BERTWave MP2100B
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- Summary
Market Conditions

- Global Data center IP traffic grows at a compound annual growth rate (CAGR) of 23 percent, resulting in increasing production of optical modules. (Production of optical modules exceeded 15 million units.)

- Full-scale mass production for 40GbE (4x10G) QSFP+ started from CY2015, and the predicted CAGR is 48%. 40GbE is expected to become the market mainstream for optical modules for data-center applications.
Introduction

All-In-One : 4ch-BERT + Sampling Oscilloscope

High Speed Measurement

◆ All-in-One 4ch-BER Measurements and Eye Pattern Analyses
  ➢ No separate BERT and Eye pattern analyzer

◆ High-speed measurement reduces measurement times
  ➢ Simultaneous 4ch-BER measurement is 4 times faster than legacy models
  ➢ Fast Sampling Mode for Scope increases sampling speed 150 ksample/s, which is 1.5 times faster than legacy models

Compact and Lightweight

◆ Compact 18cm design, weight < 7kg
  ➢ Small footprint saves Benchtop space

Comparison of 40 Gbit/s (10 Gbit/s × 4ch) QSFP+ BER

Legacy Model 1 is a combination of a 2ch-BERT and sampling oscilloscope.
Legacy Model 2 integrates a 2ch-BERT and sampling oscilloscope into one instrument (set).
The MP2100B integrates a 4ch-BERT and sampling oscilloscope into one instrument (set).
Capture BER for 3 points for each of 1E-3, 1E-5, 1E-7, 1E-8, 1E-9, and 1E-10 for 4ch × 10 Gbit/s
Compare to the waveform of 1 Msample
Features (1/12) ~Shorten Measurement Times~

- All-in-One 4ch-BER Measurements and Eye Pattern Analyses
  - BER measurements and Eye pattern analyses can be performed simultaneously with one MP2100B set, increasing measurement efficiency
High-speed Eye Mask Test

- Fast Sampling Mode
  - The new Fast Sampling Mode installed as standard function increases sampling speed up to 150 ksample/s, supporting high-speed Eye pattern analyses
  - Electrical Mask tests require only about 8 s for 1 million samples at a bit rate of 10.3125 Gbit/s with a PRBS31 test pattern
Features (3/12) ~ Shorten Measurement Times ~

- **Simultaneous 4ch-BER Measurement**
  - Build-in standard function for batch capture of measurement results up to 4ch reduces measure time by half.

<table>
<thead>
<tr>
<th>ED</th>
<th>Bit Rate</th>
<th>Test Pattern</th>
<th>Start/Stop</th>
<th>Start Time</th>
<th>Progress</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10GbE LANPHY(10.3125G)</td>
<td>PRBS 2^9-1</td>
<td></td>
<td>07/08/2015 16:19:25</td>
<td>80%</td>
</tr>
<tr>
<td>2</td>
<td>10GbE LANPHY(10.3125G)</td>
<td>PRBS 2^9-1</td>
<td></td>
<td>07/08/2015 16:19:25</td>
<td>80%</td>
</tr>
<tr>
<td>3</td>
<td>10GbE LANPHY(10.3125G)</td>
<td>PRBS 2^9-1</td>
<td></td>
<td>07/08/2015 16:19:25</td>
<td>80%</td>
</tr>
<tr>
<td>4</td>
<td>10GbE LANPHY(10.3125G)</td>
<td>PRBS 2^9-1</td>
<td></td>
<td>07/08/2015 16:19:25</td>
<td>80%</td>
</tr>
</tbody>
</table>
Features (4/12) ~Full-Featured Analysis Functions~

- Wide Operation Frequency
  - PPG/ED operation frequency (with Option 092)
    - BERT operates the variable range (1 kbit/s step) of 125 Mbit/s to 12.5 Gbit/s
      - PPG/EDBERT function supports variable applications, such as OC-3/STM-1 and 10GFC
      - Bit rates for other applications are also supported

