32Gbaud PAM4 True BER Measurement Solution

Signal Quality Analyzer MP1800A Series
32Gbaud Power PAM4 Converter G0375A
32Gbaud PAM4 Decoder with CTLE G0376A
MP1800A Series PAM4 Measurement Solution Features

- Supports high 64 Gbaud rate for both PAM4 and NRZ
- 32 Gbaud 4ch PAM4 transmission capacity (256 Gbit/s for one MP1800A)
- Excellent expandability
  - 32 Gbaud PAM4 4ch Multi-channel Expandability to 64 Gbaud
- Low Intrinsic Jitter, high-quality waveforms
- High-amplitude PAM4 output (G0375A + 32G PPG)
- High-input-sensitivity error detection
- Supports 28 Gbaud CTLE and CDR functions (G0376A + 32G ED)
- Supports receiver tests using Jitter Addition function

[PAM4 Applications]
- 28 Gbaud PAM4 ICs, Backplanes, Active Optical Cables, CEI-56G-PAM4
- 53 Gbaud/26 Gbaud, 200GbE/400GbE Optical Modules, Optical Devices, IC

Future-proof instrument configuration
Effective inspection supported by functions and performance

NRZ/Multi-channel Solution

PAM4/Multi-channel Solution

Anritsu envision: ensure
32 Gbaud PAM4 BER Solution

- Compact Remote Head G0375A and G0376A for 32 Gbit/s 2ch PPG/ED
- True PAM4 BER measurement support

28 Gbaud 2.0 Vp-p (single-end), 4.0 Vp-p (differential)

- Compact Remote Head for close connection to DUT
- Multi-channel
- Excellent expandability and PAM4/NRZ support
- High-amplitude PAM4 output
- Clean Eye/low Jitter
- Emphasis output (set with MP1825B)
- Variable Eye linearity
- True PAM4 BER measurement
- High input sensitivity
- CTLE
- CDR (with ED, 28 Gbaud)
G0375A 32G High-Amplitude PAM4 Signal Generation

- EA modulator direct-driving, high-amplitude output and 3Eye independent level control support TOSA evaluation without external driver amplifier to reduce setup procedures and time
- Clean Eye and low-Jitter waveforms using reference signal source support high-reproducibility evaluations

G0375A Features
- Baud rates of 10 Gbaud to 32.1 Gbaud
- High-amplitude PAM4 output of 2.2 Vp-p (single-end), and 4.4 Vp-p (differential)
- Low-Jitter output waveforms with 200 fs (typ.) Rj
- Compact Remote Head
- Emphasis output (set with MP1825B)
G0375A PAM4 Typical Waveforms

28 Gbaud, 2.0 Vp-p, PRBS13Q

28 Gbaud, 0.9 Vp-p, PRBS13Q

25 Gbaud, 2.0 Vp-p, Linearity Control

Monitored using J1728A 40-cm cable + 41V-20 Attenuator + 70-GHz Band Oscilloscope
G0376A 32G PAM4 BER Measurement

- Implements high-input-sensitivity PAM4 True BER measurement for more accurate design verification
- Combining CTLE and CDR (32G ED function) supports device Jitter Tolerance test

G0376A Features
- Baud rate of 10 Gbaud to 32.1 Gbaud
- High input sensitivity (Eye Height 40 mV@28 Gbaud)
- Tunable CTLE (Gain −12 to 0 dB)
- CDR Function (set with MU183040B-022)

MP1800A SQA
32 Gbit/s 2ch PPG, 32 Gbit/s 2ch ED

G0375A
32Gbaud Power PAM4 Converter

G0376A
32Gbaud PAM4 Decoder with CTLE

DUT
PAM4 BER Measurement using MP1800A Series G0375A/G0376A

Combining 32G 2ch BERT (MSB/LSB) and PAM4 Converter/Decoder supports both PAM4 and NRZ BER measurements

<table>
<thead>
<tr>
<th>PPG1</th>
<th>0 0 2 2 2 0 2 0 . . .</th>
<th>(MSB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPG2</td>
<td>0 1 0 1 0 0 1 1 . . .</td>
<td>(LSB)</td>
</tr>
<tr>
<td>PAM4</td>
<td>0 1 2 3 2 0 3 1 . . .</td>
<td></td>
</tr>
<tr>
<td>ED1</td>
<td>0 0 1 1 1 0 1 0 . . .</td>
<td>(MSB)</td>
</tr>
<tr>
<td>ED2</td>
<td>0 1 0 1 0 0 1 1 . . .</td>
<td>(LSB)</td>
</tr>
</tbody>
</table>

