Stressed Receiver Conformance Test with Excellent Measurement Reproducibility of ±0.3 dB\(^1\)

By  Toshihiro Suzuki
    Tadanori Nishikobara

TABLE OF CONTENTS;

1. Introduction
2. Measurement Method
3. Verifying Measurement Data
4. Summary
5. Appendix and Recommended Equipment Setup
6. References
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.
Anritsu supplies test systems using the test instruments shown below complying with the above IEEE802.3 standard 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.
Setting Extinction Ratio

Setting VECP
- Measuring OMA
- Measuring Ao

Impressing sine-wave noise in amplitude direction

Impressing sinusoidal wave jitter in phase direction

Fig. 2.3 Stressed Waveform Calibration Procedure

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

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.
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.

If the distribution of the measurement results in Fig. 3.2 follows a normal distribution, the 99.7% probability level covers $-13.98\text{dBm} \pm 0.249 \text{dB}$. As shown above, since the dispersion of the minimum optical sensitivity measurement results under specific conditions*1 is held down to $\pm 0.3 \text{dB}$, 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 IEEE802.3 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: 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

<table>
<thead>
<tr>
<th>No.</th>
<th>Freq (Hz)</th>
<th>Upp</th>
<th>Upp (Add)</th>
<th>Upp (All)</th>
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<td>4,000,000</td>
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<td>0.103</td>
<td>0.30</td>
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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
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Company A (with Timebase)
- Bit Rate: 10.3125 Gbit/s
- Wavelength: 1310 nm
- SI Level: 4.4 dBm
- SI Freq: 100 MHz
- Pattern: PRBS31
- Gating Time: 100 sec
- Termination EC: 10
- Auto Search: OFF
- Extinction Ratio: 3.51 dB
- VECP: 2.17 dB
- Average Power: -4.09 dBm
- Tx Intrinsic Jitter: 0.146 UIp-p

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<td>2</td>
<td>4,000,000</td>
<td>0.3</td>
<td>0.103</td>
<td>0.30</td>
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- SI Level: 4.4 dBm
- SI Freq: 100 MHz
- Pattern: PRBS31
- Gating Time: 100 sec
- Termination EC: 10
- Auto Search: OFF
- Extinction Ratio: 3.51 dB
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- Average Power: -4.09 dBm
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<td>0.103</td>
<td>0.30</td>
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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.
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 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.

Fig. 3.4 Differences in Measurement Results from Oscilloscope Makers
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.

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
<table>
<thead>
<tr>
<th>Instruments</th>
<th>Model Number</th>
<th>Option</th>
<th>CAT ON/ OFF</th>
<th>P宜 ON/ OFF</th>
<th>TDR ON/ OFF</th>
<th>time Domain ON/ OFF</th>
<th>CAT 5 ON/ OFF</th>
<th>CAT 6 ON/ OFF</th>
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<td>Stressed Eye Transmitter</td>
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<td>MUH1060A</td>
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<td>DTE Converter*</td>
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*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: