Application Note

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Method for Evaluating Clock Recovery Tolerance to Contiguous 1s and 0s

Signal Quality Analyzer MP1800A

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1 About Clock Recovery Evaluation

Recent high-speed digital transmissions are now commonly recovering the clock (Clock Recovery) at the receive side instead of sending both Clock and Data signals. In this type of system, Clock Recovery characteristics are the key to assuring high-quality transmission.

Generally, Clock Recovery is configured using a PLL circuit. At Clock Recovery design using a PLL circuit, the variation of capacitance and resistance elements in the PLL circuit results in variation in the product characteristics. This variation in characteristics can cause RX errors at the downstream ID circuit, possibly resulting in longer times until the entire system operation stabilizes.

As a consequence, it is essential to correctly understand the Clock Recovery characteristics. One typical test item for evaluating Clock Recovery is the test of tolerance to contiguous 1s and 0s.

In high-speed digital signals, a scrambling method is used with signals such as PRBS patterns to maintain a fixed transmitted signal DC Offset, to keep the ratio of 1s and 0s in the transmitted pattern, and to avoid too many contiguous 1s or 0s. An effective way of understanding the product characteristics is to run tests of Rx tolerance to contiguous 1s and 0s in an environment where such contiguous 1s and 0s rarely occur.

2 Contiguous 0s and 1s Tolerance Test Method

The SDH transmission standards generally use the CID pattern defined by ITU-T G.957 for testing the Clock Recovery tolerance to contiguous 1s and 0s. As well as having SDH Frame information, the CID pattern also includes 9 bytes of contiguous 1s and 9 bytes of contiguous 0s. Since the pattern is 9 bytes, it is possible to test the tolerance to 72 bits of 1s and 0s.

However, Clock Recovery also uses other high-speed transmissions in addition to SDH and there are evaluations using other methods besides the CID pattern.

PRBS patterns generated by a BERTS are test patterns with high randomness. The pattern period changes according to the PRBS type, such as PBBS 2^7-1, PBBS 2^31-1, etc., and the lengths of contiguous 1s and 0s in the pattern period also change with pattern type. For example, the period of a PBBS 2^7-1 pattern is 2^7-1 (127) bits and within these 127 bits, there are 7 bits of contiguous 1s and 6 bits of contiguous 0s. The period length of the PBBS 2^31-1 pattern is 2^{31}-1 (2147483647 bits) with 31 bits of contiguous 1s and 30 bits of contiguous 0s. In comparing the PBBS 2^7-1 and PBBS 2^31-1 patterns, since the latter pattern has longer runs of contiguous 1s and 0s, it can impose greater stress for Clock Recovery tolerance tests.

If the PRBS period is longer, since the number of bits of contiguous 1s and 0s becomes longer as well, it becomes possible to impose greater stresses. Based on this idea, there are also Clock Recovery tests of tolerance to contiguous 1s and 0s using very long PRBS patterns such as PBBS 2^58-1 and PBBS 2^61-1. However, running these tests requires focus on the reproducibility of the test results.

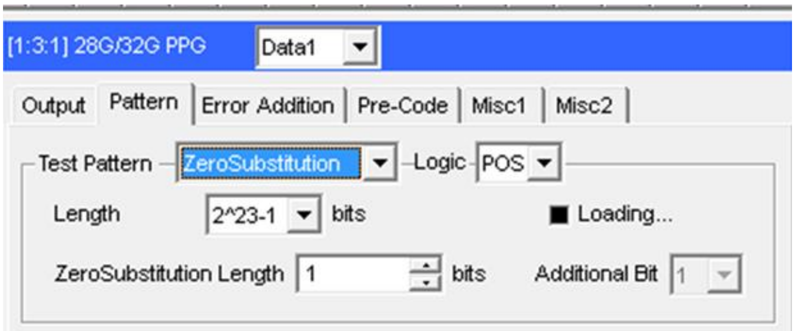
For example, let’s consider evaluation of the Clock Recovery in SERDES using 100GbE. In this case, the bit rate is 25.78125 Gbps, and the period of the PBBS 2^58-1 and PBBS 2^61-1 patterns is shown in the table below.

PRBS Type	Period (bit)	Cycle (Time @ 25 Gbps)
PBBS 2^58-1	288230376151711743 bit	129.4 days
PBBS 2^61-1	2305843009213693952 bit	1035.2 days

From the above, it is clear that any test using these patterns will require an extremely long time.

