White Paper: BERT Baseline Polish versus Polishing Process 2

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Introduction

Bit Error Rate Testing (BERT) provides cabling and connectivity manufacturers with a wealth of performance assessments with which to test and improve the performance reliability of a connectivity system with all transmit and receive components in place, simulated under real-world network conditions. Moreover, BERT offers manufacturers deploying the test a competitive advantage by offering their customers connectivity performance beyond the standards generally met by other industry manufacturers.

At OCC, BERT demonstrated that a single dirty connector can affect the Bit Error Rate of a network by 50 times or more, leading to improved cleaning methods not often deployed in the industry. In this case, we examine how BERT is being deployed to optimize multimode connector polishing and termination in a pre-terminated cable assembly to reduce further bit error rates. The results ultimately improve and ensure optimum connectivity performance at today's mega-speed rates of 10, 40, and 100Gigabit/second.

Connector Polishing Testing Details

The optical link is constructed using a group of 10 multimode LC-UPC polished connectors flowing from a 300 meter OM3 rugged HC cable. First, BERT testing is conducted on the baseline or current polishing process used; referred to as Polish Process 1. In the quest of improving multimode connector performance, a second process involving an additional buffing step used with single-mode connectors is performed and is referred to as Polish Process 2.

The additional polishing step on the multimode connectors would take an additional 2 minutes in the current manufacturing process. An exploration as to whether Polish Process 2 leads to any significant reduction in bit errors, thereby improving performance, is carefully examined. Based on the results, interferometer measurements on important connector quality criteria, such as radius of curvature, apex offset, insertion loss, and back reflection are conducted, as well. Essentially, the testing answers the questions whether there is significant multimode connector performance improvement and why, which would ultimately justify the extra 2 minute buffing process.

Initial BERT Results

The multimode connector polishing bit error test results indicate a significant improvement in connector performance with Polish Process 2, as shown in Figure 1.

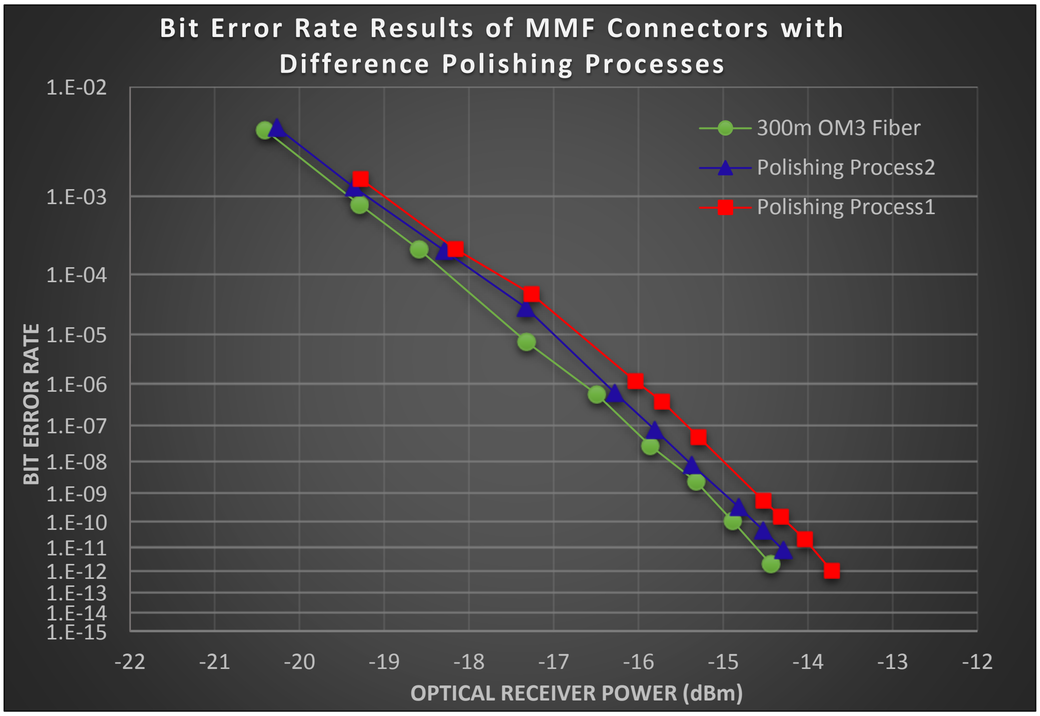
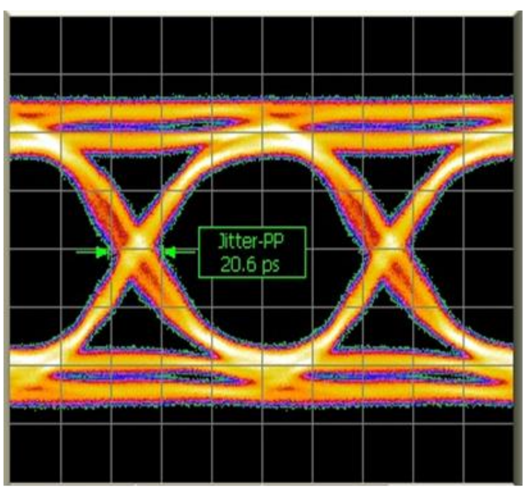


