   |          |            |            |              |                |  |             |              |             |                    |
| PRBS Inversion        | Logic Inversion/Non-Inversion of PRBS part   |          |            |            |              |                |  |             |              |             |                    |
| Data Length           | Same as Data   |          |            |            |              |                |  |             |              |             |                    |
| Gray Coding           | Gray Coding ON/OFF   |          |            |            |              |                |  |             |              |             |                    |
| HSSB Data*2           | Specification PCIe1, PCIe2, PCIe3, PCIe4, PCIe5, USB3.0, USB3.1 Gen2   |          |            |            |              |                |  |             |              |             |                    |

\*1: Configurable when 2ch Combination is set.

\*2: This can be set only when Module Combination is set to Independent and the channel is Data1.

## Pattern Sequence

|               |  |
|---------------|--|
| Sequence      | Repeat, Burst  |
| Repeat        | Continuous Pattern   |
| Burst         |  |
| Delay         | Internal: 0 to 2147483640 bits, 8 bits step<br>Ext Trigger, Enable: 0 to 2147483520 bits, 8 bits step<br>Adjust Method: Auto, Manual |
| Enable Period | Internal: 12800 bits to 2147482624 bits, 256 bits step<br>Ext Trigger: 12800 bits to 2147483392 bits, 256 bits step                  |
| Burst Cycle   | 25600 bits to 2147483648 bits, 1024 bits step  |

## Measurement

|                      |  |
|----------------------|--|
| Measurement Types    | Error Rate<br>Error Count<br>Error Interval<br>%Error Free Interval<br>Frequency<br>Frequency measurement accuracy<br>Clock Count<br>Sync Loss Interval<br>Clock Loss Interval |
| Error Detection Mode | <ul style="list-style-type: none"> <li>Total, Insertion, Omission</li> <li>Transition, Non Transition</li> </ul>   |
| SKP OS Filtering     | This function filters SKP OS in conformance with the USB3.1 Gen1/2 and PCIe Gen1/2/3/4/5 standards. Operation at each standard bit rate only is supported.                     |

## Error Analysis

|                                |  |
|--------------------------------|--|
| Block Window                   | Excludes the specified data pattern bit from the measurement target according to the settings.<br>(Mask measurement function)<br>Invalid when "Mixed" pattern or "HSSB Data" is selected for Test Pattern. |
| Bit Window                     | Excludes any channels among internal 32 channels from the measurement target.  |
| Capture Function               |  |
| Automatic Measurement Function | Eye margin* <sup>1, *2</sup> , Bathtub* <sup>1, *2</sup> , Eye Contour* <sup>1, *2</sup> , PAM4 BER measurement<br>Auto Adjust* <sup>3, *4, *5</sup> , Auto Search* <sup>3</sup> , Auto Search PAM4 mode   |

\*1: Not available when "HSSB Data" is selected for Test Pattern.

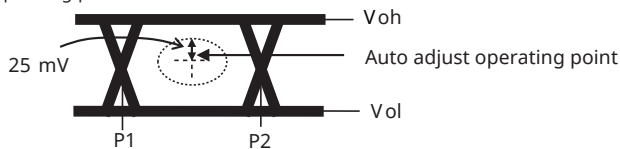
\*2: Unavailable when the system clock is set to Clock and Data Recovery.

\*3: The input pattern must be an NRZ PRBS pattern with a mark ratio of 1/2.

\*4: The Auto Adjust function obtains a point in the vicinity of the following as an optimum point:

- $(V_{oh} + V_{ol})/2$  in voltage direction
- $(P1 + P2)/2$  in phase direction

The Auto Adjust function works properly when there are no mask-hits which are observed by the oscilloscope vertically within  $\pm 25$  mV area from the Auto Adjust operating point.



\*5: If eye diagram of input signal is not symmetry, the Auto Adjust may not adjust input signals to the optimum value.

The Auto Search Fine is recommended to measure asymmetric input signals.

## Variable Clock Delay

|                       |  |
|-----------------------|--|
| Phase Variable Range  | -1000 mUI to +1000 mUI, 2 mUI step   |
| Phase Setting Error   | $\pm 50$ m UIp-p (typ.)*   |
| Calibration Indicator | This indicator is on when Calibration is required due to: <ul style="list-style-type: none"> <li>• Change in 1/Clock frequency by <math>\pm 250</math> kHz.</li> <li>• Change in the ambient temperature by <math>\pm 5^\circ\text{C}</math>.</li> </ul> |

\*: Using oscilloscope with residual jitter of less than 200 fs rms

## Clock Recovery

| Clock Source Options                              | Clock Recovery, Clock and Data Recovery Clock* <sup>1</sup>   |                   |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
|---|---|-------------------|---------------------|------------|----------------------|---|---|----------------------|--------|---|----------------------|--------|---|-----------------------|--------|---|------------------------|--------|---|------------------------|--------|---|------------------------|--------|---|------------------------|---------|---|------------------------|---------|---|------------------------|---------|---|------------------------|---------|---|------------------------|---------|---|------------------------|---------|---|------------------------|---------|---|------------------------|---------|---|------------------------|----------|---|------------------------|----------|---|
| Operating Bit Rate                                | At NRZ<br>2.4 Gbit/s to 21.0 Gbit/s* <sup>2</sup><br>2.4 Gbit/s to 32.1 Gbit/s* <sup>3</sup><br>At PAM4<br>2.4 Gbaud to 21.0 Gbaud<br>2.4 Gbaud to 28.1 Gbaud* <sup>3</sup><br>28.1100001 Gbaud to 32.1 Gbaud (BER 1.0E-7 typ.)* <sup>3</sup>   |                   |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| Setting Range                                     | 2.400000 Gbit/s to 21.000000 Gbit/s, 0.000001 Gbit/s step* <sup>2</sup><br>2.400000 Gbit/s to 32.100000 Gbit/s, 0.000001 Gbit/s step* <sup>3</sup>  |                   |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| Maximum Number of Consecutive Zeros* <sup>4</sup> | 72 bit (Zero Substitution 2 <sup>15</sup> )   |                   |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| Lock Range* <sup>4</sup>                          | $\pm 200$ ppm   |                   |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| Target Loop Band                                  | Available options are $\frac{\text{Bit rate}}{1667}$ MHz, $\frac{\text{Bit rate}}{2578}$ MHz, Jitter Tolerance* <sup>5</sup> and Variable.<br>If the Variable option is selected, the following settings are available: <table border="1" style="margin-left: 20px;"> <thead> <tr> <th>Bit Rate [Gbit/s]</th> <th>Setting Range [MHz]</th> <th>Step [MHz]</th> </tr> </thead> <tbody> <tr><td>2.400000 to 5.500000</td><td>3</td><td>—</td></tr> <tr><td>5.500001 to 7.500000</td><td>3 to 4</td><td>1</td></tr> <tr><td>7.500001 to 9.500000</td><td>3 to 5</td><td>1</td></tr> <tr><td>9.500001 to 10.500000</td><td>3 to 6</td><td>1</td></tr> <tr><td>10.500001 to 12.500000</td><td>3 to 7</td><td>1</td></tr> <tr><td>12.500001 to 14.500000</td><td>3 to 8</td><td>1</td></tr> <tr><td>14.500001 to 15.500000</td><td>3 to 9</td><td>1</td></tr> <tr><td>15.500001 to 17.500000</td><td>3 to 10</td><td>1</td></tr> <tr><td>17.500001 to 19.500000</td><td>3 to 11</td><td>1</td></tr> <tr><td>19.500001 to 20.500000</td><td>3 to 12</td><td>1</td></tr> <tr><td>20.500001 to 22.500000</td><td>3 to 13</td><td>1</td></tr> <tr><td>22.500001 to 24.500000</td><td>3 to 14</td><td>1</td></tr> <tr><td>24.500001 to 25.500000</td><td>3 to 15</td><td>1</td></tr> <tr><td>25.500001 to 27.500000</td><td>3 to 16</td><td>1</td></tr> <tr><td>27.500001 to 29.500000</td><td>3 to 17</td><td>1</td></tr> <tr><td>29.500001 to 30.500000</td><td>11 to 18</td><td>1</td></tr> <tr><td>30.500001 to 32.100000</td><td>11 to 19</td><td>1</td></tr> </tbody> </table> | Bit Rate [Gbit/s] | Setting Range [MHz] | Step [MHz] | 2.400000 to 5.500000 | 3 | — | 5.500001 to 7.500000 | 3 to 4 | 1 | 7.500001 to 9.500000 | 3 to 5 | 1 | 9.500001 to 10.500000 | 3 to 6 | 1 | 10.500001 to 12.500000 | 3 to 7 | 1 | 12.500001 to 14.500000 | 3 to 8 | 1 | 14.500001 to 15.500000 | 3 to 9 | 1 | 15.500001 to 17.500000 | 3 to 10 | 1 | 17.500001 to 19.500000 | 3 to 11 | 1 | 19.500001 to 20.500000 | 3 to 12 | 1 | 20.500001 to 22.500000 | 3 to 13 | 1 | 22.500001 to 24.500000 | 3 to 14 | 1 | 24.500001 to 25.500000 | 3 to 15 | 1 | 25.500001 to 27.500000 | 3 to 16 | 1 | 27.500001 to 29.500000 | 3 to 17 | 1 | 29.500001 to 30.500000 | 11 to 18 | 1 | 30.500001 to 32.100000 | 11 to 19 | 1 |
| Bit Rate [Gbit/s]                                 | Setting Range [MHz]   | Step [MHz]        |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 2.400000 to 5.500000                              | 3   | —                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 5.500001 to 7.500000                              | 3 to 4  | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 7.500001 to 9.500000                              | 3 to 5  | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 9.500001 to 10.500000                             | 3 to 6  | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 10.500001 to 12.500000                            | 3 to 7  | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 12.500001 to 14.500000                            | 3 to 8  | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 14.500001 to 15.500000                            | 3 to 9  | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 15.500001 to 17.500000                            | 3 to 10   | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 17.500001 to 19.500000                            | 3 to 11   | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 19.500001 to 20.500000                            | 3 to 12   | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 20.500001 to 22.500000                            | 3 to 13   | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 22.500001 to 24.500000                            | 3 to 14   | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 24.500001 to 25.500000                            | 3 to 15   | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 25.500001 to 27.500000                            | 3 to 16   | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 27.500001 to 29.500000                            | 3 to 17   | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 29.500001 to 30.500000                            | 11 to 18  | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |
| 30.500001 to 32.100000                            | 11 to 19  | 1                 |                     |            |                      |   |   |                      |        |   |                      |        |   |                       |        |   |                        |        |   |                        |        |   |                        |        |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |         |   |                        |          |   |                        |          |   |

# SI ED MU195040A Specifications

|                  |  |
|------------------|--|
| Jitter Tolerance |  |
| Clock Recovery   | At the bit rate of 28.05 Gbit/s, conforming to Jitter Tolerance Mask defined by the "32G FC standard"<br>At the bit rate of 25.78125 Gbit/s, conforming to Jitter Tolerance Mask defined by the "100 GbE (25.78 × 4) standard"<br>At the bit rate of 14.0625 Gbit/s, conforming to Jitter Tolerance Mask defined by the "InfiniBand FDR standard"<br>At the bit rate of 14.025 Gbit/s, conforming to Jitter Tolerance Mask defined by the "16G FC standard"<br>At the bit rate of 10.3125 Gbit/s, conforming to Jitter Tolerance Mask defined by the "10 GbE standard" |

- \*1: Can be selected when option x22 installed. Clock Recovery from data input to Data1 Input. PRBS input pattern and 1/2 Mark Ratio at NRZ.  
At PAM4, Clock Recovery at Middle Eye for Data1 with PRBS15, and Upper/Middle/Lower Eye for Data2.
- \*2: When option x22 is installed.
- \*3: When option x01 is installed.
- \*4: When the option x22 is installed:  
The target loop band is specified by the maximum setting value of each bit rate.
- \*5: The Jitter Tolerance option makes the loop band wider than the other options and enables the Jitter Tolerance measurement.

## Jitter Tolerance

| Jitter Tolerance          | <p>Bit rate: 16 Gbit/s, 28.1 Gbit/s*, 32.1 Gbit/s*</p> <p>Pattern: PRBS <math>2^{31} - 1</math></p> <p>SSC with a 7000 ppm amplitude and RJ of 0.3 UI can be simultaneously applied by using MU181500B.</p> <p>These specifications are defined assuming the following conditions:<br/>Loopback connection to the MU195020A, defined by one specific temperature in the range of 20°C to 30°C.<br/>When RJ + BUJ is bigger than 0.5 Ulp-p or SJ + RJ + BUJ is bigger than the standard value + 0.3 Ulp-p, "Overload" is displayed on the MU181500B screen.</p> |                           |                                   |                       |    |       |       |       |       |       |         |       |     |           |     |    |            |    |   |             |   |
|---------------------------|--|---------------------------|-----------------------------------|-----------------------|----|-------|-------|-------|-------|-------|---------|-------|-----|-----------|-----|----|------------|----|---|-------------|---|
|                           | <table border="1"> <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 |
| 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                         |                                   |                       |    |       |       |       |       |       |         |       |     |           |     |    |            |    |   |             |   |

\*: Option x01 available

## Multichannel Operation

|                    |   |
|--------------------|---|
| Combination*1      |   |
| Number of Channels | 2   |
| Pattern            | At Combination<br>n = 2 below (2ch combination)   |
| Data               | Pattern Length<br>$2 \times n$ to $268435456 \times n$ bits, n bits step*2  |
| Mixed              | Row Length<br>$2048 \times n$ to $(268435456 + 2^{31}) \times n$ bits, $1024 \times n$ bits step*2<br>Pattern Length<br>$1024 \times n$ to $268435456 \times n$ bits, n bits step*2 |

- \*1: Combination extending over multiple slots cannot be set. Cannot be set when Test Pattern is HSSB Data.
- \*2: Common to every channel specified by Combination Setting.

# SI ED MU195040A Specifications

## Automatic Measurement Function

|                      |   |
|----------------------|---|
| Eye Contour          | Measurement target<br>Data 1 to Data n*1  |
| Eye Margin           | Measurement target<br>Data 1 to Data n*1  |
| Bathtub              | Measurement target<br>Data 1 to Data n*1  |
| Capture              | 2Ch Combination is available*2  |
| PAM4 BER Measurement | <p>The following pattern selectable</p> <ul style="list-style-type: none"> <li>• GrayPRBS7, 9, 10, 11, 13Q-IEEE200G_400G [Draft2], 15,20</li> <li>• GrayPrePRBS20</li> <li>• GrayPreQPRBS13-CEI</li> <li>• GrayPreQPRBS13-IEEE100GBASE-KP4_Lane0, 1, 2, 3</li> <li>• GrayPRQS10</li> <li>• GrayQPRBS13-CEI</li> <li>• GrayQPRBS13-IEEE100GBASE-KP4_Lane0, 1, 2, 3</li> <li>• GraySSPR</li> <li>• PRBS7, 9, 10, 11, 13Q-IEEE200G_400G [Draft2], 15, 20</li> <li>• PrePRBS20</li> <li>• PreQPRBS13-CEI</li> <li>• PRQS10</li> <li>• QPRBS13-CEI</li> <li>• QPRBS13-IEEE100GBASE-KP4_Lane0, 1, 2, 3</li> <li>• Squarewave</li> <li>• SSPR</li> <li>• SSPRQ</li> <li>• Transmitter_Linearity</li> </ul> |

\*1: Separately specified for each channel.

\*2: Common to every channel specified by Combination Setting.

## General (MU195020A/MU195040A)

|                       |  |
|-----------------------|--|
| Dimensions and Mass   | 234 (W) × 21 (H) × 175 (D) mm (Excluding protrusions), 2.5 kg max. |
| Operating Temperature | 15°C to 35°C   |

## Operating Baud Rate

| Operating Baud Rate   | When the Option 001 is installed.<br>2.4 to 32.1 Gbaud<br>When the Option 002 or 112 is installed.<br>2.4 to 58.2 Gbaud<br>When the Option 003, 113, or 123 is installed.<br>2.4 to 64.2 Gbaud  |  |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
|---|---|--|-----------------------|--|--|----------------------|----------------------|---|------------------------|----------------------|--|-----------------------|----------------------|-------------------------|-----------------------|--|---|----------------------|----------------------|----------------------------------|-----------------------|----------------------|--------------------------------------|-----------------------|----------------------|----------------------------------|------------------------|----------------------|----------------------------------|------------------------|-----------------------|----------------------------------|-----------------------|----------------------|----------------------------------|-----------------------|----------------------|
| Operating Baud Rate Setting Range (MU181000B synchronized operation)                            | 2.400 000 to 25.000 000 Gbaud, 0.000 002 Gbaud step* <sup>1, *2, *3</sup><br>25.000 004 to 32.100 000 Gbaud, 0.000 004 Gbaud step* <sup>1, *2, *3</sup><br>25.000 004 to 50.000 000 Gbaud, 0.000 004 Gbaud step* <sup>2, *3</sup><br>50.000 008 to 58.200 000 Gbaud, 0.000 008 Gbaud step* <sup>2</sup><br>50.000 008 to 64.200 000 Gbaud, 0.000 008 Gbaud step* <sup>3</sup><br>Offset Setting Range/Step<br>-1000 to +1000 ppm, 1 ppm step* <sup>4</sup>  |  |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| Operating Baud Rate Setting Range (MU181000B and MU181500B synchronized operation)              | 2.400 000 to 3.125 000 Gbaud, 0.000 002 Gbaud step* <sup>1, *2, *3</sup><br>3.200 002 to 6.250 000 Gbaud, 0.000 002 Gbaud step* <sup>1, *2, *3</sup><br>6.400 002 to 12.500 000 Gbaud, 0.000 002 Gbaud step* <sup>1, *2, *3</sup><br>12.800 002 to 25.000 000 Gbaud, 0.000 002 Gbaud step* <sup>1, *2, *3</sup><br>25.600 004 to 32.100 000 Gbaud, 0.000 004 Gbaud step* <sup>1, *2, *3</sup><br>25.600 004 to 50.000 000 Gbaud, 0.000 004 Gbaud step* <sup>2, *3</sup><br>51.200 008 to 58.200 000 Gbaud, 0.000 008 Gbaud step* <sup>2</sup><br>51.200 008 to 64.200 000 Gbaud, 0.000 008 Gbaud step* <sup>3</sup><br>Offset Setting Range/Step<br>-1000 to +1000 ppm, 1 ppm step* <sup>4</sup>  |  |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| Operating Baud Rate Setting Range (with external clock source)                                  | <p>Clock Output Rate Full Rate</p> <table border="1"> <thead> <tr> <th>Baud Rate Setting Range</th> <th>Input Clock Frequency</th> <th>Relationship Between Baud Rate and Input Clock Frequency</th> </tr> </thead> <tbody> <tr> <td>2.4 to 16.05 Gbaud*<sup>1, *2, *3</sup></td> <td>2.4 GHz to 16.05 GHz</td> <td>Operate at 1/1 clock</td> </tr> <tr> <td>16.05 to 32.1 Gbaud*<sup>1, *2, *3</sup></td> <td>8.025 GHz to 16.05 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>25.0 to 32.1 Gbaud*<sup>1, *2, *3</sup></td> <td>6.25 GHz to 8.025 GHz</td> <td>Operate at 1/4 clock</td> </tr> </tbody> </table> <p>Clock Output Rate Half Rate, Quarter Rate</p> <table border="1"> <thead> <tr> <th>Baud Rate Setting Range</th> <th>Input Clock Frequency</th> <th>Relationship Between Baud Rate and Input Clock Frequency</th> </tr> </thead> <tbody> <tr> <td>2.4 to 32.1 Gbaud*<sup>1, *2, *3</sup></td> <td>1.2 GHz to 16.05 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>25.0 to 32.1 Gbaud*<sup>1</sup></td> <td>6.25 GHz to 8.025 GHz</td> <td>Operate at 1/4 clock</td> </tr> <tr> <td>25.0 to 50.0 Gbaud*<sup>2, *3</sup></td> <td>6.25 GHz to 12.50 GHz</td> <td>Operate at 1/4 clock</td> </tr> <tr> <td>32.1 to 58.2 Gbaud*<sup>2</sup></td> <td>8.025 GHz to 14.55 GHz</td> <td>Operate at 1/4 clock</td> </tr> <tr> <td>32.1 to 64.2 Gbaud*<sup>3</sup></td> <td>8.025 GHz to 16.05 GHz</td> <td>Operate at 1/4C clock</td> </tr> <tr> <td>50.0 to 58.2 Gbaud*<sup>2</sup></td> <td>6.25 GHz to 7.275 GHz</td> <td>Operate at 1/8 clock</td> </tr> <tr> <td>50.0 to 64.2 Gbaud*<sup>3</sup></td> <td>6.25 GHz to 8.025 GHz</td> <td>Operate at 1/8 clock</td> </tr> </tbody> </table> | Baud Rate Setting Range                                  | Input Clock Frequency | Relationship Between Baud Rate and Input Clock Frequency | 2.4 to 16.05 Gbaud* <sup>1, *2, *3</sup> | 2.4 GHz to 16.05 GHz | Operate at 1/1 clock | 16.05 to 32.1 Gbaud* <sup>1, *2, *3</sup> | 8.025 GHz to 16.05 GHz | Operate at 1/2 clock | 25.0 to 32.1 Gbaud* <sup>1, *2, *3</sup> | 6.25 GHz to 8.025 GHz | Operate at 1/4 clock | Baud Rate Setting Range | Input Clock Frequency | Relationship Between Baud Rate and Input Clock Frequency | 2.4 to 32.1 Gbaud* <sup>1, *2, *3</sup> | 1.2 GHz to 16.05 GHz | Operate at 1/2 clock | 25.0 to 32.1 Gbaud* <sup>1</sup> | 6.25 GHz to 8.025 GHz | Operate at 1/4 clock | 25.0 to 50.0 Gbaud* <sup>2, *3</sup> | 6.25 GHz to 12.50 GHz | Operate at 1/4 clock | 32.1 to 58.2 Gbaud* <sup>2</sup> | 8.025 GHz to 14.55 GHz | Operate at 1/4 clock | 32.1 to 64.2 Gbaud* <sup>3</sup> | 8.025 GHz to 16.05 GHz | Operate at 1/4C clock | 50.0 to 58.2 Gbaud* <sup>2</sup> | 6.25 GHz to 7.275 GHz | Operate at 1/8 clock | 50.0 to 64.2 Gbaud* <sup>3</sup> | 6.25 GHz to 8.025 GHz | Operate at 1/8 clock |
| Baud Rate Setting Range   | Input Clock Frequency   | Relationship Between Baud Rate and Input Clock Frequency |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 2.4 to 16.05 Gbaud* <sup>1, *2, *3</sup>  | 2.4 GHz to 16.05 GHz  | Operate at 1/1 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 16.05 to 32.1 Gbaud* <sup>1, *2, *3</sup>   | 8.025 GHz to 16.05 GHz  | Operate at 1/2 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 25.0 to 32.1 Gbaud* <sup>1, *2, *3</sup>  | 6.25 GHz to 8.025 GHz   | Operate at 1/4 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| Baud Rate Setting Range   | Input Clock Frequency   | Relationship Between Baud Rate and Input Clock Frequency |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 2.4 to 32.1 Gbaud* <sup>1, *2, *3</sup>   | 1.2 GHz to 16.05 GHz  | Operate at 1/2 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 25.0 to 32.1 Gbaud* <sup>1</sup>  | 6.25 GHz to 8.025 GHz   | Operate at 1/4 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 25.0 to 50.0 Gbaud* <sup>2, *3</sup>  | 6.25 GHz to 12.50 GHz   | Operate at 1/4 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 32.1 to 58.2 Gbaud* <sup>2</sup>  | 8.025 GHz to 14.55 GHz  | Operate at 1/4 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 32.1 to 64.2 Gbaud* <sup>3</sup>  | 8.025 GHz to 16.05 GHz  | Operate at 1/4C clock                                    |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 50.0 to 58.2 Gbaud* <sup>2</sup>  | 6.25 GHz to 7.275 GHz   | Operate at 1/8 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 50.0 to 64.2 Gbaud* <sup>3</sup>  | 6.25 GHz to 8.025 GHz   | Operate at 1/8 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| Operating Baud Rate Setting Range (MU181500B synchronized operation with external clock source) | <p>Clock Output Rate Full Rate</p> <table border="1"> <thead> <tr> <th>Baud Rate Setting Range</th> <th>Input Clock Frequency</th> <th>Relationship Between Baud Rate and Input Clock Frequency</th> </tr> </thead> <tbody> <tr> <td>2.4 to 15.0 Gbaud*<sup>1, *2, *3</sup></td> <td>2.4 GHz to 15.0 GHz</td> <td>Operate at 1/1 clock</td> </tr> <tr> <td>15.0 to 30.0 Gbaud*<sup>1, *2, *3</sup></td> <td>7.5 GHz to 15.0 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>25.0 to 32.1 Gbaud*<sup>1, *2, *3</sup></td> <td>6.25 GHz to 8.025 GHz</td> <td>Operate at 1/4 clock</td> </tr> </tbody> </table> <p>Clock Output Rate Half Rate, Quarter Rate</p> <table border="1"> <thead> <tr> <th>Baud Rate Setting Range</th> <th>Input Clock Frequency</th> <th>Relationship Between Baud Rate and Input Clock Frequency</th> </tr> </thead> <tbody> <tr> <td>2.4 to 30.0 Gbaud*<sup>1, *2, *3</sup></td> <td>1.2 GHz to 15.0 GHz</td> <td>Operate at 1/2 clock</td> </tr> <tr> <td>30.0 to 32.1 Gbaud*<sup>1</sup></td> <td>7.5 GHz to 8.025 GHz</td> <td>Operate at 1/4 clock</td> </tr> <tr> <td>30.0 to 58.2 Gbaud*<sup>2</sup></td> <td>7.5 GHz to 14.55 GHz</td> <td>Operate at 1/4 clock</td> </tr> <tr> <td>30.0 to 60.0 Gbaud*<sup>3</sup></td> <td>7.5 GHz to 15.0 GHz</td> <td>Operate at 1/4 clock</td> </tr> <tr> <td>60.0 to 64.2 Gbaud*<sup>3</sup></td> <td>7.5 GHz to 8.025 GHz</td> <td>Operate at 1/8 clock</td> </tr> </tbody> </table>  | Baud Rate Setting Range                                  | Input Clock Frequency | Relationship Between Baud Rate and Input Clock Frequency | 2.4 to 15.0 Gbaud* <sup>1, *2, *3</sup>  | 2.4 GHz to 15.0 GHz  | Operate at 1/1 clock | 15.0 to 30.0 Gbaud* <sup>1, *2, *3</sup>  | 7.5 GHz to 15.0 GHz    | Operate at 1/2 clock | 25.0 to 32.1 Gbaud* <sup>1, *2, *3</sup> | 6.25 GHz to 8.025 GHz | Operate at 1/4 clock | Baud Rate Setting Range | Input Clock Frequency | Relationship Between Baud Rate and Input Clock Frequency | 2.4 to 30.0 Gbaud* <sup>1, *2, *3</sup> | 1.2 GHz to 15.0 GHz  | Operate at 1/2 clock | 30.0 to 32.1 Gbaud* <sup>1</sup> | 7.5 GHz to 8.025 GHz  | Operate at 1/4 clock | 30.0 to 58.2 Gbaud* <sup>2</sup>     | 7.5 GHz to 14.55 GHz  | Operate at 1/4 clock | 30.0 to 60.0 Gbaud* <sup>3</sup> | 7.5 GHz to 15.0 GHz    | Operate at 1/4 clock | 60.0 to 64.2 Gbaud* <sup>3</sup> | 7.5 GHz to 8.025 GHz   | Operate at 1/8 clock  |                                  |                       |                      |                                  |                       |                      |
| Baud Rate Setting Range   | Input Clock Frequency   | Relationship Between Baud Rate and Input Clock Frequency |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 2.4 to 15.0 Gbaud* <sup>1, *2, *3</sup>   | 2.4 GHz to 15.0 GHz   | Operate at 1/1 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 15.0 to 30.0 Gbaud* <sup>1, *2, *3</sup>  | 7.5 GHz to 15.0 GHz   | Operate at 1/2 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 25.0 to 32.1 Gbaud* <sup>1, *2, *3</sup>  | 6.25 GHz to 8.025 GHz   | Operate at 1/4 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| Baud Rate Setting Range   | Input Clock Frequency   | Relationship Between Baud Rate and Input Clock Frequency |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 2.4 to 30.0 Gbaud* <sup>1, *2, *3</sup>   | 1.2 GHz to 15.0 GHz   | Operate at 1/2 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 30.0 to 32.1 Gbaud* <sup>1</sup>  | 7.5 GHz to 8.025 GHz  | Operate at 1/4 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 30.0 to 58.2 Gbaud* <sup>2</sup>  | 7.5 GHz to 14.55 GHz  | Operate at 1/4 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 30.0 to 60.0 Gbaud* <sup>3</sup>  | 7.5 GHz to 15.0 GHz   | Operate at 1/4 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |
| 60.0 to 64.2 Gbaud* <sup>3</sup>  | 7.5 GHz to 8.025 GHz  | Operate at 1/8 clock                                     |                       |  |  |                      |                      |   |                        |                      |  |                       |                      |                         |                       |  |   |                      |                      |                                  |                       |                      |                                      |                       |                      |                                  |                        |                      |                                  |                        |                       |                                  |                       |                      |                                  |                       |                      |

\*1: When the Option 001 is installed.

