The 3M™ Volition™ VF-45™ Interconnect
An Emerging Standard For High-Speed Fiber To The Desktop

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Executive Summary

Although fiber offers many advantages for today's high-speed, bandwidth-intensive computing environments, the implementation of fiber to the desktop has been impeded by concerns of cost and difficulty of installation. The Volition™ VF-45™ interconnect from 3M offers a new fiber optic connection technology which significantly reduces many of the costs associated with fiber-to-the-desktop cabling installations without sacrificing performance.

The design of the VF-45 completely eliminates the need for ferrules in making a fiber optic connection. Instead, the connector uses a much simpler, and less expensive, V-groove technology. This change in connector design significantly reduces the component cost, simplifies installation and maintenance (which reduces labor costs) and requires half as much space as the duplex SC connector.

The full-duplex VF-45 connector has the look and feel of the familiar RJ-45 modular jack. It performs to — and in many cases, exceeds — industry standards and is compatible with standard optical glass fiber. Through vigorous partnering activities and an aggressive licensing strategy, 3M is working to ensure the broad availability of equipment and technologies to support the Volition fiber-to-the-desktop solution.

Performance and Cost Advantages of Fiber

As transmission protocols reach higher and higher speeds and bandwidth requirements continue to increase, fiber offers significant advantages over copper for premises cabling. Yet, despite its many advantages, implementation of fiber in the horizontal has been slow. Cost has been the primary obstacle; however, recent improvements in the supporting electronics and infrastructure plus increased volume of fiber production are causing the per port cost of fiber to fall rapidly.

As the system component and installation costs of fiber become comparable to copper, architectural flexibility and life cycle management advantages of fiber tip the scales in fiber's favor. Perhaps most important of all is the savings fiber's high bandwidth can produce by eliminating the need to pull new cable when a network is upgraded to support higher bandwidth protocols. The net result is that the premium associated with optical fiber is decreasing to the point where it will be the preferred choice for most purchasers.

The 3M™ Volition™ Fiber Optic Cabling System

3M has developed a cost-effective fiber-to-the-desktop solution that meets the growing need for increased bandwidth and transmission rates while ensuring long network life. The Volition Fiber Optic Cabling System, part of the Volition family of high-speed networking infrastructure products, includes all

the components required for a complete fiber optic structured cabling system from the backbone to the workstation:

- interconnect socket (field terminated)
- fiber optic cable
- VF-45 patch cord, factory terminated (VF-45 plug to VF-45 plug)
- hybrid patch cord, factory terminated (VF-45 plug to SC or ST)
- wall outlets and faceplates
- termination and cleaning kits
- media converters (optical/electrical conversion)
- patch panels (rack mounted)
- test equipment

With technologies that simplify installation and maintenance, the Volition system not only meets growing bandwidth demands but also provides the lower component and labor costs that finally make fiber implementation cost effective.

The Volition VF-45 Interconnect: Breakthrough Application of a Proven Technology

Integral to 3M's fiber to the desktop solution is an innovative new fiber interconnect— the Volition VF-45 interconnect — developed specifically to reduce both complexity and cost of fiber-to-the-desktop installations.

3M has replaced the costly and complex ferrules used in traditional SC fiber optic connectors with V-groove Traditional SC connectors are complex and costly because they both align and protect with the same structure. Termination requires: technology. V-grooves have been used successfully in millions of fiber splices installed in telecommunications networks around the world. This technology is used in 3M's Fibrlok™ fiber optic splice which has been in service for 10 years without any failures. With the VF-45 interconnect, 3M has now applied this technology to create an effective and cost-efficient fiber connector.

- use of costly ceramic ferrules
- exact alignment of fiber and precision parts
- multiple components
- difficult fiber preparation
- adhesives and curing time

The VF-45 connector achieves low cost and low complexity by aligning and protecting the fiber cores independently, not jointly. The VF-45 design recognizes that the optical fiber is inherently a precision part, and the fiber cores are aligned simply and inexpensively using V-groove technology. Protection is provided separately by the plug and socket housings.