Figure 1: The Bit Error Rate performance comparison of MMF LC/UPC connectors with two different polishing processes. The testing was performed with 10 connectors cascaded with a 300m OM3 cable.

The results indicate that at a BER of 10^{-12}, the optimized polishing process 2 has improved approximately 0.3dB of dispersion power penalty at 10 Gigibit/sec compared with that of polishing process 1. At first, it may seem that 0.3dB is a miniscule improvement. However, if one considers that 0.25db can be equated to 1 connector loss that could severely compromise signal transmission, then an improvement of 0.3db is truly significant. Figure 2 expounds on the improvement in jitter with Polishing Process 2.



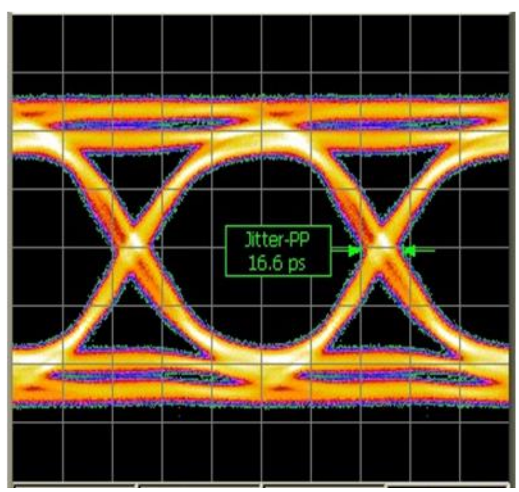


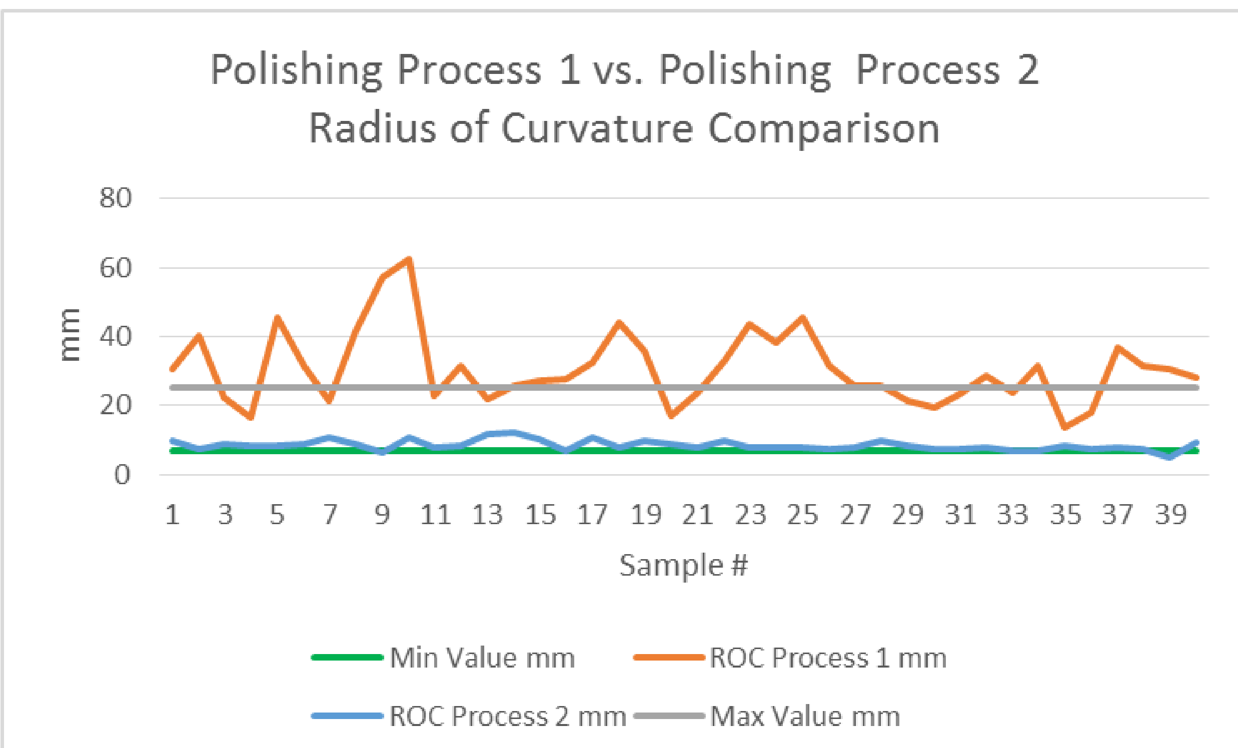
Figure 2. The eye diagram of the optical link with connectors polished with process 1(left) and process 2 (right).

Jitter involves the variation in the delay of received packets. Due to network congestion, configuration errors, or other causes, the delay between packets can vary instead of remaining constant. Among the causes of jitter are electromagnetic interference (EMI) and crosstalk with other signals. Jitter can affect the desired performance of desktops or servers and even cause loss of transmitted data between network devices. Generally, the lower the Jitter per Bit Interval, the better. By adding the extra buffer step in Polishing Process 2, the likelihood of jitter is diminished, thereby improving connector and overall system performance.

Since 10Gigabit/sec line speed is the building block for 40G and first generation of 100G data rates, these test results also apply to 40 and 100Gigabit/sec data rates. To determine the cause of the performance increase of Polishing Process 2, an examination using interferometer readings was conducted. The first two examinations for radius of curvature and apex offset deal with the important geometry of the connector to ensure optimal connector performance for the minimization of insertion loss and back reflection that is also carefully assessed.

Radius of Curvature Comparison:

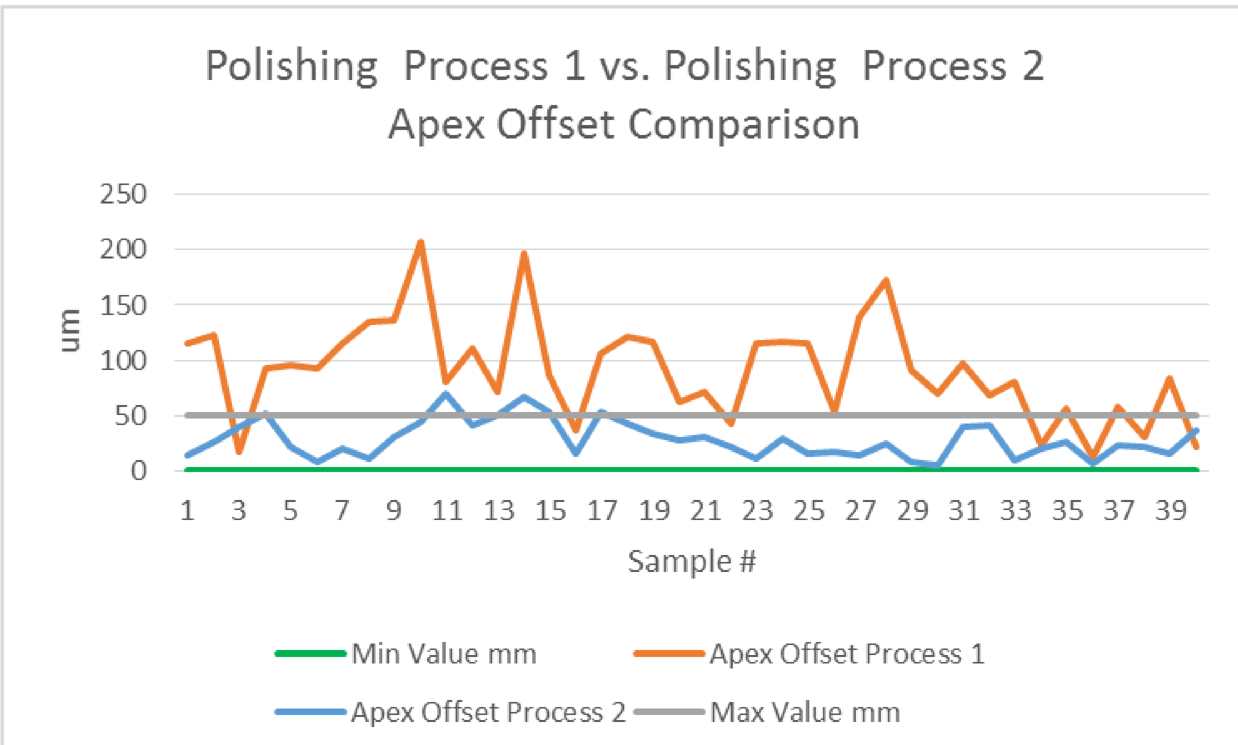
The endface of connector ferrules are domed to guarantee that the mating of connectors is at the center of the ferrule where the fiber core is located. The dome's radius is referred to as the "Radius of Curvature." If the radius is too low, for example, there would be too small of a contact area, thereby applying too much force on the fiber during mating. Conversely, if the radius is too high, contact between the fibers may not be achieved. Therefore, the Radius of Curvature is one of the most important connector performance indicators.



According to the data reading, there is significant difference in the Radius of Curvature between the baseline polish Polishing Process 1 and Polishing Process 2. 27 out of 40 (67.5%) of the samples failed with Polishing Process 1, while only 4 out of 40 (10.0%) failed with the extra buffing step of Polishing Process 2. The graphs reveal that majority of the readings for the baseline polish have a tendency to exceed the maximum pass/fail rate of 25.0mm, while the majority of the readings for Polishing Process 2 are maintained within the pass/fail criteria. However, 4 of the Radius of Curvature readings for Process 2 fell a little below the minimum pass fail limit of 7.0mm.

