Technical Note

Enabling Precision EYE Pattern Analysis

Extinction Ratio, Jitter, Mask Margin

MP2100A Series
BERTWave

Contents

1 Introduction

The rapid spread of the Internet is driving development and manufacturing of FTTx and 10-Gbit Ethernet optical modules. In addition, increased speed of data transfers between servers in data centers is driving R&D into optical interconnects.

Using optical modules at the physical layer of transmission equipment supports communication of link signals over optical fiber. Moreover, interoperability is assured by standardization of optical modules, such as XFP, SFP, or SFP+ under Multi-Source Agreements (MSA) and by measuring EYE patterns.

Measurement of optical modules commonly uses inspection of EYE patterns with a sampling oscilloscope to measure extinction ratio, jitter, mask margin, etc., but test results can differ between test instruments. In addition, some models may show unit-to-unit variation, causing inconsistent results.

This technical note reviews measurement using EYE patterns, and discusses the characteristics required to test instruments to obtain more accurate results. In addition, it compares test results for extinction ratio, jitter (rms) and mask margin measured using Anritsu's new MP2100A BERTWave series EYE pattern Analyzer Bnd traditional sampling oscilloscopes from two other makers.

2 EYE Pattern Fundamentals

This chapter explains EYE pattern measurement principles and definitions.

2.1 Analyzing EYE Pattern

An EYE diagram is a useful tool for understanding signal impairments in the physical layer of high-speed digital data systems, verifying transmitter outputs in manufacturing, and clarifying the amplitude and time distortion elements that degrade the Bit Error Ratio (BER). A broadband sampling oscilloscope samples high-speed digital signals by taking a high-speed digital data stream of random 0s and 1s, superimposing them, and synchronizing the rise and fall times of the data transitions. The result is the “EYE” of the EYE diagram (Fig. 2-1).

For easy viewing, the time axis in Fig. 2-1 is normalized for 2 bits, with the 1-bit EYE opening in the center of the display and 1 bit to the left and right of the center for capturing rise/fall transitions.

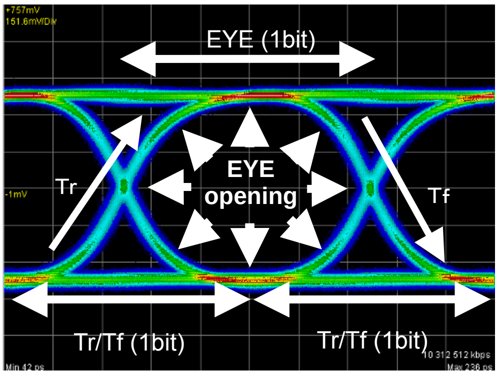


Fig. 2-1

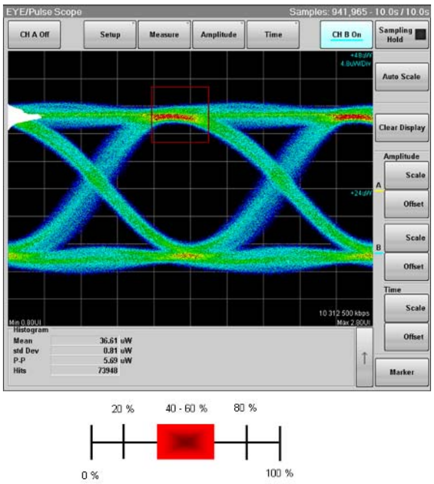
Although the EYE pattern in Fig. 2-1 shows some noise and jitter, more examples below show waveforms with considerably more noise and a significantly closed center EYE. Generally speaking, the more open the EYE (arrows in diagram), the less chance that the receiver will mistake a logical 1 bit for a logical 0 bit, and *vice versa*. Noise, both amplitude and time jitter, reduces that margin as closure of the EYE. The percentage of bits with errors compared to total bits is called BER. A lower BER is always better.

The EYE diagram does not show protocol or logic problems. However, it does help engineers to more easily view signal impairments in the physical layer in terms of amplitude and time distortion. To analyze the data stream, a Bit Error Rate Tester is used to measure BER in the circuit. The Anritsu MP2100A BERTWave incorporates both a scope function and a BERT function in an all-in-one unit. Using this integrated error detector supports simultaneous testing and analysis of both BER and EYE pattern.

2.2 Amplitude Definitions for Vertical Eye Patterns

Amplitude distortions can be extracted from an EYE diagram using the EYE Pattern Analyzer Bnd are typically based on calculations from histogram data.

The 1 level in an EYE pattern is defined in Fig. 2-2. It is calculated from 0% to 100% between the crossing points as the mean value of the top histogram distribution in the middle 20% of the EYE. This middle 20% is also called the 40% – 60% region and is highlighted in the scale under the EYE pattern below. The actual calculated value of the 1 level comes from the histogram mean of all data samples captured inside the middle 20%. Likewise, the actual calculated value of the 0 level comes from middle 20%.



Histogram
Mean 36.61 uW
std Dev 0.81 uW
P-P 5.69 uW
Hits 73948

Fig. 2-2

2.3 Time Definitions for Horizontal EYE Pattern

Like amplitude distortion, time distortion can be extracted from an EYE diagram using the EYE Pattern Analyzer. While these parameters are commonly-known pulsed-data terms, measurement by the EYE Pattern Analyzer is described mostly in terms of histograms derived from the EYE pattern.

Before defining these terms, we must introduce the concept of a Unit Interval (UI). As shown in Eq. 2-1, a UI is defined as one data bit-width, irrespective of data rate. For example, in a 10-Gbit/s data stream, one UI is equivalent to 100 ps; for a 2-Gbit/s data stream, one UI is equivalent to 500 ps.

$$UI = \frac{1}{BitRate} \quad \text{…Eq. 2-1}$$

3. Main Measurement Items for EYE Pattern Analysis

This chapter defines the extinction ratio, jitter (rms), and mask margin tests, which are the objective of this technical note.

3.1 Extinction Ratio

Extinction ratio is one of the most important measurements for evaluating an optical transmitter. The extinction ratio is calculated from the 1 and 0 levels of the EYE pattern.

$$ER = \frac{OneLevel}{ZeroLevel} \qquad \text{…Eq. 3-1}$$

$$ER(dB) = 10\log_{10}\frac{OneLevel}{ZeroLevel} \qquad \text{…Eq. 3-2}$$

Here, the 1 and 0 levels in Eqs. 3-3 and 3-4, and Fig. 3-1 are subtracted from the dark power, meaning when there is no optical power.

