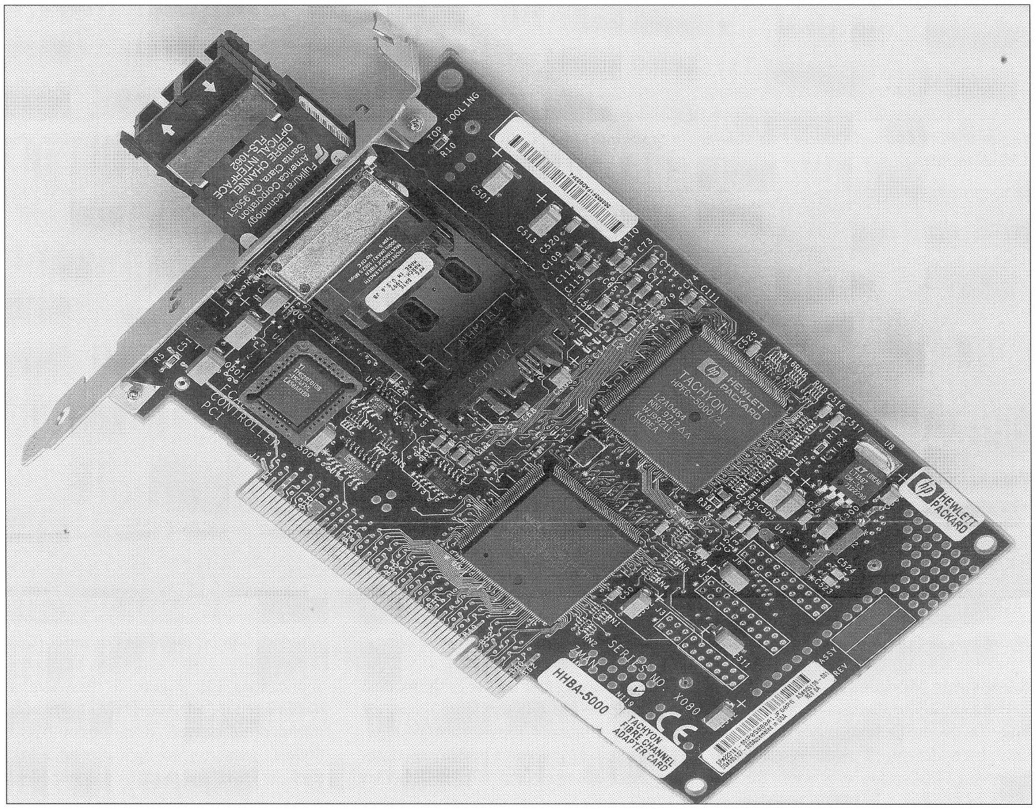
Standards-Based Transceivers Simplify Gigabit/Second Datacom Link Design



Hewlett-Packard HHBA-5000A PCI NIC with Fibre Channel GBIC transceiver.

Robert Dahlgren, Manager Research & Applications Development Group
Fujikura America, Inc.

Nineteen-ninety-six was the year that gigabit datacom technology was ushered into reality. That year, the release of the ANSI Fibre Channel FC-PH standard [1], and also several protocol ICs and PCI engine ICs became a reality. OEMs and numerous start-ups announced a set of products which initially targeted the storage-to-server market, such as storage arrays and host adapter cards. Since then, the IT and MIS market has started embracing gigabit/second (Gbps) technology, and interoperability testing is moving forward. Figure 1 shows a projected port volume for Fibre Channel [2]. Note this does not include ESCON, ATM, Gigabit Ethernet, or other high-speed market segments.

Until recently, datacom applications tended to be lower-speed (below 100 MHz) and used primarily copper media such as Category-5 cable. Fibre was employed for telecom applications, to link a WAN, or the occasional low-speed backbone or token ring LAN. In the early 1990s, it was demonstrated that telecom technology, which routinely operated above a Gbps, could be exploited for datacom usage. Subsequently, the datacomm community initiated the standardization process for gigabit technology. As the Fibre Channel FC-PH standard evolved, it leveraged the telecom technology as much as possible, with several cost-reducing refinements. It defined a duplex communication link and protocol transparency for multi-mode optical fibre, single-mode optical fibre, and various types of copper cable.

