Stressed Receiver Conformance Test with Excellent Measurement Reproducibility of ±0.3 dB*1

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MP1800 Signal Quality Analyzer Series

Stressed Receiver Conformance Test with Excellent Measurement Reproducibility of ±0.3 dB[*1] for Checking Interoperability among Vendors

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1. Introduction

The recent spread of rich-content and triple-play services, etc., over the Internet has caused a steady increase in transmission capacity supported by use of 10-GbE transmission equipment and optical modules used in such equipment.

Optical module vendors have established various types of Multi Source Agreement (MSA) to help cut costs by expanding the market and production efficiency. These MSAs specify not only the equipment sizes, functions and performance but also the performance measurement methods. However, the performance of various optical modules supplied by vendors differs very slightly between them, making it necessary to confirm interoperability among vendors; the Stressed Receiver Conformance test standardized by IEEE802.3-2005 emulates an in-service circuit to help avoid problems in the field after shipment. Anritsu offers test equipment supporting the Stressed Receiver Conformance Test with a measurement reproducibility of ±0.3 dB*1 to improve vendors' yield of optical modules and support equipment makers' QC acceptance inspection results.

2. Measurement Method

The Stressed Receiver Conformance test system specified by IEEE802.3-2005 is shown below.

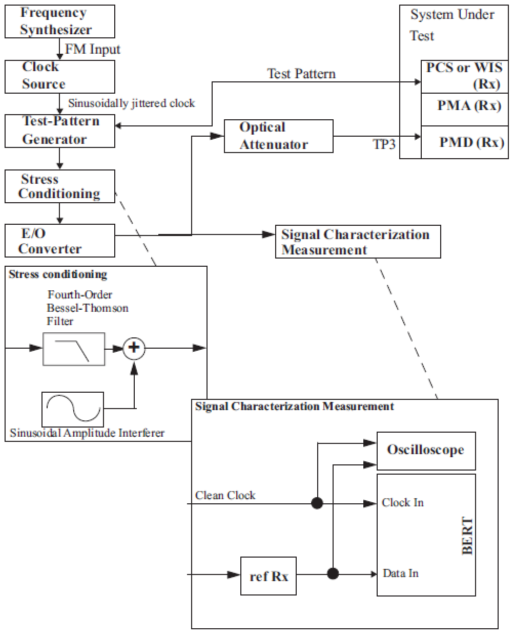


Figure 52–10—Stressed receiver conformance test block diagram

Fig. 2.1 IEEE802.3-2005 Test System

Anritsu supplies test systems using the test instruments shown below complying with the above IEEE802.3 standard test system.