One Level = $L_1 - L_D$ …Eq. 3-3)

Zero Level = $L_0 - L_D$ …Eq. 3-4)

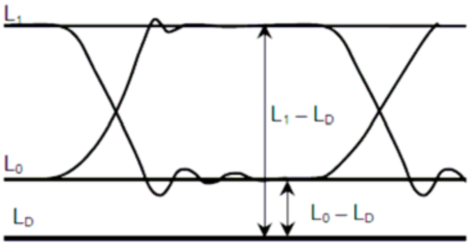
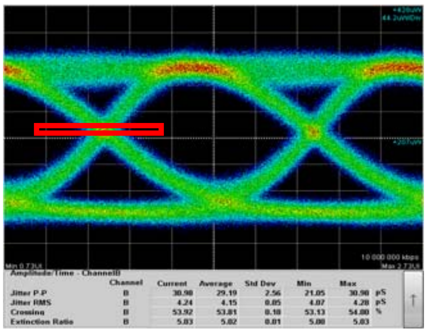


Fig. 3-1 Calculating extinction ratio

3.2 Jitter (RMS, Peak-to-Peak)

Jitter—the time deviation from the ideal timing of a data-bit event—is one of the most important topics in high-speed digital data signals. To calculate jitter, the time variance of the rising and falling edges of the EYE diagram at the crossing point are captured as shown in Fig. 3-2. Fluctuations can be random and/or deterministic. The time histogram is analyzed to determine the amount of jitter. The peak-to-peak jitter (jitter p-p) is defined as the full width of the histogram; The RMS jitter (jitter rms) is defined as the standard deviation (±1σ) from the mean. If the jitter is completely random—follows a Gaussian contribution—jitter p-p is 14 times jitter rms when the edges of 1E+12 bits are captured. However, in practice, jitter is never completely random due to the presence of deterministic jitter, such as data-dependent jitter from the transmitter bandwidth limitations, and periodic jitter from switching power sources.



Amplitude/Time - ChannelB

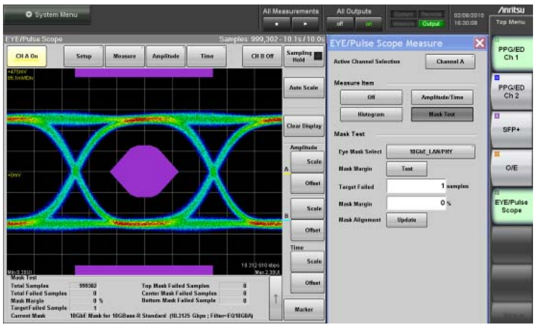
	Channel	Current	Average	Std Dev	Min	Max	
Jitter P-P	B	30.98	29.19	2.56	21.05	30.98	pS
Jitter RMS	B	4.24	4.15	0.05	4.07	4.28	pS
Crossing	B	53.92	53.81	0.18	53.13	54.00	%
Extinction Ratio	B	5.03	5.02	0.01	5.00	5.03	

Fig. 3-2

3.3 Compliance Mask Test

Sophisticated measurements are required because current technology in the datacom/telecom/fibre-channel sectors is at the cutting edge. As a result, the low pass filter (LPF) used for EYE pattern analysis must match every application. To achieve this goal, the Anritsu MP2100A BERTWave has an internal bank of six selectable filters.

Most recommendations describe performance limit lines called “masks” for the EYE pattern. Typical test EYE pattern at a bit rate of 10.3125 Gbit/s with 1 million samples and the associated masks is shown in Fig. 3-3. To pass the mask compliance test, the transmitter output must have no samples within the “keep-out” regions. There are several kinds of mask pattern, depending on the recommendation and bit rate. Generally, the mask test is executed after capturing some specified sample count, because the fail probability increases with count.



EYE/Pulse Scope Measure

Active Channel Selection: Channel A

Measure Item: Off, Amplitude/Time, Histogram, Mask Test

Mask Test

Eye Mask Select: 10GbE_LAN/PHY

Mask Margin: Test

Target Failed: 1 samples

Mask Margin: 0 %

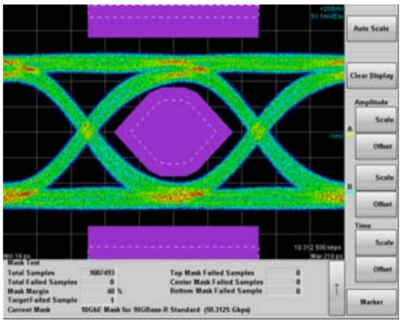
Mask Alignment: Update

Mask Test

Total Samples	999302	Top Mask Failed Samples	0
Total Failed Samples	0	Center Mask Failed Samples	0
Mask Margin	0 %	Bottom Mask Failed Sample	0
TargetFailed Sample	1		

Current Mask: 10GbE Mask for 10GBase-R Standard (10.3125 Gbps ; Filter=EQ10GBA)

Fig. 3-3



Mask Test

Total Samples	1007493	Top Mask Failed Samples	0
Total Failed Samples	0	Center Mask Failed Samples	0
Mask Margin	40 %	Bottom Mask Failed Sample	0
TargetFailed Sample	1		

Current Mask: 10GbE Mask for 10GBase-R Standard (10.3125 Gbps)

Fig. 3-4

3.4 Mask Margin Test

Compliance mask testing evaluates whether the measured signal passes the compliance for the application. Most R&D and production engineers want to know the margin from the compliance mask limit. An example of a mask margin test is shown in Fig. 3-4. The white dashed line is the compliance mask limit, and the purple area shows the accentual EYE opening means mask margin. In this case, the DUT output jitter is increased and the waveform is close to the center of the EYE. However, this signal passes the mask compliance with a 40% margin.

The Anritsu MP2100A BERTWave minimizes tact time when measuring mask margin using high-speed sampling and an automatic real-time mask margin test function (patent pending) that searches automatically for the mask margin. As a result the “Total Failed Samples” count is less than the “Target Failed Sample” count.

Traditional analyzers require time-consuming manual searches.

4 Ensuring Accurate Measurement Results

To measure extinction ratio, jitter, and mask margin of an optical transmitter we recommend using a Bessel Thomson Low Pass Filter (BT-LPF) with a bandwidth of 75% of the bit rate. Traditionally, since most optical transmitters use a directly modulated laser source, the rising waveform has large overshoot. Therefore, recommendations including IEC, IEEE 802.3 and ITU-T for optical communications specify use of a BT-LPF to eliminate overshoot when measuring EYE pattern. This section discusses the effect of BT-LPF characteristics on test results and dispersion.