\*2: When the Option 002 or 112 is installed.

\*3: When the Option 003, 113, or 123 is installed.

\*4: Offset setting range depends on the bit rate. The range is -1000 to 0 ppm at the following bit rate.

Full Rate: 12.500 000 Gbaud, 25.000 000 Gbaud

Half Rate, Quarter Rate: 25.000 000 Gbaud, 50.000 000 Gbaud



# PAM4 PPG MU196020A Specifications

## External Clock Input

|                       |   |
|-----------------------|---|
| Number of Input       | 1 (Single-end)                          |
| Input Frequency Range | 1.2 GHz to 16.05 GHz                    |
| Input Amplitude       | 0.3 Vp-p to 1.0 Vp-p (-6.5 to +4.0 dBm) |
| Termination           | 50Ω, AC Coupling                        |
| Connector             | SMA (f)                                 |

## Aux Input

|                     |   |
|---------------------|---|
| Number of Input     | 1 (Single-end)  |
| Variation           | Error Injection, Burst  |
| Minimum Pulse Width | 1/256 of data rate  |
| Input level         | <ul style="list-style-type: none"> <li>• 0/-1V (H: -0.25 V to 0.05 V, L: -1.1 V to -0.8 V)</li> <li>• 0/-0.5 V (H: -0.05 V to 0.05 V, L: -0.55 V to -0.45 V)</li> <li>• Vth 0 V (Input amplitude: 0.5 Vp-p to 1.0 Vp-p)</li> </ul> Select one of the above. |
| Termination         | GND, 50Ω  |
| Connector           | SMA (f)   |

## Aux Output

|                     |  |
|---------------------|--|
| Number of Output    | 2 (Differential)   |
| Output Control      | ON/OFF switching   |
| Variation           | 1/n Clock (n = 8, 12, 16, 20 ... 1020, 1024), Pattern Sync, Burst Out2   |
| Pattern Sync        | PRBS, PRGM<br>Position: 1 to {(Least common multiple of Pattern Length' and 256) -263}, in 8 steps<br>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 | 0 to (Burst Cycle - 256) bits, 8 bits step   |
| Pulse Width         | 16 bits to (Burst Cycle - 256) bits, 8 bits step   |
| Output Level        | 0/-0.6 V (H: -0.25 V to 0.05 V, L: -0.80 V to -0.45 V)   |
| Termination         | GND, 50Ω   |
| Connector           | SMA (f)  |

## Gating Output

|                           |   |
|---------------------------|---|
| Number of Output          | 1 (Single-end)  |
| 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 bits to (Burst Cycle - 256) bits, 8 bits step  |
| Output Level              | 0/-1 V (H: -0.25 V to 0.05 V, L: -1.25 V to -0.8 V) *   |
| Repeat                    | Timing Signal Output  |
| Timing Signal Cycle       | $\text{INT} \left( \frac{\text{Pattern length}}{\text{length}} \right) \times 256$  |
| Timing Signal Delay       | 0 to {(Least common multiple of Pattern Length' and 256) -256}<br>The maximum settable number is 68 719 476 480, in 8- bit steps.<br>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}<br>The maximum settable number is 68 719 476 480, in 8- bit steps.<br>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 V to 0.05 V, L: -1.25 V to -0.8 V) *   |
| Termination               | GND, 50Ω  |
| Connector                 | SMA (f)   |

\*: L: Output Enable, H: Output Disable

# PAM4 PPG MU196020A Specifications

## Generated Pattern\*

|                                 |   |
|---------------------------------|---|
| PRBS                            |   |
| Pattern Length                  | $2^n - 1$ (n = 7, 9, 10, 11, 13, 15, 20, 23, 31)  |
| Mark Ratio                      | 1/2 (1/2INV is supported by a logical inversion.)   |
| PRBS Generator Polynomial       | n = 7: $1 + X^6 + X^7$<br>n = 9: $1 + X^5 + X^9$<br>n = 10: $1 + X^7 + X^{10}$<br>n = 11: $1 + X^9 + X^{11}$<br>n = 13: $1 + X + X^2 + X^{12} + X^{13}$<br>n = 15: $1 + X^{14} + X^{15}$<br>n = 20: $1 + X^3 + X^{20}$<br>n = 23: $1 + X^{18} + X^{23}$<br>n = 31: $1 + X^{28} + X^{31}$  |
| PRBS Inversion                  | This is available in PAM4 mode only.<br>Logical inversion of 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.   |
| Length of Consecutive Zero Bits | 1 bits to (Pattern Length - 1) bits<br>If the bit coming after Zero-substitution is "0", then it is replaced with "1".  |
| Data                            |   |
| Data Length                     | NRZ: 2 bits to 268 435 456 bits, 1 bit step<br>PAM4: 2 to 268 435 456 symbols, 1 symbol step  |
| Bit Shift                       | This is available in PAM4 mode only.<br>Bit shift of MSBs can be controlled in the range of $\pm 256$ bits (in 1-bit steps).  |
| PAM4 Standard Pattern           | Standard-compliant PAM4-mode patterns   |
| CEI                             | QPRBS13-CEI, QPRBS31-CEI  |
| IEEE                            | IEEE802.3bs/cd: PRBS13Q, PRBS31Q, SSPRQ, Square Wave<br>IEEE802.3bj: QPRBS13, JP03A, JP03B, Transmitter Linearity   |
| RS-FEC (Option 042)             | RS-FEC Scrambled Idle 50G 1 Lane (26.5625 Gbaud, 50GBASE-KR/CR/SR/FR/LR)<br>RS-FEC Scrambled Idle 100G 1 Lane (53.125 Gbaud, 100GBASE-DR/KR1/CR1)<br>RS-FEC-Int Scrambled Idle 100G 1 Lane (53.125 Gbaud, 100GBASE-P)<br>RS-FEC Scrambled Idle 100G 2 Lanes (26.5625 Gbaud, 100GBASE-KR2/CR2/SR2)<br>RS-FEC Scrambled Idle 200G 4 Lanes (26.5625 Gbaud, 200GBASE-SR4/DR4/FR4/LR4)<br>RS-FEC Scrambled Idle 200G 2 Lanes (53.125 Gbaud, 200GBASE-KR2/CR2)<br>RS-FEC Scrambled Idle 400G 4 Lanes (53.125 Gbaud, 400GBASE-DR4/KR4/CR4)<br>RS-FEC Scrambled Idle 400G 8 Lanes (26.5625 Gbaud, 400GBASE-FR8/LR8) |
| InfiniBand                      | PRBS13Q (InfiniBand), PRBS23Q, PRBS31Q (InfiniBand)   |
| Fibre Channel                   | PRBS31Q (Fibre Channel)   |
| NRZ Standard Pattern            | Standard-compliant NRZ-mode pattern   |
| CEI                             | SSPR  |
| RS-FEC (Option 042)             | RS-FEC Scrambled Idle 25G 1 Lane (25.78125 Gbaud, 25GBASE-KR/CR/SR/LR/ER)<br>RS-FEC Scrambled Idle 50G 2 Lanes RS (544, 514) (26.5625 Gbaud, 50GAUI-2)<br>RS-FEC Scrambled Idle 100G 4 Lanes (25.78125 Gbaud, 100GBASE-KR4/CR4/SR4)<br>RS-FEC Scrambled Idle 100G 4 Lanes RS (544, 514) (26.5625 Gbaud, 100GBASE-KP4)   |

\*: Since the output circuit is DC-terminated using the AC-coupled Bias Tee method, the same symbol pattern has a 50% change in output level over a continuous period of about 5  $\mu$ s.

## Pattern Sequence

|               |  |
|---------------|--|
| 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: 12800 bits to 2 147 483 136 bits, 256 bits step<br>Ext Trigger/Enable: 12800 bits to 2 147 483 648 bits, 256 bits step |
| Burst Cycle   | 25600 bits to 2 147 483 648 bits, 1024 bits step   |

# PAM4 PPG MU196020A Specifications

## Coding

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

\*: Generator polynomial compliant with the IEEE802.3

## Error Addition

|                                  |  |
|----------------------------------|--|
| Type                             | Bit, Error on MSB, Error on LSB, Error on LSB&MSB, RS-FEC Symbol Error (Option 042)  |
| Bit                              | This is available only when Coding is NRZ.   |
| Burst Error                      | 1 bits to 256 bits   |
| 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 is 3.0E-3   |
| Error Route                      | Select 1 to 32, Scan   |
| Error on MSB                     | Adds the specified symbol error.<br>This is available only when Coding is PAM4.<br>The set error is added to MSB only.   |
| Burst Error                      | 1 symbols to 256 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 Rate                | *E - n (*= 1 to 9, n = 3 to 12), Upper limit is 3.0E-3   |
| Error on LSB                     | Adds the specified symbol error.<br>This is available only when Coding is PAM4.<br>The set error is added to LSB only.   |
| Burst Error                      | 1 symbols to 256 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 Rate                | *E - n (*= 1 to 9, n = 3 to 12), Upper limit is 3.0E-3   |
| Error on LSB & MSB               | Adds the specified symbol error.<br>This is available only when Coding is PAM4.<br>An error is inserted to make the PAM4 signal change by one level only.  |
| Burst Error                      | 1 symbols to 256 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 Rate                | *E - n (*= 1 to 9, n = 3 to 12), Upper limit is 3.0E-3   |
| Error Addition Method            | Type1:<br>Level 0 → Level 1, Level 1 → Level 2, Level 2 → Level 3, Level 3 → Level 2<br>Type2:<br>Level 0 → Level 1, Level 1 → Level 2, Level 2 → Level 1, Level 3 → Level 2<br>Type3:<br>Level 0 → Level 1, Level 1 → Level 0, Level 2 → Level 1, Level 3 → Level 2 |
| RS-FEC Symbol Error (Option 042) | Inserts error to change only one PAM4 signal level<br>NRZ: Inserts error at 10-bit gap<br>PAM4: Inserts error at 10 PAM4 Symbol or 20 PAM4 Symbol gap  |
| Control Method                   | Internal, External-Trigger (Rising edge trigger), External-Disable (L: Disable)  |
| Addition Method                  | Repeat, Single, (Can select Variation at Source External-Trigger)  |
| Symbol Error per Code Word       | 1 to 20  |
| Symbol Error Rate                | *E - n (*= 1 to 9, n = 3 to 12), Upper limit is 3.0E-3<br>Error addition range changes with number of Symbol Errors per Code Word  |
| Error Addition Method (PAM4)     | Type1:<br>Level 0 → Level 1, Level 1 → Level 2, Level 2 → Level 3, Level 3 → Level 2<br>Type2:<br>Level 0 → Level 1, Level 1 → Level 2, Level 2 → Level 1, Level 3 → Level 2<br>Type3:<br>Level 0 → Level 1, Level 1 → Level 0, Level 2 → Level 1, Level 3 → Level 2 |

# PAM4 PPG MU196020A Specifications

## Data Output\*<sup>1</sup>

|  |  |
|--|--|
| Number of Outputs  | 2 (Data, XData) Non independent variable   |
| Waveform   | NRZ, PAM4  |
| NRZ Eye Amplitude  |  |
| Setting Range  | NRZ: 70 mVp-p to 800 mVp-p, 2 mV step (Single-end)   |
| Accuracy   | When using the J1789A: $\pm 35$ mV $\pm 12\%$ (Single-end) * <sup>2</sup><br>When using the J1790A: $\pm 35$ mV $\pm 12\%$ (Single-end) * <sup>3, *4, *5</sup>   |
| PAM4 Eye Amplitude                                       |  |
| PAM4 (0/3 Level) Setting Range                           | PAM4 (0/3 Level): 70 mVp-p to 800 mVp-p, 1 mV step (Single-end) * <sup>6</sup>   |
| PAM4 (0/3 Level) Accuracy                                | When using the J1789A: $\pm 35$ mV $\pm 12\%$ of Amplitude* <sup>2, *7</sup><br>When using the J1790A: $\pm 35$ mV $\pm 12\%$ of Amplitude* <sup>3, *4, *5, *7</sup>   |
| PAM4 (0/1, 1/2, 2/3 Level) Independent variable function | Provided, 20 to 50%, 1 mV Step (Eye amplitude conversion)<br>(PAM4 Amplitude 0/3 level is assumed to be 100%)  |
| PAM4 (0/1, 1/2, 2/3 Level) Setting Range                 | PAM4 (0/1 Level): 23 mVp-p to 266 mVp-p, 1 mV step (Single-end)<br>PAM4 (1/2 Level): 24 mVp-p to 268 mVp-p, 1 mV step (Single-end)<br>PAM4 (2/3 Level): 23 mVp-p to 266 mVp-p, 1 mV step (Single-end)  |
| PAM4 (0/1, 1/2, 2/3 Level) Accuracy                      | When using the J1789A: $\pm 35$ mV $\pm 12\%$ of Amplitude* <sup>8</sup><br>When using the J1790A: $\pm 35$ mV $\pm 12\%$ of Amplitude* <sup>9, *10, *11</sup>   |
| Offset   |  |
| Setting Range  | -2.0-Eye Amplitude/2 to +3.3-Eye Amplitude/2 Vth, 1 mV step (Single-end)   |
| Accuracy   | $\pm 65$ mV $\pm 10\%$ of offset (Vth) $\pm$ (Eye Amplitude Accuracy/2)<br>(Except when Emphasis is turned On with the MU196020A-x11 installed.)<br>(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:<br>Typ. 8.5 ps (20 to 80%)* <sup>12</sup><br>Typ. 9 ps (20 to 80%)* <sup>13</sup><br>When using the J1790A:<br>Typ. 8.8 ps (20 to 80%)* <sup>12</sup><br>Typ. 9.5 ps (20 to 80%)* <sup>13</sup>   |
| Half Period Jitter                                       |  |
| Setting Range  | -20 to 20, 1step   |
| Accuracy   | Typ. $\pm 0.04$ UI* <sup>14</sup>  |
| Jitter   |  |
| Measurement conditions                                   | NRZ,<br>Bit rate: 32.1 Gbit/s (When the Option 001 is installed)<br>58.2 Gbit/s (When the Options 002 and 112 are installed)<br>64.2 Gbit/s (When the Options 003, 113 and 123 are installed)<br>Eye Amplitude 0.5 Vp-p (Single-end)<br>At a constant temperature between 20°C and 30°C, measure with a 70-GHz bandwidth sampling oscilloscope with residual jitter of less than 200 fs rms. |
| Peak-to-Peak Jitter                                      | Typ. 6 ps p-p (Count of measured jitters: 30)  |
| Jitter RMS   | Typ. 600 fs rms (Count of measured jitters: 30)  |
| Intrinsic RJ (RMS)                                       | Typ. 170 fs (Repeating pattern of 1,0) * <sup>15</sup>   |
| Waveform Distortion (0-peak)                             | Typ. $\pm 110$ mV* <sup>16</sup>   |
| PAM4 Level Separation Mismatch Ratio (R <sub>LM</sub> )  | 0.95 (min.) * <sup>17</sup>  |
| PAM4 Signal to noise and distortion ratio (SNDR)         | 33 dB (min.) * <sup>18, *19</sup>  |
| Electrical TDECQ   | 0.9 dB* <sup>20</sup>  |
| Output ON/OFF  | ON/OFF switching available   |
| Data/XData Skew  | $\pm 1$ ps<br>Cable error not included.  |
| Termination  | AC, DC switching<br>For DC: GND, -2V, +1.3V, +3.3V, Open (LVDS), 50Ω   |
| Connector  | V (f)  |
| Offset Reference   | Vth  |
| Level Guard  | Amplitude, Voh and Vol can be set.   |
| External ATT Factor                                      | -40 to 0 dB, 0.1 dB step<br>When the fixed attenuator is connected, the amplitude and offset of the signal output via the fixed attenuator are displayed.  |

\*1: Unless otherwise specified, these are specified with the conditions of PRBS2<sup>31</sup> - 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  $\leq 700$  mVp-p

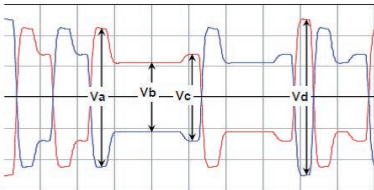
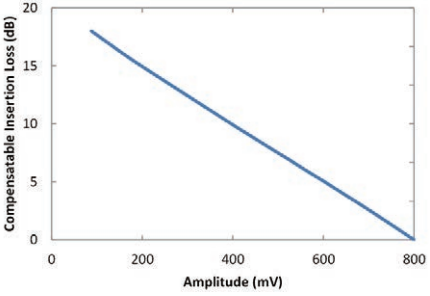
\*3: Setting Range  $\leq 700$  mVp-p ( $\leq 32.1$  Gbit/s, when the Options 001, 002, 112, 003, 113 and 123 are installed)

\*4: Setting Range  $\leq 600$  mVp-p ( $\leq 58.2$  Gbit/s, when the Options 002, 112, 003, 113 and 123 are installed)

# PAM4 PPG MU196020A Specifications

- \*5: Setting Range  $\leq 550$  mVp-p ( $\leq 64.2$  Gbit/s, when the Options 003, 113 and 123 are installed)
- \*6: When inputting the PAM4 output signal directly to the ED, the lower amplitude limit that makes it free from errors depends on the performance of the ED used. When using MP1862A as ED, the lower amplitude limits (reference data) that make the data to be free from any errors are as follows:  
 125 mV (0/3 Level,  $\leq 32.1$  Gbaud, when the Option 001 is installed)  
 250 mV (0/3 Level,  $\leq 58.2$  Gbaud, when the Options 002, 112, 003, 113 and 123 are installed)  
 Pattern: PRBS15, at a constant temperature between 20°C and 30°C
- \*7: Single-end, PAM4 0/3 Level, and when setting each of PAM4 Amplitude (3/2, 2/1 and 1/0) equally to 33%
- \*8: Setting Range  $\leq 234$  mVp-p, Single-end, at each amplitude level (Upper, Middle, Lower)
- \*9: Setting Range  $\leq 234$  mVp-p, Single-end, at each amplitude level (Upper, Middle, Lower) ( $\leq 32.1$  Gbit/s, when the Options 001, 002, 112, 003, 113 and 123 are installed)
- \*10: Setting Range  $\leq 200$  mVp-p, Single-end, at each amplitude level (Upper, Middle, Lower) ( $\leq 58.2$  Gbit/s, when the Options 002, 112, 003, 113 and 123 are installed)
- \*11: Setting Range  $\leq 184$  mVp-p, Single-end, at each amplitude level (Upper, Middle, Lower), when using the J1790A coaxial cable (0.8m) ( $\leq 64.2$  Gbit/s, when the Options 003, 113 and 123 are installed)
- \*12: NRZ, 58.2 Gbit/s (when the Options 002 and 112 are installed), 64.2 Gbit/s (when the Options 003, 113 and 123 are installed), Eye Amplitude 0.5 Vp-p (Single-end), only when Coding is NRZ and Emphasis is Off.
- \*13: NRZ, 32.1 Gbit/s, Eye Amplitude 0.5 Vp-p (Single-end), only when Coding is NRZ and Emphasis is Off.
- \*14: 2.4, 8, 16, 26.5625, 32.1 Gbit/s (When the Option 001 is installed), 2.4, 8, 16, 26.5625, 32.1, 40, 53.125, 58.2 Gbit/s (When the Options 002 and 112 are installed) 2.4, 8, 16, 26.5625, 32.1, 40, 53.125, 58.2, 64.2 Gbit/s (When the Options 003, 113 and 123 are installed), Eye Amplitude 0.5 Vp-p (Single-end)
- \*15: NRZ, Bit rate 58.2 Gbit/s (When the Options 002 and 112 are installed), 64.2 Gbit/s (When the Options 003, 113 and 123 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 112 are installed), 64.2 Gbit/s (When the Options 003, 113 and 123 are installed)  
 Eye Amplitude 0.5 Vp-p (Single-end)
- \*17: PAM4, 26.5625 Gbaud (When the Option 001 is installed), 53.125 Gbaud (When the Options 002, 112, 003, 113 and 123 are installed), 1.0 Vp-p (Differential), refer to the IEEE P802.3bs for equation to calculate.
- \*18: PAM4, 26.5625 Gbaud (When the Option 001 is installed), 53.125 Gbaud (When the Options 002, 112, 003, 113 and 123 are installed), 1.0 Vp-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, 112, 003, 113 and 123 are installed), Using an equalizer, Single, Pattern: SSPRQ

## Emphasis (Option 011)

|  |  |
|--|--|
| Emphasis Tap                           | 4 (1post-cursor, 2pre-cursor)<br>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.   |
| Cursor Setting Range/Step              | -20 to +20 dB, 0.1 dB step<br>(Post-Cursor: $20\log_{10}V_a/V_b$ , Pre-Cursor: $20\log_{10}V_c/V_b$ )<br>   |
| Accuracy                               | Typ. $\pm 1$ dB<br>(16 Gbaud, Amplitude 0.5 Vp-p (Single-end), De-Emphasis, Pre-Cursor1 = 6 dB, Post Cursor1 = 3.5 dB)   |
| Setting Range of Emphasis Peak Voltage | 70 mVp-p to 800 mVp-p (Single-end)   |
| Channel Emulator (Option 040)          | Normal: Outputs signal simulating transmission path equivalent to loaded S-Parameter file at PPG Data Output<br>Inverse: Outputs signal with set De-Emphasis for correcting loss of transmission path equivalent to loaded S-Parameter file at PPG Data Output<br><br>The following graph shows the maximum transmission path loss correction using the Channel Emulator function without reducing amplitude.<br> |
| S-Parameter File                       | S2P File (*.s2p file extension),<br>S4P File (*.s4p file extension)<br>Supports files output by Vector Network Analyzer MS4640B series   |
| Response                               | Normal, Inverse  |
| Gain Adjust                            | At Normal, matches loaded S-Parameter file loss with emulated loss for 0 GHz or 1 GHz or Nyquist Frequency   |

# PAM4 PPG MU196020A Specifications

|                             |  |
|-----------------------------|--|
| Adjustable ISI (Option 040) | Sets ISI generation channel loss and outputs emulated waveform at PPG Data output signal (output waveform amplitude normalized as set amplitude)<br>Used in combination with channel board, such as J1800A/J1758A (optional accessories), or Noise Module MU195050A  |
| Insertion Loss Setting      | Sets relative loss from Loss Channel for Nyquist and 1/2 Nyquist Frequency<br>-8.00 to 8.00 dB, 0.01-dB step @ Nyquist Frequency<br>-8.00 to 8.00 dB, 0.01-dB step @ 1/2 Nyquist Frequency   |
| Insertion Loss Accuracy     | ±1.0 dB Nominal @ Nyquist Frequency 6 dB, 26.6 GBaud 1,0 repetition pattern<br>±1.5 dB Nominal @ Nyquist Frequency 6 dB, 53.1 GBaud 1,0 repetition pattern<br>±1.0 dB Nominal @ 1/2Nyquist Frequency 3 dB, 26.6 GBaud 1,1,0,0 repetition pattern<br>±1.5 dB Nominal @ 1/2Nyquist Frequency 3 dB, 53.1 GBaud 1,1,0,0 repetition pattern<br>Each specified at Eye Amplitude = 0.5 Vp-p, and constant temperature of 20°C to 30°C<br>The Insertion Loss characteristics are as follows (ISI Nominal Data) when set Nyquist Frequency = 6 dB and 1/2 Nyquist Frequency = 3 dB. |
|                             |  |
| Emulator On/Off             | Can synthesize any of Channel Emulator, Adjustable ISI, and Emphasis Tap   |

## Clock Output

These values are monitored using an applicable part (Coaxial Cable J1439A, 0.8 m, K connector) at a sampling oscilloscope bandwidth of 70 GHz.

|                  |  |
|------------------|--|
| Frequency        |  |
| Full Rate        | Operation Baud Rate = Clock Output Frequency<br>2.4 GHz to 32.1 GHz (Option 001)   |
| Half Rate        | Operation Baud Rate = (Clock Output Frequency) × 2<br>1.2 GHz to 16.05 GHz (Option 001)<br>1.2 GHz to 29.1 GHz (When the Options 002 and 112 are installed)<br>1.2 GHz to 32.1 GHz (When the Options 003, 113 and 123 are installed)   |
| Quarter Rate     | Operation Baud Rate = (Clock Output Frequency) × 4<br>0.6 GHz to 8.025 GHz (Option 001)<br>0.6 GHz to 14.55 GHz (When the Options 002 and 112 are installed)<br>0.6 GHz to 16.05 GHz (When the Options 003, 113 and 123 are installed) |
| Number of Output | 1  |
| Amplitude        | Min. 0.3 Vp-p Max. 1.0 Vp-p (Output Frequency ≤ 16.05 GHz)<br>Min. 0.4 Vp-p Max. 1.0 Vp-p (Output Frequency > 16.05 GHz)   |
| Output Control   | ON, OFF switching  |
| Termination      | 50Ω, AC Coupling   |
| Connector        | K (f)  |

## Data Delay

When Option x30 is added.

|                       |  |
|-----------------------|--|
| Phase Variable Range  | -1000 mUI to +1000 mUI, 2 mUI step   |
| Accuracy              | Typ. ±50 mUIp-p*1, *2<br>Typ. ±100 mUIp-p*1, *3  |
| 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 occur:<br>• 1/1 Clock frequency change by ±250 kHz.<br>• Ambient temperature change by ±5 degree. |

\*1: Measured with a sampling oscilloscope with residual jitter of less than 200 fs rms, at a constant amplitude setting.