(PAM4 Encode: G0375A)

(PAM4 Decode: G0376A)
Reference Setup for 32Gbaud PAM4 BER Solution
True BER measurement of PAM4 signal

- **MU183020A**
  - 32G 2ch PPG
  - (Opt-02x, 031)
- **MU181000B**
  - Synthesizer

**MP1800A**
- Signal Quality Analyzer

**JP1800A**
- 32G 2ch ED
  - (Opt-020, 022)

**G0375A**
- 32Gbaud Power PAM4 Converter

**G0376A**
- 32Gbaud PAM4 Decoder with CTLE

**DUT**
- J1741A cable x 4 (80 cm, skew <1 ps)
- J1728A cable x 2 (40 cm, skew <1 ps)
- (*1) J1728A or lower loss cable

- J1728A cable x 2 (skew < 1ps)
- Decoder Full-rate Clock (optional)
- CTLE Input
- Decoder Input

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Reference Setup for TOSA Evaluation Solution

High-amplitude, low-Jitter PAM4 signal generation with Linearity control

- MU183020A 32G 2ch PPG (Opt-02x, 031) x2
- MU181000B Synthesizer

J1742A cable x 2 (84 cm, skew <1 ps)

G0375A 32Gbaud Power PAM4 Converter

J1728A cable x 2 (40 cm, skew <1 ps)

MP1800A Signal Quality Analyzer

J1741A cable x 4 (80 cm, skew <1 ps)

J1735A Combiner x 2
G0375A/G0376A I/O Control

- **G0375A:**
  PAM4 output level controlled by using control software to control output amplitude of connected PPG

- **G0376A:**
  Control CLTE gain and Pam4 Decoder input threshold voltage (Vref for each of Upper/Middle/Lower) via USB connection
  (Control Software can be downloaded from download site at MP1800A home page)

Control Software Screen Examples

- **G0375A**

- **G0376A**
Main Application (1)

Evaluation of 28Gbaud PAM4 TOSA/ROSA

- High-quality, low-Jitter PAM4 signals
- PAM4 Linearity control
- Eye opening adjustment using CTLE function
Main Application (2)
Supports 400 GAUI-8, CEI-56G-VSR-PAM4 Electrical I/F Rx tests
- Low-Jitter PAM4 waveform
- 4Tap Emphasis function
- Jitter Addition function RJ/BUJ/SJ
- CTLE (14 GHz peak frequency)
- CDR function (as set with MU183040B-022)

**MP1800A**
MU183020A 32 G 2ch PPG
MU183040B 32 G 2ch ED
MU181500B Jitter
MU181000B Synthesizer
MX183000A JTOL software

**G0375A**
32Gbaud Power PAM4 Converter

**G0376A**
32Gbaud PAM4 Decoder with CTLE

Artek ISI generator

PAM4 Transceiver, Re-timer

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Anritsu envision: ensure
# Recommended 32G PAM4 BER Measuring Instruments