Examples of Supported Bit Rates and Applications (with Option 092)

<table>
<thead>
<tr>
<th>PPG/ED Supported Bit Rates</th>
<th>Application Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>125 Mbit/s to 12.5 Gbit/s</td>
<td>InfiniBand (SDR, DDR, QDR), Fibre Channel (1G, 2G, 4G, 8G, 10G, 10G FEC), GbE, 2 GbE, 10 GbE (WAN, LAN), XAUI (3.125G), 40 GbE (10 Gbit/s × 4), CPRI (×1, ×2, ×4, ×5, ×8, ×10), OBSAI (RP3, RP3 ×2, RP3 ×4, RP3 ×8), OC-3/STM-1, OC-12/STM-4, OC-24, OC-48/STM-16, OC-192/STM-64, OC-192/STM-64 FEC (G.975), OTU-1, OTU-2, OTU-1e, OTU-2e, SFP, SFP+, XFP, Active Optical Cable (AOC), QSFP/QSFP+, CFP, CXP, TOSA/ROSA</td>
</tr>
</tbody>
</table>
Features (5/12) ~Full-Featured Analysis Functions~

- **Clock Recovery**
  - **ED Clock recovery function** *(standard function)*
    - 125 Mbit/s ~ 12.5 Gbit/s
      - Data signal input without clock, and BER analysis
    - 4 Gbit/s ~ 6.25 Gbit/s, 8 Gbit/s ~ 12.5 Gbit/s
      - Supported as scope trigger
  - **Eye/Pulse Scope Clock recovery function**
    - 8.5 GHz ~ 12.5 GHz, 0.1 GHz ~ 2.7 GHz *(Option 055)*
      - Supports evaluation of characteristics of long-distance transmissions and equipment without clock output
      - Variable loop band

### Eye/Pulse Scope clock recovery loop bandwidth

<table>
<thead>
<tr>
<th>Bit rate</th>
<th>Loop bandwidth</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5 to 12.5 GHz</td>
<td>1,2,4,8 MHz</td>
</tr>
<tr>
<td>0.1 to 2.7 GHz</td>
<td>2488.32 MHz</td>
</tr>
<tr>
<td></td>
<td>200 kHz</td>
</tr>
<tr>
<td>622 MHz</td>
<td>50 kHz</td>
</tr>
<tr>
<td>156 MHz</td>
<td>20 kHz</td>
</tr>
</tbody>
</table>
Features (6/12) ~Full-Featured Analysis Functions~

- Wide Analog Band Eye/Pulse Scope
  - Supports electric DC to 25 GHz (typ.) and optical DC 9.5 GHz (typ.) band
    - Supports 100 Mbit/s to 12.5 Gbit/s applications, such as 1 GbE and 10 GbE

- Pulse Pattern Measurements
  - Pattern frequency trigger input not require
  - Supports pattern frequency up to 1677216 bits

- Fast Auto-Scale
  - Auto-Scale Setting within 3 s

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[Image: EYE/Pulse Scope showing Auto-Scale and Pulse pattern graphs]

**Auto-Scale**

**Pulse pattern**
Features (7/12) ~Full-Featured Analysis Functions~

- **Built-in Low Pass Filter**
  - **Max. six types** of Low Pass Filter for every measurement application
  - **No filter : need Option 086**