\*2: Baud rate ≤ 32.1 Gbaud

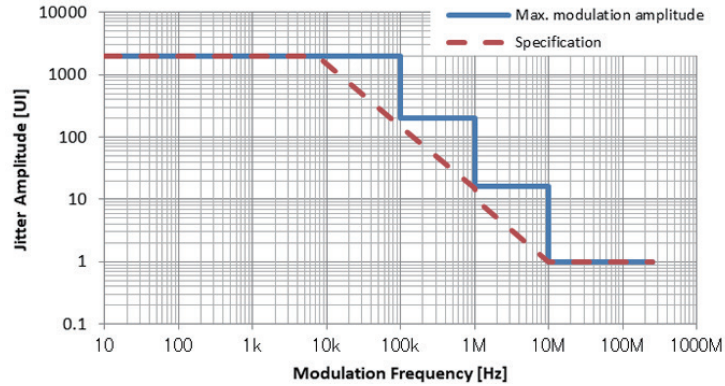
\*3: Baud rate > 32.1 Gbaud

# PAM4 PPG MU196020A Specifications

## Jitter tolerance

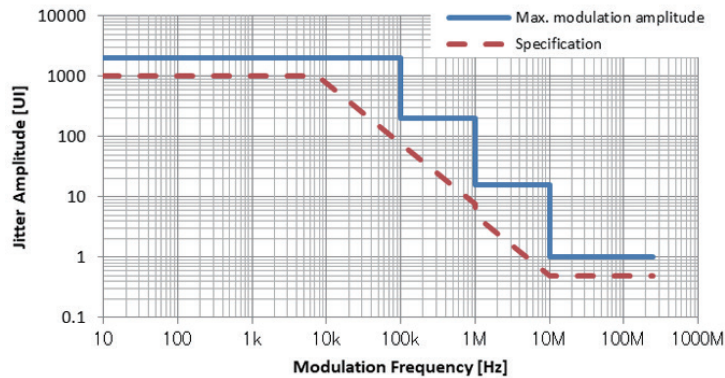
### Jitter Tolerance Mask

For NRZ output,  
 Bit rate: 32.1 Gbit/s (Option 001)  
 58.2 Gbit/s (When the Options 002 and 112 are installed)  
 64.2 Gbit/s (When the Options 003, 113 and 123 are installed)  
 Pattern: PRBS2<sup>31</sup>-1  
 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, 64.1 Gbit/s), at a constant temperature between 20°C and 30°C.  
 When RJ + BUJ is bigger than 0.5 Ulp-p or SJ1 + Built-in SJ2 + RJ + BUJ is bigger than the standard value + 0.3 Ulp-p, "Overload" is displayed on the MU181500B screen.



| 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                     |

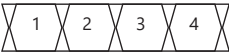
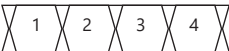
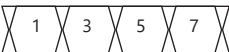
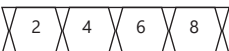
58.2 Gbit/s, 64.2 Gbit/s



| 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                   |

# PAM4 PPG MU196020A Specifications

## Multichannel Operation (Option 030 or 050)

|  |  |
|--|--|
| Shared Conditions  | <p>Option 001/002/003 can operate between same modules<br/>           Operation requires both -030 and -050 options.<br/> <math>\leq 32.1</math> GBaud: Aligns bit generation timing with <math>&lt;1</math> UI accuracy*<br/> <math>&gt; 32.1</math> GBaud: Aligns bit generation timing with <math>&lt;5</math> UI accuracy*<br/>           * The bit generation timing is assured when the change in ambient temperature from that at Multi-Calibration is within <math>\pm 3^\circ\text{C}</math>.</p>   |
| Channel Sync between Modules<br>(Installed in Slot 1 to 4 tracking Slot 1) | <p>Generates signal with bit timing aligned between modules</p> <p>Slot 1<br/>           Data </p> <p>Slot 2, 3, 4<br/>           Data </p> <p>CH Sync Image</p>   |
| 2ch Combination between Modules<br>(Only NRZ, Installed in Slot 1 and 2)   | <p>Generates signal with bit timing aligned between modules and bit pattern interleaved between modules</p> <p>Slot1<br/>           Data </p> <p>Slot2<br/>           Data </p> <p>CH Combination Image</p> <p>Phase Setting: <math>-64,000</math> mUI to <math>+64,000</math> mUI, 2-mUI steps (independently for each channel)<br/>           Pattern Length: 4 to 536,870,912 bits, 2-bit steps</p> |

## General

|                       |  |
|-----------------------|--|
| Dimensions and Mass   | 234 (W) × 21 (H) × 175 (D) mm (Protrusions excluded), 2.5 kg max.  |
| Operating Temperature | $+15^\circ\text{C}$ to $+35^\circ\text{C}$<br>MP1900A's ambient temperature. MU196040A shall operate when installed. |
| Storage Temperature   | $-20^\circ\text{C}$ to $+60^\circ\text{C}$<br>MU196040A installed to MP1900A shall comply with MIL-T-28800E Class 5. |



# PAM4 ED MU196040B Specifications

## Operating Baud Rate

|                     |  |
|---------------------|--|
| Operating Baud Rate | <p>When the Option 001 is installed.</p> <p>PAM4 input: 2.4 Gbaud to 32.1 Gbaud<br/>NRZ input: 2.4 Gbit/s to 32.1 Gbit/s</p> <p>When the Option 002 or 112 is installed.</p> <p>PAM4 input: 2.4 Gbaud to 58.2 Gbaud<br/>NRZ input: 2.4 Gbit/s to 64.2 Gbit/s</p> |
|---------------------|--|

## System Clock

|              |  |
|--------------|--|
| System Clock | <p>External, Recovered Clock (When the Option x21, x22, x23, or x24 is installed)</p> <p>External: Clock input from the Ext Clock Input connector<br/>For PAM4, select from 2.4 Gbaud to 32.1 Gbaud, 32.1 Gbaud to 58.2 Gbaud and Auto.<br/>For NRZ, select from 2.4 Gbit/s to 32.1 Gbit/s, 32.1 Gbit/s to 64.2 Gbit/s and Auto.</p> <p>Recovered Clock: Clock recovered from the data input from the Data Input connector</p> |
|--------------|--|

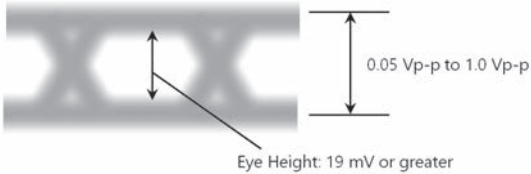
## Data Input

|                     |  |
|---------------------|--|
| Number of Inputs    | 2 (Data, XData) (Differential)   |
| Input Condition     | <p>Single-end, Differential 50Ω, Differential 100Ω</p> <p>When set to Differential 50Ω or Differential 100Ω:<br/>Independent, Tracking, Alternate*1</p> <p>When set to Alternate: Data-XData, XData-Data*2</p> <p>When set to Single-end: Data, XData*3</p>  |
| Signal Type         | NRZ, PAM4  |
| LSB/MSB Diagnostics | <p>When set to PAM4, the PAM4 mode can be switched between as follows:</p> <p>Diagnostics Mode OFF:<br/>Treats signals as symbols by receiving LSB and MSB while synchronizing them with each other.</p> <p>Diagnostics Mode ON:<br/>Asynchronously receives LSB and MSB.</p>  |
| Input Amplitude     | <p>NRZ: The range in which the Auto Adjust function and the Auto Search function operate.</p> <p>0.05 Vp-p to 1.0 Vp-p*4, *5<br/>0.1 Vp-p to 1.0 Vp-p*4, *6</p> <p>PAM4: The range in which the Auto Search PAM4 Fine function operates.</p> <p>0.3 Vp-p to 1.0 Vp-p*7, *8<br/>0.4 Vp-p to 1.0 Vp-p*7, *9</p>  |
| Threshold Voltage   | <p>NRZ, PAM4 Middle Eye Threshold: -3.5 V to +3.3 V, 1 mV step*2, *10</p> <p>PAM4 Upper Eye Threshold: -3.9 V to +3.7 V, 1 mV step*11</p> <p>PAM4 Lower Eye Threshold: -3.9 V to +3.7 V, 1 mV step*11</p>  |
| Input Sensitivity   | <p>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,<br/>Error free at a constant temperature between 20°C and 30°C</p>  |
| Eye Amplitude       | <p>NRZ</p> <p>Typ. 25 mVp-p, ≤50 mVp-p*12 (26.5625 Gbit/s, 32.1 Gbit/s)<br/>Typ. 31 mVp-p, ≤55 mVp-p*13 (53.125 Gbit/s)<br/>Typ. 43 mVp-p, ≤60 mVp-p*13 (64.2 Gbit/s)</p>  |
| Eye Height          | <p>NRZ</p> <p>Typ. 19 mV*12 (26.5625 Gbit/s, 32.1 Gbit/s)<br/>Typ. 21 mV*13 (53.125 Gbit/s)<br/>Typ. 32 mV*13 (64.2 Gbit/s)</p> <p>PAM4</p> <p>0/1 1/2 2/3 Level, PRBS31, when using External Clock<br/>Typ. 23 mV, ≤50 mV*12 (26.5625 Gbaud, 32.1 Gbaud)<br/>Typ. 36 mV, ≤60 mV*13 (53.125 Gbaud)<br/>Typ. 49 mV, ≤70 mV*13 (58.2 Gbaud)</p> <p>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.</p> |
| Phase Margin        | <p>Differential, Mark Ratio 1/2, PRBS31, when inputting 0.5 Vp-p, when connecting directly to the MU196020A using J1789A and an attenuator.<br/>Error free at a constant temperature between 20°C and 30°C, when using External Clock</p> <p>NRZ*14</p> <p>Typ. 25.8 ps*12 (26.5625 Gbit/s)<br/>Typ. 18.0 ps*12 (32.1 Gbit/s)<br/>Typ. 10.5 ps*13 (53.125 Gbit/s)<br/>Typ. 8.7 ps*13 (64.2 Gbit/s)</p> <p>PAM4</p> <p>Typ. 5.3 ps*12 (26.5625 Gbaud)<br/>Typ. 4.5 ps*12 (32.1 Gbaud)<br/>Typ. 4.1 ps*13,*14 (53.125 Gbaud)<br/>Typ. 2.5 ps*13,*14 (58.2 Gbaud)</p>   |
| Stressed Margin     |  |
| Stressed Eye Height | <p>PAM4 0/1 1/2 2/3 Level, QPRBS13-CEI, Eye Height where BER is 1E-06, when using External Clock</p> <p>≥32 mV*15,*16<br/>≥37 mV*17,*18</p>  |
| Stressed Eye Width  | <p>PAM4 0/1 1/2 2/3 Level, QPRBS13-CEI, Eye Width where BER is 1E-06, when using External Clock</p> <p>≥7.53 ps*15,*16<br/>≥3.76 ps*17,*18</p>   |

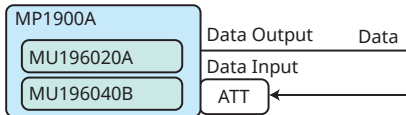
# PAM4 ED MU196040B Specifications

|                             |  |
|-----------------------------|--|
| Termination                 | 50Ω, GND, Variable   |
| Termination Voltage         | When set to Variable: -2.5 V to +3.5 V, 10 mV step                 |
| Connector                   | V connector (f)  |
| Decision Feedback Equalizer | With a built-in Decision Feedback Equalizer (DFE) <sup>*19</sup>   |
| Tap                         | 1  |
| Coefficient                 | Setting Range: 0 to 30, 1 step                                     |
| Loss Compensation           | Nom. 1.4 dB <sup>*20</sup>   |
| Low Frequency Equalizer     | With a built-in Low Frequency Equalizer <sup>*19</sup>             |
| Gain                        | Setting Range: -2.0 to 0 dB, 0.5 dB step<br>Accuracy: Typ. ±1.0 dB |
| Ideal Frequency Response    |  |

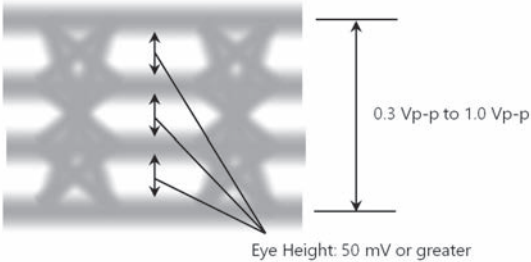
- \*1: Tracking is available only for NRZ.
- \*2: The absolute value of the difference between Data and XData Threshold values shall be 1.5 V or less.
- \*3: PAM4 Upper Eye and Lower Eye can be set by relative values to Middle Eye in the range of -0.4 V to +0.4 V.
- \*4: Single-Ended, Differential, Mark Ratio1/2, the Eye Height shall meet the specification. Example of waveform input to MU196040B when bit rate is 32.1 Gbit/s



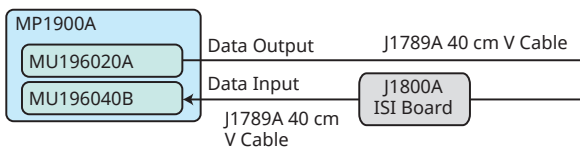
- \*5: Bit rate ≤32.1 Gbit/s
- \*6: Bit rate >32.1 Gbit/s
- \*7: 0/3 Level, PRBS31, Mark Ratio1/2, with connected to the MU196020A using an attenuator, with Emphasis adjusted so that the Eye Height meets the specification



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



- \*8: Single-Ended, Differential, Baud rate ≤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.
- \*12: When the Option 001, 002, or x12 is installed.
- \*13: When the Option 002 or x12 is installed.
- \*14: Value including RJ equivalent to BER 1E-12 of input signal
- \*15: 26.5625 Gbaud, when installed with the Option 001, 002 or x12 and the Option x11, BER 1E-12
- \*16: 26.5625 Gbaud, Differential, Mark Ratio1/2, when J1789A is used to connect J1800A (1 pc) and MU196020A



# PAM4 ED MU196040B Specifications

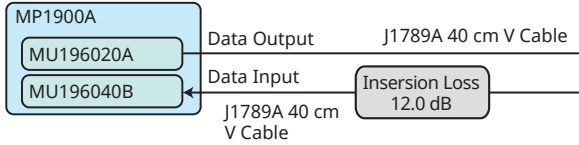
At a constant temperature between 20°C and 30°C, measure with a 70-GHz bandwidth sampling oscilloscope with residual jitter of less than 200 fs rms. Adjust De-Emphasis (2 Pre Cursors and 1 Post Cursor) of MU196020A so that the product of Eye Height (1E-06) and Eye Width (1E-06) can be maximized in the 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 RLM 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, x12 and x11 are installed, BER 1E-8 nom.

\*18: 53.125 Gbaud, Differential, Mark Ratio 1/2, when connecting a device with 12.0 dB insertion loss and MU196020A.



At a constant temperature between 20°C 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 RLM 0.85 or more.

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

\*19: When the Option x11 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.

## Clock Input

|                  |  |
|------------------|--|
| Number of Inputs | 1 (Single-end)   |
| Frequency Range  | 1.2 GHz to 32.1 GHz  |
| Amplitude        | 0.3 Vp-p to 1.0 Vp-p (-6.5 to +4.0 dBm) (Input Frequency ≤ 16.05 GHz)<br>0.4 Vp-p to 1.0 Vp-p (-3.9 to +4.0 dBm) (Input Frequency > 16.05 GHz) |
| Termination      | 50Ω, AC Coupling   |
| Connector        | K (f)  |

## Aux Input

|                     |  |
|---------------------|--|
| Number of Inputs    | 1 (Single-end)   |
| Variation           | External Mask, Burst, Capture External Trigger   |
| Minimum Pulse Width | 1/256 of Data rate   |
| Input Level         | • 0/-1 V (H: -0.25 V to 0.05 V, L: -1.1 V to -0.8 V)<br>• 0/-0.5 V (H: -0.05 V to 0.05 V, L: -0.55 V to -0.45 V)<br>• Vth 0 V (Input amplitude 0.5 Vp-p to 1.0 Vp-p)<br>Select one of the above. |
| Termination         | GND, 50Ω   |
| Connector           | SMA (f)  |

## Aux Output

|                   |   |
|-------------------|---|
| 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<br>Position: 1 to {(Least common multiple of Pattern Length' and 256) - 263}, 8 step<br>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 V to 0.05 V, L: -0.80 V to -0.45 V)  |
| Termination       | GND, 50Ω  |
| Connector         | SMA (f)   |

## Pattern Detection

|                           |   |
|---------------------------|---|
| PRBS                      |   |
| Pattern Length            | 2 <sup>n</sup> - 1 (n = 7, 9, 10, 11, 13, 15, 20, 23, 31)   |
| Mark Ratio                | 1/2, 1/2INV   |
| PRBS Generator Polynomial | n=7: 1 + X <sup>6</sup> + X <sup>7</sup><br>n=9: 1 + X <sup>5</sup> + X <sup>9</sup><br>n=10: 1 + X <sup>7</sup> + X <sup>10</sup><br>n=11: 1 + X <sup>9</sup> + X <sup>11</sup><br>n=13: 1 + X + X <sup>2</sup> + X <sup>12</sup> + X <sup>13</sup><br>n=15: 1 + X <sup>14</sup> + X <sup>15</sup><br>n=20: 1 + X <sup>3</sup> + X <sup>20</sup><br>n=23: 1 + X <sup>18</sup> + X <sup>23</sup><br>n=31: 1 + X <sup>28</sup> + X <sup>31</sup> |

## PAM4 ED MU196040B Specifications

|  |   |
|--|---|
| PRBS Inversion                             | This is available in PAM4 mode only.<br>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 bits to (Pattern Length – 1) bits<br>If the bit coming after Zero-substitution is "0," then it is replaced with "1."  |
| Data                                       |   |
| Data Length                                | NRZ: 2 bits to 268 435 456 bits, 1 bit step<br>PAM4: 2 to 268 435 456 symbols, 1 symbol step  |
| Coding                                     | NRZ, PAM4   |
| NRZ  | Normal, Invert  |
| PAM4 Gray Coding                           | ON, OFF   |
| PAM4 Precoding<br>( $1/(1 + D) \bmod 4$ )* | ON, OFF   |
| PAM4 Standard Pattern                      | Standard-compliant PAM4-mode patterns   |
| CEI  | QPRBS13-CEI, QPRBS31-CEI  |
| IEEE                                       | IEEE802.3bs/cd: PRBS13Q, PRBS31Q, SSPRQ, Square Wave<br>IEEE802.3bj: QPRBS13, JP03A, JP03B, Transmitter Linearity   |
| RS-FEC (Option 042)                        | RS-FEC Scrambled Idle 50G 1 Lane (26.5625 Gbaud, 50GBASE-KR/CR/SR/FR/LR)<br>RS-FEC Scrambled Idle 100G 1 Lane (53.125 Gbaud, 100GBASE-DR/KR1/CR1)<br>RS-FEC-Int Scrambled Idle 100G 1 Lane (53.125 Gbaud, 100GBASE-P)<br>RS-FEC Scrambled Idle 100G 2 Lanes (26.5625 Gbaud, 100GBASE-KR2/CR2/SR2)<br>RS-FEC Scrambled Idle 200G 4 Lanes (26.5625 Gbaud, 200GBASE-SR4/DR4/FR4/LR4)<br>RS-FEC Scrambled Idle 200G 2 Lanes (53.125 Gbaud, 200GBASE-KR2/CR2)<br>RS-FEC Scrambled Idle 400G 4 Lanes (53.125 Gbaud, 400GBASE-DR4/KR4/CR4)<br>RS-FEC Scrambled Idle 400G 8 Lanes (26.5625 Gbaud, 400GBASE-FR8/LR8) |
| InfiniBand                                 | PRBS13Q (InfiniBand), PRBS23Q, PRBS31Q (InfiniBand)   |
| Fibre Channel                              | PRBS31Q (Fibre Channel)   |
| NRZ Standard Pattern                       | Standard-compliant NRZ-mode pattern   |
| CEI  | SSPR  |
| RS-FEC (Option 042)                        | RS-FEC Scrambled Idle 25G 1 Lane (25.78125 Gbaud, 25GBASE-KR/CR/SR/LR/ER)<br>RS-FEC Scrambled Idle 50G 2 Lanes RS (544, 514) (26.5625 Gbaud, 50GAUI-2)<br>RS-FEC Scrambled Idle 100G 4 Lanes (25.78125 Gbaud, 100GBASE-KR4/CR4/SR4)<br>RS-FEC Scrambled Idle 100G 4 Lanes RS (544, 514) (26.5625 Gbaud, 100GBASE-KP4)   |

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

### Pattern Sequence

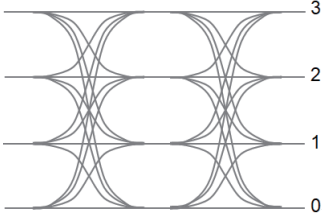
|               |   |
|---------------|---|
| Sequence      | Repeat, Burst   |
| Repeat        | Continuous Pattern  |
| Burst         | This is available only when Coding is NRZ.  |
| Source        | Internal, External-Trigger (Aux Input), External-Enable (Aux Input)   |
| Delay         | Internal: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

# PAM4 ED MU196040B Specifications

## Measurement

|         |   |
|---------|---|
| Counter | <p>Error Rate (ER) Total<br/> Error Count (EC) Total<br/> Error Interval<br/> %Error Free Interval<br/> Error Rate (ER) Insertion (INS)<br/> Error Count (EC) Insertion (INS)<br/> Error Rate (ER) Omission (OMI)<br/> Error Count (EC) Omission (OMI)<br/> Frequency: 2 400.000 MHz to 64 200.000 MHz<br/> Frequency measurement accuracy: <math>\pm 1</math> ppm <math>\pm 1</math> kHz*<br/> Clock Count<br/> Sync. Loss Interval<br/> Clock Loss Interval<br/> Expressions enclosed in parentheses are abbreviations.</p> <hr/> <p>The following are available when the Option x42 FEC Analysis is installed.<br/> Uncorrectable Codeword Error Rate (UCWER)<br/> Uncorrectable Codeword Error Count (UCWEC)<br/> Uncorrectable Codeword Error Interval<br/> Uncorrectable Codeword %Error Free Interval<br/> FEC Symbol Error Rate (ER)<br/> FEC Symbol Error Count (EC)<br/> FEC Symbol Error Interval<br/> FEC Symbol %Error Free Interval<br/> Total Codeword Count</p> <hr/> <p>The following are available only for PAM4 (Diagnostics Mode ON) measurement.<br/> MSB Error Rate (ER) Total<br/> MSB Error Count (EC) Total<br/> MSB Error Rate (ER) Insertion (INS)<br/> MSB Error Count (EC) Insertion (INS)<br/> MSB Error Rate (ER) Omission (OMI)<br/> MSB Error Count (EC) Omission (OMI)<br/> LSB Error Rate (ER) Total<br/> LSB Error Count (EC) Total<br/> LSB Error Rate (ER) Insertion (INS)<br/> LSB Error Count (EC) Insertion (INS)<br/> LSB Error Rate (ER) Omission (OMI)<br/> LSB Error Count (EC) Omission (OMI)<br/> Expressions enclosed in parentheses are abbreviations.</p> |
|---------|---|