At that time, telecom laser technology in production included 1300 nm and 850 nm Fabry-Perot (FP) lasers, 780 nm compact disk (CD) lasers, and more recently, vertical cavity surface emitting lasers (VCSELs). Another technology which enabled the Gbps datacom market is the widening availability of high-speed optical receiver ICs, and electrical and optical driver ICs. A typical optical module would contain a laser, photodetector, duplex-SC receptacle and associated optics, and the aforementioned drive electronics. Like the lower-speed LAN components, a number of common footprints have been developed; please refer to Table 1, which summarizes some of the attributes of the different types of transceivers.

Fixed Modules

In many applications, it is desired to have the transceiver mounted directly on a PCB in the simplest manner. For example, many non-optical network interface cards (NICs) have the copper cable connector mounted directly on the NIC PCB. In the "on-board" implementation, no module is needed; the cable is driven by the serializer-deserializer IC, or via a high-speed buffer. Often a Fibre Channel Style-1 (like a D-sub-9) is the receptacle used, and the Fibre Channel Style-2 (8-pin HSSDC) is also used in this application.

For optical implementations, a module is typically soldered onto the PCB. Figure 2 shows a 1x9 optical module intended for Gigabit Ethernet (1.25 Gbps), whose form-factor is based on the ubiquitous LCF-FDDI package. This package is also popular for Fibre Channel, ATM, and other Gbps applications. Figure 3 illustrates the 1x28 package, which is another common footprint. The devices shown are for up to 1.5 Gbps applications, and is shown in optical and copper cable variants. These types of modules have been very successful because of multi-vendor availability, and similarity to lower-speed packages.

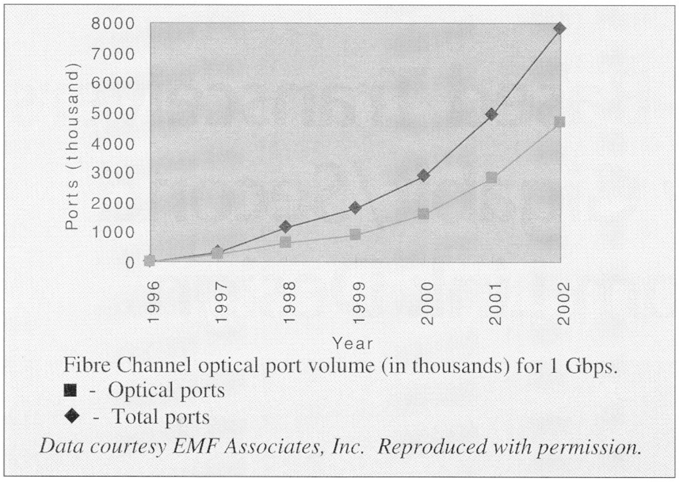


Figure 1: Fibre Channel Optical Port Volume (in thousands) for 1 Gpbs. [Data courtesy EMF Associates.]

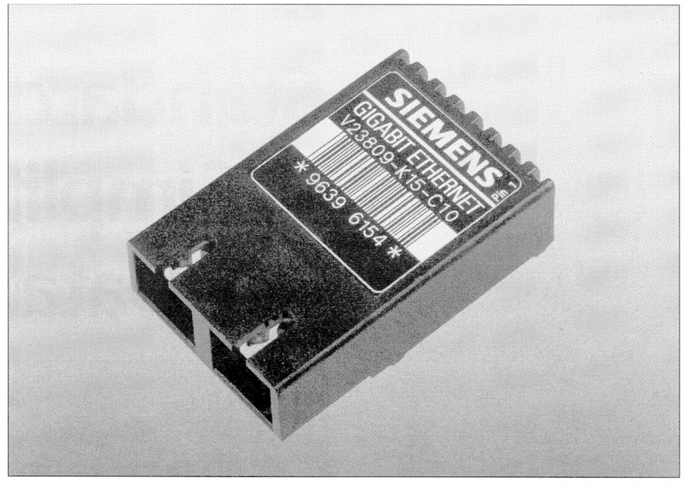


Figure 2: 1x9 Optical Fibre Transceiver Module. [Photo courtesy Siemens Communications.]