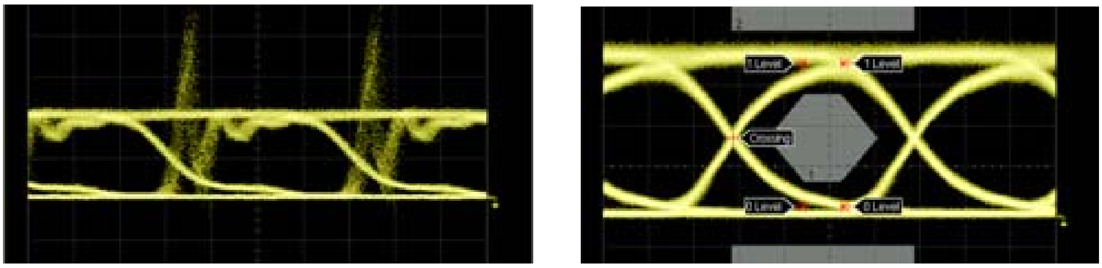


Fig. 4-1 Example of relaxation oscillation and filtered waveform

4.1 Effect of BT-LPF Characteristics on Test Result Accuracy

If the device has an infinite flat frequency response (gain and group delay), the ideal output should be a square waveform related directly to the input square waveform. However, since all devices have a cutoff frequency and group delay dispersion, all output waveforms have distortion, overshoot, undershoot, jitter, and inter-symbol interference (ISI).

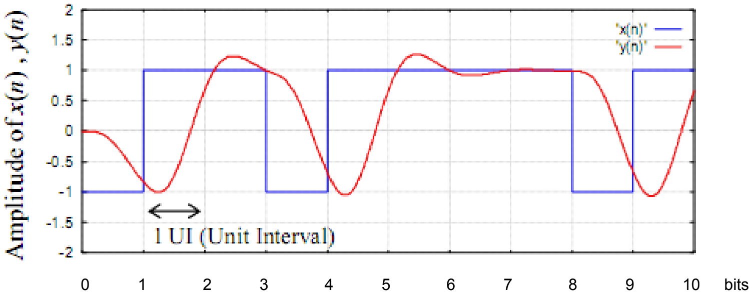


Fig. 4-2 Example of non-ideal frequency response

On the other hand, oscilloscopes, especially EYE pattern analyzers used for NRZ optical communications, should have an optimized BT-LPF with a bandwidth of 75% of the bit rate as well as very low group delay distortion characteristics as specified in ITU-T G.975 or IEEE 802.3, and should suppress waveform distortion, jitter and ISI. Figure 4-3 shows the reference receiver characteristics defined in ITU-T G.957 and G.691. G.957 defines the attenuation and group delay distortion of the optical reference receiver, and the –3 dB cutoff frequency is specified at f/fo = 0.75. G.691 defines the tolerance values for attenuation of the optical reference receiver. IEEE802.3 refers to these ITU-T recommendations.

ITU-T G.957 TABLE B.1

Nominal values of attenuation and group delay distortion of optical reference receiver

f/fo	f/fr	Attenuation (dB)	Group delay distortion (UI)
0.15	0.2	0.1	0
0.3	0.4	0.4	0
0.45	0.6	1	0
0.6	0.8	1.9	0.002
0.75	1	3	0.008
0.9	1.2	4.5	0.025
1	1.33	5.7	0.044
1.05	1.4	6.4	0.055
1.2	1.6	8.5	0.1
1.35	1.8	10.9	0.14
1.5	2	13.4	0.19
2	2.67	21.5	0.3

ITU-T G.691 Table A.1

Tolerance values for attenuation of optical reference receiver

f/fr	Δa [dB]		
	STM-4	STM-16	STM-64
0.001 to 1	±0.3	±0.5	±0.85
1 to 2 (Note)	±0.3 to ±2.0	±0.5 to ±3.0	±0.85 to ±4.0

NOTE: Intermediate values of Δa should be interpolated linearly on a logarithmic frequency scale.

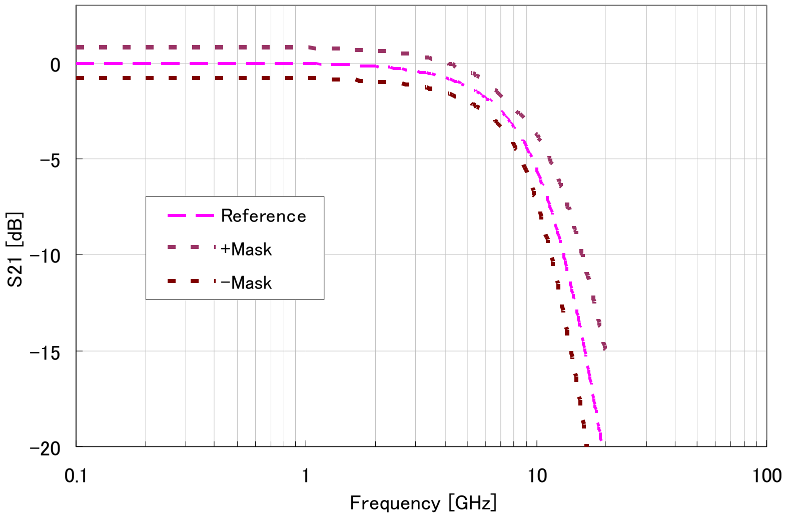


Fig. 4-3 Reference receiver characteristics specified by ITU-T G.691/G.957

Figure 4-4 shows a simulated output EYE pattern for an ideal BT-LPF with a bandwidth of 75% of the bit rate when an ideal square-wave is input. The waveform distortion is well suppressed. In contrast, Fig. 4-5 shows a simulated output EYE pattern for an LPF with a bandwidth of 60% of the bit rate; it has large ripple and group delay distortion. Clearly these differences in EYE pattern have a large impact on test results for extinction ratio, jitter, and mask margin.