# PAM4 ED MU196040B Specifications

|                           |   |
|---------------------------|---|
| Counter (Cont'd)          | <p>The following are available when the Option x41 SER Measurement is installed.<br/> The following are available only for PAM4 (Diagnostics Mode OFF) measurement.</p>  <p>Symbol Error Rate (SER)<br/> Symbol Error Count (SEC)<br/> Symbol Error Interval<br/> Symbol %Error Free Interval</p> <p>Details-Display1<br/> Level 0 → 3 EC, Level 1 → 3 EC<br/> Level 0 → 2 EC, Level 1 → 2 EC<br/> Level 0 → 1 EC, Level 1 → 0 EC<br/> Level 0 → 3 ER, Level 1 → 3 ER<br/> Level 0 → 2 ER, Level 1 → 2 ER<br/> Level 0 → 1 ER, Level 1 → 0 ER<br/> Level 0 EC Total, Level 1 EC Total<br/> Level 0 ER Total, Level 1 ER Total</p> <p>Level 2 → 3 EC, Level 3 → 2 EC<br/> Level 2 → 1 EC, Level 3 → 1 EC<br/> Level 2 → 0 EC, Level 3 → 0 EC<br/> Level 2 → 3 ER, Level 3 → 2 ER<br/> Level 2 → 1 ER, Level 3 → 1 ER<br/> Level 2 → 0 ER, Level 3 → 0 ER<br/> Level 2 EC Total, Level 3 EC Total<br/> Level 2 ER Total, Level 3 ER Total</p> <p>Details-Display2<br/> Transition 1level<br/> Level 0 → 1 and Level 1 → 0 SEC<br/> Level 1 → 2 and Level 2 → 1 SEC<br/> Level 2 → 3 and Level 3 → 2 SEC</p> <p>Transition 2level<br/> Level 0 → 2 and Level 2 → 0 SEC<br/> Level 1 → 3 and Level 3 → 1 SEC</p> <p>Transition 3level<br/> Level 0 → 3 and Level 3 → 0 SEC</p> <p>Upper Eye Total SEC, Middle Eye Total SEC, Lower Eye Total SEC<br/> Upper Eye Total SER, Middle Eye Total SER, Lower Eye Total SER<br/> Expressions enclosed in parentheses are abbreviations.</p> |
| RS-FEC Error Distribution | Available when the Option x42 FEC Analysis is installed.  |
| Gating                    | Time, Clock Count, Error Count  |
| Gating Unit               | Time: 1 second to 99 days 23 hours 59 minute 59 seconds<br>Clock Count: >E+4 to >E+16<br>Error Count: >E+4 to >E+16   |
| Cycle                     | Single, Repeat, Untimed   |
| Current                   | ON, OFF can be set.<br>Calculation: Progressive, Immediate<br>Interval: 100 ms, 200 ms  |
| Auto Sync                 | ON, OFF can be set.<br>Synchronization threshold: INT, E-2 to E-8   |
| Sync Control              | PRBS: Automatic Synchronization<br>Data: Frame On   |
| Frame Length              | NRZ: 4 bits to 64 bits, 4 bits step<br>PAM4: 4 to 64 symbols, 4 symbol step   |
| Frame Mask                | Available   |
| Frame Position            | NRZ: 1 bits to (Pattern Length – Frame Length + 1) bits, 1 bit step<br>PAM4: 1 to (Pattern Length – Frame Length + 1) symbols, 1 symbol step  |
| Error/Alarm Condition     |   |
| Error Detection           | NRZ: Insertion/Omission, Transition/Non transition<br>PAM4: Not available   |
| El/EFI Interval           | 1 ms, 10 ms, 100 ms, 1 s  |

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

# PAM4 ED MU196040B Specifications

## Error Analysis

| Block Window               | Excludes the specified data pattern from measurement.   |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
|----------------------------|---|-----------------------|-------------|----------------|---|------------------------|---|------------------------|---|-------------------------|---|--------------------------|----|--------------------------|----|---------------------------|----|----------------------------|-----|
| Setting Resolution         | <table border="1"> <thead> <tr> <th>Pattern length (bits)</th> <th>Step (bits)</th> </tr> </thead> <tbody> <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> </tbody> </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<br>L: Mask   |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| Capture                    | NRZ, PAM4 (When LSB/MSB Diagnostics is set to OFF)<br>PAM4 is available when the Option x41 SER Measurement is installed.   |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| Capture Mode               | Sync Mode Capture: Performs error judgment. Synchronization is required between input data and pattern setting.<br>Raw Data Capture: Does not perform error judgment. Synchronization is not required between input data and pattern setting.<br>FEC Symbol Capture: Performs FEC Symbol error judgement. Synchronization is required between input data and pattern setting.   |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| Number of Blocks           | 1, 2, 4, 8, 16, 32, 64, 128   |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| Block Length               | NRZ: 8 Mbits/n (n = Number of blocks)<br>PAM4: 4 Msymbols/n (n = Number of blocks)  |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| Trigger                    | Error Detect, Match Pattern, Manual Trigger, External Trigger (Rising Edge)<br>Error Detect cannot be selected when Capture Mode is Raw Data Capture.   |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| Capture Data               | Displays captured results by bit or symbol sequence in NRZ or PAM4 mode.<br>When Capture Mode is Sync Mode Capture, error bits and symbols are displayed with background color.   |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| Error Display              | NRZ: Insertion Error, Omission Error<br>PAM4: Lower Eye Error, Middle Eye Error, Upper Eye Error, Middle/Lower Eye Error, Upper/Middle Eye Error, Upper/Middle/Lower Eye Error<br>This is available only when Capture Mode is Sync Mode Capture.  |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| Error Search               | In PAM4 mode only, a search target can be selected from All, Upper Eye, Middle Eye and Lower Eye.<br>Searches for continuous error bits/symbols.<br>This is available only when Capture Mode is Sync Mode Capture.  |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| File Save/Open             | Saves the captured results and pattern to a file.<br>Redisplays the captured results.   |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| FEC Symbol Capture Setting | Number of FEC Symbols in a Codeword: 68, 132, 136, 272, 528, 544 FEC Symbols<br>Bit Length in a FEC Symbol: 10, 20 bits<br>FEC Symbol Error Threshold: 1 to 32 FEC Symbols/step 1   |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| Error Mapping              | Visually maps errors using bits with colored-background in NRZ or PAM4 mode.<br>This is available only when Capture Mode is Sync Mode Capture.  |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| Error Display              | NRZ: Insertion Error, Omission Error<br>PAM4: Lower Eye Error, Middle Eye Error, Upper Eye Error, Middle/Lower Eye Error, Upper/Middle Eye Error, Upper/Middle/Lower Eye Error  |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |
| File Open                  | Remaps the captured results (errors).   |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |

## Auto Measurement

|                 |  |
|-----------------|--|
| Auto Adjust     | NRZ: Vth direction only (Phase direction not supported.)*1<br>PAM4: MSB Vth direction only (Phase direction not supported.)*1.*2 |
| Auto Search     | NRZ: Available*1<br>PAM4 (LSB/MSB Diagnostics ON/OFF): Available*1.*3  |
| BER/SER Logging | NRZ: With BER Logging<br>PAM4: With SER Logging  |

\*1: PRBS Pattern, Mark Ratio 1/2

\*2: Each of amplitudes shall be equal.

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

## Variable Clock Delay

|                       |   |
|-----------------------|---|
| Phase Variable Range  | -1000 mUI to +1000 mUI, 2 mUI step  |
| Accuracy              | ±50 mUIp-p* (Baud rate ≤32.1 Gbaud, Typical value)<br>±100 mUIp-p* (Baud rate >32.1 Gbaud, Typical value)   |
| 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"> <li>Change in 1/1Clock frequency by ±250 kHz.</li> <li>Change in the ambient temperature by ±5°C.</li> </ul> |

\*: Measure using an oscilloscope with residual jitter of less than 200 fs rms.

# PAM4 ED MU196040B Specifications

## Jitter Tolerance

### Jitter Tolerance

For NRZ Input

Bit rate: 32.1 Gbit/s, 64.2 Gbit/s\*

Pattern: PRBS2<sup>31</sup> - 1

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.

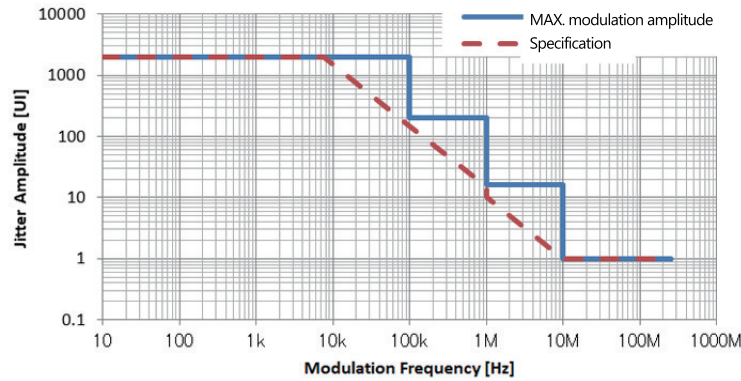
64.2 Gbits: With MU181500B, SSC with frequency of 33 kHz and deviation of 3300 ppm can be applied simultaneously with RJ with amplitude of 0.3 UI.

These specifications are defined assuming the following conditions:

Loopback connection to the MU196020A, at a constant temperature between 20°C and 30°C.

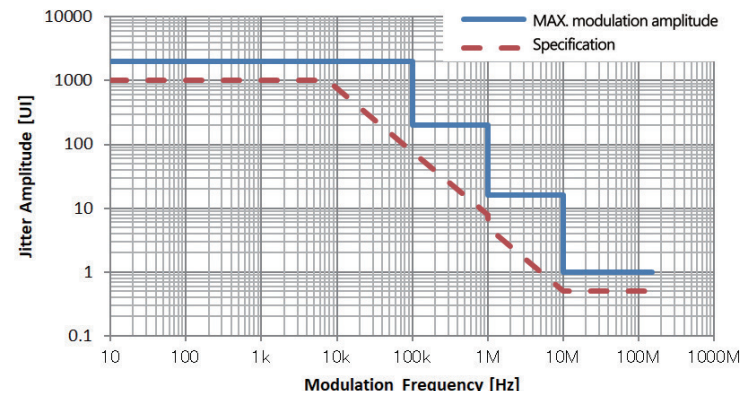
When RJ+BUJ is bigger than 0.5 Ulp-p or SJ + RJ + BUJ is bigger than the standard value + 0.3 Ulp-p, "Overload" is displayed on the MU181500B screen.

32.1 Gbit/s



| 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                     |
| 150 000 000               | 1                                 | 1                     |

64.2 Gbit/s



| 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                   |



# PAM4 ED MU196040B Specifications

For PAM4 Input

Baud rate: 32.1 Gbaud, 58.2 Gbaud\*

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.

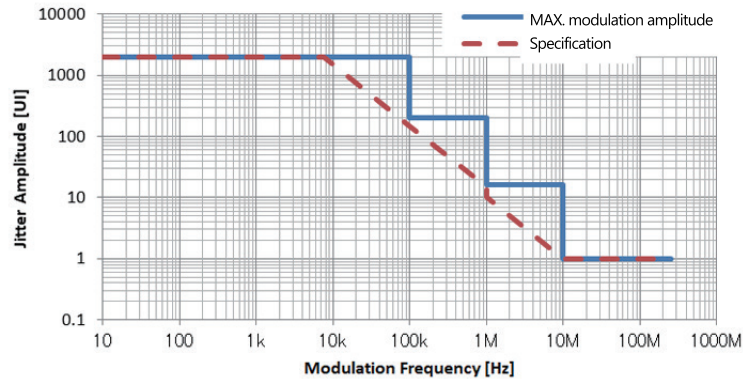
58.2 Gbaud: With MU181500B, SSC with frequency of 33 kHz and deviation of 3300 ppm can be applied simultaneously with RJ with amplitude of 0.3 UI.

These specifications are defined assuming the following conditions:

Loopback connection to the MU196020A, at a constant temperature between 20°C and 30°C.

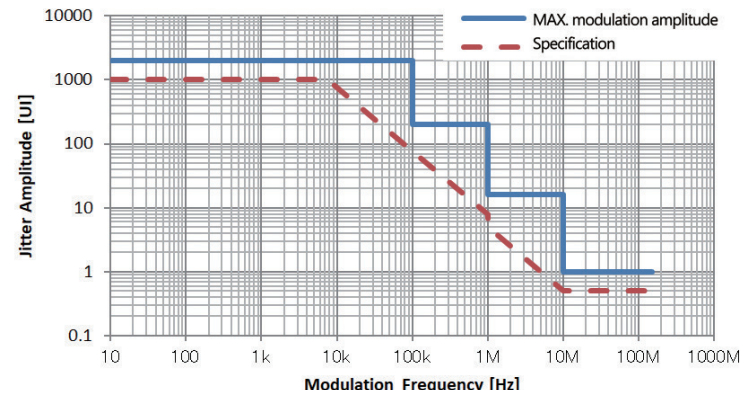
When RJ+BUJ is bigger than 0.5 Ulp-p or SJ + RJ + BUJ is bigger than the standard value + 0.3 Ulp-p, "Overload" is displayed on the MU181500B screen.

32.1 Gbaud



| 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                     |
| 150 000 000               | 1                                 | 1                     |

58.2 Gbaud



| 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                   |

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

# PAM4 ED MU196040B Specifications

## Clock Recovery

| Operating Bit Rate*1                  | <p>When the Option x21 is installed.<br/>NRZ: 2.4 Gbit/s to 29.0 Gbit/s<br/>PAM4: 2.4 Gbaud to 29.0 Gbaud</p> <p>When the Option x22, or x21 + x24 is installed.<br/>NRZ: 2.4 Gbit/s to 32.1 Gbit/s<br/>PAM4: 2.4 Gbaud to 32.1 Gbaud</p> <p>When the Option x23 is installed.<br/>NRZ: 51.0 Gbit/s to 58.2 Gbit/s<br/>PAM4: 51.0 Gbaud to 58.2 Gbaud</p>  |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
|---------------------------------------|--|----------|-------------------|-----------|------------|------------|------------|----------|------------|-----------|------------|-------------|------------|----------------------|------------|------------------|------------|------------------|------------|----------|------------|-------------------|------------|-------------------|------------|--------|------------|------------|------------|----------|------------|----------|------------|------------------|------------|-----------------|-----------|---------|-----------|--------|-----------|------------------|-----------|---------|-----------|--------|-----------|--------|-----------|------------------|-----------|----------------|-----------|----------|------------------|------------|------------|----------------------|------------|----------|------------|-----------|------------|----------------------|------------|------------------|------------|
| Setting Range*2                       | <p>When the Option x21 is installed.<br/>NRZ: 2.400 000 Gbit/s to 29.000 000 Gbit/s, 0.000 001 Gbit/s step<br/>PAM4: 2.400 000 Gbaud to 29.000 000 Gbaud, 0.000 001 Gbaud step</p> <p>When the Option x22, or x21 + x24 is installed.<br/>NRZ: 2.400 000 Gbit/s to 32.100 000 Gbit/s, 0.000 001 Gbit/s step<br/>PAM4: 2.400 000 Gbaud to 32.100 000 Gbaud, 0.000 001 Gbaud step</p> <p>When the Option x23 is installed.<br/>NRZ: 51.000 000 Gbit/s to 58.200 000 Gbit/s, 0.000 001 Gbit/s step<br/>PAM4: 51.000 000 Gbaud to 58.200 000 Gbaud, 0.000 001 Gbaud step</p>   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| Supported Standard and Bit Rate       | <p>For NRZ mode</p> <table border="1"> <thead> <tr> <th>Standard</th> <th>Bit rate [Gbit/s]</th> </tr> </thead> <tbody> <tr><td>CEI-56G*3</td><td>56.000 000</td></tr> <tr><td>100G ULH*4</td><td>32.100 000</td></tr> <tr><td>32G FC*5</td><td>28.050 000</td></tr> <tr><td>CEI-28G*5</td><td>28.000 000</td></tr> <tr><td>100G OTU4*5</td><td>27.952 496</td></tr> <tr><td>100 GbE(25.78 × 4)*5</td><td>25.781 250</td></tr> <tr><td>InfiniBand EDR*5</td><td>25.781 250</td></tr> <tr><td>InfiniBand FDR*5</td><td>14.062 500</td></tr> <tr><td>16G FC*5</td><td>14.025 000</td></tr> <tr><td>10G FC Over FEC*5</td><td>11.316 800</td></tr> <tr><td>10 GbE Over FEC*5</td><td>11.095 700</td></tr> <tr><td>OTU2*5</td><td>10.709 225</td></tr> <tr><td>G975 FEC*5</td><td>10.664 228</td></tr> <tr><td>10G FC*5</td><td>10.518 750</td></tr> <tr><td>10 GbE*5</td><td>10.312 500</td></tr> <tr><td>InfiniBand QDR*5</td><td>10.000 000</td></tr> <tr><td>OC-192/STM-64*5</td><td>9.953 280</td></tr> <tr><td>8G FC*5</td><td>8.500 000</td></tr> <tr><td>HSBI*5</td><td>6.250 000</td></tr> <tr><td>InfiniBand DDR*5</td><td>5.000 000</td></tr> <tr><td>4G FC*5</td><td>4.250 000</td></tr> <tr><td>XAUJ*5</td><td>3.125 000</td></tr> <tr><td>OTU1*5</td><td>2.666 060</td></tr> <tr><td>InfiniBand SDR*5</td><td>2.500 000</td></tr> <tr><td>OC-48/STM-16*5</td><td>2.488 320</td></tr> </tbody> </table> <p>For PAM4 mode</p> <table border="1"> <thead> <tr> <th>Standard</th> <th>Bit rate [Gbaud]</th> </tr> </thead> <tbody> <tr><td>CEI 112G*3</td><td>56.000 000</td></tr> <tr><td>400 GbE (53.1 × 4)*3</td><td>53.125 000</td></tr> <tr><td>64G FC*5</td><td>28.900 000</td></tr> <tr><td>CEI 56G*5</td><td>28.000 000</td></tr> <tr><td>200 GbE (26.6 × 4)*5</td><td>26.562 500</td></tr> <tr><td>InfiniBand HDR*5</td><td>26.562 500</td></tr> </tbody> </table> | Standard | Bit rate [Gbit/s] | CEI-56G*3 | 56.000 000 | 100G ULH*4 | 32.100 000 | 32G FC*5 | 28.050 000 | CEI-28G*5 | 28.000 000 | 100G OTU4*5 | 27.952 496 | 100 GbE(25.78 × 4)*5 | 25.781 250 | InfiniBand EDR*5 | 25.781 250 | InfiniBand FDR*5 | 14.062 500 | 16G FC*5 | 14.025 000 | 10G FC Over FEC*5 | 11.316 800 | 10 GbE Over FEC*5 | 11.095 700 | OTU2*5 | 10.709 225 | G975 FEC*5 | 10.664 228 | 10G FC*5 | 10.518 750 | 10 GbE*5 | 10.312 500 | InfiniBand QDR*5 | 10.000 000 | OC-192/STM-64*5 | 9.953 280 | 8G FC*5 | 8.500 000 | HSBI*5 | 6.250 000 | InfiniBand DDR*5 | 5.000 000 | 4G FC*5 | 4.250 000 | XAUJ*5 | 3.125 000 | OTU1*5 | 2.666 060 | InfiniBand SDR*5 | 2.500 000 | OC-48/STM-16*5 | 2.488 320 | Standard | Bit rate [Gbaud] | CEI 112G*3 | 56.000 000 | 400 GbE (53.1 × 4)*3 | 53.125 000 | 64G FC*5 | 28.900 000 | CEI 56G*5 | 28.000 000 | 200 GbE (26.6 × 4)*5 | 26.562 500 | InfiniBand HDR*5 | 26.562 500 |
| Standard                              | Bit rate [Gbit/s]  |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| CEI-56G*3                             | 56.000 000   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 100G ULH*4                            | 32.100 000   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 32G FC*5                              | 28.050 000   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| CEI-28G*5                             | 28.000 000   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 100G OTU4*5                           | 27.952 496   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 100 GbE(25.78 × 4)*5                  | 25.781 250   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| InfiniBand EDR*5                      | 25.781 250   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| InfiniBand FDR*5                      | 14.062 500   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 16G FC*5                              | 14.025 000   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 10G FC Over FEC*5                     | 11.316 800   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 10 GbE Over FEC*5                     | 11.095 700   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| OTU2*5                                | 10.709 225   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| G975 FEC*5                            | 10.664 228   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 10G FC*5                              | 10.518 750   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 10 GbE*5                              | 10.312 500   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| InfiniBand QDR*5                      | 10.000 000   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| OC-192/STM-64*5                       | 9.953 280  |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 8G FC*5                               | 8.500 000  |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| HSBI*5                                | 6.250 000  |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| InfiniBand DDR*5                      | 5.000 000  |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 4G FC*5                               | 4.250 000  |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| XAUJ*5                                | 3.125 000  |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| OTU1*5                                | 2.666 060  |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| InfiniBand SDR*5                      | 2.500 000  |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| OC-48/STM-16*5                        | 2.488 320  |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| Standard                              | Bit rate [Gbaud]   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| CEI 112G*3                            | 56.000 000   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 400 GbE (53.1 × 4)*3                  | 53.125 000   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 64G FC*5                              | 28.900 000   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| CEI 56G*5                             | 28.000 000   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| 200 GbE (26.6 × 4)*5                  | 26.562 500   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| InfiniBand HDR*5                      | 26.562 500   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |
| Operating Bit 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*2 | <p>When the Option x21, x22, or x21 + x24 is installed.<br/>72 bit<br/>Zero Substitution 2<sup>15</sup>,<br/>Target loop band: 1/1667, 1/2578 at 2.4G to 25.499 999G,<br/>1/1667, 1/2578, 1/6640 at 25.5G to 32.1G</p> <p>When the Option x23 is installed.<br/>72 bit<br/>Zero Substitution 2<sup>15</sup>,<br/>Target loop band: 1/6640, 1/13280 at 51.0G to 58.2G</p>   |          |                   |           |            |            |            |          |            |           |            |             |            |                      |            |                  |            |                  |            |          |            |                   |            |                   |            |        |            |            |            |          |            |          |            |                  |            |                 |           |         |           |        |           |                  |           |         |           |        |           |        |           |                  |           |                |           |          |                  |            |            |                      |            |          |            |           |            |                      |            |                  |            |

## PAM4 ED MU196040B Specifications

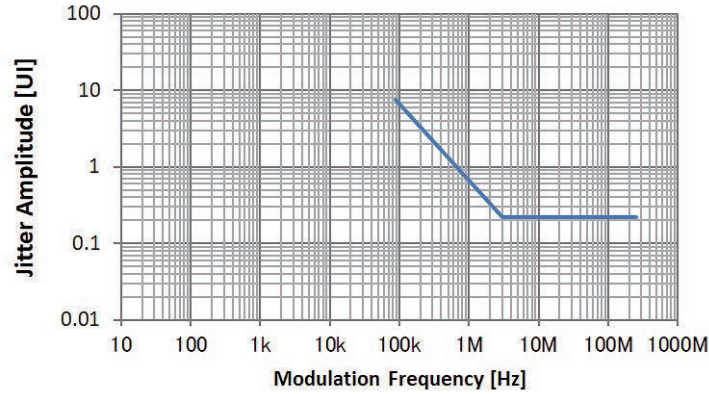
| Lock Range*2             | <p>When the Option x21, x22, or x21 + x24 is installed.</p> <ul style="list-style-type: none"> <li>±200 ppm</li> <li>2.4G to 25.499 999G, The target loop band is specified by 1/1667, 1/2578.</li> <li>±100 ppm</li> <li>25.5G to 32.1G, The target loop band is specified by 1/1667, 1/2578, 1/6640.</li> </ul> <p>When the Option x23 is installed.</p> <ul style="list-style-type: none"> <li>±100 ppm</li> <li>51.0 to 58.2 G, The target loop band is specified by 1/6640, 1/13280.</li> </ul>   |                   |             |            |                        |   |   |                        |        |   |                        |        |   |                         |        |   |                          |        |   |                          |        |   |                          |        |   |                          |         |   |                          |         |   |                          |         |   |                          |         |   |                          |         |   |                          |         |   |
|--------------------------|--|-------------------|-------------|------------|------------------------|---|---|------------------------|--------|---|------------------------|--------|---|-------------------------|--------|---|--------------------------|--------|---|--------------------------|--------|---|--------------------------|--------|---|--------------------------|---------|---|--------------------------|---------|---|--------------------------|---------|---|--------------------------|---------|---|--------------------------|---------|---|--------------------------|---------|---|
| Target Loop Band*3       | <p>When the Option x21, x22, or x21 + x24 is installed.</p> <ul style="list-style-type: none"> <li>25.5G to 32.1G*6</li> <li>Baud rate/1667</li> <li>Baud rate/2578</li> <li>Baud rate/6640</li> <li>Jitter Tolerance</li> <li>2.4G to 25.499 999G</li> <li>Baud rate/1667</li> <li>Baud rate/2578</li> <li>Jitter Tolerance</li> <li>Variable</li> </ul> <p>When Variable is selected, the ranges are as follows:</p> <table border="1"> <thead> <tr> <th>Baud rate [Gbaud]</th> <th>Range [MHz]</th> <th>Step [MHz]</th> </tr> </thead> <tbody> <tr> <td>2.400 000 to 5.500 000</td> <td>3</td> <td>—</td> </tr> <tr> <td>5.500 001 to 7.500 000</td> <td>3 to 4</td> <td>1</td> </tr> <tr> <td>7.500 001 to 9.500 000</td> <td>3 to 5</td> <td>1</td> </tr> <tr> <td>9.500 001 to 10.500 000</td> <td>3 to 6</td> <td>1</td> </tr> <tr> <td>10.500 001 to 12.500 000</td> <td>3 to 7</td> <td>1</td> </tr> <tr> <td>12.500 001 to 14.500 000</td> <td>3 to 8</td> <td>1</td> </tr> <tr> <td>14.500 001 to 15.500 000</td> <td>3 to 9</td> <td>1</td> </tr> <tr> <td>15.500 001 to 17.500 000</td> <td>3 to 10</td> <td>1</td> </tr> <tr> <td>17.500 001 to 19.500 000</td> <td>3 to 11</td> <td>1</td> </tr> <tr> <td>19.500 001 to 20.500 000</td> <td>3 to 12</td> <td>1</td> </tr> <tr> <td>20.500 001 to 22.500 000</td> <td>3 to 13</td> <td>1</td> </tr> <tr> <td>22.500 001 to 24.500 000</td> <td>3 to 14</td> <td>1</td> </tr> <tr> <td>24.500 001 to 25.499 999</td> <td>3 to 15</td> <td>1</td> </tr> </tbody> </table> <p>When the Option x23 is installed.</p> <ul style="list-style-type: none"> <li>51.0G to 58.2G*7</li> <li>Baud rate/6640</li> <li>Baud rate/13280</li> <li>Jitter Tolerance</li> </ul> | 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 |
| 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                 |             |            |                        |   |   |                        |        |   |                        |        |   |                         |        |   |                          |        |   |                          |        |   |                          |        |   |                          |         |   |                          |         |   |                          |         |   |                          |         |   |                          |         |   |                          |         |   |

