New PHD Technology Yields Higher Density, Lower Optical Loss Interconnect Solutions

Current fiber optic technology fails to deliver a High Performance Interconnect solution which provides service and maintainability, high-density channel count, low-loss optical performance, and high reliability.

New broadband service networks, high fiber densities, increasing end-user bandwidth demands, and inadequate legacy systems are influencing the direction of fiber optic interconnect solutions. Today's photonic equipment requires dense optical packaging with interconnects meeting the requirements of Bellcore GR-326 and GR-1435. Newer scalable equipment will be challenged to deliver the flexibility demanded in the marketplace while also delivering near transparency in networks.

ITT's line of Cannon PHD™ connectors deliver the optical performance and ease of maintenance/handling of tuned small form factor simplex interconnects combined with the optical density delivered by ribbon (MT ferrule) architecture products. The PHD optical interconnect solution offers flexibility to system designers deploying next generation infrastructure equipment including ultra-dense high-performance photonic switching technology/hardware, DWDM add/drop-MUX equipment, and high bandwidth scalable storage equipment.

The PHD product line delivers dense optical interconnect architectures of up to 50 contacts per square inch including the following characteristics: single channel serviceability, low optical insertion loss of 0.20db typical and 0.30db maximum random mated for single mode, low optical insertion loss of 0.30db typical and 0.50db maximum for multi-mode, radiated emission suppression with metallic shell components, stable back reflection performance of 55db typical and 50db minimum, flexible structured cable designs with break-outs including ribbonization and plenum ratings, and integrated support tools for cleaning, inspection, field and factory maintenance.

ITT's evaluation of competing multi-channel interconnects quickly identified the benefits of using discrete channel 1.25mm ferrule technology. The development team revealed that advantages inherent to individual channel alignment, as found on the ferrule-sleeve designs, favorably positioned PHD products to solve many of the problems inherent in optical system design.

ITT's PHD Series single- and multi-mode fiber optic termini are based upon the industry standard 1.25mm zirconia ceramic ferrule/sleeve technology introduced in a small form factor terminus. These manufacturing and termination technologies are field proven with more than 15,000,000 connectors in service on the LC format, supplying a wealth of process and application experience. This experience assures the successful deployment of the PHD solution by customers experienced in using LC technology.

MT and MP style multi-channel optical connects rely on either secondary metallic alignment posts or substrate alignment to properly couple optical channels. A single structured substrate prevents tuning to compensate for fiber and fiber attachment concentricity. When working with single mode, half micron core misalignments lead to significant insertion loss and channel-to-channel performance variation.

Low optical insertion loss is becoming increasingly critical as bandwidth continues to grow and link margins continue to decrease. When compared to other multi-channel interconnects, ITT Cannon's PHD terminus' low insertion loss allows more connections in the link. For most SFF connectors (other than LC), no more than two interconnections – one at the equipment patch panel and one at the communications outlet – are recommended. In fact, many active optical component manufacturers specify an interconnect link loss no greater than 1.5 db. The use of existing MT/MP solutions limits the total interconnects to two.

The additional power margin offered by the PHD series of connectors makes it practical to have as many as four interconnects in the link. This functionality increases flexibility in system architecture, as physical layer cross connects or service interfaces may be added without the need for signal regeneration. This capability allows systems designers to add modularity and flexibility to their design and the customer receives built-in growth capability with enhanced reparability. The PHD system is one of the few multi-channel interconnect solutions that provides this flexibility to system designers.

ITT's PHD terminus can deliver high levels of multi-channel single mode performance due to the de-coupling of physical limitations present in other competing designs. Competitors' multi-channel products (MT/MP) position fibers extremely compactly on the same physical substrate. This positioning prevents tolerance absorption for manufacturing variation in either the substrate or the

optical fiber itself. Hence, channel-to-channel variation increases. Also, linear optic solutions limit polishing dome formation. With ITT's PHD design, each channel is allowed to "float" into its alignment sleeve. Single termini may be removed from the connector bodies, entire sleeves may be removed from connector bodies, and bodies may be removed from top-level assemblies without interruption of adjacent channels.

ITT's PHD terminus follows leading edge industry standards, delivering superior levels of performance. The terminus rear body is manufactured from a metallic alloy for low unit cost and secure assembly. This precision machined component is pressed over a zirconia ceramic ferrule which is manufactured to ITT's proprietary specifications. Exacting tolerances assure concentricity of the fiber locating hole while allowing for secure epoxy bonding of the fiber into the ferrule. ITT's baseline ferrule allows use of single mode fiber.

