

Fiber Optic Multi Channel Expanded Beam Connector

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ABSTRACT

To compliment the development of the single channel small form factor size 16 optical Expanded Beam (EB) pin and socket contacts, we have explored the possibility of designing a multi-fiber high density lensed termini (HDLT). This paper describes the design efforts of an insert containing two ferrules accommodating a total of 24 fibers and mountable into a size 8 Quadrax cavity of a 38999 style connector. To take advantage of the expanded beam concept and to keep the design cost effective, the ferrules are molded with a 12 fiber v-groove array positioned behind integral lenses. Originally, the ferrules were designed for the relative benign environment of datacom applications. Therefore, in order to accommodate the broader operational environment of aerospace applications which includes mechanical vibration, thermal cycling and high humidity exposure a suitable epoxy had to be identified. Design details, proposed solution, and initial test results are discussed.

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INTRODUCTION

Most of today's multi-fiber applications make use of the widely known MT ferrule which requires physical contact (PC) between the mated fibers. In order to achieve a suitable PC fiber endface, a precision abrasive polishing process must be used for the termination. Based on application experience, the MT design requires frequent maintenance in an attempt to reduce the degradation that is likely to occur for any PC connector when forced glass to glass contact exists in an environment of dust and other contaminants. In contrast, the HDLT concept offers a contactless beam expansion across the optical interface which is a technology known for its low sensitivity to the presence of airborne contamination particles. To make the design more cost effective, the ferrules are manufactured by high precision micro-molding of a material suitable for light transmission at the application wavelengths. The challenge here is to mold an array of V-grooves which are precisely aligned with the integral lens features. The fibers are cut by a laser process with no additional processing steps needed and therefore eliminates the time consuming abrasive polishing procedures required for the MT. The result of the HDLT design is that a pair of existing Quadrax copper contacts can easily be replaced with a 24-fiber multimode insert and thus provides a high channel density per cavity (see Figure 1). For example, an 8Q8-38999 connector can hold up to 8 HDLT inserts, yielding a total of

192 fiber channels. The high channel density results in a substantial data rate increase transfer per connector.

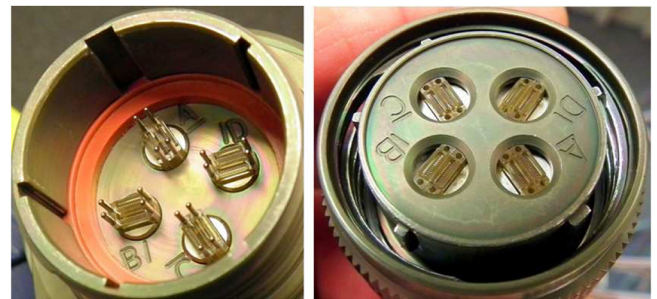


Figure 1. HDLT ferrules mounted in a 4Q4 38999 Receptacle and Plug shells (96 fiber channels)

24-FIBER HDLT ASSEMBLY

Multi-Fiber Ferrule

The stripped ribbon fibers are positioned in v-grooves with their end faces in contact with the first wall of the molded ferrule. As the light exits the launch fiber, it immediately enters through the first wall of the molded ferrule. The beam expands as it travels through the composite material and when exiting the lens-shaped second ferrule wall the expanded beam is collimated and travels across the airgap at the ferrule interface. When the collimated beam enters the lens of the receiving ferrule, the process is reversed and the

beam is eventually focused onto the endface of the receiving fiber. The propagation concept is illustrated in [Figure 2](#).

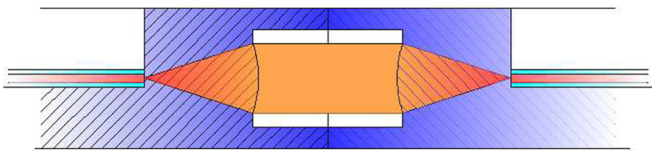


Figure 2. Optical propagation through a pair of mated expanded beam HDLT ferrules

Due to expansion of the beam across the interface, the optics have reduced sensitivity to contamination and very little signal distortion is experienced due to dust particles inherently present in the environment. For protection, the lenses are recessed below a rectangular mechanical interface and require very little maintenance. During all of our prototype testing, a brief blast from a can with compressed air was usually a sufficient cleaning process. If not, a dry wipe across the lenses with a lint-free swap followed by an airblast would restore the performance.