# PAM4 ED MU196040B Specifications

## Jitter Tolerance\*<sup>8</sup>

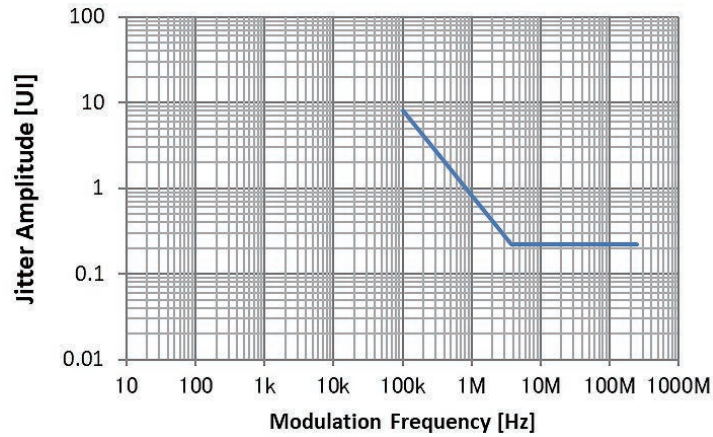
NRZ Input

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 typical values:



| Modulation Frequency [Hz] | Jitter Tolerance Mask [Ulp-p] |
|---------------------------|-------------------------------|
| 87 349                    | 7.5                           |
| 2 977 820                 | 0.22                          |
| 250 000 000               | 0.22                          |

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:

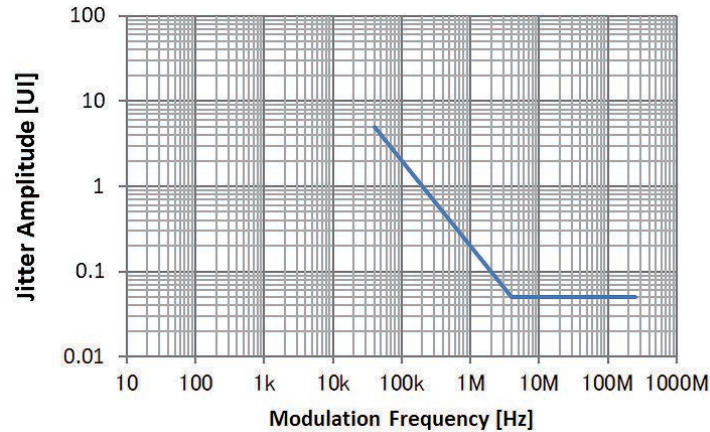


| Modulation Frequency [Hz] | Jitter Tolerance Mask [Ulp-p] |
|---------------------------|-------------------------------|
| 100 000                   | 8.16                          |
| 3 709 271                 | 0.22                          |
| 250 000 000               | 0.22                          |

# PAM4 ED MU196040B Specifications

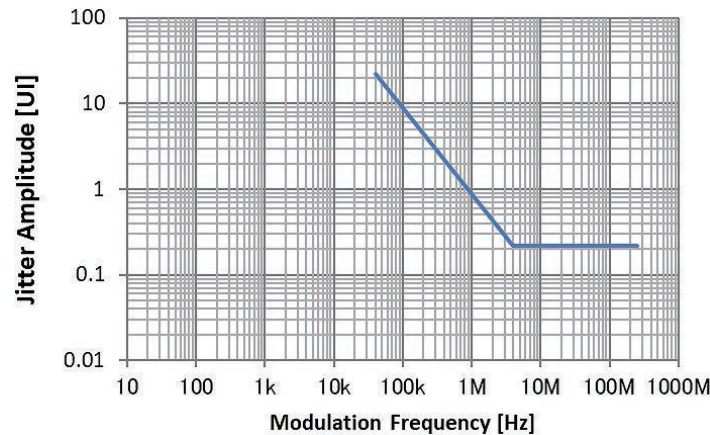
PAM4 Input

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:



| Modulation Frequency [Hz] | Jitter Tolerance Mask [Ulp-p] |
|---------------------------|-------------------------------|
| 40 004                    | 5                             |
| 4 000 377                 | 0.05                          |
| 250 000 000               | 0.05                          |

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:



| Modulation Frequency [Hz] | Jitter Tolerance Mask [Ulp-p] |
|---------------------------|-------------------------------|
| 40 000                    | 22                            |
| 4 000 000                 | 0.22                          |
| 250 000 000               | 0.22                          |

- \*1: When the Option x21, x22, x23, or x24 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: 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.
- \*3: When the Option x23 is installed.
- \*4: When the Option x22, or x21 + x24 is installed.
- \*5: When the Option x21, x22, or x21 + x24 is installed.
- \*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.
- \*8: Specified at a constant temperature between +20° and +30°C.

## General

|                       |  |
|-----------------------|--|
| Dimensions and Mass   | 234 (W) × 21 (H) × 175 (D) mm (Protrusions excluded), 2.5 kg max.                        |
| Operating Temperature | +15°C to +30°C<br>MP1900A's ambient temperature. MU196040B shall operate when installed. |
| Storage Temperature   | -20°C to +60°C<br>MU196040B installed to MP1900A shall comply with MIL-T-28800E Class 5. |

# PAM4 ED MU196040A Specifications

## Operating Baud Rate

|                     |                         |
|---------------------|-------------------------|
| Operating Baud Rate | 2.4 Gbaud to 32.1 Gbaud |
|---------------------|-------------------------|

## System Clock

|              |  |
|--------------|--|
| System Clock | External, Recovered Clock (When the Option x22 is installed) |
|--------------|--|

## Data Input

|                     |   |
|---------------------|---|
| Number of Inputs    | 2 (Data, XData) (Differential)  |
| Input Condition     | Single-end, Differential 50Ω, Differential 100Ω<br>When set to Differential 50Ω or Differential 100Ω:<br>Independent, Tracking, Alternate*1<br>When set to Alternate:<br>Data-XData, XData-Data*2<br>When set to Single-end:<br>Data, XData*3   |
| Signal Type         | NRZ, PAM4   |
| LSB/MSB Diagnostics | When set to PAM4, the PAM4 mode can be switched between as follows:<br>Diagnostics Mode OFF:<br>Treats signals as symbols by receiving LSB and MSB while synchronizing them with each other.<br>Diagnostics Mode ON:<br>Asynchronously receives LSB and MSB.  |
| Input Amplitude     | NRZ: The range in which the Auto Adjust function operates.<br>PAM4: The range in which the Auto Search PAM4 Fine function operates.<br>NRZ: 0.05 Vp-p to 1.0 Vp-p*4<br>PAM4: 0.3 Vp-p to 1.0 Vp-p*5   |
| Threshold Voltage   | NRZ, PAM4 Middle Eye Threshold: -3.5 V to +3.3 V, 1 mV step*2, *6<br>PAM4 Upper Eye Threshold: -3.9 V to +3.7 V, 1 mV step*7<br>PAM4 Lower Eye Threshold: -3.9 V to +3.7 V, 1 mV step*7   |
| Input Sensitivity   | Single-end, Mark Ratio 1/2, when connecting directly to the MU196020A with J1789A.<br>When the Option 001 is installed, 34VKF50 shall be included.<br>At a constant temperature between 20°C and 30°C   |
| Eye Amplitude       | NRZ, PRBS31<br>Typ. 32 mVp-p, ≤ 50 mVp-p*8  |
| Eye Height          | NRZ, PRBS31<br>Typ. 23 mV*8<br>PAM4<br>Typ. 23 mV, ≤ 50 mV*9  |
| Phase Margin        | When connecting directly to the MU196020A with J1789A.<br>When the Option 001 is installed, 34VKF50 shall be included.<br>At a constant temperature between 20°C and 30°C, when using External Clock<br>NRZ, PRBS31, Differential, Mark Ratio 1/2, when inputting 1.0 Vp-p<br>Typ. 25.8 ps*10<br>Typ. 18.0 ps*11<br>PAM4 0/3 Level, Eye Width where BER is 1E-06, PRBS31, Single-end, Mark Ratio 1/2, when inputting 0.5 Vp-p, Emphasis ON (Best values in the range of 1Pre ≤ 5 dB and 1Post ≤ 5 dB)<br>Typ. 5.3 ps*12<br>Typ. 4.5 ps*13 |
| Stressed Margin*14  |   |
| Stressed Eye Height | PAM4 0/1 1/2 2/3 Level, QPRBS13-CEI, Eye Height where BER is 1E-06, when using External Clock<br>≥ 32 mV*15   |
| Stressed Eye Width  | PAM4 0/1 1/2 2/3 Level, QPRBS13-CEI, Eye Width where BER is 1E-06, when using External Clock<br>≥ 7.15 ps*15  |
| Termination         | 50Ω, GND, Variable  |
| Termination Voltage | When set to Variable: -2.5 V to +3.5 V, 10 mV step  |
| Connector           | K (f) (When the Option 001 is installed)  |

\*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-end, Differential

\*5: 0/3 Level, PRBS31, Single-end, 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.

\*8: 26.5625 Gbit/s, 32.1 Gbit/s, when the Option 001 is installed.

\*9: 26.5625 Gbaud, 32.1 Gbaud, when the Option 001 is installed.

\*10: 26.5625 Gbit/s, when the Option 001 is installed.

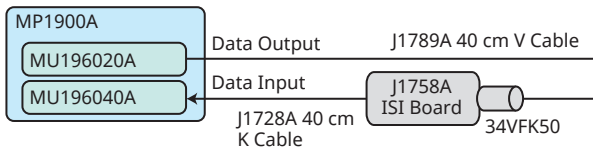
\*11: 32.1 Gbit/s, when the Option 001 is installed.

\*12: 26.5625 Gbaud, when the Option 001 is installed.

\*13: 32.1 Gbaud, when the Option 001 is installed.

# PAM4 ED MU196040A Specifications

\*14: Differential, Mark Ratio 1/2, when connecting J1758A and MU196020A by using J1789A, 34VKF50 and J1728A.



At a constant temperature between 20°C and 30°C, measure with a 70-GHz bandwidth sampling oscilloscope with residual jitter of less than 200 fs rms. Adjust MU196020A De-Emphasis (2 Pre Cursors and 1 Post Cursor) so that the product of Eye Height (1E-06) and Eye Width (1E-06) can be maximized in the differential waveform.

Calculate the 4th 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 Vp-p (Diff) or less and Eye Linearity RLM 0.85 or more.

\*15: 28 Gbaud, when the Option 001 is installed, BER 1E-12

## Clock Input

|                  |  |
|------------------|--|
| Number of Inputs | 1 (Single-end)   |
| Frequency Range  | 2.4 GHz to 32.1 GHz  |
| Amplitude        | 0.3 Vp-p to 1.0 Vp-p (-6.5 to +4.0 dBm) (Input Frequency ≤ 16.05 GHz)<br>0.4 Vp-p to 1.0 Vp-p (-3.9 to +4.0 dBm) (Input Frequency > 16.05 GHz) |
| Termination      | 50Ω, AC Coupling   |
| Connector        | K (f)  |

## Aux Input

|                     |   |
|---------------------|---|
| Number of Inputs    | 1 (Single-end)  |
| Variation           | External Mask, Burst  |
| Minimum Pulse Width | 1/256 of Data rate  |
| Input Level         | <ul style="list-style-type: none"> <li>0/-1 V (H: -0.25 V to 0.05 V, L: -1.1 V to -0.8 V)</li> <li>0/-0.5 V (H: -0.05 V to 0.05 V, L: -0.55 V to -0.45 V)</li> <li>Vth 0 V (Input amplitude 0.5 Vp-p to 1.0 Vp-p)</li> </ul> Select one of the above. |
| Termination         | GND, 50Ω  |
| Connector           | SMA (f)   |

## Aux Output

|                   |  |
|-------------------|--|
| 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<br>Position: 1 to {(Least common multiple of Pattern Length' and 128) - 135}, 8 step (When the Option 001 is installed)<br>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 V to 0.05 V, L: -0.80 V to -0.45 V)   |
| Termination       | GND, 50Ω   |
| Connector         | SMA (f)  |

## Pattern Detection

|                           |   |
|---------------------------|---|
| PRBS                      |   |
| Pattern Length            | 2 <sup>n</sup> - 1 (n = 7, 9, 10, 11, 13, 15, 20, 23, 31)   |
| Mark Ratio                | 1/2, 1/2INV   |
| PRBS Generator Polynomial | n=7: 1 + X <sup>6</sup> + X <sup>7</sup><br>n=9: 1 + X <sup>5</sup> + X <sup>9</sup><br>n=10: 1 + X <sup>7</sup> + X <sup>10</sup><br>n=11: 1 + X <sup>9</sup> + X <sup>11</sup><br>n=13: 1 + X + X <sup>2</sup> + X <sup>12</sup> + X <sup>13</sup><br>n=15: 1 + X <sup>14</sup> + X <sup>15</sup><br>n=20: 1 + X <sup>3</sup> + X <sup>20</sup><br>n=23: 1 + X <sup>18</sup> + X <sup>23</sup><br>n=31: 1 + X <sup>28</sup> + X <sup>31</sup> |
| PRBS Inversion            | This is available in PAM4 mode only.<br>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 <sup>n</sup> or 2 <sup>n</sup> - 1 (n = 7, 9, 10, 11, 15, 20, 23)   |
| Start Position            | Substitutes the bit coming after the maximum "0" successive bits.   |
| Zero-Length               | 1 bits to (Pattern Length - 1) bits<br>If the bit coming after Zero-substitution is "0," then it is replaced with "1."  |
| Data                      |   |

# PAM4 ED MU196040A Specifications

|                                     |   |
|-------------------------------------|---|
| Data Length                         | NRZ: 2 bits to 268 435 456bits, 1 bit step<br>PAM4: 2 to 268 435 456 symbol, 1 symbol step                        |
| Coding                              | NRZ, PAM4   |
| NRZ                                 | Normal, Invert  |
| PAM4 Gray Coding                    | ON, OFF   |
| PAM4 Precoding<br>(1/(1 + D)mod 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<br>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  |

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

## Pattern Sequence

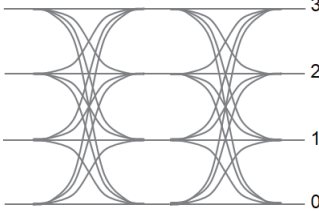
|               |   |
|---------------|---|
| Sequence      | Repeat, Burst   |
| Repeat        | Continuous Pattern  |
| Burst         | This is available only when Coding is NRZ.  |
| Source        | Internal, External-Trigger (Aux Input), External-Enable (Aux Input)   |
| Delay         | Internal: 0 to 2 147 483 640 bits, 8 bits step<br>Ext Trigger, Enable: 0 to 2 147 483 520 bits, 8bits step<br>Adjust Method: Auto, Manual |
| Enable Period | Internal: 12800 bits to 2 147 482 624 bits, 256 bits step<br>Ext Trigger: 12800 bits to 2 147 483 136 bits, 256 bits step                 |
| Burst Cycle   | 25600 bits to 2 147 483 648 bits, 1024 bits step  |

## Measurement

|         |  |
|---------|--|
| Counter | <p>Error Rate (ER) Total<br/>Error Count (EC) Total<br/>Error Interval<br/>%Error Free Interval<br/>Error Rate (ER) Insertion (INS)<br/>Error Count (EC) Insertion (INS)<br/>Error Rate (ER) Omission (OMI)<br/>Error Count (EC) Omission (OMI)<br/>Frequency: 2 400.000 MHz to 32 100.000 MHz<br/>Frequency measurement accuracy: <math>\pm 1 \text{ ppm } \pm 1 \text{ kHz}^*</math><br/>Clock Count<br/>Sync. Loss Interval<br/>Clock Loss Interval<br/>Expressions enclosed in parentheses are abbreviations.</p> <p>The following are available only for PAM4 (Diagnostics Mode ON) measurement.<br/>MSB Error Rate (ER) Total<br/>MSB Error Count (EC) Total<br/>MSB Error Rate (ER) Insertion (INS)<br/>MSB Error Count (EC) Insertion (INS)<br/>MSB Error Rate (ER) Omission (OMI)<br/>MSB Error Count (EC) Omission (OMI)<br/>LSB Error Rate (ER) Total<br/>LSB Error Count (EC) Total<br/>LSB Error Rate (ER) Insertion (INS)<br/>LSB Error Count (EC) Insertion (INS)<br/>LSB Error Rate (ER) Omission (OMI)<br/>LSB Error Count (EC) Omission (OMI)<br/>Expressions enclosed in parentheses are abbreviations.</p> |
|---------|--|



# PAM4 ED MU196040A Specifications

|                       |  |
|-----------------------|--|
| Counter (Cont'd)      | <p>The following are available when the Option x41 SER Measurement is installed.<br/>The following are available only for PAM4 (Diagnostics Mode OFF) measurement.</p>  <p>Symbol Error Rate (SER)<br/>Symbol Error Count (SEC)<br/>Symbol Error Interval<br/>Symbol %Error Free Interval</p> <p>Level 0 → 3 EC,      Level 1 → 3 EC<br/>Level 0 → 2 EC,      Level 1 → 2 EC<br/>Level 0 → 1 EC,      Level 1 → 0 EC<br/>Level 0 → 3 ER,      Level 1 → 3 ER<br/>Level 0 → 2 ER,      Level 1 → 2 ER<br/>Level 0 → 1 ER,      Level 1 → 0 ER<br/>Level 0 EC Total,    Level 1 EC Total<br/>Level 0 ER Total,    Level 1 ER Total</p> <p>Level 2 → 3 EC,      Level 3 → 2 EC<br/>Level 2 → 1 EC,      Level 3 → 1 EC<br/>Level 2 → 0 EC,      Level 3 → 0 EC<br/>Level 2 → 3 ER,      Level 3 → 2 ER<br/>Level 2 → 1 ER,      Level 3 → 1 ER<br/>Level 2 → 0 ER,      Level 3 → 0 ER<br/>Level 2 EC Total,    Level 3 EC Total<br/>Level 2 ER Total,    Level 3 ER Total</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<br>Clock Count: >E+4 to >E+16<br>Error Count: >E+4 to >E+16  |
| Cycle                 | Single, Repeat, Untimed  |
| Current               | ON, OFF can be set.<br>Calculation: Progressive, Immediate<br>Interval: 100 ms, 200 ms   |
| Auto Sync             | ON, OFF can be set.<br>Synchronization threshold: INT, E-2 to E-8  |
| Sync Control          | PRBS: Automatic Synchronization<br>Data: Frame On  |
| Frame Length          | NRZ: 4 bits to 64 bits, 4 bits step<br>PAM4: 4 to 64 symbols, 4 symbol step  |
| Frame Mask            | Available  |
| Frame Position        | NRZ: 1 bits to (Pattern Length – Frame Length + 1) bits, 1 bit step<br>PAM4: 1 to (Pattern Length – Frame Length + 1) symbols, 1 symbol step   |
| Error/Alarm Condition |  |
| Error Detection       | NRZ: Insertion/Omission, Transition/Non transition<br>PAM4: Not available  |
| EI/EFI Interval       | 1 ms, 10 ms, 100 ms, 1 s   |

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

## Error Analysis

| Block Window               | Excludes the specified data pattern from measurement.   |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |  |
|----------------------------|---|-----------------------|-------------|----------------|---|------------------------|---|------------------------|---|-------------------------|---|--------------------------|----|--------------------------|----|---------------------------|----|----------------------------|-----|--|
| Setting Resolution         | <table border="1"> <thead> <tr> <th>Pattern length (bits)</th> <th>Step (bits)</th> </tr> </thead> <tbody> <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> </tbody> </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<br>L: Mask   |                       |             |                |   |                        |   |                        |   |                         |   |                          |    |                          |    |                           |    |                            |     |  |

# PAM4 ED MU196040A Specifications

## Auto Measurement

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

\*1: PRBS Pattern, Mark Ratio 1/2  
\*2: Each of amplitudes shall be equal.

## Variable Clock Delay

|                       |   |
|-----------------------|---|
| Phase Variable Range  | -1000 mUI to +1000 mUI, 2 mUI step  |
| Accuracy              | Typ. $\pm 50$ mUIp-p*   |
| 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"> <li>Change in 1/1Clock frequency by <math>\pm 250</math> kHz.</li> <li>Change in the ambient temperature by <math>\pm 5^\circ\text{C}</math>.</li> </ul> |

\*: Measure using an oscilloscope with residual jitter of less than 200 fs rms.

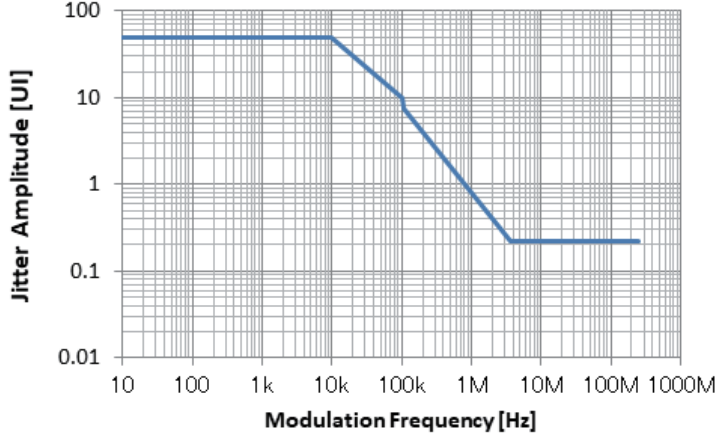
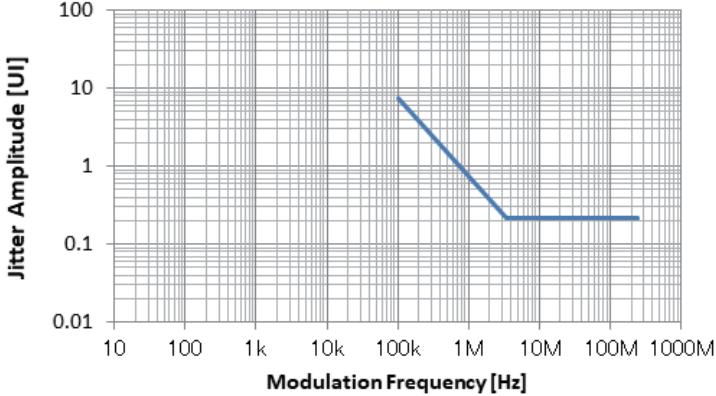
## Jitter Tolerance

| <p>Jitter Tolerance</p>   | <p>For NRZ output<br/>Bit rate: 32.1 Gbit/s<br/>Pattern: PRBS2<sup>31</sup>-1<br/>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.<br/>These specifications are defined assuming the following conditions:<br/>Loopback connection to the MU196020A, at a constant temperature between 20°C and 30°C.<br/>When RJ+BUJ is bigger than 0.5 Ulp-p or SJ + RJ + BUJ is bigger than the standard value + 0.3 Ulp-p, "Overload" is displayed on the MU181500B screen.</p> <table border="1"> <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                         |                                   |                       |    |       |       |       |       |       |         |       |     |           |     |    |            |    |   |             |   |   |

## Clock Recovery

| Operating Bit Rate              | NRZ: 25.5 Gbit/s to 32.1 Gbit/s<br>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 Bit Rate | <p>For NRZ mode</p> <table border="1"> <thead> <tr> <th>Standard</th> <th>Bit rate [Gbit/s]</th> </tr> </thead> <tbody> <tr> <td>100G ULH</td> <td>32.100 000</td> </tr> <tr> <td>32G FC</td> <td>28.050 000</td> </tr> <tr> <td>CEI-28G</td> <td>28.000 000</td> </tr> <tr> <td>100G OTU4</td> <td>27.952 496</td> </tr> <tr> <td>100GbE (25.78 × 4)</td> <td>25.781 250</td> </tr> <tr> <td>InfiniBand EDR</td> <td>25.781 250</td> </tr> </tbody> </table> <p>For PAM4 mode</p> <table border="1"> <thead> <tr> <th>Standard</th> <th>Bit rate [Gbaud]</th> </tr> </thead> <tbody> <tr> <td>64G FC</td> <td>28.900 000</td> </tr> <tr> <td>CEI-56G</td> <td>28.000 000</td> </tr> <tr> <td>200GbE (26.6 × 4)</td> <td>26.562 500</td> </tr> <tr> <td>InfiniBand HDR</td> <td>26.562 500</td> </tr> </tbody> </table> | Standard | Bit rate [Gbit/s] | 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 [Gbaud] | 64G FC | 28.900 000 | CEI-56G | 28.000 000 | 200GbE (26.6 × 4) | 26.562 500 | InfiniBand HDR | 26.562 500 |
| Standard                        | Bit rate [Gbit/s]   |          |                   |          |            |        |            |         |            |           |            |                    |            |                |            |          |                  |        |            |         |            |                   |            |                |            |
| 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 [Gbaud]  |          |                   |          |            |        |            |         |            |           |            |                    |            |                |            |          |                  |        |            |         |            |                   |            |                |            |
| 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.  |          |                   |          |            |        |            |         |            |           |            |                    |            |                |            |          |                  |        |            |         |            |                   |            |                |            |

# PAM4 ED MU196040A Specifications

| Maximum Number of Consecutive Zeros*2 | 72 bit (Zero Substitution 2 <sup>15</sup> )   |                           |                               |    |    |        |    |         |    |         |     |           |      |             |      |                           |                               |         |     |           |      |             |      |
|---------------------------------------|---|---------------------------|-------------------------------|----|----|--------|----|---------|----|---------|-----|-----------|------|-------------|------|---------------------------|-------------------------------|---------|-----|-----------|------|-------------|------|
| Lock Range*2                          | ±100 ppm  |                           |                               |    |    |        |    |         |    |         |     |           |      |             |      |                           |                               |         |     |           |      |             |      |
| Target Loop Band*3                    | $\frac{\text{Baud rate}}{1667}$ MHz, $\frac{\text{Baud rate}}{2578}$ MHz, $\frac{\text{Baud rate}}{6640}$ MHz, Jitter Tolerance   |                           |                               |    |    |        |    |         |    |         |     |           |      |             |      |                           |                               |         |     |           |      |             |      |
| 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 [Ulp-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 "100 GbE (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 [Ulp-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 [Ulp-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 [Ulp-p] | 100,000 | 7.5 | 3,409,256 | 0.22 | 250,000,000 | 0.22 |
| Modulation Frequency [Hz]             | Jitter Tolerance Mask [Ulp-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 [Ulp-p]   |                           |                               |    |    |        |    |         |    |         |     |           |      |             |      |                           |                               |         |     |           |      |             |      |
| 100,000                               | 7.5   |                           |                               |    |    |        |    |         |    |         |     |           |      |             |      |                           |                               |         |     |           |      |             |      |
| 3,409,256                             | 0.22  |                           |                               |    |    |        |    |         |    |         |     |           |      |             |      |                           |                               |         |     |           |      |             |      |
| 250,000,000                           | 0.22  |                           |                               |    |    |        |    |         |    |         |     |           |      |             |      |                           |                               |         |     |           |      |             |      |

\*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.  
 \*4: Defined assuming the following conditions: Loop-back connection to MU196020A, NRZ input, Test Pattern (Length): PRBS 2<sup>31</sup>-1, Data input amplitude: 0.1 Vp-p  
 \*5: Typical value, specified at a constant temperature between 20°C and 30°C.