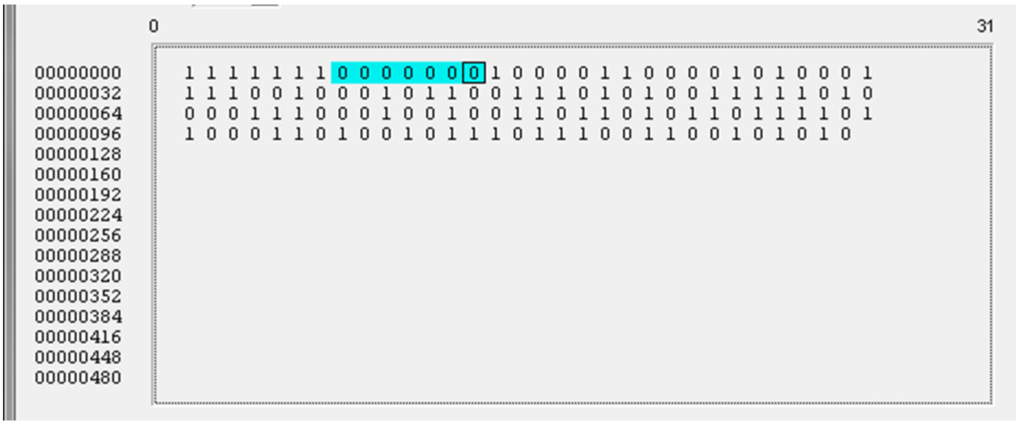
3 Anritsu Solution

The Signal Quality Analyzer MP1800A has a Zero Substitution pattern function in which the PRBS pattern is changed for testing the tolerance of Clock Recovery to contiguous 1s and 0s.



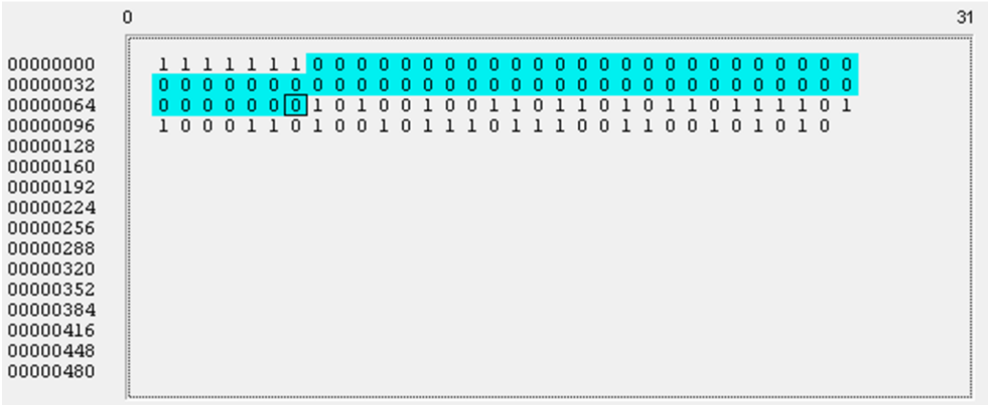
The MP1800A Zero Substitution pattern function can select any pattern equivalent to PBBS 2^7-1 to 2^23-1 while having the same basic pattern as PRBS. However, with Zero Substitution, the last bit of the part with the longest contiguous 0s substitutes 0 for 1, increasing the length of the contiguous 0s, which is what differentiates this method from PRBS. Increasing and decreasing the Zero Substitution Length setting in the above figure can be used to change the length of the contiguous 0s in the pattern.

For example, the following figures show the pattern when the Zero Substitution Length is set to 1 bit for a Zero Substitution of 2^7-1. In a PBBS 2^7-1 pattern, there are 7 bits of contiguous 1s (at left side of blue highlight in following diagram) followed by 6 bits of contiguous 0s (blue highlight in following diagram). However, in this example with the Zero Substitution Length set to 1 bit, the 6 bits of contiguous 0s of the PBBS 2^7-1 pattern are increased by 1 bit (black square on blue highlight in following figure) to 7 bits.



Lengthening the Zero Substitution Length increases the length of the contiguous 0s in the Zero Substitution pattern in 1-bit steps to impose stronger stress at the Clock recovery tolerance test.

The following shows an example of the Zero Substitution pattern when the Zero Substitution Length is set to 58 bits. The 2^7-1 Zero Substitution is the same as PBBS 2^7-1 with the original 6 bits of contiguous 0s, but the Zero Substitution Length setting substitutes 58 bits of contiguous 0s, giving a total of 6 + 58 contiguous 0s (blue highlight) in this example.



If a pattern with higher randomness than PBBS 2^7-1 is required, it is possible to select 2^{23}-1 Zero Substitution equivalent to PBBS 2^23-1 to lengthen the Zero Substitution Length. The pattern length is equivalent to PBBS 2^23-1 and is generated at the previously described 25.78125 Gbps, but since the length of one period is 0.3 ms ((2^{23} - 1 bit)/25.78125 Gbps), the test can be run in a realistically practical time compared to tests using PBBS 2^58-1 and PBBS 2^61-1. In addition, inverting the pattern polarity also supports testing the Clock Recovery Rx tolerance to contiguous 1s instead of contiguous 0s.

4 Summary

This article explains how to use the Zero Substitution Pattern function to test the Rx tolerance of Clock Recovery to contiguous 1s and 0s in a realistically practical time.

Anritsu is continuing to develop new solutions supporting customers' future test and verification needs.

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