Apex Offset Comparison

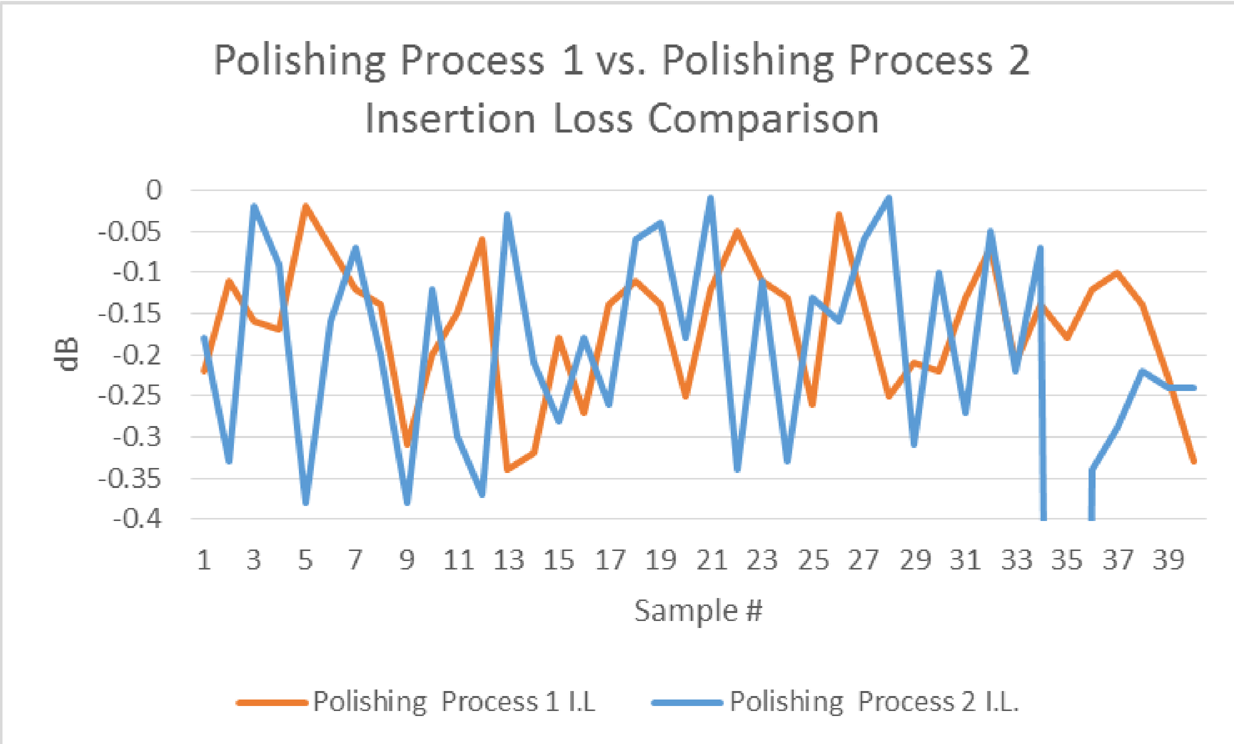
The second measurement involving connector geometry that affects overall connector quality is the Apex Offset. Simply, the center of the fibers should be the highest point on the endface to ensure excellent alignment.



As the data reading indicates, there is a significant difference between Apex Offsets for Polishing Process 1 and Process 2. 33 out of 40 (82.5%) of the samples failed with the baseline polish Process 1, while only 5 out of 40 (12.5%) failed with Polishing Process 2. The graphs reveal that the majority of the readings for the baseline polish have a tendency to exceed the maximum pass/fail rate of 50µm, while the majority of the readings for the Polishing Process 2 are maintained within the pass/fail criteria. These findings again support that the extra buffing step on the multimode connectors improve the quality of the connector and, thereby, overall connectivity performance.

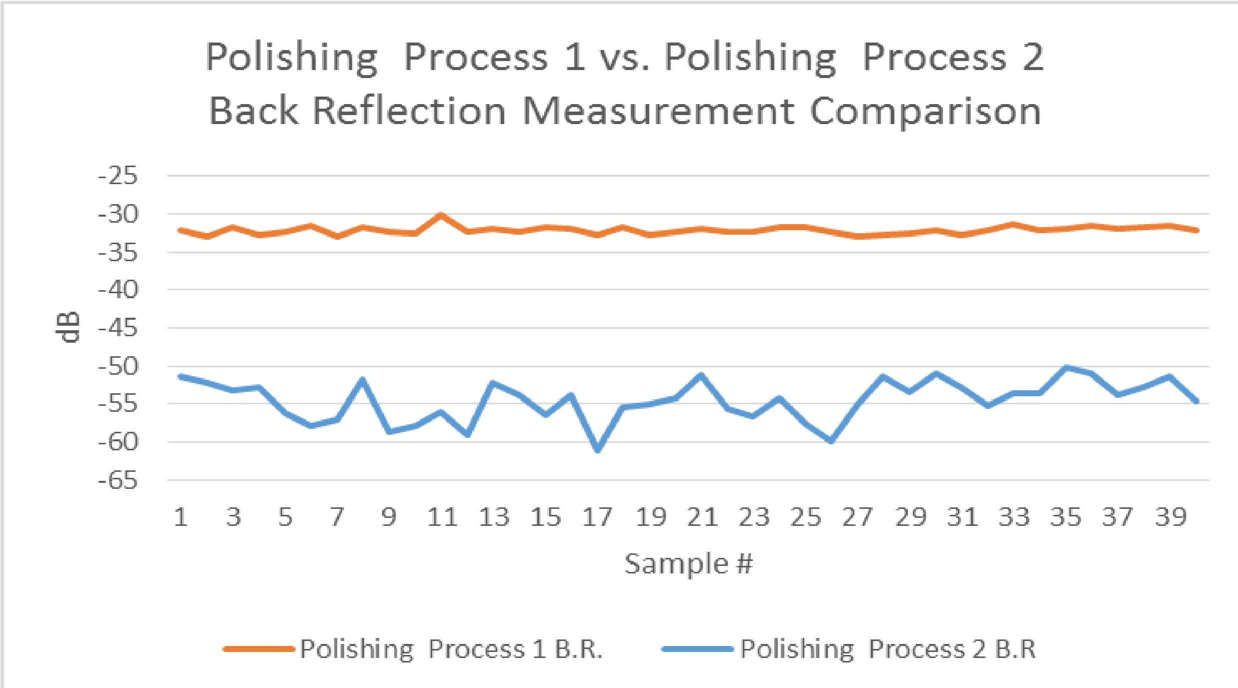
Insertion Loss Comparison:

There are no significant differences between the baseline Polishing Process 1 and Process 2 for insertion loss. All of the samples for both the processes are maintained within the -0.4dB to 0dB range, with the exception of one outlier (Sample #35 of 1551-574 = -3dB).



Back Reflection Comparison:

Unlike single-mode fiber, multimode can be susceptible to back reflection or the amount of light that is reflected back up the fiber, especially when VCSEL lasers are used. Therefore, return loss is a measurement of great importance to customers when assessing the quality of the connectors.



As the reading indicates, there is a significant difference between Back Reflection measurements for the baseline Polishing Process 1 and Polishing Process 2. The back reflection measurements for the baseline polish ranged from -30.2dB to -32.9dB, while the measurements for Polishing Process 2 shows minimal reflectance with ranges from -50.1dB to -61.1dB. This finding validates that the additional buffing process deployed on the connectors improved connector performance by reducing back reflection and return loss.

Conclusion and Summary of Results:

Samples 1551-573 (Polishing Process 1) and samples 1551-574 (Polishing Process 2) have been compared on two levels. The first level of assessment was based on the BERT results, and the second level of analysis from the various interferometer measurement results and their pass/fail criteria. The BERT results clearly revealed that there is a significant improvement in performance when the extra buffing step of the multimode connectors is conducted with Polishing Process 2 versus baseline Polishing Process 1. Therefore, an examination of the interferometer readings was done to learn more about the specifics of the performance increase.

All 40 samples were tested on the interferometer and it was determined that 2 out of the 14 measurement parameters, Radius of Curvature and Apex Offset, were causing the samples to fail. The interferometer measurements concluded that 38/40 (95.0%) samples failed with polishing process 1 while only 5/40 (12.5%) failed with polishing process 2; resulting in an 82.5% performance improvement.

Insertion loss and back reflection measurements were also examined. It was determined that there was no significant differences between Polishing Process 1 and Polishing Process 2 for insertion loss, but there was a significant difference in the back reflection measurements. The back reflection measurements yielded opposite results with the Polishing Process 1 ranging from -28.8dB to -33dB, and Polishing Process 2 maintaining minimal reflectance with ranges from -50.1dB to -61.1dB.

These findings conclude that the addition of the 2-minute buffing step of Polishing Process 2 improved the geometric quality of the multimode connectors leading to reduced back reflection and overall better connectivity performance. Having conducted these stringent tests, OCC has improved the quality of its multimode connectors beyond many of those on the market by other manufacturers, many of which rely on minimal standard connector testing. Therefore, network managers and installers can rest assured that OCC's pre-terminated cable assemblies are one of the, if not the most, reliable assemblies on the market today for 10, 40, and 100Gigabit/second networks.