When the 38999 connector halves are mated, the inherent shell keying features performs a pre-alignment of the ferrules. The final ferrule alignment is accomplished by alignment pins similarly to what is used for an MT ferrule. While the center distance between the alignment pins is similar to that of the MT, the thickness of the HDLT ferrule is only 60% of the MT ferrule thickness. The density of 24 channels per quadrax cavity is accomplished by reverse stacking two HDLT ferrules in the insert. The ferrules are not firmly clamped in the adapter insert, but are designed with sufficient clearance to allow for mating “float” in the adapter and also relative to each other.

Fiber Cleaving and Termination

To eliminate the costly and time consuming abrasive polishing process required for MT assemblies, laser-shaping/polish is introduced to prepare the fiber end faces of each of the 12-fiber ribbons prior to termination. [Figure 3](#) shows some examples of laser prepared fibers which achieve a flawless finish by the process.

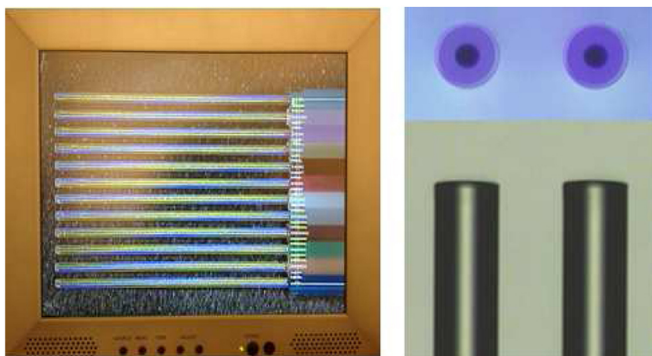


Figure 3. Left: Laser cleaved 12 fiber ribbon. Right: Close-up of profile of 2 cleaved fiber.

In order to achieve optimal performance, it is required that the fibers are kept in contact with the thermoplastic composite material of the ferrule, i.e. the wall that constitutes the first surface of the integral molded lens. Due to the large difference in the coefficient of thermal expansion (CTE) between the glass fiber and the composite material (close to a factor of 100x) an adhesive with sufficient elasticity must be chosen so no separation occurs between the fiber and the wall during excursions to the temperature extremes. As an example, consider that if the fibers are seated in a 2 mm long v-groove then the difference in thermal expansion between the ferrule material and the glass fiber is 5 microns at +70 C and approx. 6 microns difference in contraction at -40 C. Identification of an adhesive meeting these requirements has been one of the biggest challenges during the development phase.

[Figure 4](#) shows various views of a terminated HDLT receptacle ferrule and adapter.

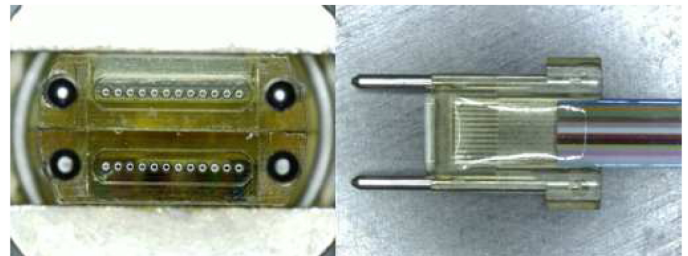


Figure 4a. Frontal view of a receptacle adapter and a terminated ferrule

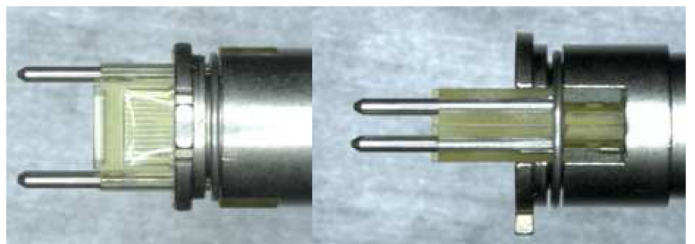


Figure 4b. Side views of a receptacle adapter containing two stacked ferrules and alignment pins

Insert Adapter

In order to create the desired 24-fiber count, the adapter insert design supports two stacked micro-molded 12-fiber array ferrules. Because the 38999 Quadrax cavity originally was designed for electrical contacts, the allowed longitudinal tolerance build-up from both the cavity, the retainers and the 38999 shells is excessive for the more sensitive alignment requirements existing for fiber optics. It is therefore necessary to use an insert design which has a one-sided spring load to allow for mating interference in order to assure that the mechanical interfaces of the ferrules will make contact in both the minimum and maximum tolerance range scenario. Contrary to the MT configuration, which would fail