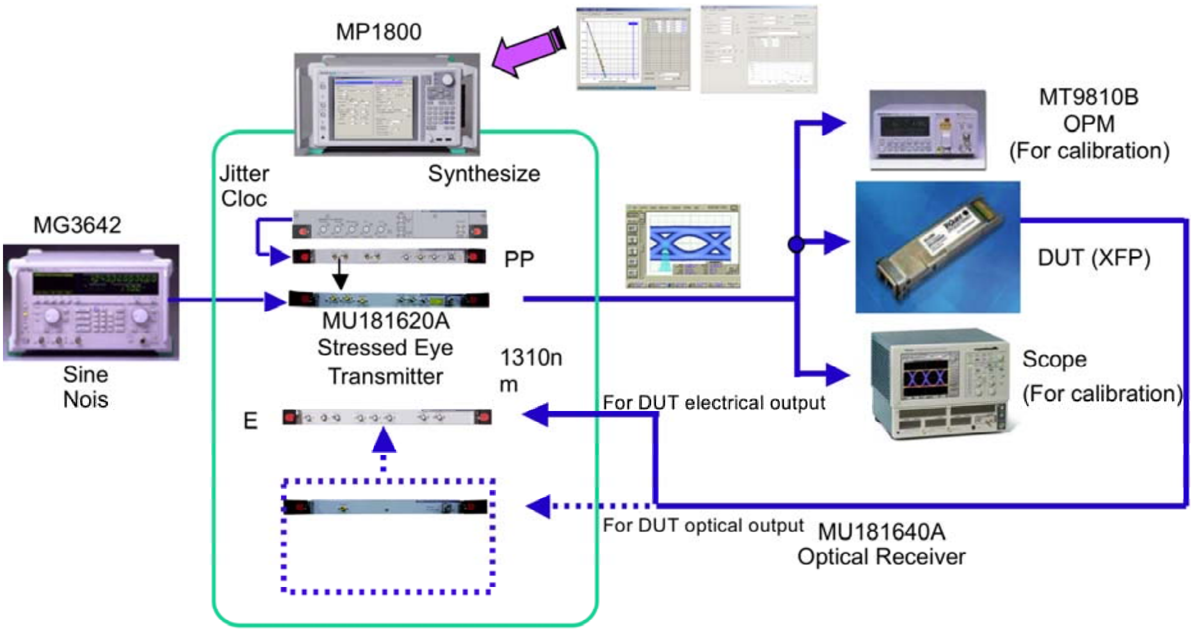


Fig. 2.2 MP1800 Series Stressed Receiver Conformance Test System

The test emulates an actual in-service transmission path with degraded waveform by imposing jitter in the phase direction and noise in the voltage direction.
Before testing, the stressed waveform used by the test is calibrated by the following method.

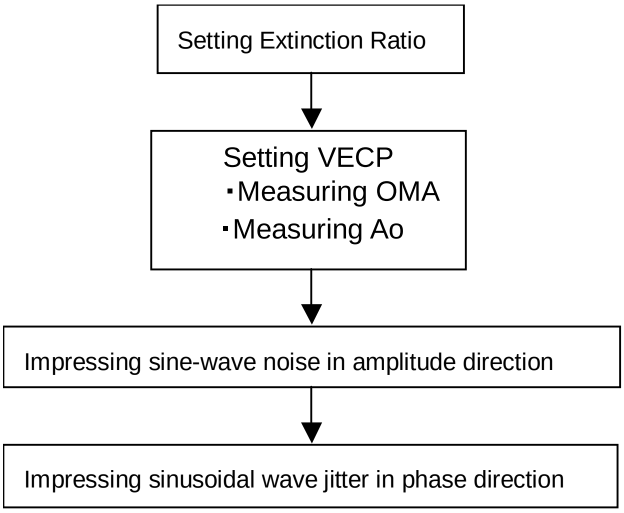
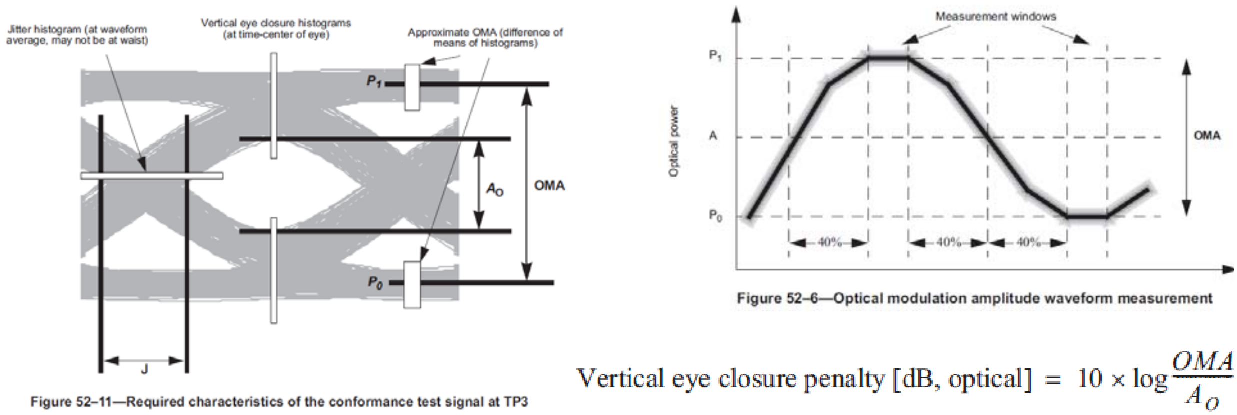


Fig. 2.3 Stressed Waveform Calibration Procedure

Here, Ao, OMA, and VECP are specified as follows by IEEE802.3-2005



$$\text{Vertical eye closure penalty [dB, optical]} = 10 \times \log \frac{OMA}{A_O}$$

Fig. 2.4 Definition of A0, OMA, and VECP

The minimum optical receiving sensitivity is measured using the waveforms defined above.