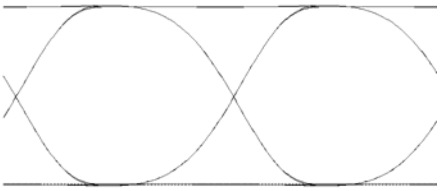


Fig. 4-4 Ideal BT-LPF

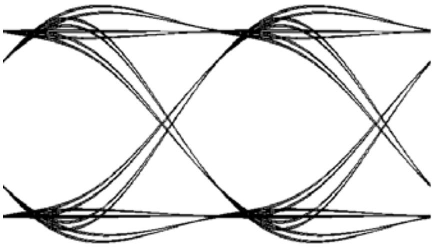


Fig. 4-5 LPF with 60% bandwidth

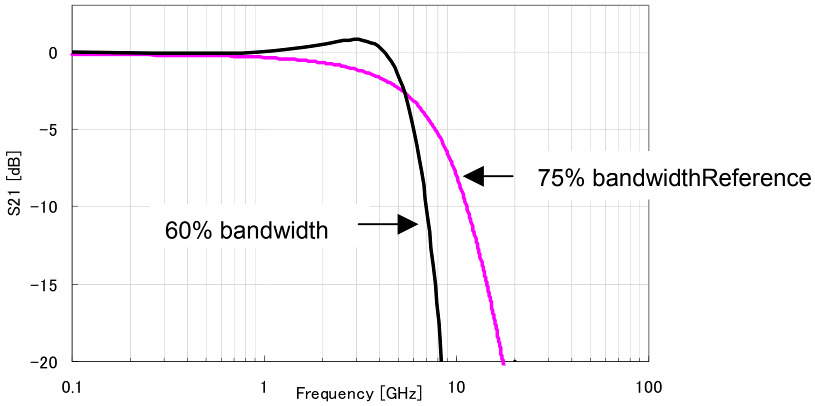
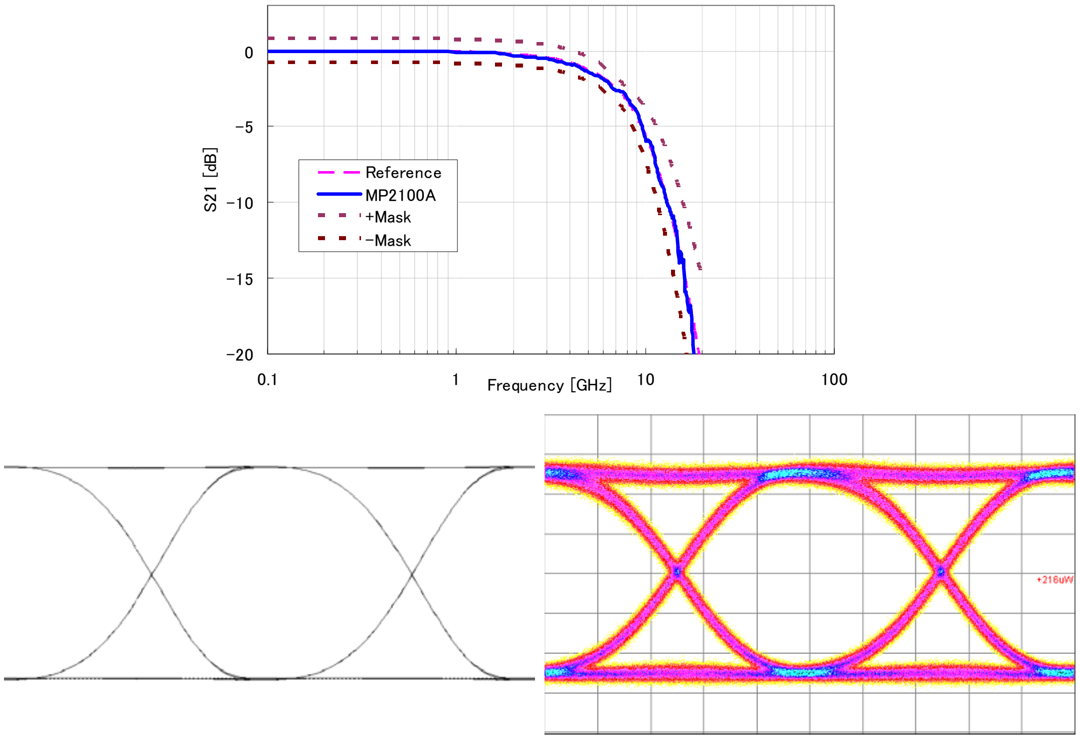


Fig. 4-6 Frequency response for ideal BT-LPF and LPF with 60% bandwidth

Since receiver frequency response largely affects measured waveform, the EYE pattern analyzer should have optimized characteristics close to the ideal frequency response. Anritsu has developed a unique precision BT-LPF (patent pending) for this purpose. The system frequency response of the Anritsu MP2100A optical channel is close to the ideal Bessel characteristics, helping suppress waveform distortion, jitter, and ISI. Figure 4-7 shows the system frequency response of the MP2100A as well as the EYE pattern of a reference transmitter measured using the MP2100A. This EYE pattern is close to the simulated waveform for an ideal BT-LPF and has suppressed distortion.



Simulated EYE pattern for ideal BT-LPF

EYE pattern measured using MP2100A

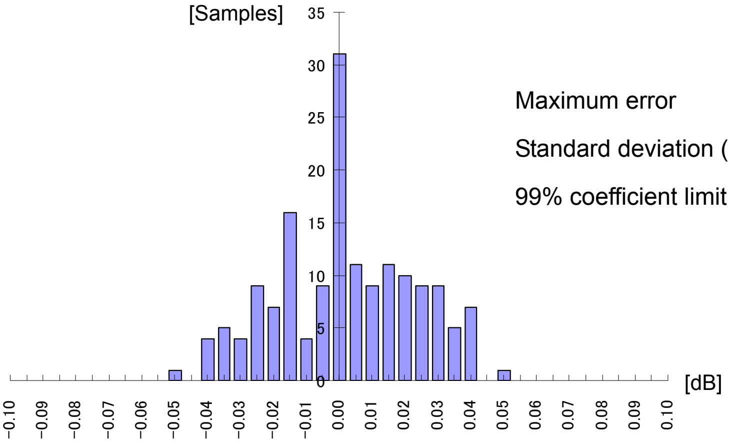
Fig. 4-7 MP2100A Receiver frequency response and EYE pattern of reference transmitter

4.2 Improving Analyzer Unit-to-Unit Variation for Measuring Extinction Ratio

As explained in section 4.1, because the measurement equipment characteristics, especially BT-LPF characteristics, have a large impact on extinction ratio measurement results, results can have a wide statistical dispersion even using the same model of analyzer.