## General

|                       |  |
|-----------------------|--|
| Dimensions and Mass   | 234 (W) × 21 (H) × 175 (D) mm (Protrusions excluded), 2.5 kg max.                        |
| Operating Temperature | +15°C to +30°C<br>MP1900A's ambient temperature. MU196040A shall operate when installed. |
| Storage Temperature   | -20°C to +60°C<br>MU196040A installed to MP1900A shall comply with MIL-T-28800E Class 5. |

# Noise Generator MU195050A Specifications

## Operating Bit Rate

|                    |                           |
|--------------------|---------------------------|
| Operating Bit Rate | 2.4 Gbit/s to 32.1 Gbit/s |
|--------------------|---------------------------|

## Data Input

|                              |  |
|------------------------------|--|
| Number of Channels           | 2  |
| Number of Inputs per Channel | 2 (Data, $\overline{\text{Data}}$ ) (Differential)         |
| Input Amplitude              | 1.5 Vp-p max. (Single-end)<br>3.0 Vp-p max. (Differential) |
| Offset                       | -2.0 V to +3.3 V   |
| Impedance                    | 50Ω  |
| Connector                    | K (f)  |

## Data Output

The signal that is output from the noise source is AC-coupled.

|                               |   |
|-------------------------------|---|
| Number of Channels            | 2   |
| Number of Outputs per Channel | 2 (Data, $\overline{\text{Data}}$ ) (Differential)  |
| Insertion Loss                | -3 dB +1/-2.5 dB*                                   |
| Impedance                     | 50Ω (Output Signal from noise source is AC-coupled) |
| Connector                     | K (f)   |

\*: Defined for 12.890625 GHz and sine wave.

## External Input

For connecting to USB3.1 Receiver Test Adapter G0373A or the Gating Output signal of MU195020A.

|                              |  |
|------------------------------|--|
| Number of Channels           | 1*   |
| Number of Inputs Per Channel | 2 (Differential)   |
| Input Amplitude              | 1.5 Vp-p max. (Single-end)<br>3.0 Vp-p max. (Differential) |
| Impedance                    | 50Ω, AC-coupled  |
| Connector                    | SMA (f)  |

\*: Data Input 1 Channel only

## Differential Mode Interface (DMI)

The setting is common for Data Input 1 and Data Input 2. However, the Output Control can be turned On or Off individually.

|                        |   |
|------------------------|---|
| Amplitude              | 4 mVp-p to 200 mVp-p (Differential)   |
| Amplitude Setting Step | 1 mV  |
| Amplitude Accuracy     | ±20% ±10 mV*  |
| Frequency              | 2 GHz to 10 GHz   |
| Frequency Setting Step | 10 MHz  |
| Waveform               | Sine wave   |
| Presets                | PCIe Gen3, PCIe Gen4, PCIe Gen5   |
| Output Control         | Capability of switching On/Off of Data Input 1 Channel and Data Input 2 Channel simultaneously.<br>(Either White Noise or External Input can be selected for Data Input 1 Channel).<br>(Either Data Input 2 Channel or White Noise can be selected) |

\*: Defined at certain temperature between 20°C to 30°C for 2.1 GHz, 4.2 GHz, 10 GHz.

## Noise Generator MU195050A Specifications

### Common Mode Interface (CMI)

The setting is common for Data Input 1 and Data Input 2. However, the Output Control can be turned On or Off individually.

|                        |  |
|------------------------|--|
| Amplitude              | 10 mVp-p to 250 mVp-p (Single-end)   |
| Amplitude Setting Step | 2 mV   |
| Amplitude Accuracy     | ±20% ±25 mV*   |
| Frequency              | Low Band: 100 MHz to 1 GHz<br>High Band: 1 GHz to 6 GHz  |
| Frequency Setting Step | Low Band: 1 MHz<br>High Band: 10 MHz   |
| Waveform               | Sine wave  |
| Presets                | TBT3   |
| Output Control         | Capability of switching On/Off of Data Input 1 Channel and Data Input 2 Channel simultaneously.<br>(Either DMI/CMI or External Input can be selected for Channel 1)<br>(Either Channel 2 or DMI/CMI can be selected) |

\*: Defined at certain temperature between 20°C to 30°C for 120 MHz, 400 MHz, 1 GHz, 6 GHz.

### White Noise

The setting is common for Data Input 1 and Data Input 2.

|                        |  |
|------------------------|--|
| Flatness               | ±5 dB (10 MHz to 10 GHz)   |
| Crest Factor           | >5 (p-p/rms)   |
| Amplitude              | 0.2 mV rms to 25 mV rms  |
| Amplitude Setting Step | 0.2 mV rms   |
| Amplitude Accuracy     | ±20% ±2.5 mVrms*   |
| On/Off                 | Capability of switching On/Off of Data Input 1 Channel and Data Input 2 Channel simultaneously.<br>(Either DMI/CMI or External Input can be selected for Channel 1)<br>(Either Channel 2 or DMI/CMI can be selected) |

\*: Defined at one specific temperature between 20°C to 30°C, subtracting the residual noise value from the data by sampling oscilloscope with 50 GHz bandwidth.

### General

|                       |  |
|-----------------------|--|
| Dimensions and Mass   | 234 (W) × 21 (H) × 175 (D) mm (Excluding protrusions), 1.2 kg max. |
| Operating Temperature | +15°C to +35°C   |
| Storage Temperature   | -20°C to +60°C   |

## 12.5 GHz 4port Synthesizer MU181000B Specifications

|               |  |
|---------------|--|
| Clock Output  | Number of Output: 4<br>Frequency Range: 0.1 GHz to 12.5 GHz, Steps: 1 kHz/1 MHz<br>Offset from Set Frequency: -1000 to +1000 ppm, Steps: 1 ppm, 1 Hz (Min)<br>Level: 0.4 Vp-p to 1 Vp-p (AC)<br>SSB Phase Noise: ≤-80 dBc/Hz (10 kHz offset)<br>Intrinsic Jitter: ≤20 ps p-p, ≤20 ps p-p (fc>400 MHz)<br>Waveform: Square wave (<1 GHz), Square wave or Sine wave (≥1 GHz)<br>Duty: 50 ±10%<br>Inter-channel Skew: ≤10 ps (12.5 GHz)<br>Connector: SMA (f), Termination: 50Ω/GND |
| 10 MHz Input  | Frequency: 10 MHz ±10 ppm<br>Level: 0.5 Vp-p to 2.0 Vp-p<br>Waveform: Square wave or Sine wave<br>Duty: 50 ±10%<br>Connector: BNC, Termination: 50Ω/GND  |
| 10 MHz Output | Level: 1.0 Vp-p ±30% (AC)<br>Waveform: Square wave<br>Duty: 50 ±10%<br>Connector: BNC, Termination: 50Ω/GND  |

# Jitter Modulation Source MU181000B-001 Specifications

| External Modulation Input            | <p>Frequency Range: 9 Hz to 1 GHz<br/>                     Level Range: 3 Vp-p, 0 V(dc) (Max.)<br/>                     Waveform: Sine wave<br/>                     Connector: SMA (f), Termination: 50Ω/GND</p>   |                       |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
|--------------------------------------|---|-----------------------|-----------------|------------------|--------------------|--------------------|--------------|--------------------|-------------------|--------------------|-----------------|--------------------|-------------------|--------------------|------------------|---------------------|-----------------|--------------------|----------------------|-------------------|--------------|---------------------|--------------|-------|--------|----|---|---------------------|---|----------------------|----|---------------------|----|
| External I, Q Input                  | <p>Frequency Range: DC to 320 MHz (-3 dB)<br/>                     Bandwidth Limit: 5 MHz (0.1 GHz ≤ fc ≤ 0.4 GHz), 10 MHz (0.4 GHz &lt; fc ≤ 0.65 GHz), 20 MHz (0.65 GHz &lt; fc ≤ 1.4 GHz), 100 MHz (1.4 GHz &lt; fc ≤ 2.4 GHz), 320 MHz (2.4 GHz &lt; fc ≤ 4.0 GHz)<br/>                     Level Range: ±0.5 V<br/>                     Connector: BNC, Termination: 50Ω/GND</p>   |                       |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 100 MHz Reference Signal Input (SSC) | <p>Output Center Frequency is × 25 or × 50 of Reference Input Frequency<br/>                     Modulation Frequency: 30 kHz to 33 kHz<br/>                     Frequency Deviation: 50 kHz<br/>                     Level: 1.0 Vp-p ±30% (AC)<br/>                     Waveform: Square wave or Sine wave<br/>                     Duty: 50 ±10%<br/>                     Connector: BNC, Termination: 50Ω/GND</p>  |                       |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| Trigger Output                       | <p>Available from 800 MHz to 12.5 GHz of Center frequency (fc)<br/>                     Frequency: 1/64 (800 MHz &lt; fc ≤ 6.4 GHz), 1/1 or 1/64 selectable (6.4 GHz &lt; fc ≤ 12.5 GHz)<br/>                     Level: 0.4 Vp-p to 1.1 Vp-p (AC)<br/>                     Connector: SMA (f), Termination: 50Ω/GND</p>  |                       |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| Internal Jitter Function             | <p>Modulation Frequency Range</p> <table border="1"> <thead> <tr> <th>Center Frequency (fc)</th> <th>fm1</th> <th>fm2</th> <th>fm3</th> </tr> </thead> <tbody> <tr> <td>0.1 GHz to 0.8 GHz</td> <td>13.75 Hz</td> <td>250 kHz</td> <td>5 MHz</td> </tr> <tr> <td>0.8 GHz to 1.6 GHz</td> <td>27.5 Hz</td> <td>500 kHz</td> <td>10 MHz</td> </tr> <tr> <td>1.6 GHz to 3.2 GHz</td> <td>55 Hz</td> <td>1 MHz</td> <td>20 MHz</td> </tr> <tr> <td>3.2 GHz to 6.4 GHz</td> <td>110 Hz</td> <td>2 MHz</td> <td>40 MHz</td> </tr> <tr> <td>6.4 GHz to 12.5 GHz</td> <td>220 Hz</td> <td>4 MHz</td> <td>80 MHz</td> </tr> </tbody> </table> <p>Modulation Frequency Accuracy: ±100 ppm<br/>                     Jitter Amplitude Accuracy:<br/>                     ±0.01 UI ±Q% (0.001 UIp-p to 2.19 UIp-p, fc &lt; 1 GHz)<br/>                     ±0.02 UI ±Q% (0.001 UIp-p to 2.19 UIp-p, fc ≥ 1 GHz)<br/>                     ±0.2 UI ±Q% (2.2 UIp-p to 21.99 UIp-p)<br/>                     ±2 UI ±Q% (22 UIp-p to 4000 UIp-p)</p> <table border="1"> <thead> <tr> <th>FM</th> <th>Q</th> </tr> </thead> <tbody> <tr> <td>9 Hz ≤ fm ≤ 500 kHz</td> <td>7</td> </tr> <tr> <td>500 kHz &lt; fm ≤ 2 MHz</td> <td>12</td> </tr> <tr> <td>2 MHz &lt; fm ≤ 80 MHz</td> <td>15</td> </tr> </tbody> </table> <p>Jitter Mask</p>   | Center Frequency (fc) | fm1             | fm2              | fm3                | 0.1 GHz to 0.8 GHz | 13.75 Hz     | 250 kHz            | 5 MHz             | 0.8 GHz to 1.6 GHz | 27.5 Hz         | 500 kHz            | 10 MHz            | 1.6 GHz to 3.2 GHz | 55 Hz            | 1 MHz               | 20 MHz          | 3.2 GHz to 6.4 GHz | 110 Hz               | 2 MHz             | 40 MHz       | 6.4 GHz to 12.5 GHz | 220 Hz       | 4 MHz | 80 MHz | FM | Q | 9 Hz ≤ fm ≤ 500 kHz | 7 | 500 kHz < fm ≤ 2 MHz | 12 | 2 MHz < fm ≤ 80 MHz | 15 |
| Center Frequency (fc)                | fm1   | fm2                   | fm3             |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 0.1 GHz to 0.8 GHz                   | 13.75 Hz  | 250 kHz               | 5 MHz           |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 0.8 GHz to 1.6 GHz                   | 27.5 Hz   | 500 kHz               | 10 MHz          |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 1.6 GHz to 3.2 GHz                   | 55 Hz   | 1 MHz                 | 20 MHz          |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 3.2 GHz to 6.4 GHz                   | 110 Hz  | 2 MHz                 | 40 MHz          |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 6.4 GHz to 12.5 GHz                  | 220 Hz  | 4 MHz                 | 80 MHz          |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| FM                                   | Q   |                       |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 9 Hz ≤ fm ≤ 500 kHz                  | 7   |                       |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 500 kHz < fm ≤ 2 MHz                 | 12  |                       |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 2 MHz < fm ≤ 80 MHz                  | 15  |                       |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| External Jitter Function             | <p>Modulation Frequency Range: 9 Hz to 5 MHz (0.1 GHz ≤ fc ≤ 0.4 GHz)<br/>                     9 Hz to 10 MHz (0.4 GHz &lt; fc ≤ 0.65 GHz)<br/>                     9 Hz to 20 MHz (0.65 GHz &lt; fc ≤ 1.4 GHz)<br/>                     9 Hz to 100 MHz (1.4 GHz &lt; fc ≤ 2.4 GHz)<br/>                     9 Hz to 500 MHz (2.4 GHz &lt; fc ≤ 4.0 GHz)<br/>                     9 Hz to 1 GHz (4.0 GHz &lt; fc ≤ 12.5 GHz)</p> <p>UI Range: 0.22, 2.0, 20, 200, 4000 UI</p> <p>Modulation Frequency Range</p> <table border="1"> <thead> <tr> <th>Center Frequency</th> <th>Input Frequency</th> <th>Jitter Amplitude</th> </tr> </thead> <tbody> <tr> <td>1.4 GHz to 2.4 GHz</td> <td>80 MHz to 100 MHz</td> <td rowspan="3">Max. 0.22 UI</td> </tr> <tr> <td>2.4 GHz to 4.0 GHz</td> <td>80 MHz to 500 MHz</td> </tr> <tr> <td>4.0 GHz to 8.0 GHz</td> <td>80 MHz to 1 GHz</td> </tr> <tr> <td rowspan="2">8.0 GHz to 8.5 GHz</td> <td>80 MHz to 500 MHz</td> <td rowspan="2">Max. 0.10 UI</td> </tr> <tr> <td>500 MHz to 1 GHz</td> </tr> <tr> <td>8.5 GHz to 11.3 GHz</td> <td>80 MHz to 1 GHz</td> <td>Max. 0.22 UI</td> </tr> <tr> <td rowspan="2">11.3 GHz to 12.5 GHz</td> <td>80 MHz to 250 MHz</td> <td>Max. 0.22 UI</td> </tr> <tr> <td>250 MHz to 1 GHz</td> <td>Max. 0.10 UI</td> </tr> </tbody> </table> | Center Frequency      | Input Frequency | Jitter Amplitude | 1.4 GHz to 2.4 GHz | 80 MHz to 100 MHz  | Max. 0.22 UI | 2.4 GHz to 4.0 GHz | 80 MHz to 500 MHz | 4.0 GHz to 8.0 GHz | 80 MHz to 1 GHz | 8.0 GHz to 8.5 GHz | 80 MHz to 500 MHz | Max. 0.10 UI       | 500 MHz to 1 GHz | 8.5 GHz to 11.3 GHz | 80 MHz to 1 GHz | Max. 0.22 UI       | 11.3 GHz to 12.5 GHz | 80 MHz to 250 MHz | Max. 0.22 UI | 250 MHz to 1 GHz    | Max. 0.10 UI |       |        |    |   |                     |   |                      |    |                     |    |
| Center Frequency                     | Input Frequency   | Jitter Amplitude      |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 1.4 GHz to 2.4 GHz                   | 80 MHz to 100 MHz   | Max. 0.22 UI          |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 2.4 GHz to 4.0 GHz                   | 80 MHz to 500 MHz   |                       |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 4.0 GHz to 8.0 GHz                   | 80 MHz to 1 GHz   |                       |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 8.0 GHz to 8.5 GHz                   | 80 MHz to 500 MHz   | Max. 0.10 UI          |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
|                                      | 500 MHz to 1 GHz  |                       |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 8.5 GHz to 11.3 GHz                  | 80 MHz to 1 GHz   | Max. 0.22 UI          |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
| 11.3 GHz to 12.5 GHz                 | 80 MHz to 250 MHz   | Max. 0.22 UI          |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |
|                                      | 250 MHz to 1 GHz  | Max. 0.10 UI          |                 |                  |                    |                    |              |                    |                   |                    |                 |                    |                   |                    |                  |                     |                 |                    |                      |                   |              |                     |              |       |        |    |   |                     |   |                      |    |                     |    |

# Jitter Modulation Source MU181000B-001 Specifications

|   |   |                 |                         |                         |
|---|---|-----------------|-------------------------|-------------------------|
| External Jitter Function                      | Modulation Sensitivity: 0.22 UI Range, Input level: 0.5 Vp-p  |                 |                         |                         |
|   | Output Clock Frequency  | FM Frequency    | Input Frequency         | Jitter Amplitude        |
|   | 0.1 GHz $\leq$ fc $\leq$ 12.5 GHz   | 4 MHz           | 9 Hz to 4 MHz           | 0.1 Ulp-p $\pm$ 0.03 UI |
|   |   | 80 MHz          | 4 MHz to 80 MHz         |                         |
|   |   | 500 MHz         | 80 MHz to 500 MHz       |                         |
|   | 2.4 GHz < fc $\leq$ 12.5 GHz  | 1 GHz           | 500 MHz to 1 GHz        |                         |
|   | Modulation Sensitivity: 2, 20, 200, 4000 UI Range, Input level: 0.5 Vp-p  |                 |                         |                         |
|   | Clock Frequency: 0.1 GHz $\leq$ fc $\leq$ 0.8 GHz   |                 |                         |                         |
|   | Jitter Amplitude Category   | FM Frequency    | Input Frequency         | Jitter Amplitude        |
|   | 2 UI  | 250 kHz         | 27.5 kHz                | 1 Ulp-p $\pm$ 0.3 UI    |
|   | 20 UI   | 27.5 kHz        | 2.75 kHz                | 10 Ulp-p $\pm$ 3 UI     |
|   | 200 UI  | 2.75 kHz        | 275 Hz                  | 100 Ulp-p $\pm$ 30 UI   |
|   | 4000 UI   | 275 Hz          | 13.75 Hz                | 1000 Ulp-p $\pm$ 300 UI |
|   | Clock Frequency: 0.8 GHz < fc $\leq$ 1.6 GHz  |                 |                         |                         |
|   | Jitter Amplitude Category   | FM Frequency    | Input Frequency         | Jitter Amplitude        |
| 2 UI  | 500 kHz   | 55 kHz          | 1 Ulp-p $\pm$ 0.3 UI    |                         |
| 20 UI   | 55 kHz  | 5.5 kHz         | 10 Ulp-p $\pm$ 3 UI     |                         |
| 200 UI  | 5.5 kHz   | 550 Hz          | 100 Ulp-p $\pm$ 30 UI   |                         |
| 4000 UI                                       | 550 Hz  | 27.5 Hz         | 1000 Ulp-p $\pm$ 300 UI |                         |
| Clock Frequency: 1.6 GHz < fc $\leq$ 3.2 GHz  |   |                 |                         |                         |
| Jitter Amplitude Category                     | FM Frequency  | Input Frequency | Jitter Amplitude        |                         |
| 2 UI  | 1 MHz   | 110 kHz         | 1 Ulp-p $\pm$ 0.3 UI    |                         |
| 20 UI   | 110 kHz   | 11 kHz          | 10 Ulp-p $\pm$ 3 UI     |                         |
| 200 UI  | 11 kHz  | 1.1 kHz         | 100 Ulp-p $\pm$ 30 UI   |                         |
| 4000 UI                                       | 1.1 kHz   | 55 Hz           | 1000 Ulp-p $\pm$ 300 UI |                         |
| Clock Frequency: 3.2 GHz < fc $\leq$ 6.4 GHz  |   |                 |                         |                         |
| Jitter Amplitude Category                     | FM Frequency  | Input Frequency | Jitter Amplitude        |                         |
| 2 UI  | 2 MHz   | 220 kHz         | 1 Ulp-p $\pm$ 0.3 UI    |                         |
| 20 UI   | 220 kHz   | 22 kHz          | 10 Ulp-p $\pm$ 3 UI     |                         |
| 200 UI  | 22 kHz  | 2.2 kHz         | 100 Ulp-p $\pm$ 30 UI   |                         |
| 4000 UI                                       | 2.2 kHz   | 110 Hz          | 1000 Ulp-p $\pm$ 300 UI |                         |
| Clock Frequency: 6.4 GHz < fc $\leq$ 12.5 GHz |   |                 |                         |                         |
| Jitter Amplitude Category                     | FM Frequency  | Input Frequency | Jitter Amplitude        |                         |
| 2 UI  | 4 MHz   | 440 kHz         | 1 Ulp-p $\pm$ 0.3 UI    |                         |
| 20 UI   | 440 kHz   | 44 kHz          | 10 Ulp-p $\pm$ 3 UI     |                         |
| 200 UI  | 44 kHz  | 4.4 kHz         | 100 Ulp-p $\pm$ 30 UI   |                         |
| 4000 UI                                       | 4.4 kHz   | 220 Hz          | 1000 Ulp-p $\pm$ 300 UI |                         |
| Jitter Mask                                   |   |                 |                         |                         |
|   |   |                 |                         |                         |
| Triangle Wave Modulation                      | PCIe-Gen I (2.5 GHz) or PCIe-Gen II (5 GHz)<br>Clock Output Frequency Setting: Spread Method Center/Spread Method Down selectable<br>Frequency Offset: -1000 ppm to +1000 ppm, Steps: 1 ppm<br>Modulation Frequency Accuracy: 31.25 kHz $\pm$ 1000 ppm<br>Frequency Deviation: $\pm$ 6.25 MHz (PCIe-Gen I, 2.5 GHz), $\pm$ 12.5 MHz (PCIe-Gen II, 5 GHz)<br>Deviation Accuracy: $\pm$ 10% |                 |                         |                         |

# SSC Extension MU181000B-002 Specifications

|                                      |  |
|--------------------------------------|--|
| 100 MHz Reference Signal Input (SSC) | Outputs either 100 MHz with phase deviation x25, x50, or x80 frequency-multiplied clock from Clock Output connector<br>Supports PCI Express Host RefClk input<br>Modulation Frequency: 30 kHz to 33 kHz<br>Frequency Deviation: 500 kHzp-p max.<br>Level: 0.15 Vp-p to 1.3 Vp-p (AC)<br>Waveform: Square wave or Sine wave<br>Duty: 50 $\pm$ 10%<br>Connector: BNC |
|--------------------------------------|--|

## Jitter Modulation Source MU181500B Specifications

|                        |   |
|------------------------|---|
| External Clock Input   | <p>Number of Input: 1</p> <p>Frequency Range: 6.400 001 GHz to 12.500 000 GHz (MU181000B, Combination: On)<br/>0.800 000 GHz to 15.000 000 GHz (MU181000B, Combination: Off, or External synthesizer)</p> <p>Amplitude: 0.4 Vp-p to 1.0 Vp-p</p> <p>Connector: SMA (f), Termination: 50Ω/AC Coupling</p>  |
| External Jitter Input  | <p>Number of Input: 1</p> <p>Frequency Range: 10 kHz to 1 GHz</p> <p>Amplitude: 0 to 2.0 Vp-p</p> <p>Connector: SMA (f), Termination: 50Ω/GND</p>   |
| Jittered Clock Output  | <p>Number of Output: 2</p> <p>Frequency Range: 0.800 001 GHz to 1.562 500 GHz (MU181000B, Combination: On), Steps: 0.000 001 GHz<br/>1.600 001 GHz to 3.125 000 GHz (MU181000B, Combination: On), Steps: 0.000 001 GHz<br/>3.200 001 GHz to 6.250 000 GHz (MU181000B, Combination: On), Steps: 0.000 001 GHz<br/>6.400 001 GHz to 12.500 000 GHz (MU181000B, Combination: On), Steps: 0.000 001 GHz<br/>12.800 002 GHz to 15.000 000 GHz (MU181000B, Combination: On), Steps: 0.000 002 GHz<br/>0.8 GHz to 15 GHz (MU181000B, Combination: Off, or External synthesizer)</p> <p>Frequency Offset: 1000 to +1000 ppm (MU181000B, Combination: On), Steps: 1 ppm<br/>None (MU181000B, Combination: Off, or External synthesizer)</p> <p>Amplitude: 0.4 Vp-p (Min.), 1.0 Vp-p (Max.)</p> <p>Intrinsic Jitter: ≤350 fs (4.25, 7.0125, 10, 12.5, 14, 15 GHz)</p> <p>Connector: SMA (f), Termination: 50Ω/AC Coupling</p> |
| IQ Output              | <p>Number of Output: 2 (I, Q)</p> <p>Amplitude: 1 Vp-p (Max.)</p> <p>Connector: SMA (f), Termination: 50Ω/GND</p>   |
| AUX Input              | <p>Number of Input: 1</p> <p>Frequency Range: Same frequency with External Clock Input</p> <p>Amplitude: 0.4 Vp-p (Min.), 1.1 Vp-p (Max.)</p> <p>Connector: SMA (f), Termination: 50Ω/AC Coupling</p>   |
| Reference Clock Output | <p>Number of Output: 2</p> <p>Reference Clock: External Clock Input or AUX Input (MU181000B, Combination: On)<br/>External Clock Input (MU181000B, Combination: Off, or External synthesizer)</p> <p>Frequency Range: 1/N of Jittered Clock Output Frequency (N: 1, 2, or 4)</p> <p>Amplitude: 0.4 Vp-p (Min.), 1.0 Vp-p (Max.) (Jittered Clock Output Frequency: ≥4 GHz)<br/>0.4 Vp-p (Min.), 1.2 Vp-p (Max.) (Jittered Clock Output Frequency: &lt;4 GHz)</p> <p>Connector: SMA (f), Termination: 50Ω/AC Coupling</p>   |
| Sub-rate Clock Output  | <p>Number of Output: 2 (Differential)</p> <p>Frequency Range: 1/N of Jittered Clock Output Frequency (N: 8 to 256, Steps: 1)</p> <p>Amplitude: 0.1 Vp-p to 0.7 Vp-p, Steps: 10 mV</p> <p>Accuracy: ±70 mV ±20% of Amplitude (N: 8)</p> <p>Connector: SMA (f), Termination: 50Ω/AC Coupling</p>  |