3. Verifying Measurement Data

The repeatability of minimum optical receiving sensitivity measurement results has a major impact on optical module yields. When the repeatability is low, the error is large and yield is badly impacted because some margin is required for just that part.

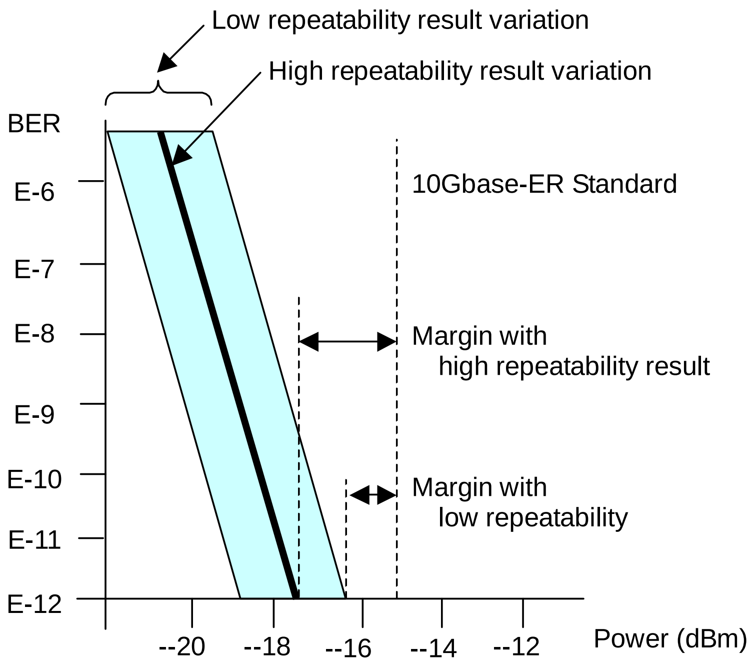


Fig. 3.1 Minimum Optical Sensitivity and Reproducibility

Figure 3.2 shows measurement results for the Anritsu measurement system. The measurement system inputs the electrical output of the DUT to the ED in Fig. 2.2.

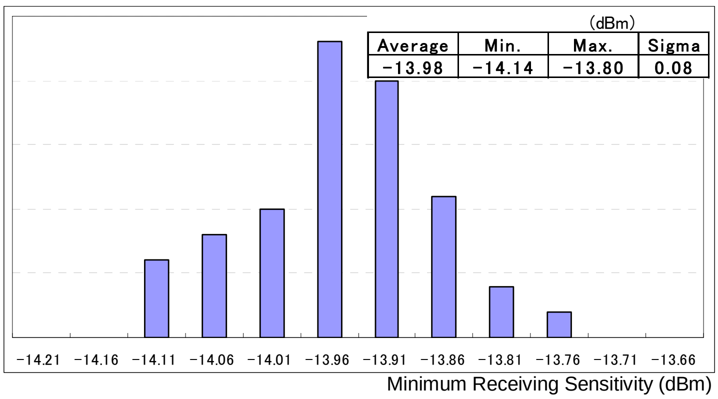


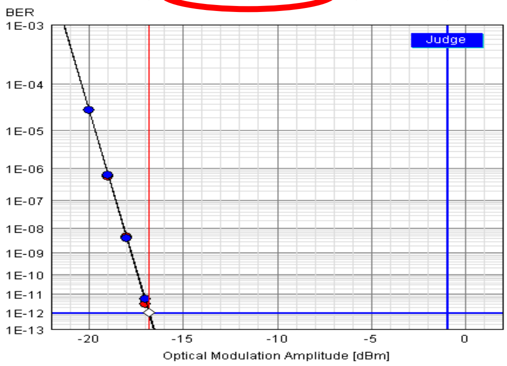
Fig. 3.2 Distribution of Minimum Optical Receiving Sensitivity Measurement Results

If the distribution of the measurement results in Fig. 3.2 follows a normal distribution, the 99.7% probability level covers –13.98dBm ±0.249 dB. As shown above, since the dispersion of the minimum optical sensitivity measurement results under specific conditions*1 is held down to ±0.3 dB*1, customers can minimize the impact of measurement results on yield by using the Anritsu measurement system.