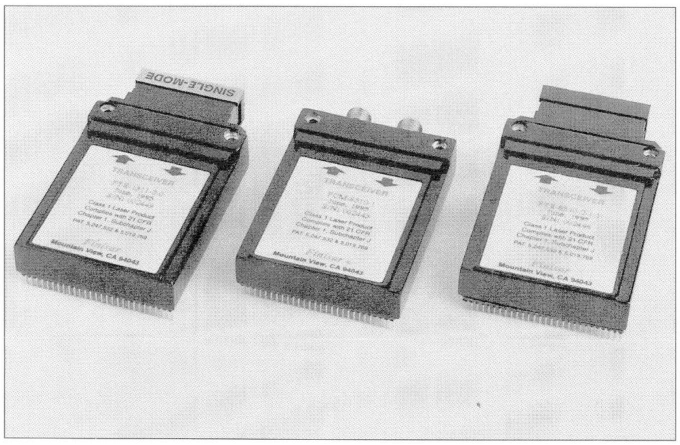


Figure 3: 1x28 Optical Fibre and Copper Cable Modules. [Photo courtesy Finisar Corporation.]

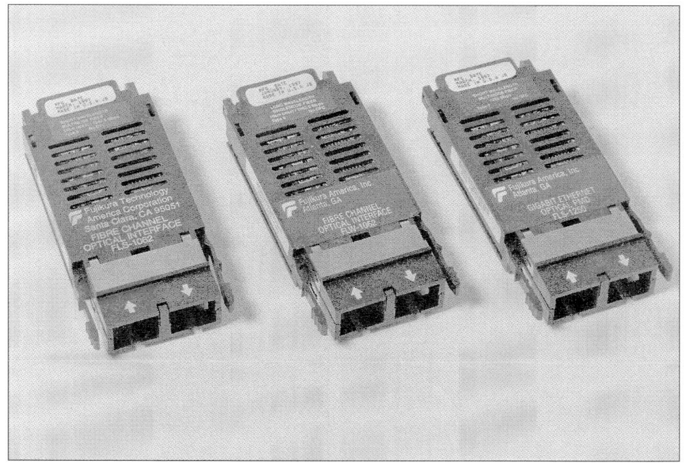


Figure 4: Gigabit Interface Converter (GBIC) Modules, 780 nm and 1300 nm.

Removable Modules

For applications that require more flexibility in the media, transceiver footprints have been developed with an electrical connector. This makes it possible for the OEM or the end-user to change the module to accommodate different fibre types, for example. Figure 4 shows a trio of gigabaud interface converter (GBIC) modules for Fibre Channel and Gigabit Ethernet applications [3]. Figure 5 illustrates a media interface adapters (MIAs), which is intended to convert from an on-board Style-1 connector to optical media [4]. Both the GBIC and the MIA accommodate full-speed complementary ECL/PECL signals, and have hot-plugging features.

The gigabaud link module (GLM) is a popular footprint because it accepts and presents a 20-bit parallel TTL byte. This type of module contains the clock recovery unit (CRU) and the serializer-deserializer (SERDES) electronics. This configuration was popular with the early adopters of optical Fibre Channel, because it eliminated the need to route gigabit signals on the host PCB. The GLM generates complementary TTL 53.125 MHz recovered clock outputs, and the parallel TTL bytes are clocked at 1/20 of the baud rate. Examples of this package is shown in Figure 6, of short-wave, long-wave, and copper variants. The first GLM products contained the so-called Open Fibre Control (OFC), which is a handshake implemented in the GLM hardware, that manages laser safety. If the fiber is disconnected or broken, the handshake pulses the laser at a very low duty cycle, until it can verify that a closed optical path exists - only then may the laser be fully powered up. Advances in laser driver technology and the standards has eliminated the need for OFC except for legacy applications. When integrating gigabit transceivers into a design, the system integrator must pay particular attention to PCB layout, enclosure aperture mechanical tolerance, thermal, and signal integrity issues, such as Vcc conditioning, transmission line effects, termination, ground homogeneity, EMI, and ESD. While these topics ar