Instead of having 40 or more complex, precision parts made of costly materials and different manufacturing processes, only 10 simple parts made of injection-molded engineering thermoplastic comprise the VF-45's duplex connection. These 10 parts combine to only four pieces the technician must work with during installation. Because the precision is built into the mold and the mold replicates millions of parts, the precision V-grooves are produced with low cost and low complexity.

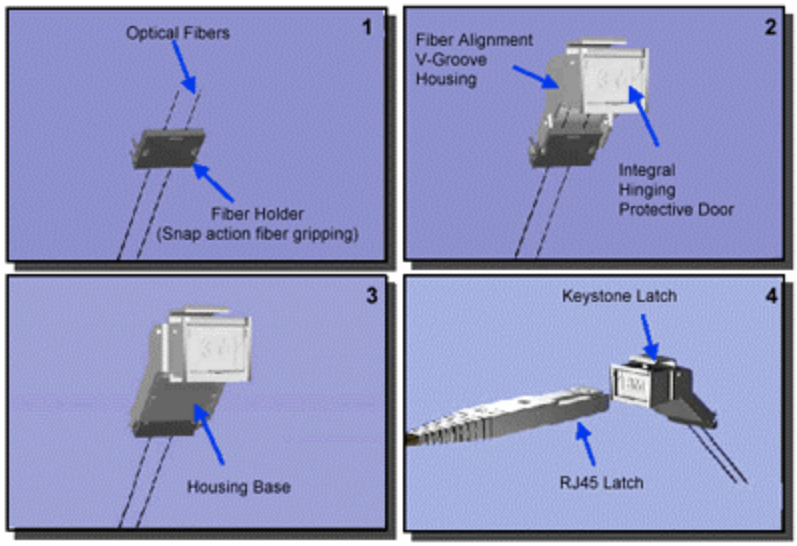

Figure 1 — *Socket construction of the VF-45 includes: a fiber holder which secures the fibers and simplifies termination; a main body which houses the V-grooves that assure exact fiber alignment and features an integral door to provide dust protection; and a housing base which snaps into place to complete the protective shell.*

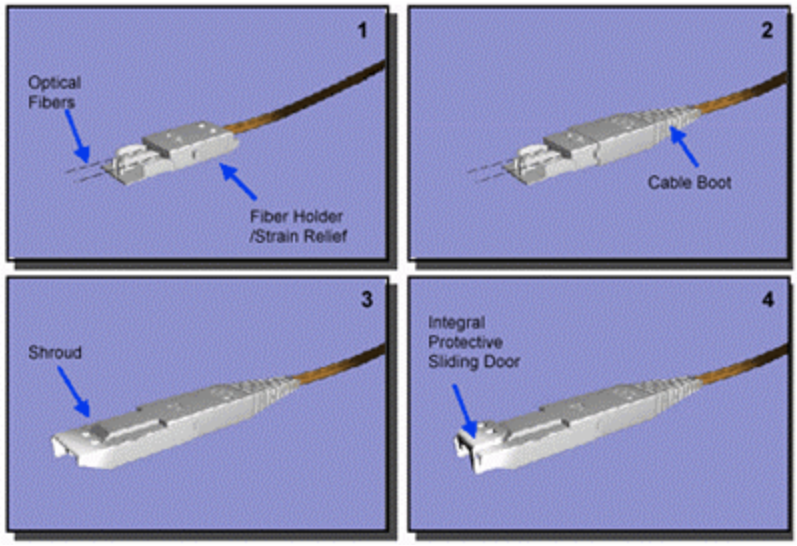

Figure 2 — *The VF-45's factory-terminated patch cord/plug comprises a few basic parts: a fiber holder which secures two or more fibers in place; a shroud and boot which protect the fibers and secure the cable to the connector; and an integral door which acts as a dust cover, improving the durability of the connector in the field.*

The VF-45 socket is terminated on site using a simple process that requires no precision alignment by the technician. The V-grooves align the fibers within the socket and a mechanical gripping action holds the fibers securely in place. This simple mechanical connection can be installed much more easily and quickly than traditional ferruled fiber optic connectors. There is no lengthy fiber preparation process, no difficult fiber alignment and no curing time (because no adhesives are used). The result is that the duplex

VF-45 can be terminated in less than two minutes (compared to 15 minutes for a traditional duplex connection) with a 98+% yield. Furthermore, the installed cost of the VF-45 interconnect (component costs plus labor) is approximately one-seventh the cost of duplex SC connectors.