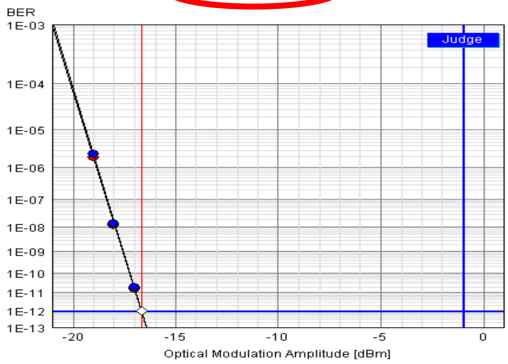
*1: 20° to 30°C
Typical measurement reproducibility when optical output of MU181620A connected directly to DUT and electrical output of DUT received by MU181040A

The following describes the differences in measurement results caused by using oscilloscopes from different makers for calibrating the waveform for the stress test. Figure 3.3 shows an example of the impact on minimum optical receiving sensitivity when using and not using a module operated at high accuracy by a trigger signal.
Generally, when using a high-accuracy reference clock module and monitoring a 10-Gbps waveform, the total jitter value is about 2 to 3 ps; when not using a high-accuracy reference clock module, the total jitter increases to about 7 to 8 ps due to the effect of random noise in the oscilloscope. From this observation, we can see that the jitter deteriorates by about 5 ps, depending on the presence or absence of a high-accuracy reference clock module.
When calibrating the waveform for the stress test without using a high-accuracy reference clock module, the value of the jitter monitored by the oscilloscope is apparently higher. As a consequence, the amount of jitter impressed from the measuring instrument required to generate a waveform matching the specifications is several ps smaller than the theoretical value (approx. 50 mUI).
The results in Fig. 3.3 show that there is no difference in the Tx residual jitter whether or not a high-accuracy reference clock module is used. This conjecture is based on the IEEEE802.3 jitter measurement specifications using 99% of the histogram measurement area and discarding the remaining 1%. When noise is impressed in the amplitude direction, this component also has an impact in the phase direction and the jitter increases. This is considered to be due to the impact of the histogram measurement area and the oscilloscope random jitter components including the discarded 1% and there is almost no effect of using or not using the high-accuracy reference clock module. In addition, the results of Fig. 3.3 also show that the difference in the maximum received optical sensitivity when using and not using a high-accuracy reference clock module is about 0.1 to 0.3 dB. From this example, it is clear that using a high-accuracy reference clock module has no major impact on the minimum optical receiving sensitivity measurement result. However, the theoretical difference of about 50 mUI is about 17% of the 300 mUI jitter value impressed in the IEEE802.3 recommendations. When the DUT jitter tolerance is low, this difference could have an impact on the Pass/Fail result, so it is better to use a high-accuracy reference clock module for module tests requiring higher-accuracy measurements.

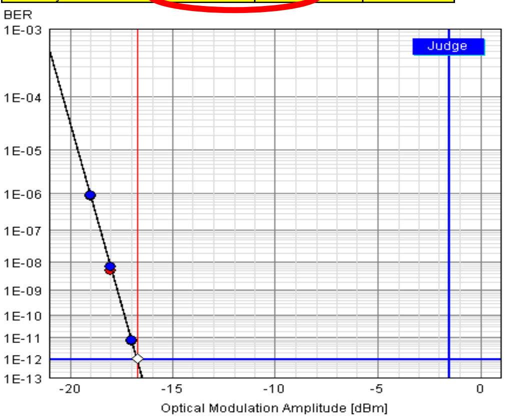
Company A	(with Timebase)			
Bit Rate	10.3125	Gbit/s		
Wavelength	1310	nm		
SI Level	7.4	dBm		
SI Freq	100	MHz		
Pattern	PRBS31			
Gating Time	100	sec		
Termination EC	10			
Auto Search	OFF			
Extinction Ratio	3.49	dB		
VECP	2.2	dB		
Average Power	-4.25	dBm		
Tx Intrinsic Jitter	0.146	UIp-p		
No.	Freq[Hz]	UIpp	UIpp(Add)	UIpp(All)
1	40,000	5	5	5
2	4,000,000	0.3	0.161	0.306
Penality	-16.8	dBm	1.00E-12	