Name	Electrical	Media Connector	Data Connector	Media Rate	Applicable Datacom Standards	Features	Comment	Announced Vendors
on-board	n.a.	DB-9	1.0625 HSSDC	Copper 1.25	FC-PH 10-bit	Low-cost copper cable solution	All parts on PCB, including SERDES	Vitesse HP AMCC, TriQuint...
1x9 (Fig. 2)	9-pin linear	duplex-SC	1.0625 1.25	SW, LW,	FC-PH LCF-FDDI	Low-cost optical solution	May be soldered	HP, Molex Honeywell MRV, OCP, Panasonic Siemens AMP, Methode Sumitomo
1x28 (Fig. 3)	28-pin linear	duplex-SC	1.0625 1.25	SW, LW, Copper OFC option	FC-PH	Flexible media choices.	May be soldered. OFC optional.	Finisar, Methode
GBIC (Fig. 4)	2x10-pin hot-plug connector	duplex-SC HSSDC DB-9	1.0625 1.25	SW, LW, Copper	FC-PH FC-PH-2 GBIC	Hot-plugging. Flexible media choices.	Serial ID optional.	Fujikura, IBM, AMP, Panasonic, Vixel.
MIA (Fig. 5)	9-pin connector	duplex-SC	1.0625	SW, LW,	FC-PH MIA	Hot-plugging.		Methode Panasonic W.L. Gore
GLM (Fig. 6)	4x20-pin connector	duplex-SC DB-9 HSSDC	1.0625	SW, LW, Copper, OFC option	FC-PH FC-PH-2 GLM	CRU, SERDES in the module. 20-bit TTL parallel byte.	53.125 Mhz clock required. OFC optional.	Fujikura HP, IBM, Methode, Siemens, Vixel, W.L. Gore
mini-MT (Fig. 7)	10 pin, 20 pin	mini-MT-RJ	1.0625 1.25	SW, LW		Small form-factor. Intuitive latch feature.	may be soldered	AMP, HP, Fujikura
VF-45 (Fig. 8)	9 pin	SG	1.0625 1.25	SW, LW	FC-PH-3	Small form-factor.	v-groove ferrule less technology	Honeywell, 3M

Table 1: Module Attributes

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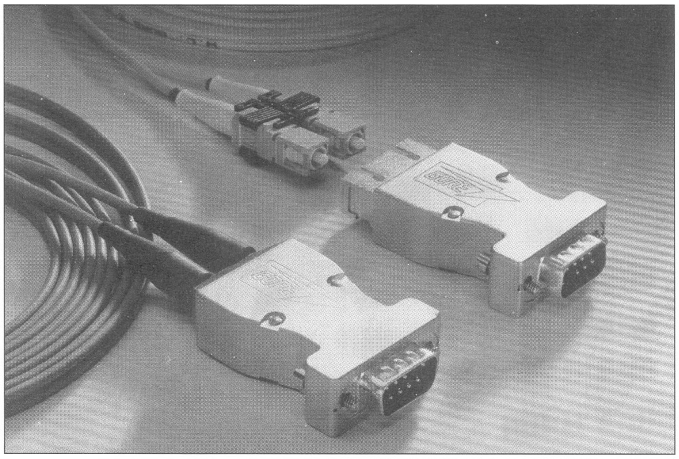

Figure 5: Media Interface Adapter Modules. [Photo courtesy W.L. Gore, Inc.]

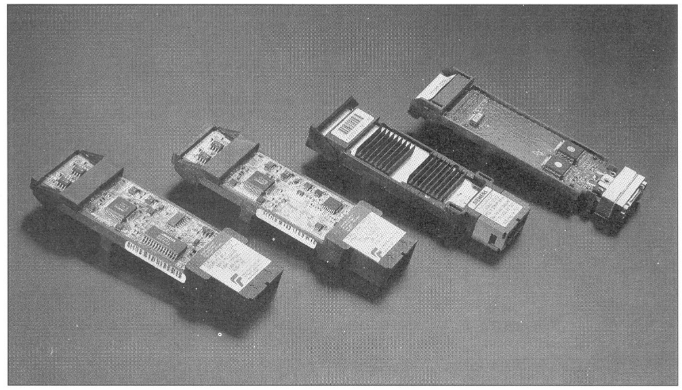

Figure 6; Gigabaud Link Modules (GLM) with Open Fiber Control (OFC), non-OFC, Long-wave, and Copper Cable.