<table>
<thead>
<tr>
<th>LPF</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>156M</td>
<td>OC-3/STM-1 (155.52M)</td>
</tr>
<tr>
<td>622M</td>
<td>CPRI x1 (614.4M), OC-12/STM-4 (622.08M)</td>
</tr>
<tr>
<td>1.0G</td>
<td>FC (1.0625G)</td>
</tr>
<tr>
<td>1.2G</td>
<td>CPRI x2 (1.2288G), OC-24 (1.244G), GbE (1.25G)</td>
</tr>
<tr>
<td>2.1G</td>
<td>2GFC (2.125G)</td>
</tr>
<tr>
<td>2.5G</td>
<td>CPRI x4 (2.4576G), OC-48/STM-16 (2.488G), InfiniBand Optical (2.5G), 2GbE (2.5G)</td>
</tr>
<tr>
<td>2.6G</td>
<td>OTU-1 (2.666G)</td>
</tr>
<tr>
<td>3.1G</td>
<td>CPRI x5 (3.072G), OBSAI RP3 x4 (3.072G), 10GBASE-LX4 (3.125G), 10GFC-LX4 (3.1875G)</td>
</tr>
<tr>
<td>4.2G</td>
<td>4GFC (4.25G)</td>
</tr>
<tr>
<td>5.0G</td>
<td>CPRI x8 (4.9515G), InfiniBand optical x2 (5G)</td>
</tr>
<tr>
<td>6.2G</td>
<td>CPRI x10 (6.144G), XAUI Optical x2 (6.25G)</td>
</tr>
</tbody>
</table>

- **Supports Wide Wavelength Range**
  - Supports wavelengths from 750 to 1650 nm
Features (8/12) ~Full-Featured Analysis Functions~

- **Application Test**
  - Eye/Pulse Scope supports signal integrity analysis
    - **Time/Amplitude Test**
      - 0 Level, 1 Level, SNR, Eye Cross Ratio, Eye Amplitude, Eye Height, Eye width, Jitter (p-p), Jitter (rms), Extinction Ratio, Rise time, Fall time, Duty cycle distortion, OMA, Average Power (Note)
    - **Mask Test/Mask Margin Test**
      - Automatic Mask Margin Test
    - **Histogram Test**
      - Measure the mean, standard deviation, p-p, and total number of hits in the histogram window

(Note) Extinction ratio and average optical power measured using O/E converter
Features (9/12) ~Full-Featured Analysis Functions~

- **Mask/Mask Margin Test**
  - Automatically confirm product margin against standards to improve yield through Mask Margin Test
  - Real-time mask margin measurements measure mask margin within 1 s after waveform input

![Mask Margin Test](image-url)
Features (10/12) ~ Ideal Extinction Ratio Measurement ~

- **High-accuracy Results**
  - Calibration using reference light source holds error to less than ±0.05 dB (typ.)
    - Max. Error: +/- 0.05 dB
    - SD(one-tail): 1.1%
    - 99% Conf.Lim: +/- 0.05 dB

  Typical values based on average of each bit rate and set extinction ratio
  Normalized results of 162 samples
  Random sampling of actual measurements for multiple instruments

- **Correction Function**
  - Same linearity as competing instruments, so extinction ratio can be corrected using offset.

### O/E Configuration

<table>
<thead>
<tr>
<th>Wavelength</th>
<th>1310nm</th>
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<tbody>
<tr>
<td>Extinction Ratio Correction</td>
<td><strong>ON</strong></td>
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<tr>
<td>Extinction Ratio Correction Factor</td>
<td><strong>0.3</strong></td>
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</table>

### Correction Value Input Display

<table>
<thead>
<tr>
<th>Variable ER transmitter ER [dB]</th>
<th>Measured ER [dB]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP2100A_A</td>
<td></td>
</tr>
<tr>
<td>MP2100A_B</td>
<td></td>
</tr>
<tr>
<td>86105C_A</td>
<td></td>
</tr>
<tr>
<td>86105C_B</td>
<td></td>
</tr>
<tr>
<td>86106B</td>
<td></td>
</tr>
</tbody>
</table>
Features (11/12) ~High-quality waveform~

- **High-quality PPG, High-sensitivity ED**
  - High-quality PPG (1 ps Jitter typ.) and high-sensitivity ED (10 mVp-p) simplify precision measurement of DUT characteristics.

- **PPG**
  - Jitter (RMS) ※10.3125Gbit/s, Amplitude 0.4Vp-p
    - 1 ps(typ.), 2 ps (max.)
  