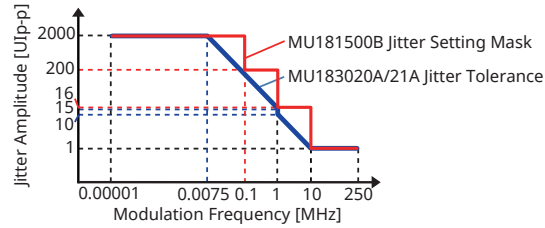
# Jitter Modulation Source MU181500B Specifications

Internal Sinusoidal Jitter (SJ1)

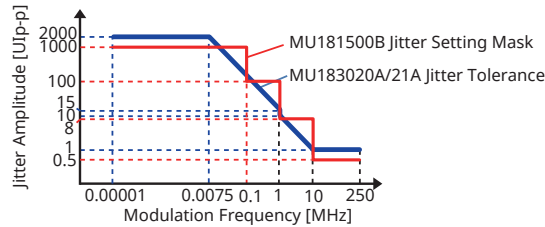
32G PPG

Full rate Clock Out setting, Bit-rate: 15 Gbit/s to 32.1 Gbit/s

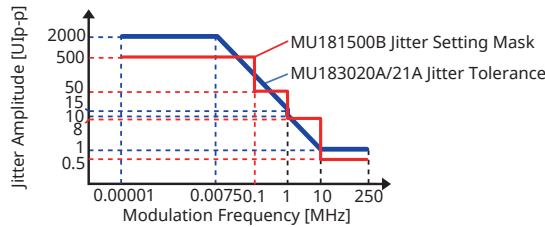
Half rate Clock Out setting, Bit-rate: 2.4 Gbit/s to 32.1 Gbit/s



Full rate Clock Out setting, Bit-rate: 4 Gbit/s to 15 Gbit/s



Full rate Clock Out setting, Bit-rate: 2.4 Gbit/s to 4 Gbit/s



32G PPG (Full rate Clock Out, Bit-rate: 4 Gbit/s to 15 Gbit/s)

- 0 to 1000 Ulp-p (FM: 10 Hz to 100 kHz), Steps: 0.001 UI
- 0 to 100 Ulp-p (FM: 100.1 kHz to 1 MHz), Steps: 0.001 UI
- 0 to 8 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.001 UI
- 0 to 0.5 Ulp-p (FM: 10.01 MHz to 250 MHz), Steps: 0.001 UI

32G PPG (Full rate Clock Out, Bit-rate: 2.4 Gbit/s to 4 Gbit/s)

- 0 to 500 Ulp-p (FM: 10 Hz to 100 kHz), Steps: 0.001 UI
- 0 to 50 Ulp-p (FM: 100.1 kHz to 1 MHz), Steps: 0.001 UI
- 0 to 8 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.001 UI
- 0 to 0.5 Ulp-p (FM: 10.01 MHz to 250 MHz), Steps: 0.001 UI

32G PPG (Full rate Clock Out, Bit-rate: 15 Gbit/s to 30 Gbit/s, Half rate Clock Out, Bit-rate: 2.4 Gbit/s to 30 Gbit/s)

- 0 to 2000 Ulp-p (FM: 10 Hz to 100 kHz), Steps: 0.002 UI
- 0 to 50 Ulp-p (FM: 100.1 kHz to 1 MHz), Steps: 0.002 UI
- 0 to 8 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.002 UI
- 0 to 0.5 Ulp-p (FM: 10.01 MHz to 250 MHz), Steps: 0.002 UI

32G PPG (Full rate Clock Out, Half rate Clock Out, Bit-rate: 30 Gbit/s to 32.1 Gbit/s)

- 0 to 2000 Ulp-p (FM: 10 Hz to 100 kHz), Steps: 0.004 UI
- 0 to 200 Ulp-p (FM: 100.1 kHz to 1 MHz), Steps: 0.004 UI
- 0 to 16 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.004 UI
- 0 to 1 Ulp-p (FM: 10.01 MHz to 250 MHz), Steps: 0.004 UI

Accuracy:  $\pm 0.03$  UI  $\pm Q\%$  (Amplitude: 0.001 Ulp-p to 2.199 Ulp-p)

$\pm 0.2$  UI  $\pm Q\%$  (Amplitude: 2.2 Ulp-p to 21.999 Ulp-p)

$\pm 2$  UI  $\pm Q\%$  (Amplitude: 22 Ulp-p to 219.999 Ulp-p)

$\pm 20$  UI  $\pm Q\%$  (Amplitude: 220 Ulp-p to 2000 Ulp-p)

| FW                   | Q  |
|----------------------|----|
| 10Hz to 500 kHz      | 7  |
| 500.1 kHz to 2 MHz   | 10 |
| 2.01 MHz to 80 MHz   | 13 |
| 80.01 MHz to 250 MHz | 15 |

On/Off Function: supported

# Jitter Modulation Source MU181500B Specifications

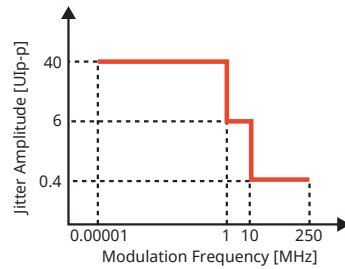
External Sinusoidal Jitter (SJ2)  
[MU181000B-001]

## Jitter Setting Mask

Jittered Clock Output Frequency: 6.400 001 GHz to 15 GHz

Full Rate Mode

Bit-rate: 6.400 001 Gbit/s to 15 Gbit/s

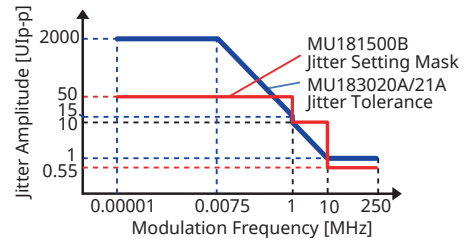


Half Rate Mode

Bit-rate: 12.800 001 Gbit/s to 30 Gbit/s

Quarter Rate Mode

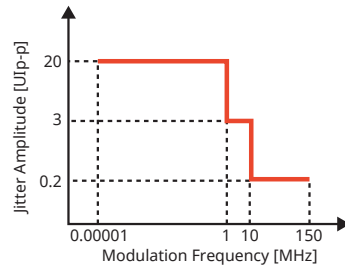
Bit-rate: 25.600 004 Gbit/s to 32.1 Gbit/s



Jittered Clock Output Frequency: 3.200 001 GHz to 6.25 GHz

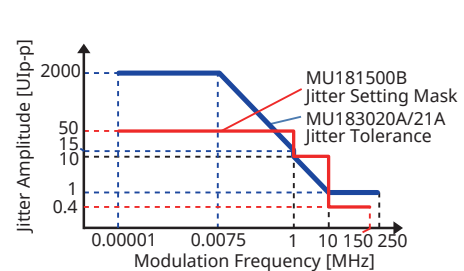
Full Rate Mode

Bit-rate: 3.200 001 Gbit/s to 6.25 Gbit/s



Half Rate Mode

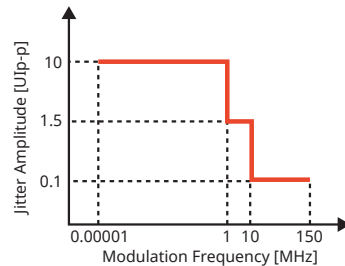
Bit-rate: 8 Gbit/s to 12.5 Gbit/s



Jittered Clock Output Frequency: 1.800 001 GHz to 3.125 GHz

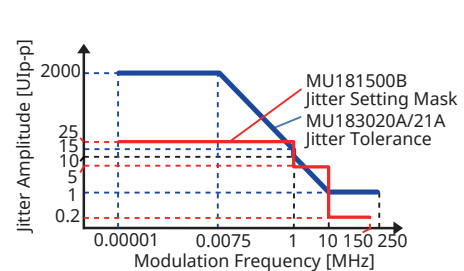
Full Rate Mode

Bit-rate: 1.800 001 Gbit/s to 3.125 Gbit/s



Half Rate Mode

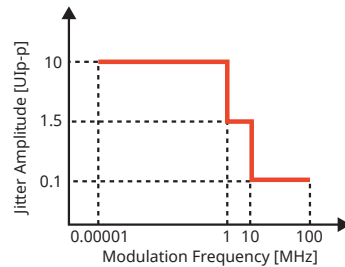
Bit-rate: 3.600 002 Gbit/s to 6.25 Gbit/s



Jittered Clock Output Frequency: 1.600 001 GHz to 1.8 GHz

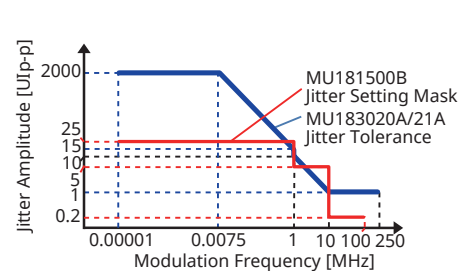
Full Rate Mode

Bit-rate: 1.600 001 Gbit/s to 1.8 Gbit/s



Half Rate Mode

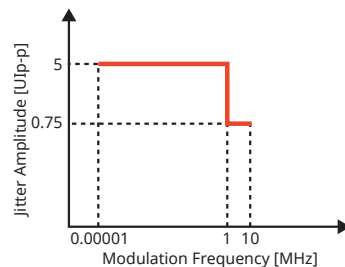
Bit-rate: 3.200 002 Gbit/s to 3.6 Gbit/s



Jittered Clock Output Frequency: 0.800 001 GHz to 1.562 5 GHz

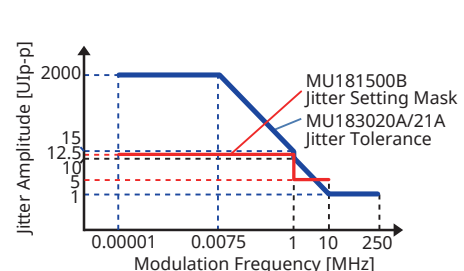
Full Rate Mode

Bit-rate: 0.800 001 Gbit/s to 1.562 5 Gbit/s



Half Rate Mode

Bit-rate: 1.600 002 Gbit/s to 3.125 Gbit/s



# Jitter Modulation Source MU181500B Specifications

| <p>External Sinusoidal Jitter (SJ2)<br/>[MU181000B-001]</p> | <p>Modulation Frequency (FM): 10 Hz to 10 kHz, Steps: 1 Hz<br/>           10 kHz to 100 kHz, Steps: 10 Hz<br/>           100 kHz to 1 MHz, Steps: 100 Hz<br/>           1 MHz to 10 MHz, Steps: 1 kHz<br/>           10 MHz to 100 MHz, Steps: 10 kHz<br/>           100 MHz to 250 MHz, Steps: 100 kHz</p> <p>Accuracy: <math>\pm 100</math> ppm<br/>           Amplitude:<br/>           Full Rate Mode<br/>           Bit-rate: 6.400 001 Gbit/s to 15 Gbit/s<br/>           0 to 40 Ulp-p (FM: 10 Hz to 1 MHz), Steps: 0.001 UI<br/>           0 to 6 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.001 UI<br/>           0 to 0.4 Ulp-p (FM: 10.01 MHz to 250 MHz), Steps: 0.001 UI<br/>           Bit-rate: 3.200 001 Gbit/s to 6.25 Gbit/s<br/>           0 to 20 Ulp-p (FM: 10 Hz to 1 MHz), Steps: 0.001 UI<br/>           0 to 3 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.001 UI<br/>           0 to 0.2 Ulp-p (FM: 10.01 MHz to 150 MHz), Steps: 0.001 UI<br/>           Bit-rate: 1.800 001 Gbit/s to 3.125 Gbit/s<br/>           0 to 10 Ulp-p (FM: 10 Hz to 1 MHz), Steps: 0.001 UI<br/>           0 to 1.5 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.001 UI<br/>           0 to 0.1 Ulp-p (FM: 10.01 MHz to 150 MHz), Steps: 0.001 UI<br/>           Bit-rate: 1.600 001 Gbit/s to 1.8 Gbit/s<br/>           0 to 10 Ulp-p (FM: 10 Hz to 1 MHz), Steps: 0.001 UI<br/>           0 to 1.5 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.001 UI<br/>           0 to 0.1 Ulp-p (FM: 10.01 MHz to 100 MHz), Steps: 0.001 UI<br/>           Bit-rate: 0.800 001 Gbit/s to 1.562 5 Gbit/s<br/>           0 to 5 Ulp-p (FM: 10 Hz to 1 MHz), Steps: 0.001 UI<br/>           0 to 0.75 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.001 UI</p> <p>Half Rate Mode<br/>           Bit-rate: 12.800 001 Gbit/s to 30 Gbit/s<br/>           0 to 50 Ulp-p (FM: 10 Hz to 1 MHz), Steps: 0.2 UI<br/>           0 to 10 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.02 UI<br/>           0 to 0.55 Ulp-p (FM: 10.01 MHz to 250 MHz), Steps: 0.002 UI<br/>           Bit-rate: 8 Gbit/s to 12.5 Gbit/s<br/>           0 to 50 Ulp-p (FM: 10 Hz to 1 MHz), Steps: 0.2 UI<br/>           0 to 10 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.02 UI<br/>           0 to 0.4 Ulp-p (FM: 10.01 MHz to 150 MHz), Steps: 0.002 UI<br/>           Bit-rate: 3.600 002 Gbit/s to 6.25 Gbit/s<br/>           0 to 25 Ulp-p (FM: 10 Hz to 1 MHz), Steps: 0.2 UI<br/>           0 to 5 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.02 UI<br/>           0 to 0.2 Ulp-p (FM: 10.01 MHz to 150 MHz), Steps: 0.002 UI<br/>           Bit-rate: 3.200 002 Gbit/s to 3.6 Gbit/s<br/>           0 to 25 Ulp-p (FM: 10 Hz to 1 MHz), Steps: 0.2 UI<br/>           0 to 5 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.02 UI<br/>           0 to 0.2 Ulp-p (FM: 10.01 MHz to 100 MHz), Steps: 0.002 UI<br/>           Bit-rate: 1.600 002 Gbit/s to 3.125 Gbit/s<br/>           0 to 12.5 Ulp-p (FM: 10 Hz to 1 MHz), Steps: 0.2 UI<br/>           0 to 2.5 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.02 UI</p> <p>Quarter Rate Mode<br/>           Bit-rate: 25.600 004 Gbit/s to 32.1 Gbit/s<br/>           0 to 50 Ulp-p (FM: 10 Hz to 1 MHz), Steps: 0.004 UI<br/>           0 to 10 Ulp-p (FM: 1.001 MHz to 10 MHz), Steps: 0.004 UI<br/>           0 to 0.548 Ulp-p (FM: 10.01 MHz to 250 MHz), Steps: 0.004 UI</p> <p>Accuracy: <math>\pm 0.03</math> UI <math>\pm Q\%</math> (Amplitude: 0.002 Ulp-p to 2.19 Ulp-p)<br/> <math>\pm 0.2</math> UI <math>\pm Q\%</math> (Amplitude: 2.2 Ulp-p to 21.9 Ulp-p)<br/> <math>\pm 2</math> UI <math>\pm Q\%</math> (Amplitude: 22 Ulp-p to 50 Ulp-p)</p> <table border="1"> <thead> <tr> <th>FW</th> <th>Q</th> </tr> </thead> <tbody> <tr> <td>10 Hz <math>\leq</math> fm <math>\leq</math> 500 kHz</td> <td>10</td> </tr> <tr> <td>500 kHz &lt; fm <math>\leq</math> 2 MHz</td> <td>13</td> </tr> <tr> <td>2 MHz &lt; fm <math>\leq</math> 80 MHz</td> <td>15</td> </tr> <tr> <td>80 MHz &lt; fm <math>\leq</math> 250 MHz</td> <td>18</td> </tr> </tbody> </table> <p>On/Off Function: Supported</p> | FW | Q | 10 Hz $\leq$ fm $\leq$ 500 kHz | 10 | 500 kHz < fm $\leq$ 2 MHz | 13 | 2 MHz < fm $\leq$ 80 MHz | 15 | 80 MHz < fm $\leq$ 250 MHz | 18 |
|---|---|----|---|--------------------------------|----|---------------------------|----|--------------------------|----|----------------------------|----|
| FW  | Q   |    |   |                                |    |                           |    |                          |    |                            |    |
| 10 Hz $\leq$ fm $\leq$ 500 kHz                              | 10  |    |   |                                |    |                           |    |                          |    |                            |    |
| 500 kHz < fm $\leq$ 2 MHz                                   | 13  |    |   |                                |    |                           |    |                          |    |                            |    |
| 2 MHz < fm $\leq$ 80 MHz                                    | 15  |    |   |                                |    |                           |    |                          |    |                            |    |
| 80 MHz < fm $\leq$ 250 MHz                                  | 18  |    |   |                                |    |                           |    |                          |    |                            |    |
| <p>Spread Spectrum Clocking (SSC)</p>                       | <p>SSC Profile: Triangular, USB4, Variable<br/>           Type: Down-Spread, Center-Spread, Up-Spread, Asymmetric<br/>           Modulation Frequency: 28 kHz to 37 kHz, Steps: 1 Hz<br/>           Accuracy: <math>\pm 100</math> ppm<br/>           Deviation: 0 to 7000 ppm, Steps: 1 ppm<br/>           Modulation<br/>           Periodic Burst: Repeatedly outputs Asymmetric SSC<br/>           Continuous: Outputs Triangular waveform after single Asymmetric SSC output<br/>           On/Off Function: Supported</p>   |    |   |                                |    |                           |    |                          |    |                            |    |

# Jitter Modulation Source MU181500B Specifications

| <p>Random Jitter (RJ)</p>                | <p>Bandwidth: 10 kHz to 1 GHz<br/>           Crest Factor: 16 dB<br/>           Filter Type<br/>           User Filter<br/>           Filter: 10 MHz, 20 MHz, Through (HPF 3 dB bandwidth)<br/>           100 MHz, Through (LPF 3 dB bandwidth)<br/>           Amplitude<br/>           Full Rate Mode</p> <table border="1"> <thead> <tr> <th>Jittered Clock Output Frequency [ GHz]</th> <th>Setting Range [UIp-p]</th> <th>Steps [mUI]</th> </tr> </thead> <tbody> <tr> <td>≥2.5</td> <td>0 to 0.5</td> <td>2</td> </tr> <tr> <td>&lt;2.5</td> <td>0 to 0.2f</td> <td>2</td> </tr> </tbody> </table> <p>Half Rate Mode*1</p> <table border="1"> <thead> <tr> <th>Jittered Clock Output Frequency [ GHz]</th> <th>Setting Range [UIp-p]</th> <th>Steps [mUI]</th> </tr> </thead> <tbody> <tr> <td>≥2.5</td> <td>0 to 0.5</td> <td>4</td> </tr> <tr> <td>&lt;2.5</td> <td>0 to 0.2f</td> <td>4</td> </tr> </tbody> </table> <p>Quarter Rate Mode</p> <table border="1"> <thead> <tr> <th>Jittered Clock Output Frequency [ GHz]</th> <th>Setting Range [UIp-p]</th> <th>Steps [mUI]</th> </tr> </thead> <tbody> <tr> <td>≥2.5</td> <td>0 to 0.496</td> <td>8</td> </tr> <tr> <td>&lt;2.5</td> <td>0 to 2f</td> <td>8</td> </tr> </tbody> </table> <p>f: Jittered Clock Output Frequency [ GHz]<br/>           Accuracy: ±4.9 ps ±15% (Jittered Clock Output Frequency: ≥4 GHz)<br/>           ±7.0 ps ±15% (Jittered Clock Output Frequency: &lt;4 GHz)<br/>           PCIe (Data clocked) or PCIe (Common Ref. clock) Filter<br/>           Filter: LF (10 kHz to 1.5 MHz) or HF (1.5 MHz to 100 MHz) for PCIe<br/>           Amplitude<br/>           Full Rate Mode</p> <table border="1"> <thead> <tr> <th>Jittered Clock Output Frequency [ GHz]</th> <th>LF and HF Setting Range [ps rms]</th> <th>Steps [ps rms]</th> </tr> </thead> <tbody> <tr> <td>≥4</td> <td>0 to 8.8</td> <td>0.1</td> </tr> </tbody> </table> <p>Half Rate Mode</p> <table border="1"> <thead> <tr> <th>Jittered Clock Output Frequency [ GHz]</th> <th>LF and HF Setting Range [ps rms]</th> <th>Steps [ps rms]</th> </tr> </thead> <tbody> <tr> <td>≥4</td> <td>0 to 8.8</td> <td>0.2</td> </tr> </tbody> </table> <p>Quarter Rate Mode</p> <table border="1"> <thead> <tr> <th>Jittered Clock Output Frequency [ GHz]</th> <th>LF and HF Setting Range [ps rms]</th> <th>Steps [ps rms]</th> </tr> </thead> <tbody> <tr> <td>≥4</td> <td>0 to 8.8</td> <td>0.4</td> </tr> </tbody> </table> <p>LF Amplitude ≥ HF Amplitude<br/>           Accuracy: ±0.6 ps ±10%<br/>           On/Off Function: Supported</p> | Jittered Clock Output Frequency [ GHz] | Setting Range [UIp-p] | Steps [mUI] | ≥2.5 | 0 to 0.5 | 2 | <2.5 | 0 to 0.2f | 2 | Jittered Clock Output Frequency [ GHz] | Setting Range [UIp-p] | Steps [mUI] | ≥2.5 | 0 to 0.5 | 4 | <2.5 | 0 to 0.2f | 4 | Jittered Clock Output Frequency [ GHz] | Setting Range [UIp-p] | Steps [mUI] | ≥2.5 | 0 to 0.496 | 8 | <2.5 | 0 to 2f | 8 | Jittered Clock Output Frequency [ GHz] | LF and HF Setting Range [ps rms] | Steps [ps rms] | ≥4 | 0 to 8.8 | 0.1 | Jittered Clock Output Frequency [ GHz] | LF and HF Setting Range [ps rms] | Steps [ps rms] | ≥4 | 0 to 8.8 | 0.2 | Jittered Clock Output Frequency [ GHz] | LF and HF Setting Range [ps rms] | Steps [ps rms] | ≥4 | 0 to 8.8 | 0.4 |
|--|--|--|-----------------------|-------------|------|----------|---|------|-----------|---|--|-----------------------|-------------|------|----------|---|------|-----------|---|--|-----------------------|-------------|------|------------|---|------|---------|---|--|----------------------------------|----------------|----|----------|-----|--|----------------------------------|----------------|----|----------|-----|--|----------------------------------|----------------|----|----------|-----|
| Jittered Clock Output Frequency [ GHz]   | Setting Range [UIp-p]  | Steps [mUI]                            |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| ≥2.5                                     | 0 to 0.5   | 2                                      |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| <2.5                                     | 0 to 0.2f  | 2                                      |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| Jittered Clock Output Frequency [ GHz]   | Setting Range [UIp-p]  | Steps [mUI]                            |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| ≥2.5                                     | 0 to 0.5   | 4                                      |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| <2.5                                     | 0 to 0.2f  | 4                                      |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| Jittered Clock Output Frequency [ GHz]   | Setting Range [UIp-p]  | Steps [mUI]                            |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| ≥2.5                                     | 0 to 0.496   | 8                                      |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| <2.5                                     | 0 to 2f  | 8                                      |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| Jittered Clock Output Frequency [ GHz]   | LF and HF Setting Range [ps rms]   | Steps [ps rms]                         |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| ≥4                                       | 0 to 8.8   | 0.1                                    |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| Jittered Clock Output Frequency [ GHz]   | LF and HF Setting Range [ps rms]   | Steps [ps rms]                         |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| ≥4                                       | 0 to 8.8   | 0.2                                    |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| Jittered Clock Output Frequency [ GHz]   | LF and HF Setting Range [ps rms]   | Steps [ps rms]                         |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| ≥4                                       | 0 to 8.8   | 0.4                                    |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| <p>Bounded Uncorrelated Jitter (BUJ)</p> | <p>PRBS Pattern Length: <math>2^n - 1</math> (n = 7, 9, 11, 15, 23, or 31)<br/>           BUJ Rate: 0.1 Gbit/s to 3.2 Gbit/s, Steps: 1 k bit/s<br/>           4.9 Gbit/s to 6.25 Gbit/s, Steps: 1 k bit/s (Jittered Clock Output Frequency: &gt;4 GHz)<br/>           9.8 Gbit/s to 12.5 Gbit/s, Steps: 1 k bit/s (Jittered Clock Output Frequency: &gt;4 GHz)<br/>           Filter Type (LPF 3 dB Bandwidth): 50, 100, 200, 300, 500 MHz, Through (Jittered Clock Output Frequency: &gt;4 GHz)<br/>           50, 100, 200, 300 MHz, Through (Jittered Clock Output Frequency: ≤4 GHz)<br/>           Amplitude:<br/>           Full Rate Mode</p> <table border="1"> <thead> <tr> <th>Jittered Clock Output Frequency [ GHz]</th> <th>Setting Range [UIp-p]</th> <th>Steps [mUI]</th> </tr> </thead> <tbody> <tr> <td>≥2.5</td> <td>0 to 0.5</td> <td>2</td> </tr> <tr> <td>&lt;2.5</td> <td>0 to 0.2f</td> <td>2</td> </tr> </tbody> </table> <p>Half Rate Mode</p> <table border="1"> <thead> <tr> <th>Jittered Clock Output Frequency [ GHz]</th> <th>Setting Range [UIp-p]</th> <th>Steps [mUI]</th> </tr> </thead> <tbody> <tr> <td>≥2.5</td> <td>0 to 0.5</td> <td>4</td> </tr> <tr> <td>&lt;2.5</td> <td>0 to 0.2f</td> <td>4</td> </tr> </tbody> </table> <p>f: Jittered Clock Output Frequency [ GHz]<br/>           Accuracy: ±4.9 ps ±15% (Jittered Clock Output Frequency: ≥4 GHz)<br/>           ±7.0 ps ±15% (Jittered Clock Output Frequency: &lt;4 GHz)<br/>           PRBS Pattern Length: <math>2^n - 1</math> (n = 7, 9)<br/>           BUJ Rate: 6, 5.5, 4.9 Gbit/s, LPF 500 MHz<br/>           BUJ Rate: 3.2 Gbit/s, 3 Gbit/s, LPF 300 MHz<br/>           BUJ Rate: 3.2 Gbit/s, 2 Gbit/s, LPF 200 MHz<br/>           BUJ Rate: 2 Gbit/s, 1.1 Gbit/s, LPF 100 MHz<br/>           On/Off Function: Supported</p>   | Jittered Clock Output Frequency [ GHz] | Setting Range [UIp-p] | Steps [mUI] | ≥2.5 | 0 to 0.5 | 2 | <2.5 | 0 to 0.2f | 2 | Jittered Clock Output Frequency [ GHz] | Setting Range [UIp-p] | Steps [mUI] | ≥2.5 | 0 to 0.5 | 4 | <2.5 | 0 to 0.2f | 4 |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| Jittered Clock Output Frequency [ GHz]   | Setting Range [UIp-p]  | Steps [mUI]                            |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| ≥2.5                                     | 0 to 0.5   | 2                                      |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| <2.5                                     | 0 to 0.2f  | 2                                      |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| Jittered Clock Output Frequency [ GHz]   | Setting Range [UIp-p]  | Steps [mUI]                            |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| ≥2.5                                     | 0 to 0.5   | 4                                      |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| <2.5                                     | 0 to 0.2f  | 4                                      |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |
| <p>External Jitter</p>                   | <p>Bandwidth: 10 kHz to 1 GHz<br/>           Accuracy*1: 0.5 UI ±10% (2 Vp-p)<br/>           Linearity*1: ±6 ps ±10%<br/>           On/Off Function: Supported</p>   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |          |   |      |           |   |  |                       |             |      |            |   |      |         |   |  |                                  |                |    |          |     |  |                                  |                |    |          |     |  |                                  |                |    |          |     |