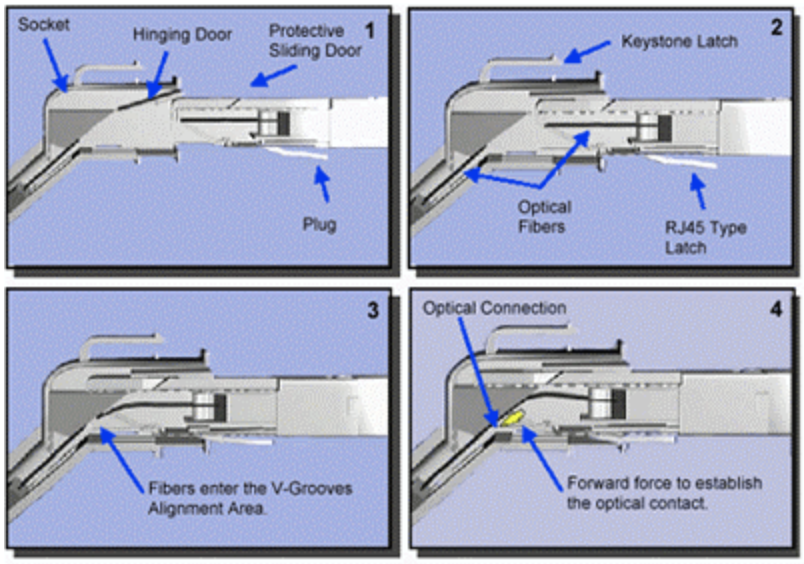

Figure 3 -

1. *The hinging door on the socket and the protective sliding door on the plug serve as dust covers to protect the fiber inside. As the plug enters the socket, these dust cover mechanisms engage automatically, with the hinging door opening and the sliding door moving to the side.*
2. *When the plug is inserted into the socket, the fibers within the plug travel along the V-grooves.*
3. *The fiber end faces in the plug are beveled, preventing wear by allowing the fibers to glide smoothly down the V-grooves and mate with the stationary fibers of the socket.*
4. *As the connector locks into place with an audible "click," the plug fibers bend, creating forward and upward pressure to optimize fiber-to-fiber optical contact. The V-grooves force the fibers to self-adjust for precise alignment. Additionally, each fiber is allowed to adjust for variations in fiber length or differences due to environmental factors.*

The plug-and-socket configuration of the VF-45 connector has been designed to have the look and feel of an RJ-45 modular jack. Use of molded plastic parts provides a low-cost, high-density alternative to traditional ferruled fiber optic connectors and assures ease of manufacturing.

Sockets may be field terminated in wall outlets at computer workstation locations and in patch panels in the telecommunications closet or equipment room locations. The mating plug is currently designed for factory termination onto patch cords which provide a full duplex connection from VF-45 socket to VF-45 socket or from VF-45 socket to VF-45 transceiver device. Additionally, hybrid patch cords are available to allow connection between an installed SC or ST connector and the VF-45. Patch cords are available in a variety of cable lengths, and a field-terminated plug and patch cord option will be available in future product offerings.

The VF-45 interconnect meets industry performance standards, and is compatible with standard optical glass fiber. In typical workstation outlet or patch panel applications, this innovative new fiber interconnect offers several termination advantages, as summarized in Table 1.