The PHD terminus has been designed to maximize the performance of single mode compact core optical fiber. The inherent precision of zirconia ferrules is enhanced with tuning features on the terminus body. ITT's tuning ensures 60 degree sectorization of any core offset. This sectorization yields a theoretical average insertion loss of 0.069db plus end face geometry impacts.

Installation of the fiber into the ferrule/body is accomplished by stripping the acrylate fiber buffer to expose the clad glass core. The ferrule and rear body cavity are prepared by injecting a heat curable epoxy into the cavity. The prepared fiber is then installed into the cavity and a cure cycle is initiated to lock the fiber into the terminus assembly. This entire assembly is then loaded into a precision polishing fixture and processed through a proprietary multi-stage polishing process. The polishing process delivers a precise physical contact interface for low insertion loss performance. And, specific dome characteristics assure glass core contact, at specific stress levels, when coupling is performed using ITT's PHD contact spring system. ITT's end face geometry meets Telcordia requirements for SFF fiber optic applications.

Behind the rear body of the terminus, the jacketed optical fiber is further reinforced with a strain relief system. The system helps prevent fiber damage due to mechanical deflection of the fiber once the terminus is installed into the body of a connector assembly. The guiding design rule, used for the fiber optic terminus, assures both manufacturing and operating robustness. The use of epoxy fiber retention methods, originally developed for severe military

environments, and a secure strain-relief system allow ease of handling with assurance that the performance and reliability of the link path will remain secure across a broad range of environments.

Installation of the PHD terminus into standard interconnect configurations ensures flexibility in the final application. The terminus is retained using a derivative of ITT's patented Little Caesar® rear release contact retention system. This clip retention system has more than 25 years of field reliability in many types of connector systems and has proven its durability in military and aerospace applications including harsh environments.

When designing the PHD connector series, ITT considered cleaning and field repair of the operational terminus. Each terminus is individually removable from its associated alignment sleeve and repair or cleaning operations may be performed with common tools while the connector remains in a mated condition. Consequently, other channels may remain operational while the channel needing attention is addressed. Direct access to the ceramic tips is typically designed into the receptacle side product. In most applications, the receptacle side product is located on the fixed equipment.

ITT has developed a full range of Cannon PHD interconnect products, including the 38999 connector and a panel mount configuration. The PHD 38999 connector starts with the basic form and functional characteristics of the MIL-C-38999 series III electrical connector. A standard fastener mounting flange, backshell threaded plug/receptacle, and vibration/shock insensitive coupling ring are all included. The PHD 38999 connector surpasses standard MIL-C-38999 connectors using only Mil-T-29504 optical termini in density, optical performance, and durability. In group testing of optical interconnect solutions under consideration for a next generation fighter aircraft, the PHD 38999 outperformed the competition in shock and vibration environments.

ITT's PHD panel mount series features a three-piece front panel mount connector designed using today's demanding optical systems requirements. The panel mount series offers a fully integrated metallic shutter system that removes optical hazards and aids in maintaining a clean optical cavity. This configuration also incorporates a connector position assurance, electrical sensing loop, and optional EMI/RFI shielding flanges for isolation up to 50 GHz.

An adapter assembly houses ceramic sleeves and couples the cable side plug to the unit side receptacle. Each of the connector bodies may be individually removed from the panel-mounted adapter for mass interconnection, service, or cleaning using the integral jackscrew. Similarly, each individual channel may be quickly removed for maintenance, replacement, or cleaning.

Figure 1: From left to right, ITT's Cannon panel mount, 38999, and SuperLC PHD fiber optic connectors

The PHD product line development plan is grounded in technology and manufacturing core competencies inherent within ITT. From precision machined metallic shell components to volume production of optical components, ITT is uniquely positioned in the interconnect industry to provide solutions for dense optical interconnects.

The approach taken within the PHD product line identifies performance, density, reliability, and maintenance as the key features that must be continuously addressed to support stringent market needs. Low-cost solutions that lead to system downtime are unacceptable in mission critical networking equipment. Consequently, photonic-based products will be securely positioned within the high-end of optical communications equipment for an extended period of time. ITT Cannon is well positioned to address both this segment and other key segment needs as the introduction of complex systems continues and their integration challenges gain increasing importance.