To solve this problem, Anritsu developed a unique BT-LPF with low unit-to-unit variation, and designed an Analyzer Ao minimize unit-to-unit variation for extinction ratio results. The statistical data for measurement of a transmitter with variable extinction ratio (Fig. 4-8), and SFP+ and XFP modules (Fig. 4-9) are shown below.

Figure 4-8 shows the typical values for several units of MP2100A based on the means at the set extinction ratio for each bit rate; they are normalized for 162 samples and are random samples of actual measurements. The maximum variation is only ±0.05 dB and the standard deviation (one tail) is 1.1%. The 99% coefficient limit is ±0.051 dB.

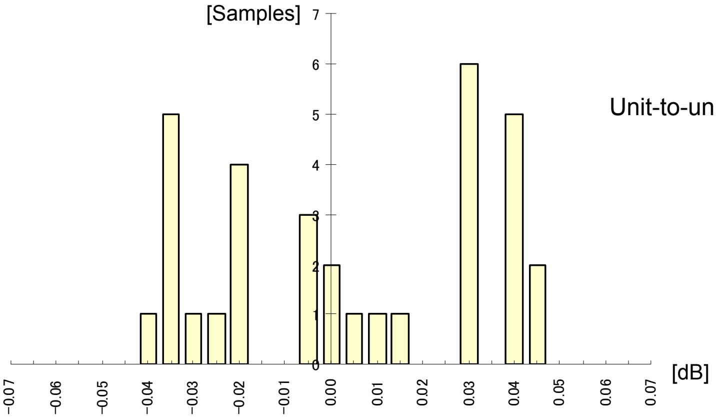


Maximum error : ±0.05 dB

Standard deviation (one tail) : 1.1%

99% coefficient limit : ±0.05 dB

Fig. 4-8 Measured extinction ratio of transmitter



Unit-to-unit variation: –0.045 to 0.045 dB

Fig. 4-9 Measured extinction ratio of SFP+ and XFP

Figure 4-9 shows the typical values for several units of MP2100A based on the means at the set extinction ratio for each bit rate; they are normalized for 32 samples and are random samples of actual measurements. Since there are few samples, it is impossible to show a meaningful standard deviation, but the instrument error is ±0.045 dB when a transceiver module was used.

These results show that the MP2100A unit-to-unit variation is very small regardless of the DUT.

5 Practical Measurement

This chapter compares the test results measured by the MP2100A BERTWave with sampling scopes from companies T and A. The DUTs (Table 5-1) are multiple transceiver modules, such as XFP and SFP+. The measurement items are extinction ratio, jitter (rms), mask margin.

Table 5-1 DUT Transceiver modules

	10.3125 Gbit/s	9.95328 Gbit/s
SFP+ 1310 nm	X	
SFP+ 1550 nm	X	
XFP 1310 nm	X	X
XFP 1550 nm	X	X

5.1 Measurement Block Diagram

Figure 5-1 shows the measurement block diagram. The same PPG and DUT are used for measurement and the optical signal is connected to each analyzer via an optical ATT and switch.

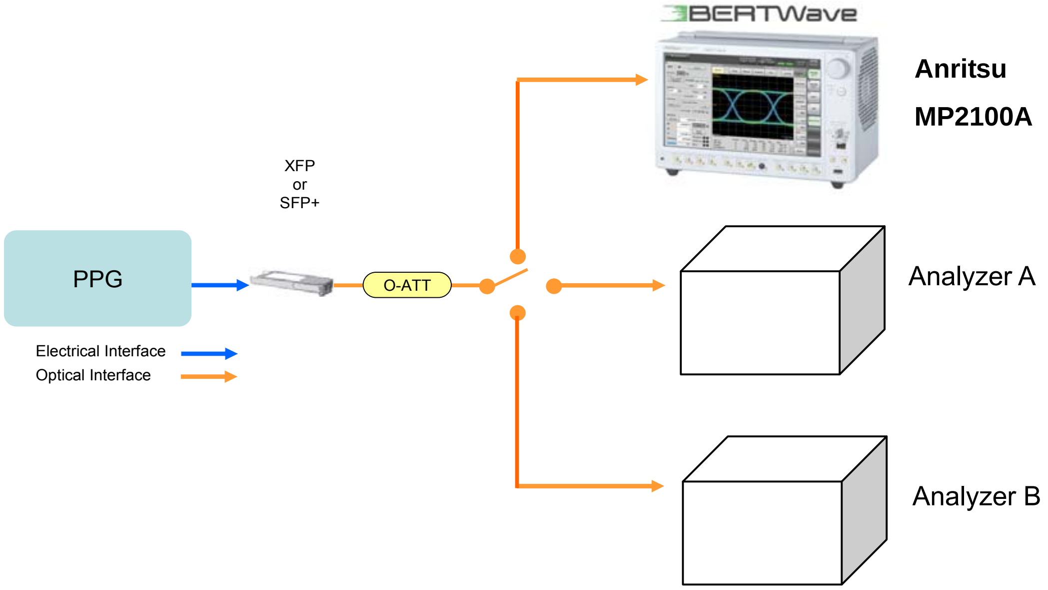


Fig. 5-1 Measurement setup

5.2 Extinction Ratio Test Results

5.2.1 Using SFP+ and XFP Modules

Table 5-2 shows the measured extinction ratio for the SFP+ and XFP modules. The Anritsu MP2100A and Analyzer A produce similar results. The result for Analyzer B is smaller than the other two analyzers. However, using the 4% correction factor recommended by the maker brings the result closer to the other analyzers.