  - Intrinsic RJ (RMS) ※10.3125Gbit/s, Amplitude 0.4Vp-p
    - 600 fs(typ.), 1 ps (max.)

  - Tr/Tf ※11.32Gbit/s, Amplitude 0.8Vp-p
    - 24 ps(typ.), 28 ps(max.)

- **ED**
  - Input Sensitivity
    - 10 mVp-p(typ.)
    - 20 mVp-p(max.)
Features (12/12) ~ Simple Operation, High Durability, Eco-friendly Design ~

- **Improved Operability**
  - Simple setting for PPG/ED
  - 12.1-inch wide display
  - Touch-panel operation

- **High Reliability**
  - Flash disk
    - Prevents data loss from hard-disk crashes

- **Eco-design**
  - Compact 180-mm design (341 (W)× 221.5 (H)×180 (D) mm)
  - Lightweight (Less than 7 kg)
  - Low power consumption (Less than 300 VA)
Application Examples (1/3)

40 Gbit/s QSFP+ (4 × 10 Gbit/s) Measurement

- All-in-one Simultaneous BER and Eye pattern Measurement
- 4ch Simultaneous BER measurements
- Fast Sampling Mode with high sampling speed up to 150 ksample/s
- High-quality PPG and high sensitivity ED

Comparison of 40 Gbit/s (10 Gbit/s × 4ch) QSFP+ BER Measurement Times

Legacy Model 1 is a combination of a 2ch-BERT and sampling oscilloscope. Legacy Model 2 integrates a 2ch-BERT and sampling oscilloscope into one instrument (set). The MP2100B integrates a 4ch-BERT and sampling oscilloscope into one instrument (set).

Capture BER for 3 points for each of 1E-3, 1E-5, 1E-7, 1E-8, 1E-9, and 1E-10 for 4ch × 10 Gbit/s

Measurements times are reduced by 80%
Application Examples (2/3)

Active Optical Cable (AOC) Measurement

**Eye pattern analysis**
- $T_r/T_f$, Amplitude, etc.

**Eye Mask Tests**

**Jitter Analysis**
- $T_J$, $D_J$, $R_J$, $D_DJ$ measurement, DDPWS etc.

**High-speed Simultaneous Measurement**
- Eye pattern analyses, Jitter measurements, and Eye Mask tests can all be performed simultaneously
- Fast DDJ measurement is supported using the fast triggering method
- Measurement times, including Jitter, are reduced by 90% compared to legacy models
Application Examples (3/3)

PON Device BOB (BOSA On Board) Evaluations

**Fast Mask Tests**
- The new Fast Sampling Mode (150 ksample/s) reduces Eye Mask tests to about 8 s *(Note)*, helping shorten measurement times
- Clock Recovery: With support for frequencies from 8.5 to 12.5 GHz, and 0.1 to 2.7 GHz, Mask tests can be run for nearly all applications

**Full Line of Mask Patterns Tests**
- Acceptance inspection tests are supported for optical devices in transmission equipment for various applications, including 2G, 4G, and 8GFC

*(Note)* At bit rate of 10.3125 Gbit/s with PRBS31 test pattern and 1 million back-to-back samples
Typical Waveform

Electrical Looped-back

PPG Data out

Scope CH_A Electrical Input

Filtered optical waveform

Transmitter

Scope CH_B Optical Input

Bit rate: 10.3125 Gbit/s, PRBS31, Power: -7 dBm
An external optical transmitter

Bit rate: 10.3125 Gbit/s, PRBS31, Amplitude: 0.5 Vp-p
PPG to ED/Scope Looped back
Summary

- All-in-one BER and Eye Pattern Measurements
- Simultaneous 4ch-BER Measurements and Eye Pattern Analysis
- High-speed Mask Tests
Appendix
Features ~Full-Featured Analysis Functions~

- **Wideband operating Frequency**
  - Supporting various applications such as 10GbE and 5G InfiniBand