Features	*Benefits*
• Plug to socket design • High density duplex interconnect • V-groove alignment w/injection molded parts	• Low cost: (no expensive ferrules, sleeves, or precision components) • Half the size of the SC connector • Minimum space required when mounted in telecom closet or other racks
• RJ-45 style latch	• Ease of use, familiarity
• Socket has simple 4-piece, snap-together assembly • Two minutes per duplex termination	• Low cost labor, installs easily in less than 2 minutes per termination
• High yield -- 98+%	• Little, if any rework
• Works on standard 62.5µm or 50µm multimode fiber • Single mode testing is ongoing and will be released in the near future	• No proprietary fiber required
• Hybrid patch cord available for use with installed SC or ST connectors	• Can retrofit existing fiber systems
• Tested to TIA and IEC performance specifications	• Reliable

Table 1

The breakthrough VF-45 design brings unprecedented economy (one-seventh the installed cost of conventional duplex SC), robustness and simplicity to the equation. As a result, fiber in the horizontal LAN will dramatically increase and the resulting expansion of bandwidth will allow network applications to offer increasingly sophisticated functionality.

Standards Adoption

In recognition of the potential advantages offered by small form-factor connectors in premises cabling, TR41.8.1 determined in draft 4 of ANSI/TIA/EIA-568-B to allow the use of alternate standardized optical fiber connectors, such as the VF-45 connector, in spaces other than at the work area outlet.

In February 1997, the Fibre Channel ASC-X3T11 Technical Committee adopted the VF-45 interface as the new "SG" interface, which is the small form factor fiber optical interface for future variants of Fibre Channel.

The SG interface specification (see Appendix A for Fibre Channel specifications) defines mechanical alignment of the optical fibers to an optical port on a component such as a transmitter or receiver in order to ensure:

- intermateability
- mechanical/optical performance
- maximum supplier flexibility

The VF-45 was the only interface selected following a lengthy review of eight optical fiber connector proposals.

Fibre Channel is an NCITS[1] standard gigabit connectivity technology that has been designed to meet the new breed of data- and communications-intensive applications, such as data warehousing/data mining, on-line transaction processing (OLTP) Internet/intranet access and film/video/broadcast implementations, that require high data availability and integrity. Its open architecture and support of multiple protocols, including SCSI and IP, make it ideal for connecting today's client/server distributed networks with next-generation storage networks.

Fibre Channel operates over copper and fiber optic cabling at distances of up to 10 kilometers. It is unique in its support of multiple inter-operable topologies including point-to-point, arbitrated-loop and switching, and it offers several qualities of service for network optimization. With its large packet sizes, Fibre Channel supports storage, video, graphic and mass data transfer applications. Fibre Channel is quickly becoming the de facto connectivity standard for high-speed storage access and server clustering, and is a natural solution for gigabit enterprise backbones, and gigabit LANs for high speed storage, image, video and mass data transfer applications.

National Committee for Information Technology Standards, formerly known as ANSI.

The Fibre Channel Association (FCA), a 120-plus worldwide member organization, was formed to foster the development of Fibre Channel interconnect technology in order to achieve true interoperability, allowing users to implement plug-and-play products from various companies in open systems environments. Its membership consists of systems integrators, and systems and communications companies that develop, manufacture and market cutting-edge Fibre Channel products ranging from test equipment, storage and adapters, to hubs, switches and servers. These include Digital Equipment Corporation, Hewlett-Packard, IBM, Intel, Fujitsu, LSI Logic, Sun Microsystems, Texas Instruments and Unisys.

Form Factor — Improvements Over Duplex SC Connectors

Size and Connection Density. The plug-and-socket configuration of the VF-45 interconnect is half the size of its duplex SC counterpart. Not only does this save space at wall outlets and patch panels, it also saves extremely valuable space on circuit boards.

One VF-45 connector (plug and socket) replaces the four ferrules and two sleeves required by a standard SC connector, as shown in Figure 4.