Table 5-2 Comparison of extinction ratio measurement results for SFP+ and XFP modules

Bit Rate: 10.3125 Gbit/s unit: [dB]

Analyzer / DUT	Anritsu MP2100A	Analyzer A	Analyzer B	
	Without correction	Without correction	Without correction	+4% correction *
XFP 1310 nm	7.06	6.90	6.51	7.22
XFP 1550 nm	11.16	11.01	9.84	11.49
SFP+ 1310 nm	5.01	5.03	4.67	5.14

Bit Rate: 9.953 Gbit/s

Analyzer / DUT	Anritsu MP2100A	Analyzer A	Analyzer B	
	Without correction	Without correction	Without correction	+4% correction *
XFP 1310 nm	7.18	7.10	6.60	7.35
XFP 1550 nm	11.16	11.08	9.84	11.65
SFP+ 1310 nm	5.14	5.17	4.96	5.31

*: Added +4% correction factor recommended by maker

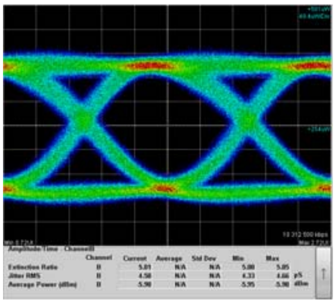


Fig. 5-2 Examples of EYE pattern when measuring extinction ratio (SFP+ 1310 nm) 10.3125G

5.2.2 Using Variable Extinction Ratio Transmitter

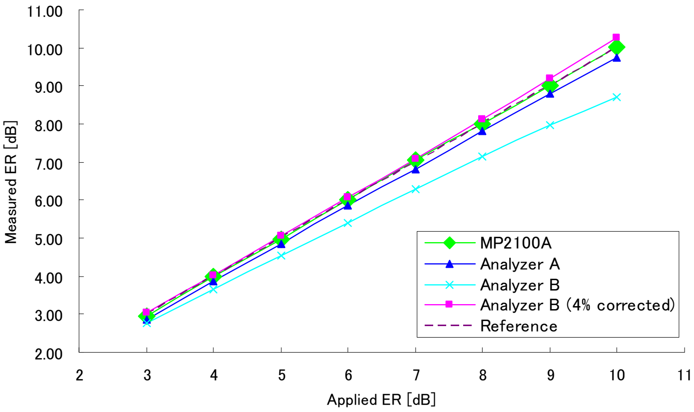
Figure 5-3 shows the measured extinction ratio results for a variable extinction ratio transmitter instead of SFP+ and XFP modules. The results for the Anritsu MP2100A and Analyzer A are close to TX ER, which is the variable extinction ratio transmitter setting. The result for Analyzer B without correction is smaller than the expected value. However, adding the maker's recommended 4% correction factor largely improves the error.

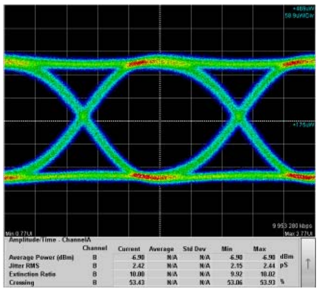
In addition, while there is some difference between analyzers measured results, all have good linearity. Figure 5-3 shows an example waveform when 10 dB was set at the variable extinction ratio transmitter.

Table 5-3 Extinction ratio measured with variable extinction ratio transmitter unit: [dB]

TX ER	Anritsu MP2100A	Analyzer A	Analyzer B	
	Without correction	Without correction	Without correction	+4% correction *
3	2.95	2.91	2.75	3.03
4	3.99	3.93	3.72	4.15
5	5.04	4.92	4.67	5.21
6	6.01	5.93	5.51	6.18
7	6.99	6.92	6.35	7.17
8	7.99	7.96	7.21	8.23
9	8.99	8.95	7.96	9.28
10	10.00	9.96	8.81	10.38

*: Added +4% correction factor recommended by maker





Amplitude/Time - ChannelA

	Channel	Current	Average	Std Dev	Min	Max	
Average Power (dBm)	B	-6.90	N/A	N/A	-6.90	-6.90	dBm
Jitter RMS	B	2.42	N/A	N/A	2.15	2.44	pS
Extinction Ratio	B	10.00	N/A	N/A	9.92	10.02	
Crossing	B	53.43	N/A	N/A	53.06	53.93	%

Fig. 5-3 Examples of EYE pattern when measuring variable extinction ratio transmitter

5.2.3 Adding Extinction Ratio Correction Factor

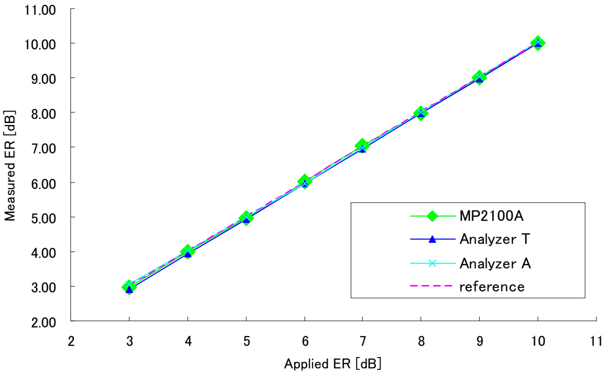
As discussed in section 3.1, there is no national or international standard for extinction ratio measurement accuracy, and measurement results differ between makers and models. As a result, each measurement may be different. One solution is to use a correction factor for extinction ratio. Table 5-4 shows the results when applying a correction factor so the measured result is 10 dB when TX ER = 10 dB using the variable extinction ratio transmitter described in section 5.2.2.

The correction factor is +0.1% for Analyzer A and 3.5% for Analyzer B. (The maker of Analyzer B recommends 4% but notes that there may be 0.5% unit-to-unit variation. Here, +3.5% is used to get the 10 dB test result.) As a result, all results for each analyzer between 3 dB and 10 dB are very close, showing that even if absolute values are different, all analyzers have good linearity and use of a correction factor is effective.

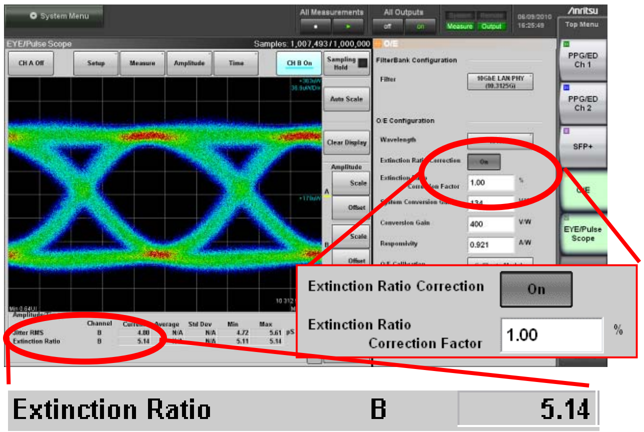
Table 5-4 Test result measured with variable extinction ratio transmitter (corrected at 10 dB)

unit: [dB]

TX ER	Anritsu MP2100A	Analyzer A	Analyzer B
	Without correction	+0.1% corrected	+3.5% corrected
3	2.95	2.92	3.02
4	3.99	3.94	4.06
5	5.04	4.93	5.10
6	6.01	5.95	6.03
7	6.99	6.94	7.00
8	7.99	7.98	8.01
9	8.99	8.99	8.93
10	10.00	10.00	10.02



Like the sampling scopes of the other companies, Anritsu's MP2100A has a correction function for extinction ratio. By using this function, we can maintain a consistent measurement result even using a different maker or model. Figure 5-4 shows the correction factor input screens of the MP2100A. The result is corrected by changing the extinction ratio Correction Factor [%].