\*1: Jittered Clock Output Frequency: Specified as 5 GHz, Modulation Frequency: 0.5 GHz, Sinusoidal Jitter

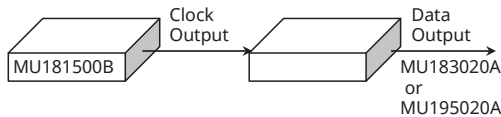
# Jitter Modulation Source MU181500B Specifications

| SJ2 Switching                      | Function for switching built-in SJ2 and MU181000B-001 input  |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
|------------------------------------|--|-----------------|-----------------------|------------------------|--------|------------------------|-----------------|------------------------------------|--------------------------|-----------------------|--------------------------|----------------------|------------------------|--|--|--|----------------------------------|--|-----------------|--|--|-----------------------|-----------|-----------------------|-----------|--------|---------|-------|---------|-------|---------|-----------|-------|----------|-------|---------|------------|-------|-----------|-------|----------------------|------------------------|--|--------------------|--|--|-----------------------|-----------|--------|---------|-------|---------|----------|-------|---------|------------|-------|----------------------|------------------------|--|--|--|-----------------------|--|-----------------------|--|--|-----------------------|-----------|-----------------------|-----------|--------|----------|-------|----------|-------|---------|-----------|-------|--------|-------|---------|------------|-------|---|---|----------------------|------------------------|--|--|--|-----------------------|--|-----------------------|--|--|-----------------------|-----------|-----------------------|-----------|--------|-----------|-------|-----------|-------|---------|----------|-------|----------|-------|---------|-----------|-------|------------|-------|----|---|--------|---|--------------------------------|----|
| Built-in SJ2 <sup>*2, *3, *4</sup> | <p>Modulation Frequency: 33 kHz, 100 MHz, 210 MHz</p> <p>Bandwidth:</p> <table border="1"> <thead> <tr> <th>Clock Frequency</th> <th>Bandwidth</th> </tr> </thead> <tbody> <tr> <td>0.8 GHz &lt; Fc ≤ 1.2 GHz</td> <td>33 kHz</td> </tr> <tr> <td>1.2 GHz &lt; Fc ≤ 8.5 GHz</td> <td>33 kHz, 100 MHz</td> </tr> <tr> <td>4 GHz &lt; Fc ≤ 8.5 GHz<sup>*3</sup></td> <td>33 kHz, 100 MHz, 210 MHz</td> </tr> <tr> <td>8.5 GHz &lt; Fc ≤ 15 GHz</td> <td>33 kHz, 100 MHz, 210 MHz</td> </tr> </tbody> </table> <p>Accuracy: ±100 ppm</p> <p>Amplitude Setting Range:</p> <table border="1"> <thead> <tr> <th rowspan="2">Modulation Frequency</th> <th colspan="4">Data Pattern Generator</th> </tr> <tr> <th colspan="2">Full-rate (PPG), Full-rate (MUX)</th> <th colspan="2">Half-rate (MUX)</th> </tr> <tr> <th></th> <th>Setting Range [Ulp-p]</th> <th>Step [UI]</th> <th>Setting Range [Ulp-p]</th> <th>Step [UI]</th> </tr> </thead> <tbody> <tr> <td>33 kHz</td> <td>0 to 40</td> <td>0.001</td> <td>0 to 50</td> <td>0.002</td> </tr> <tr> <td>100 MHz</td> <td>0 to 0.25</td> <td>0.001</td> <td>0 to 0.5</td> <td>0.002</td> </tr> <tr> <td>210 MHz</td> <td>0 to 0.125</td> <td>0.001</td> <td>0 to 0.25</td> <td>0.002</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th rowspan="2">Modulation Frequency</th> <th colspan="2">Data Pattern Generator</th> </tr> <tr> <th colspan="2">Quarter-rate (MUX)</th> </tr> <tr> <th></th> <th>Setting Range [Ulp-p]</th> <th>Step [UI]</th> </tr> </thead> <tbody> <tr> <td>33 kHz</td> <td>0 to 50</td> <td>0.004</td> </tr> <tr> <td>100 MHz</td> <td>0 to 0.5</td> <td>0.004</td> </tr> <tr> <td>210 MHz</td> <td>0 to 0.248</td> <td>0.004</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th rowspan="2">Modulation Frequency</th> <th colspan="4">Data Pattern Generator</th> </tr> <tr> <th colspan="2">32G PPG<sup>*5</sup></th> <th colspan="2">32G PPG<sup>*6</sup></th> </tr> <tr> <th></th> <th>Setting Range [Ulp-p]</th> <th>Step [UI]</th> <th>Setting Range [Ulp-p]</th> <th>Step [UI]</th> </tr> </thead> <tbody> <tr> <td>33 kHz</td> <td>0 to 500</td> <td>0.001</td> <td>0 to 500</td> <td>0.001</td> </tr> <tr> <td>100 MHz</td> <td>0 to 0.25</td> <td>0.001</td> <td>0 to 8</td> <td>0.001</td> </tr> <tr> <td>210 MHz</td> <td>0 to 0.125</td> <td>0.001</td> <td>—</td> <td>—</td> </tr> </tbody> </table> <table border="1"> <thead> <tr> <th rowspan="2">Modulation Frequency</th> <th colspan="4">Data Pattern Generator</th> </tr> <tr> <th colspan="2">32G PPG<sup>*7</sup></th> <th colspan="2">32G PPG<sup>*8</sup></th> </tr> <tr> <th></th> <th>Setting Range [Ulp-p]</th> <th>Step [UI]</th> <th>Setting Range [Ulp-p]</th> <th>Step [UI]</th> </tr> </thead> <tbody> <tr> <td>33 kHz</td> <td>0 to 1000</td> <td>0.002</td> <td>0 to 1000</td> <td>0.004</td> </tr> <tr> <td>100 MHz</td> <td>0 to 0.5</td> <td>0.002</td> <td>0 to 0.5</td> <td>0.004</td> </tr> <tr> <td>210 MHz</td> <td>0 to 0.25</td> <td>0.002</td> <td>0 to 0.248</td> <td>0.004</td> </tr> </tbody> </table> <p>Accuracy: ±0.03 UI ±Q% (Amplitude: 0.001 Ulp-p to 2.199 Ulp-p)<br/>           ±0.2 UI ±Q% (Amplitude: 2.2 Ulp-p to 21.999 Ulp-p)<br/>           ±2 UI ±Q% (Amplitude: 22 Ulp-p to 219.999 Ulp-p)<br/>           ±20 UI ±Q% (Amplitude: 222 Ulp-p to 2000 Ulp-p)</p> <table border="1"> <thead> <tr> <th>FW</th> <th>Q</th> </tr> </thead> <tbody> <tr> <td>33 kHz</td> <td>7</td> </tr> <tr> <td>100 MHz, 210 MHz<sup>*9</sup></td> <td>15</td> </tr> </tbody> </table> <p>Output Setting: On/Off switching</p> | Clock Frequency | Bandwidth             | 0.8 GHz < Fc ≤ 1.2 GHz | 33 kHz | 1.2 GHz < Fc ≤ 8.5 GHz | 33 kHz, 100 MHz | 4 GHz < Fc ≤ 8.5 GHz <sup>*3</sup> | 33 kHz, 100 MHz, 210 MHz | 8.5 GHz < Fc ≤ 15 GHz | 33 kHz, 100 MHz, 210 MHz | Modulation Frequency | Data Pattern Generator |  |  |  | Full-rate (PPG), Full-rate (MUX) |  | Half-rate (MUX) |  |  | Setting Range [Ulp-p] | Step [UI] | Setting Range [Ulp-p] | Step [UI] | 33 kHz | 0 to 40 | 0.001 | 0 to 50 | 0.002 | 100 MHz | 0 to 0.25 | 0.001 | 0 to 0.5 | 0.002 | 210 MHz | 0 to 0.125 | 0.001 | 0 to 0.25 | 0.002 | Modulation Frequency | Data Pattern Generator |  | Quarter-rate (MUX) |  |  | Setting Range [Ulp-p] | Step [UI] | 33 kHz | 0 to 50 | 0.004 | 100 MHz | 0 to 0.5 | 0.004 | 210 MHz | 0 to 0.248 | 0.004 | Modulation Frequency | Data Pattern Generator |  |  |  | 32G PPG <sup>*5</sup> |  | 32G PPG <sup>*6</sup> |  |  | Setting Range [Ulp-p] | Step [UI] | Setting Range [Ulp-p] | Step [UI] | 33 kHz | 0 to 500 | 0.001 | 0 to 500 | 0.001 | 100 MHz | 0 to 0.25 | 0.001 | 0 to 8 | 0.001 | 210 MHz | 0 to 0.125 | 0.001 | — | — | Modulation Frequency | Data Pattern Generator |  |  |  | 32G PPG <sup>*7</sup> |  | 32G PPG <sup>*8</sup> |  |  | Setting Range [Ulp-p] | Step [UI] | Setting Range [Ulp-p] | Step [UI] | 33 kHz | 0 to 1000 | 0.002 | 0 to 1000 | 0.004 | 100 MHz | 0 to 0.5 | 0.002 | 0 to 0.5 | 0.004 | 210 MHz | 0 to 0.25 | 0.002 | 0 to 0.248 | 0.004 | FW | Q | 33 kHz | 7 | 100 MHz, 210 MHz <sup>*9</sup> | 15 |
| Clock Frequency                    | Bandwidth  |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 0.8 GHz < Fc ≤ 1.2 GHz             | 33 kHz   |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 1.2 GHz < Fc ≤ 8.5 GHz             | 33 kHz, 100 MHz  |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 4 GHz < Fc ≤ 8.5 GHz <sup>*3</sup> | 33 kHz, 100 MHz, 210 MHz   |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 8.5 GHz < Fc ≤ 15 GHz              | 33 kHz, 100 MHz, 210 MHz   |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| Modulation Frequency               | Data Pattern Generator   |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
|                                    | Full-rate (PPG), Full-rate (MUX)   |                 | Half-rate (MUX)       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
|                                    | Setting Range [Ulp-p]  | Step [UI]       | Setting Range [Ulp-p] | Step [UI]              |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 33 kHz                             | 0 to 40  | 0.001           | 0 to 50               | 0.002                  |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 100 MHz                            | 0 to 0.25  | 0.001           | 0 to 0.5              | 0.002                  |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 210 MHz                            | 0 to 0.125   | 0.001           | 0 to 0.25             | 0.002                  |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| Modulation Frequency               | Data Pattern Generator   |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
|                                    | Quarter-rate (MUX)   |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
|                                    | Setting Range [Ulp-p]  | Step [UI]       |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 33 kHz                             | 0 to 50  | 0.004           |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 100 MHz                            | 0 to 0.5   | 0.004           |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 210 MHz                            | 0 to 0.248   | 0.004           |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| Modulation Frequency               | Data Pattern Generator   |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
|                                    | 32G PPG <sup>*5</sup>  |                 | 32G PPG <sup>*6</sup> |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
|                                    | Setting Range [Ulp-p]  | Step [UI]       | Setting Range [Ulp-p] | Step [UI]              |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 33 kHz                             | 0 to 500   | 0.001           | 0 to 500              | 0.001                  |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 100 MHz                            | 0 to 0.25  | 0.001           | 0 to 8                | 0.001                  |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 210 MHz                            | 0 to 0.125   | 0.001           | —                     | —                      |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| Modulation Frequency               | Data Pattern Generator   |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
|                                    | 32G PPG <sup>*7</sup>  |                 | 32G PPG <sup>*8</sup> |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
|                                    | Setting Range [Ulp-p]  | Step [UI]       | Setting Range [Ulp-p] | Step [UI]              |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 33 kHz                             | 0 to 1000  | 0.002           | 0 to 1000             | 0.004                  |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 100 MHz                            | 0 to 0.5   | 0.002           | 0 to 0.5              | 0.004                  |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 210 MHz                            | 0 to 0.25  | 0.002           | 0 to 0.248            | 0.004                  |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| FW                                 | Q  |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 33 kHz                             | 7  |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |
| 100 MHz, 210 MHz <sup>*9</sup>     | 15   |                 |                       |                        |        |                        |                 |                                    |                          |                       |                          |                      |                        |  |  |  |                                  |  |                 |  |  |                       |           |                       |           |        |         |       |         |       |         |           |       |          |       |         |            |       |           |       |                      |                        |  |                    |  |  |                       |           |        |         |       |         |          |       |         |            |       |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |          |       |          |       |         |           |       |        |       |         |            |       |   |   |                      |                        |  |  |  |                       |  |                       |  |  |                       |           |                       |           |        |           |       |           |       |         |          |       |          |       |         |           |       |            |       |    |   |        |   |                                |    |

\*2: The Built-in SJ2 function is used by the MX190000A V2.00.00 and later. Either the Built-in SJ2 or SJ2 via MU181000 function can be selected, but both functions cannot be used simultaneously.

\*3: When Data Pattern Generator is 32G PPG or SI PPG, or in other words when main unit and 32G PPG or SI PG are linked.

\*4: Specifications for MU183020A or MU195020A Data output on following figure



\*5: At Data rate of 4 Gbit/s to 15 Gbit/s when Full-rate Clock Out set

\*6: At Data rate of 2.4 Gbit/s to 4 Gbit/s when Full-rate Clock Out set

\*7: At Data rate of 15 Gbit/s to 30 Gbit/s when Full-rate Clock Out, or at Data rate of 2.4 Gbit/s to 30 Gbit/s when Half-rate Clock Out set

\*8: At Data rate of 30 Gbit/s to 32.1 Gbit/s when Full-rate Clock Out or Half-rate Clock Out set

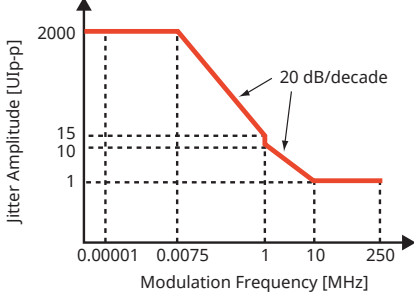
\*9: Typical value at 4 GHz ≤ Fc ≤ 8.5 GHz

# High-Speed Serial Data Test Software MX183000A Specifications

## Operation Conditions

|                     |   |
|---------------------|---|
| Install Destination | MP1900A or PC   |
| PC Specifications   | OS: English or Japanese Windows 7 Professional/Enterprise/Ultimate<br>CPU: 1 GHz min.<br>Memory: 1 GB min. (for Windows 7, 32-bit)<br>2 GB min. (for Windows 7, 64-bit)<br>Hard Disk: Free space 2 GB min.<br>Remote Interface: Ethernet (10BASE-T, 100BASE-TX)<br>Display: Resolution 800 × 600 min., 32-bit color |
| Control Target      | MP1900A<br>Controlled Units: 3 units max.<br>Version: MX190000A Installer: Version 1.00.00 or later   |

## Jitter Tolerance Test (MX183000A-PL001)

|                        |  |
|------------------------|--|
| Run Test/Stop Test     | Starts and stop Jitter Tolerance Test  |
| Jitter Tolerance Table | <p>JTOL Measurement Point Setting<br/>Sets measured SJ modulation frequency and Pass/Fail modulation degree (UI), and set search modulation range</p> <p>Jitter Frequency Setting Range<br/>Sets each of Jitter Freq. [Hz], Mask [UI], Upper Limit [UI], Lower Limit [UI], Upper Ratio, Lower Ratio<br/>Setting range depends on Jitter modulation source MU181500B</p> <p>Jitter Amplitude Setting Range</p>  <p>Note that available jitter frequency and jitter amplitude for jitter measurement depend on the clock frequency set by controller and MU181500B.</p> <p>Set All Limit<br/>Resets the Upper Limit and Lower Limit values at the ratio set for Mask.<br/>Set the ratio to reset for Upper Ratio and Lower Ratio.<br/>Upper Ratio: 1.000 to 1000, 0.001 steps<br/>Lower Ratio: 0.001 to 1.000, 0.001 steps<br/>Measurement Sequence: From higher Freq. side, From lower Freq. side</p> |
| JTOL Setting           | <p>Detection<br/>Unit: Error Rate, Error Count, Estimate, Symbol Error Rate, Bit Error Rate, MSB Error Rate, LSB Error Rate<br/>Error Threshold: 1E-3 to 1E-12, E-1 steps<br/>Error Count: 0 to 10000000, 1 steps<br/>BER for JTOL Estimation: 1.0E-20 to 9.9E-9</p>   |
| Auto Search            | OFF/FINE/COARSE  |
| Search                 | <p>Direction Search: Binary, Downwards Linear, Downwards Log, Upwards Linear, Upwards Log, Binary + Linear<br/>Step: When Downwards/Upwards Linear is selected<br/>Jitter Freq. ≤ 100 kHz<br/>0.001 to 2000.000 0.001 step<br/>100k &lt; Jitter Freq. ≤ 1 MHz<br/>0.001 to 200.000 0.001 step<br/>1M &lt; Jitter Freq. ≤ 10 MHz<br/>0.001 to 15.000 0.001 step<br/>10 MHz &lt; Jitter Freq.<br/>0.001 to 1.000 0.001 step<br/>Ratio: When Downwards/Upwards Log is selected<br/>Jitter Freq. ≤ 100 kHz, 100k &lt; Jitter Freq. ≤ 1 MHz, 1M &lt; Jitter Freq. ≤ 10 MHz, 10 MHz &lt; Jitter Freq.<br/>0.01 to 1.00 0.001 step</p>  |
| Timer [sec.]           | <p>Waiting, Setting: 1 to 99 seconds, in steps of one second<br/>Gating: 1 to 86400 seconds, in steps of one second</p>  |
| Graph Tab              | <p>Display: OFF/ON<br/>BER for JTOL Estimation: 1.0E-20 to 9.9E-9, 0.1 step, E-1 step</p>  |
| Report Tab             | Make HTML/CSV: Displays the Jitter Tolerance results in HTML or CSV.   |

# High-Speed Serial Data Test Software MX183000A Specifications

## PCIe Link Training (MX183000A-PL021, MX183000A-PL025\*)

|                                      |   |
|--------------------------------------|---|
| Link Start/Stop/Unlink               | Starts PCIe Link Training (PCIe1.0 to 4.0, 5.0*).<br>Continues sending test patterns after Link Training.                                 |
| BER Measurement                      | Click the button after a sequence is sent to execute the BER measurement.   |
| BER Monitor                          | ON/OFF  |
| Matrix Scan                          | Automatically measures BER according to Cursor setting after Link Training  |
| FS (Full Swing)                      | 24, 48, 63  |
| LF (Low Frequency)                   | Set automatically to 8, 16, or 21 according to FS setting   |
| LTSSM Log                            | Displays transition logs of LTSSM State during Link Training.   |
| LTSSM Log Items                      | Time, ΔTime, State, Detect Preset, Error Count, Use Preset, Preset, Precursor, Cursor, Postcursor   |
| Export CSV                           | Saves logs in csv format.   |
| Specification                        | 1.0/1.1 (2.5 GT/s), 2.0 (5 GT/s), 3.0/3.1 (8 GT/s), 4.0 (16 GT/s), 5.0 (32 GT/s)*   |
| Loopback Method                      | PCIe 1.0 to 4.0: Configuration, Recovery<br>PCIe 5.0*: Config EQ Bypass to 32G, Config No EQ, Recovery EQ Bypass to 32G, Recovery Full EQ |
| Test Pattern                         |   |
| Compliance                           | MCP/CP  |
| PRBS                                 | PRBS7, PRBS9, PRBS10, PRBS11, PRBS15, PRBS20, PRBS23, PRBS31  |
| Timeout                              | Sets Timeout in each LTSSM State.   |
| Result Display of PCIe Link Training |   |
| Common Parameter                     | LTSSM State, Linkup Speed   |
| SKP128b/130b                         | SKP Count, DC Balance, Sync Header Error, Parity Error, Block Lock  |
| SKP 8b/10b                           | SKP Count, DC Balance, Sync Header Error, Parity Error, Block Lock  |
| Link Equalization                    | Can display results per phase.  |
| Received                             | Tx Preset, Full Swing, Low Frequency, Link Number, Lane Number, Request Equalization  |
| PCIe 4.0/5.0* Control SKP            | Count, Margin Type, Usage Model, Payload, Receiver Number, CRC, Parity  |
| Link Control*                        | Enhanced Link Behavior Control, Precoding Request, Precoding Data   |
| Modified TS*                         | Received, Data Parity Error, Usage, Information1, Information2, Vendor ID   |
| LTSSM Trigger                        | The trigger is output from Aux Output of the SI PPG at transitioning to the specified LTSSM State.  |

\*: The PL025 option expands PL021 support to PCIe 5.0. PL025 requires the PL021 option.

## USB Link Training (MX183000A-PL022, MX183000A-PL023\*1)

|                                     |  |
|-------------------------------------|--|
| Link Start/Stop/Unlink              | Starts USB Link Training(USB3.1 Gen1/Gen2) when LFPS is detected by Data Input of MU195040A.<br>Continues sending test patterns after Link Training. |
| Specification                       | Gen1×1 (5.0 GT/s ×1), Gen1×2 (5.0 GT/s ×2), Gen2×1 (10.0 GT/s ×1), Gen2×2 (10.0 GT/s ×2)   |
| Not Wait for The LFPS Signal        | Supports simultaneous 2-Lane BER measurement when GenX×2 selected  |
| BER Measurement                     | Click the button after Link Training is sent to execute the BER measurement.<br>Supports simultaneous 2-Lane BER measurement when GenX×2 selected    |
| BER Monitor                         | ON/OFF   |
| LTSSM Log                           | Displays transition logs of LTSSM.   |
| LTSSM Log Items                     | Time, ΔTime, State (Lane0), State (Lane1), Speed[GT/s], HEX Dump (Lane0), HEX Dump (Lane1)   |
| Export CSV                          | Saves logs in csv format.  |
| Send Ping LFPS                      | Outputs Ping LFPS signal.<br>Switches DUT CP when performing Tx test of USB Compliance Test.   |
| Test Pattern                        | Compliance/USER  |
| Timeout                             | Sets Timeout for each LTSSM State.   |
| Result Display of USB Link Training |  |
| Common Parameter                    | LTSSM State, Linkup Speed  |
| 8b10b Counters                      | SKP Count*2, Symbol Err, Current RD Err, Symbol Lock   |
| 128b132b Counters                   | SKP Count*2, TS1/TS2 Symbol14-15 DC Balance*2, Sync Header Err, TS1 OS Parity Err, Block Lock, SYNCOS Counter*2                                      |

\*1: Supports USB Link Training (USB3.1 Gen1/2) (only enabled for PL022). Support for USB Link Training (USB3.2 Gen1/2 ×1×2) (enabled for PL022 and PL023).

\*2: Displays both Transmitted and Received.

## DUT Error Counts Import (MX183000A-PL031)

|                   |  |
|-------------------|--|
| DUT Control Tab   | Allows you to select and run external programs for controlling DUT.  |
| Initialize        | Allows you to select a program for initializing DUT.   |
| Measurement       | Allows you to select a program for measuring DUT.  |
| Finalize          | Allows you to select a program for finalizing DUT.   |
| Log Viewer button | Displays the log window.   |
| Finalize button   | Runs the selected Finalize program.  |
| Initialize button | Runs the selected Initialize program.  |
| BER Measure Tab   | Allows starting and stopping BER measurement, and displaying the measurement results.                        |
| Result            | Displays the measurement results, which are: error rates, error counts, and whether alarms are given or not. |
| Cycle             | Changes measurement cycle (Single/Repeat).   |
| Start/Stop        | Starts or stops the measurement.   |
| Abort             | Aborts the measurement.  |
| Debug             | Executes the measure programs, ignoring syntax errors.   |

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