Company A	(without Timebase)			
Bit Rate	10.3125	Gbit/s		
Wavelength	1310	nm		
SI Level	6.4	dBm		
SI Freq	100	MHz		
Pattern	PRBS31			
Gating Time	100	sec		
Termination EC	10			
Auto Search	OFF			
Extinction Ratio	3.5	dB		
VECP	2.17	dB		
Average Power	-4.09	dBm		
Tx Intrinsic Jitter	0.153	UIp-p		
No.	Freq[Hz]	UIpp	UIpp(Add)	UIpp(All)
1	40,000	5	5	5
2	4,000,000	0.3	0.156	0.309
Penality	-16.7	dBm	1.00E-12	



Company A	(with Timebase)			
Bit Rate	10.3125	Gbit/s		
Wavelength	1550	nm		
SI Level	4.4	dBm		
SI Freq	100	MHz		
Pattern	PRBS31			
Gating Time	100	sec		
Termination EC	10			
Auto Search	OFF			
Extinction Ratio	3.01	dB		
VECP	2.69	dB		
Average Power	-2.08	dBm		
Tx Intrinsic Jitter	0.204	UIp-p		
No.	Freq[Hz]	UIpp	UIpp(Add)	UIpp(All)
1	40,000	5	5	5
2	4,000,000	0.3	0.103	0.307
Penality	-16.7	dBm	1.00E-12	



Company A	(without Timebase)			
Bit Rate	10.3125	Gbit/s		
Wavelength	1550	nm		
SI Level	7	dBm		
SI Freq	100	MHz		
Pattern	PRBS31			
Gating Time	100	sec		
Termination EC	10			
Auto Search	OFF			
Extinction Ratio	3.03	dB		
VECP	2.71	dB		
Average Power	-2.11	dBm		
Tx Intrinsic Jitter	0.198	UIp-p		
No.	Freq[Hz]	UIpp	UIpp(Add)	UIpp(All)
1	40,000	5	5	5
2	4,000,000	0.3	0.106	0.304
Penality	-16.4	dBm	1.00E-12	

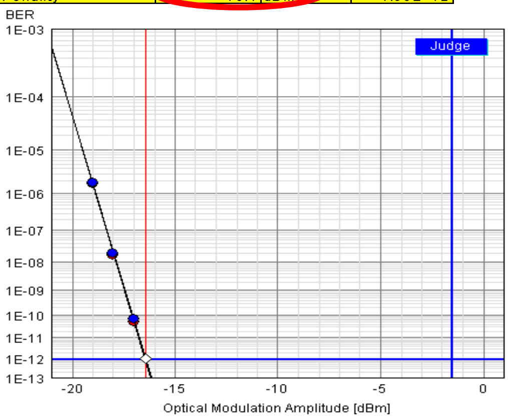
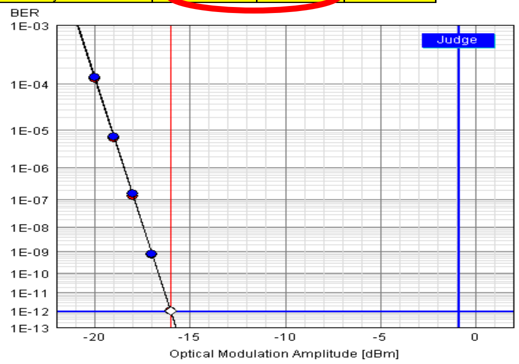


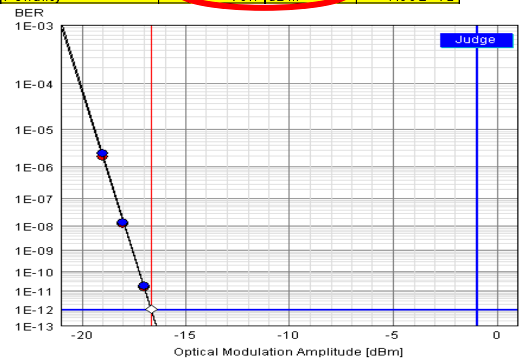
Fig. 3.3 Differences in Measurement Results for High-Accuracy Reference Clock Module

Last, the following figures show the impact on measurement results of using oscilloscopes from different makers for calibration by comparing companies A and B at wavelengths of 1310 and 1550 nm.