Extinction Ratio Correction On

Extinction Ratio Correction Factor 1.00 %

Extinction Ratio B 5.14

Fig. 5-4 Extinction ratio correction function (Anritsu MP2100A)

5.3 Jitter Test Results Jitter (rms)

Table 5-5 compares jitter (rms) test results. The difference in the measured results is less than 1 ps but the Anritsu MP2100A shows the smallest values.

Table 5-5 Jitter (rms) test result

Bit Rate: 10.3125 Gbit/s unit: [psrms]

Analyzer / DUT	Anritsu MP2100A	Analyzer A	Analyzer B
XFP 1310 nm	2.57	2.70	3.26
XFP 1550 nm	1.90	2.59	2.82
SFP+ 1310 nm	4.50	4.43	4.93

Bit Rate: 9.953 Gbit/s

Analyzer / DUT	Anritsu MP2100A	Analyzer A	Analyzer B
XFP 1310 nm	2.29	2.50	3.20
XFP 1550 nm	2.05	2.56	2.93
SFP+ 1310 nm	4.16	3.60	4.23

Jitter results are composed of the component generated by the DUT (J_{DUT}) and intrinsic jitter (J_{INT}) generated by the Analyzer Ahe formula differs depending on the type of jitter (peak-to-peak or rms).

$$Jitter_{p\text{-}p} = J_{DUT} + J_{INT} \qquad \text{…Eq. 5-1}$$

$$Jitter_{rms} = \sqrt{J_{DUT}^{\ 2} + J_{INT}^{\ 2}} \qquad \text{…Eq. 5-2}$$

Although the DUT is the same, the jitter is different between the analyzers in these results. Thus, this difference is due to intrinsic jitter of the analyzer.

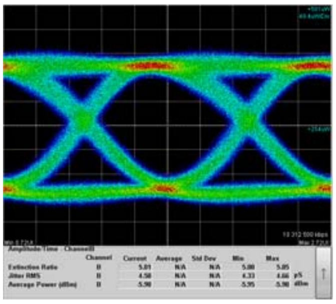


Fig. 5-5 Example of EYE pattern at jitter measurement (SFP+ 1310 nm 3125G)

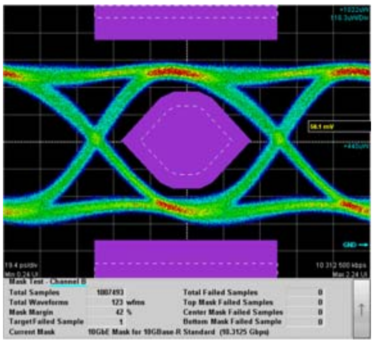
5.4 Mask Margin Test Results

Table 5-6 shows mask margin test results for the configuration in Fig. 5-1. All the analyzers show similar results with a small margin for SFP+ 1310 nm, and a large margin for XFP 1550 nm. The Anritsu MP2100A and Analyzer A are close, and the deviation from the mean is less than 3%. The results for Analyzer B are 6% (max.) higher than the average.

Table 5-6 Mask margin test result

Bit Rate: 10.3125 Gbit/s unit: [%]

Analyzer / DUT	Anritsu MP2100A	Analyzer A	Analyzer B
XFP 1310 nm	42.0	41.0	51.0
XFP 1550 nm	45.0	42.0	53.0
SFP+ 1310 nm	25.0	27.0	26.0



Mask Test - Channel B

Total Samples	1007493	Total Failed Samples	0
Total Waveforms	123 wfms	Top Mask Failed Samples	0
Mask Margin	42 %	Center Mask Failed Samples	0
TargetFailed Sample	1	Bottom Mask Failed Sample	0
Current Mask	10GbE Mask for 10GBase-R Standard (10.3125 Gbps)		

Fig. 5-6 Example EYE of mask margin test (XFP 1310 nm)

5.5 Mask Margin Measurement Time

The mask margin test results in section 5.4 were measured using 1 million samples. There are several steps in measuring mask margin: Connect the DUT to the analyzers; execute Auto Scale; capture 1 million samples; stop sampling; and measure mask margin. Minimizing measurement time increases measurement stability by avoiding short-term disturbances in the measurement system. However, the most important benefit is improved productivity.

The Anritsu MP2100A slashes measurement times due to its high-speed sampling and unique automatic test function for mask margin measurement.

Table 5-7 Mask margin measurement time unit: [s]

Measurement Items	Anritsu MP2100A	Analyzer A	Analyzer B
Auto Scale	2.5	3	3.8
1M samples Accumulation	10	9.9	30
Mask margin test	1 (Automatic)	12 (Manual search)	37 (Manual search)
Total	**13.5**	**24.9**	**70.8**

6 Relationship between Difference in Test Results and Receiver Frequency Response

As discussed in chapter 5, all the analyzers show the same trend in practical DUT measurement. In other words, all the analyzers show that: the SFP+ 1310 nm module has the smallest extinction ratio, largest jitter, and smallest mask margin; the XFP 1550nm module has the largest extinction ratio, smallest jitter, and largest mask margin. However, there are some small differences in the actual values between analyzers, which are explained here. As discussed in chapter 4, the BT-LPF performance plays a key role in EYE pattern analysis.