<table>
<thead>
<tr>
<th>Model</th>
<th>Name</th>
<th>Option</th>
<th>Qty</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>G0375A</td>
<td>32Gbaud Power PAM4 Converter</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>G0376A</td>
<td>32Gbaud PAM4 Decoder with CTLE</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>MP1800A</td>
<td>Signal Quality Analyzer</td>
<td>001, 002, 007, 015, 032</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>MU181000B</td>
<td>12.5GHz 4port Synthesizer</td>
<td>-</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>MU181500B</td>
<td>Jitter Modulation Source</td>
<td>-</td>
<td>1</td>
<td>For Jitter Tolerance Test</td>
</tr>
<tr>
<td>MU183020A</td>
<td>28G/32G bit/s PPG</td>
<td>022 or 023, 031</td>
<td>1</td>
<td>Qty is 2 when Linearity control</td>
</tr>
<tr>
<td>MU183040B</td>
<td>28G/32G bit/s High Sensitivity ED</td>
<td>020, 022</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>J1728A</td>
<td>Electrical Length Specified Coaxial Cable (0.4m, K connector)</td>
<td>-</td>
<td>(2)</td>
<td>Waveform monitoring cable</td>
</tr>
<tr>
<td>J1735A</td>
<td>Combiner</td>
<td>-</td>
<td>2</td>
<td>Need to Linearity control</td>
</tr>
<tr>
<td>J1742A</td>
<td>Electrical Length Specified Coaxial Cable (0.84m, K Connector)</td>
<td>-</td>
<td>2</td>
<td>Need to Linearity control</td>
</tr>
</tbody>
</table>
# G0375A 32Gbaud Power PAM4 Converter main Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Outputs</td>
<td>2 (Data, xData)</td>
<td>AC coupling, K (female) connector</td>
</tr>
<tr>
<td>Baud-Rate</td>
<td>10 to 32.1 Gbaud</td>
<td></td>
</tr>
<tr>
<td>Output Amplitude</td>
<td>2.2 Vp-p (typical), 2.8 Vp-p (maximum)</td>
<td>Data1 input 1.5 Vp-p, Data2 input 0.75 Vp-p, and Gc setting = 0 dB</td>
</tr>
<tr>
<td>Gain</td>
<td>0 dB (typical)</td>
<td>(Data1 input + Data2 input) to xData output, Gc setting = 0 dB</td>
</tr>
<tr>
<td>Random Jitter (RMS)</td>
<td>200 fs (typical)</td>
<td>PRBS13Q pattern</td>
</tr>
<tr>
<td>Tr/Tf (20%-80%)</td>
<td>12 ps (typical)</td>
<td>PRBS13Q pattern</td>
</tr>
<tr>
<td>Eye Linearity (RLM)</td>
<td>0.9 (typical)</td>
<td>Gc setting = 0 dB</td>
</tr>
<tr>
<td>Gain Control, Gc</td>
<td>-6 to 0 dB</td>
<td>Auxiliary gain control function</td>
</tr>
<tr>
<td>Number of Inputs</td>
<td>4 (Data1, xData1, Data2, xData2)</td>
<td>K (female) connector, Uses PPG Data3 and J1735A Combiner at 3 Eye independent level control</td>
</tr>
<tr>
<td>Maximum Input Amplitude</td>
<td>Data1, xData1 input: 1.5 Vp-p Data2, xData2 input: 0.75 Vp-p</td>
<td>Data1 input + Data2 input $\leq$ 2.25 Vp-p</td>
</tr>
</tbody>
</table>
# G0376A 32Gbaud PAM4 Decoder with CTLE Main Specifications

## PAM4 Decoder Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Inputs</td>
<td>3 (Data, xData, Clock input)</td>
<td>K (female) connector</td>
</tr>
<tr>
<td>Baud Rate</td>
<td>10 to 32.1 Gbaud (DFF = On) 10 to 28 Gbaud (DFF = Off)</td>
<td></td>
</tr>
<tr>
<td>Data Input Amplitude</td>
<td>0.4 Vp-p (maximum)</td>
<td>Single-end, AC coupling</td>
</tr>
<tr>
<td>Data Input Sensitivity</td>
<td>0.04 V (typical)</td>
<td>28 Gbaud, Single-end, Eye Height</td>
</tr>
<tr>
<td>Clock Input Frequency</td>
<td>10 to 32.1 GHz</td>
<td>Full-rate clock, for DFF On mode</td>
</tr>
<tr>
<td>Clock input amplitude</td>
<td>0.3 to 1.0 Vp-p</td>
<td></td>
</tr>
<tr>
<td>Number of Outputs</td>
<td>3 (Data1, Data2, Monitor output)</td>
<td>K (female) connector</td>
</tr>
<tr>
<td>Output Amplitude</td>
<td>0.3 Vp-p (typical)</td>
<td>Data1, Data2, Monitor output</td>
</tr>
<tr>
<td>Internal DFF</td>
<td>Selectable ON / OFF</td>
<td>Uses external Clock for D-FF ON mode</td>
</tr>
</tbody>
</table>

## CTLE Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Inputs</td>
<td>2 (Data, xData)</td>
<td>K (female) connector</td>
</tr>
<tr>
<td>Data Input Amplitude</td>
<td>0.4 Vp-p (maximum)</td>
<td>Single-end, AC coupling</td>
</tr>
<tr>
<td>CTLE Gain</td>
<td>-12 to 0 dB</td>
<td></td>
</tr>
<tr>
<td>CTLE Peak Frequency</td>
<td>14 GHz (typical)</td>
<td></td>
</tr>
<tr>
<td>Number of Outputs</td>
<td>2 (Data, xData)</td>
<td>K (female) connector</td>
</tr>
</tbody>
</table>
G0375A/G0376A Block Diagrams

- G0375A Block Diagram

  xData1 input
  xData2 input
  Data1 input
  Data2 input
  Passive Combiner
  Linear amp.
  Data output
  xData output

- G0376A Block Diagram

  Data input
  xData input
  CTLE
  PAM4 Decoder
  Binary Data
  SEL
  Decoder Circuit
  Data output
  Data input
  Use Clock input for DFF On
  Clock input
  CTLE
  Passive Combiner
  Linear amp.