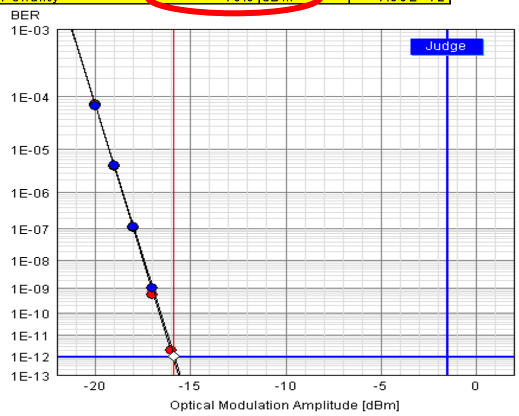
Company B	(without Timebase)			
Bit Rate	10.3125	Gbit/s		
Wavelength	1310	nm		
SI Level	14	dBm		
SI Freq	100	MHz		
Pattern	PRBS31			
Gating Time	100	sec		
Termination EC	10			
Auto Search	OFF			
Extinction Ratio	3.54	dB		
VECP	2.2	dB		
Average Power	-4.2	dBm		
Tx Intrinsic Jitter	0.192	UIp-p		
No.	Freq[Hz]	UIpp	UIpp(Add)	UIpp(All)
1	40,000	5	5	5
2	4,000,000	0.3	0.106	0.298
Penality	-16	dBm	1.00E-12	



Company A	(without Timebase)			
Bit Rate	10.3125	Gbit/s		
Wavelength	1310	nm		
SI Level	6.4	dBm		
SI Freq	100	MHz		
Pattern	PRBS31			
Gating Time	100	sec		
Termination EC	10			
Auto Search	OFF			
Extinction Ratio	3.5	dB		
VECP	2.17	dB		
Average Power	-4.09	dBm		
Tx Intrinsic Jitter	0.153	UIp-p		
No.	Freq[Hz]	UIpp	UIpp(Add)	UIpp(All)
1	40,000	5	5	5
2	4,000,000	0.3	0.156	0.309
Penality	-16.7	dBm	1.00E-12	



Company B	(without Timebase)			
Bit Rate	10.3125	Gbit/s		
Wavelength	1550	nm		
SI Level	11.2	dBm		
SI Freq	100	MHz		
Pattern	PRBS31			
Gating Time	100	sec		
Termination EC	10			
Auto Search	OFF			
Extinction Ratio	3.04	dB		
VECP	2.75	dB		
Average Power	-2.39	dBm		
Tx Intrinsic Jitter	0.231	UIp-p		
No.	Freq[Hz]	UIpp	UIpp(Add)	UIpp(All)
1	40,000	5	5	5
2	4,000,000	0.3	0.066	0.296
Penality	-15.9	dBm	1.00E-12	



Company A	(without Timebase)			
Bit Rate	10.3125	Gbit/s		
Wavelength	1550	nm		
SI Level	7	dBm		
SI Freq	100	MHz		
Pattern	PRBS31			
Gating Time	100	sec		
Termination EC	10			
Auto Search	OFF			
Extinction Ratio	3.03	dB		
VECP	2.71	dB		
Average Power	-2.11	dBm		
Tx Intrinsic Jitter	0.198	UIp-p		
No.	Freq[Hz]	UIpp	UIpp(Add)	UIpp(All)
1	40,000	5	5	5
2	4,000,000	0.3	0.106	0.304
Penality	-16.4	dBm	1.00E-12	