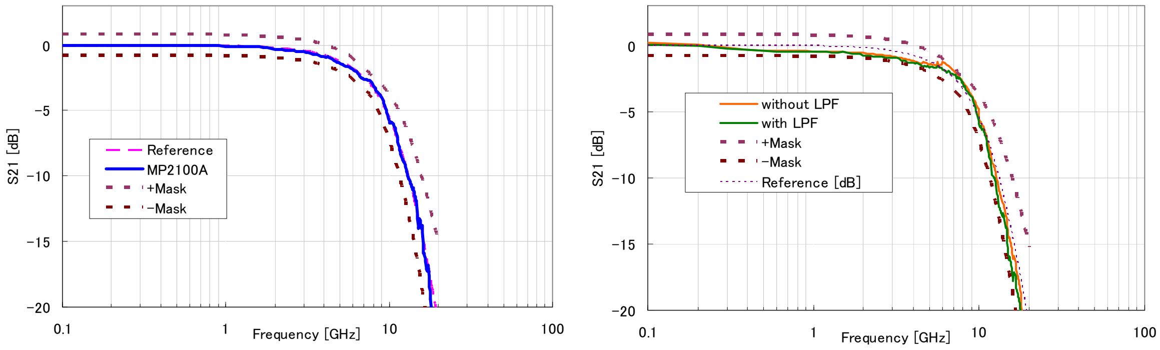


Fig. 6-1 Comparison of BT-LPF frequency response

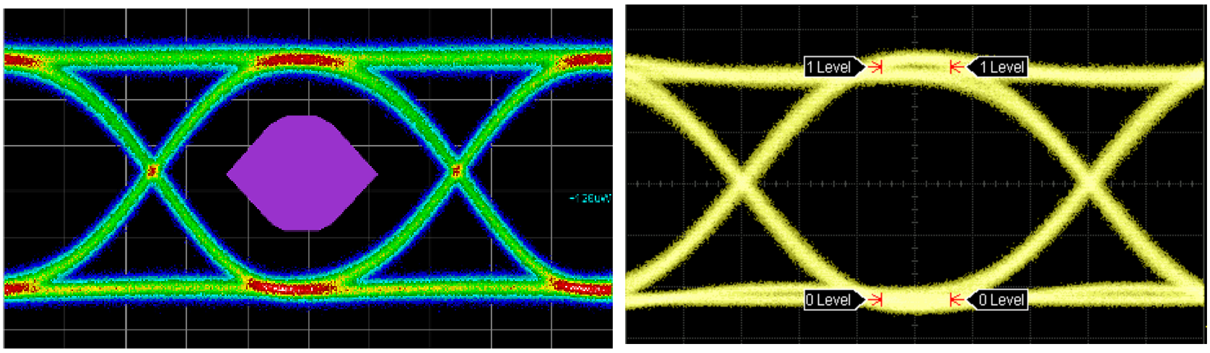


Fig. 6-2 Comparison of measured EYE pattern for reference transmitter
(Left: Anritsu MP2100A; Right: Analyzer B)

Figure 6-1 shows the frequency response of the Anritsu MP2100A and Analyzer B with 10.3125 Gbit/s specified as the BT-LPF, which has a 7.6 GHz cut-off frequency range. “Reference” is the ideal BT-LPF curve defined in ITU-T G.957, and “Mask” is the maximum limit defined in G.691. Both the Anritsu MP2100A and Analyzer B satisfy the reference receiver characteristics specified in G.957 and G.691. However, there is some difference in the measured EYE pattern due to closeness to the ideal Bessel curve. Figure 6-2 compares the measured EYE pattern of the reference transmitter specified in IEEE 802.3. The overshoot at the top side of the EYE and scatter in the baseline at the bottom are different from each other.

7 Summary

Simulations and actual tests show that the test instrument receiver characteristics have an impact on test results.

There are no international standards for measuring extinction ratio and differences in test results depend on model or unit-to-unit variation. The same results can be obtained by using correction factors. However, the test instrument should be stable and have minimum unit-to-unit variation.

Jitter and mask margin results are also affected by test instrument receiver characteristics and the system response must be close to the ideal Bessel curve.

The MP2100A BERTWave series with a unique precision BT-LPF (patent pending) developed by Anritsu supports accurate measurement of extinction ratio, jitter, and mask margin. In addition, high-speed sampling and the automatic mask margin test function (patent pending) slash tact times at EYE pattern analysis to raise production-line efficiency.

We expect the MP2100A BERTWave to have widespread applications for analyzing EYE patterns of devices like TOSA/ROSA, optical transceivers like XFP, and other transmission equipment.

We hope it will contribute to better network reliability.

References:

[1] K. Kim, J. Hwang, Y.B. Kim, and F. Lombardi, "Data Dependent Jitter (DDJ) Characterization Methodology," IEEE International Symposium on Defect and Fault Tolerance in VLSI Systems, Monterey, CA, October 3-5, 2005, pp294-302.

[2] Wolfgang Maichen, "Digital Timing Measurements From Scopes And Probes To Timing And Jitter", Springer, ISBN-10 0-387-31418-0

[3] ITU-T Recommendation G.691 "Optical Interfaces for single channel STM-64 and other SDH systems with optical amplifiers"

[4] ITU-T Recommendation G.957 "Optical interfaces for equipments and systems relating to the synchronous digital hierarchy"

[5] IEEE standard 802.3ae™-2005. "Part 3: Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications"

BERTWave

All in slimline 18cm

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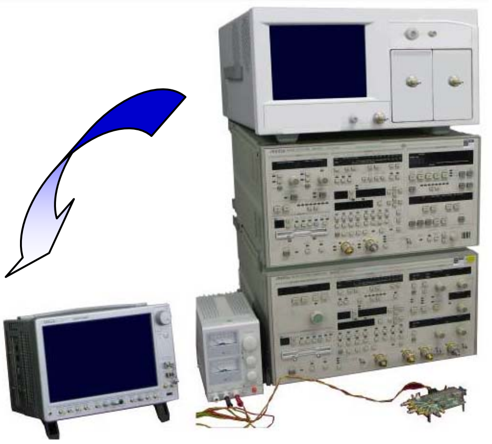

Simultaneous BER and EYE Pattern Analysis

The MP2100A BERTWave is a new-concept measuring instrument. Simultaneous BER and EYE/Pulse Scope measurements using an all-in-one tester increase efficiency and cut measurement costs by eliminating time-consuming setup. The MP2100A BERTWave series with excellent cost performance is ideal for both R&D and manufacturing tests.

Features

- **Simultaneous BER and EYE Pattern analysis**
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- **10x resolution, 10-ms BER testing**
- **Simultaneous and independent 2-channel PPG/ED**
- **High-speed sampling for EYE pattern analysis**
- **Automatic mask margin testing (patent pending)**
- **High repeatability and low unit-to-unit variation for extinction ratio and mask margin measurement (patent pending)**

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Choose from three configurations: BERT + Scope, BERT only and Scope only.

MP2100A BERTWave	BERT	Eye/Pulse Scope
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Specifications are subject to change without notice.

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