### Examples of Supported Bit Rates and Applications (without Option 092)

<table>
<thead>
<tr>
<th>PPG/ED Supported Bit Rates</th>
<th>Application Example</th>
</tr>
</thead>
</table>
| 8.5 Gbit/s to 11.32 Gbit/s  | • 8GFC  
• 10GFC  
• 10GFC FEC  
• OTU-2  
• OTU-2e  
• 10 GbE  
• 40 GbE (10 Gbit/s × 4)  
• 10 GbE FEC  
• OC-192/STM-64  
• OC-192/STM-64 FEC  
• OTU-1e |
| 4.25 Gbit/s to 5.66 Gbit/s  | • 4GFC |
| 2.125 Gbit/s to 2.83 Gbit/s | • 2GFC  
• InfiniBand  
• 2 GbE  
• OC-48/STM-16  
• OTU-1 |
| 1.0625 Gbit/s to 1.415 Gbit/s | • 1 GbE  
• 1GFC  |
| 0.53125 Gbit/s to 0.7075 Gbit/s | • OC-12/STM-4 |
| 0.265625 Gbit/s to 0.35375 Gbit/s |  |
| 0.132812 Gbit/s to 0.176875 Gbit/s | • OC-3/STM-1 |
Features ~Full-Featured Analysis Functions~

- Supports Analysis of Electrical and Optical Signals
  - Custom configuration
    - Interface:
      - Electrical, SFP+, optical receiver
    - Scope:
      - Dual electrical receiver or optical/single-end electrical receiver
    - BERT:
      - Supporting up to 4ch

[Image of an Anritsu device with various ports labeled: Scope Optical In, SFP+ Slot, PPG Data Out, Scope Data In, ED Data In]
Features ~Full-Featured Analysis Functions~

- Full Range of Sample Patterns
  - Supports each PRBS pattern and User Data (1.3 Mbits)
  - ✓ Create standard pattern library
  - ✓ User-added User Data

![PRBS Setting Display](Image1)

![Standard Pattern Selection Display](Image2)
Features ~ Reduces Measurement Times ~

- **Tracking Function**
  - Simplify BERT setting by using Ch Tracking function
  - Supports easy BERT and Eye/Pulse Scope settings
    - Eliminates troublesome setting change for Tx and Rx signals
Features ~ Full-Featured Analysis Functions

- Insertion/Omission Functions
  - Measures bit error changes
    - Insertion: 0 → 1 Conversion
    - Emission: 1 → 0 Conversion
  - Easy DUT threshold adjustment
Features ~ Full-Featured Analysis Functions ~

- **Built-in Multiple Sampling Completion Condition**
  - Select from time, number of samples, number of waveforms

- **Variable Pulse Waveform Average Processing Times**
  - The averaging processing count can be set at waveform measurement in the Pulse mode.
  - Averaging suppresses waveform noise.
Features ~ Full-Featured Analysis Functions ~

- Coherent Eye Mode
  - The BERTWave displays accurate eye waveforms using a coherent eye mode by superimposing pulse waveforms with added differential.
  - Conventional sampling oscilloscopes cannot monitor an eye pattern with added differential when skew between channels is changed.
Features ~ Full-Featured Analysis Functions ~

- Reference Trace Waveform
  - Waveform data saving function supports comparison between saved data and measured waveform
  - Visually identify phase and changes between standard and measured waveforms
Features ~ Full-Featured Analysis Functions ~

- **Waveform Position Adjustment**
  - Built-in skew function aligns phase between differential signal channels
  - Measures differential signals accurately without delay
Features ~ Full-Featured Analysis Functions ~

- **Mask Position Adjustment**
  - Mask position adjusted automatically or manually
  - Easy adjustment of waveforms without horizontal axis limits and threshold adjustment for waveforms

Note: Align Method settable only for User Defined
Features ~ Full-Featured Analysis Functions ~

- **Mask Area Change**
  - Change mask area for measurement
  - Evaluate positions in open eye where mask margin maximum and minimum