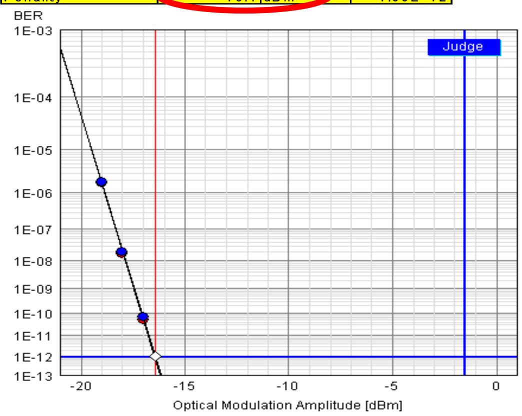


Fig. 3.4 Differences in Measurement Results from Oscilloscope Makers

Irrespective of the wavelength, the results show that the minimum optical receiving sensitivity is worse for company B. The big difference in the company A and B calibration results is the due to the effect of sine-wave noise level in the amplitude direction. When the optical signal power is attenuated, the noise level in the amplitude direction directly affects the BER measurement, explaining the worse minimum optical receiving sensitivity for company B with large noise level in the amplitude direction.

This difference in the impressed amplitude noise level is believed to be due to the effect of the frequency response of the oscilloscopes from company A and B. At this range, the gain tends to rise with frequency for company B but tends to fall for company A. The difference in the frequency response at the high range can be ignored due to the 4th order Bessel-Thompson filter used by measurement but the difference in the frequency response at the low range can be expressed as the OMA error. Because OMA is composed of frequency components in the low range, the OMA value for company A is bigger than the value for company B due to the different frequency response in the low range. As a result, to achieve the specified VECP value, company B requires a smaller value of Ao than company B, making it necessary to increase the externally impressed noise in the amplitude direction.

$$\text{Vertical eye closure penalty [dB, optical]} = 10 \times \log \frac{OMA}{A_O}$$

As a result, measurement using company B's oscilloscope impresses more noise in the amplitude direction than company A, resulting in worse minimum optical receiving sensitivity. However, from the perspective of preventing post-shipment problems, it is better to use an oscilloscope like company B's because module tests should be performed under the worst conditions.

4. Summary

The minimum optical receiving sensitivity test results obtained using the Stressed Receiver Conformance function of Anritsu's MP1800 series have a high reproducibility of ±0.3 dB*1. This reproducibility can be assured when using oscilloscopes from the same maker but testing shows that different results are obtained when using oscilloscopes from different makers.
However, whether or not an oscilloscope with a high-accuracy clock module is used, there seems to be no major impact on the minimum optical receiving sensitivity measurement. Notwithstanding this, Anritsu recommends performing measurement using an oscilloscope with a high-accuracy reference clock module to assure optical module quality, because tests should be performed under the worst conditions.
To increase the quality of customer's products, Anritsu offers the better measurement method.

5. Appendix and Recommended Equipment Setup

Instruments	Model Number	Option	Func: (Cal On) Penalty Test	Func: (Cal Off) Penalty Test	Func: (Cal On) Optical Jitter Sweep	Func: (Cal On) Optical Jitter Tolerance	Func: (Cal Off) Optical Jitter Tolerance
Clock Signal Generator	MU181000A/B	x01	○	○	○	○	○
			–		–	–	–
PPG	MU181020A	x02, x30	○	○	○	○	○
ED	MU181040A	x01 x02, x20, x30	○	○	○	○	○
Stressed Eye Transmitter	MU181620A	x01, x02 or x03 x11, x12 or x13	○	○	○	○	○
O/E Converter*1	MU181640A	–	○	○	○	○	○
	MU181600A	–					
Noise Generator (Vertical Noise)	MG3642A*2		△	△	○	△	△
Optical Attenuator	MU181620A	x04	○	○	○	○	○
	MN96xx	–					
Sampling Oscilloscope	86100A/B/C	-86106B-410 28 GHz optical channel single-mode unamplified (1000-1600 nm) -86107A Precision timebase reference module -86107A-020 10 and 20 GHz clock input capability or -86107A-040 10, 20 and 40 GHz clock input capability	○	–	○	○	○
	DSA8200	-80C11 30GHz Long Wavelength Multi-rate 10Gb/s Optical Module -82A04 Phase Reference Module		–			

*1：This is not required when the DUT output is directly connected to the ED.

*2：Measurement can be performed without this instrument if noise is not required (No VECP setting).

6. References

* IEEE802.3-2005

Note:

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Specifications are subject to change without notice.

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