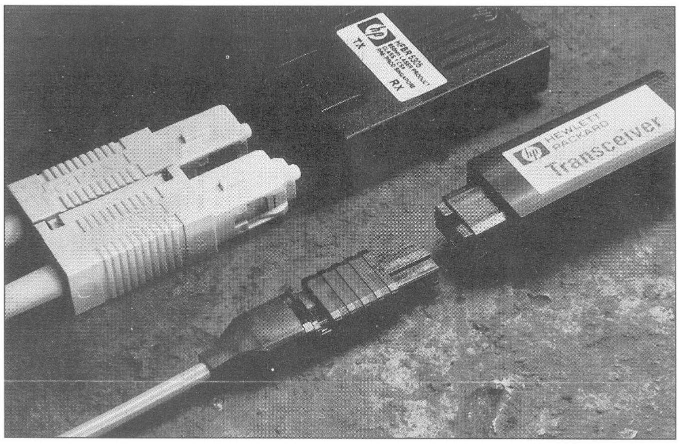

Figure 7: Small Form-Factor Optical Transceiver Module, using Mini-MT connector. [Photo courtesy AMP, Inc.]

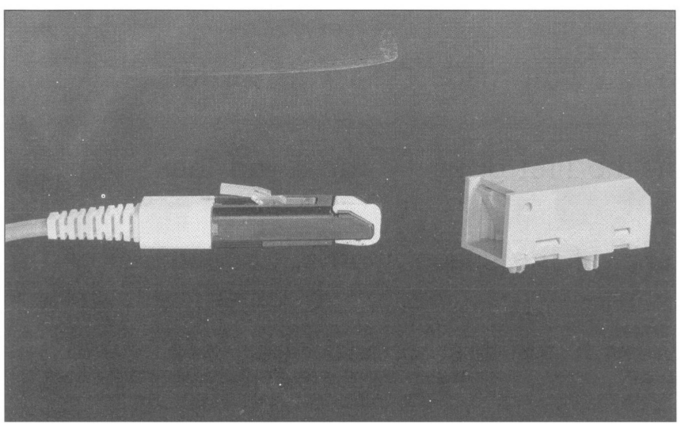

Figure 8: Small Form-Factor Optical Transceiver Module, using VF-45 connector. [Photo courtesy 3M Corp.]

beyond the scope of this article, the interested reader is referred to [6] and [7] for further information.

Future Modules

There has been recent activity in the various physical layer committees to adopt a connector with a smaller form-factor than the current duplex-SC. The goal is to have a connector which is lower cost than the current duplex-SC technology. and have a cross-section no bigger than the RJ-45 connector used in LANs (0.55 inches.) Small form-factor transceivers have incorporated the VF-45-connector and the mini-MT connector to meet this requirement. Figure 7 shows a mini-MT module that employs a RJ-45 style latch mechanism. A 1x9 module and duplex-SC connector is also shown for comparison. Figure 8 shows a transceiver based upon the VF-45 connector, which has been adopted into the ANSI Fibre Channel as a future PHY variant. The FC-PH-2 standard also specifies data rates of 2.25 Gbps and above. This and parallel optical communication over ribbon fibre will ensure that interconnect technology can keep pace with Moore's Law for years to come.

REFERENCES:

[1] "Fibre Channel Physical & Signaling Interface," American National Standards Institute, FC-PH, FC-PH-2, FC-PH-3, or most recent revision.

[2] "Fibre Channel 97 and Beyond," EMF Associates, Half Moon Bay, CA.

[3] "Giga-Bit Interface Converter Standard," Sun Microsystems Computer Co., et. al.

[4] "Media Interface Adapter for Fibre Channel," Rev. 2.6, Norm Harris, Ed.

[5] "Gigabaud Link Module Family (GLM, HGLM, QGLM, and EGLM): Physical, Electrical, and Link Specification," Fibre Channel Systems Initiative

[6] "Design Guidelines for Fiberoptic Transceivers," Alan Wolke, Fiberoptic Product News, April 1997, Pages 27 - 30.

[7] "Transmitters and Receivers: Meeting Technology Demands," Jack Koscinski, Fiberoptic Product News, August 1997, Pages 17 - 20.

FOR FURTHER INFORMATION:

Fibre Channel Standards and General Information:
http://www1.cern.ch/HSI/fcs
www.Fibrechannel.com
www.fcloop.com
http://www.wco.com/~schelto
ftp://ftp.network.com/FC/PH

MIA, GBIC, GLM, Jitter standards and drafts:
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ftp://playground.sun.com/pub/OEmod
ftp://playground.sun.com/pub/FCSI
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