![Mask Area Restriction Off](image1)

![Mask Area Restriction On (45 degrees, 0.1UI)](image2)
Features ~ Full-Featured Analysis Functions ~

- Arbitrary Mask Creation
  - User-defined mask files
  - Quickly support new applications
Features ~ Full-Featured Analysis Functions ~

- **Time/Amplitude Test**
  - 0 Level, 1 Level, SNR, Eye Cross Ratio, Eye Amplitude, Eye Height, Eye width, Jitter (p-p), Jitter (rms), Extinction Ratio, Rise time, Fall time, Duty cycle distortion, OMA, Average Power

(Note) Extinction ratio and average optical power measured using O/E converter
Features ~ Full-Featured Analysis Functions ~

- Measurement Area Change for Levels 1 and 0
  - Changes measurement area for waveform levels 1 and 0
Features ~ Full-Featured Analysis Functions ~

- **Histogram Test**
  - Measure the mean, standard deviation, p-p, and total number of hits in the histogram window
  - Contribute trouble shooting by element analysis of incoming signals

---

Histogram Test (Amplitude)

Histogram Test (Time)
## Measurement Items

<table>
<thead>
<tr>
<th>Measurement Items</th>
<th>MP2100B BERTWave</th>
<th>MS9740A Optical Spectrum Analyzer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tx</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Rate Tolerance</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Center wavelength</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Side Mode Suppression Ratio</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Average Optical Output Power(min./max.)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Extinction Ratio</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Mask Test</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Rx</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Sensitivity($10^{-12}$)</td>
<td>✓</td>
<td>(Note)</td>
</tr>
</tbody>
</table>

(Note) Programmable optical attenuator is needed
### Interface

<table>
<thead>
<tr>
<th>Interface</th>
<th>MP2100B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Option 011</td>
</tr>
<tr>
<td>1ch-BERT (Electrical Data 1, xData 1)</td>
<td>✓</td>
</tr>
<tr>
<td>2ch-BERT (Electrical Data 2, xData 2)</td>
<td>✓</td>
</tr>
<tr>
<td>4ch-BERT (Electrical Data 4, xData 4)</td>
<td>✓</td>
</tr>
<tr>
<td>Differential Electrical Scope</td>
<td></td>
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<tr>
<td>O/E Scope</td>
<td></td>
</tr>
<tr>
<td>Addition Interface</td>
<td></td>
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<tr>
<td>SFP+ Slot</td>
<td>✓ (Note1)</td>
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</tbody>
</table>

(Note 1): Option-051 Selected
## Functions

<table>
<thead>
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<th>Interface</th>
<th>MP2100B</th>
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<tbody>
<tr>
<td></td>
<td>Option 011</td>
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<tr>
<td>Crosstalk tests</td>
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<tr>
<td>Optical Module Simultaneous TRx measurement (QSFP+)</td>
<td></td>
</tr>
<tr>
<td>Optical Module Simultaneous TRx measurement (SFP+)</td>
<td>✓</td>
</tr>
<tr>
<td>1ch-BER measurement</td>
<td>✓</td>
</tr>
<tr>
<td>2ch-BER measurements</td>
<td>✓</td>
</tr>
<tr>
<td>4ch-BER measurements</td>
<td>✓</td>
</tr>
<tr>
<td>Eye pattern Analysis (Electrical)</td>
<td></td>
</tr>
<tr>
<td>• Time and Amplitude Tests</td>
<td></td>
</tr>
<tr>
<td>• Histogram Tests</td>
<td></td>
</tr>
<tr>
<td>• Eye Mask/ Mask Margin Tests</td>
<td></td>
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<tr>
<td>• Jitter Analysis</td>
<td></td>
</tr>
<tr>
<td>Eye pattern Analysis (O/E)</td>
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<td>• Time and Amplitude Tests</td>
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<tr>
<td>• Jitter Analysis</td>
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