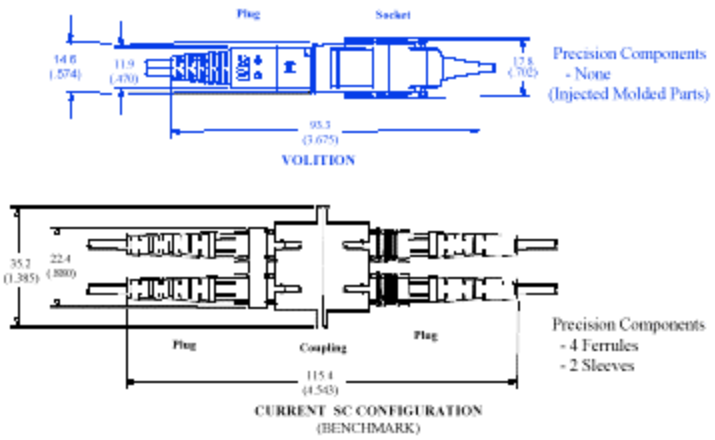

Figure 4 — *The full duplex VF-45 interconnect is half the size of its SC counterpart,saving space at the wall outlet as well as at the patch panel.*

The half-size feature of Volition sockets mean that 24 connections (48 fibers) fit into a standard 1U-height rack space (1.72"/43.7 mm). An added feature is that the plug boots tilt downward slightly, easing boot and cable bending and therefore providing a more rugged cable dressing.

Duplex with Polarity. The factory-terminated Volition patch cords conform to the duplex SC polarity cross-over scheme. The socket installation procedure ensures that polarity is maintained from wall outlet to patch panel. The plug and socket shapes ensure that reversed-polarity cannot occur. The plug is designed so that it cannot be inserted incorrectly — it will only install one way.

Ergonomics and Aesthetics. VF-45 plugs and sockets are color-coded, using the standard colors for office telecommunications connections. Since the parts are made of injection-molded plastic, other colors are easily provided.

Modeled on the common RJ-45 telecommunications connection, the VF-45 interconnect has strong aesthetic appeal. The entry size, lead-in funnel and connection force are all similar to the commonly-used RJ-45. The VF-45 also provides audible latching to assure signal integrity.

Dust Protection. Optical fiber connections are more susceptible to dust and dirt than electrical connections, and so the robustness of a fiber connection in an office environment has been a concern. With ferruled connectors, the dust caps are separate components which are commonly lost. Exposed ferrules of existing connectors are subject to contamination from handling. The VF-45 connector design solves the dust and dirt problem in three ways.

First, there are built-in, automatically-operating dust covers on both the plug and socket. These covers cannot be lost so even when the plug and socket are unmated, the fiber is protected from dust and dirt. No other fiber optic connection system provides this benefit.

Second, the VF-45 socket is dust protected within seconds after the fibers are polished. Ferruled connectors must have their dust covers removed before they are inserted in the mating adapters. Pulling the close-fitting dust covers off the ferrules generates static electricity and creates an inrush of air. This operation occurs amid all the construction dirt and wallboard dust, so it is not surprising that many ferruled connections are dirty.

Third, the VF-45 plug and socket have the simplest cleaning procedure of all. One squirt of a cleaning fluid directly into the plug or socket and the fibers are cleaned. The velocity of the cleaning fluid washes the dirt off the fibers and out of the device, and then evaporates in a few seconds. There is no need for disassembly, skin contact with solvents, or subjective inspection as with ferruled connectors. The 3M™

HFE cleaning fluid used to clean the VF-45 interconnect has been in use for many years in printed circuit board manufacture. It is an inert, non-flammable, non-conductive fluid. (An MSDS and other documentation is available upon request.)

Outdoor Use. The ANSI/TIA/EIA-568-A and ISO/IEC-11801 testing requires operation between -10° and +60° Celsius. This temperature range is beyond what is actually experienced by most electronic telecommunications equipment. While some manufacturers may tout connectors operating at more extreme temperatures, these temperatures are not encountered in workplace situations. Such designs simply add more complexity and cost without providing practical benefits. The standards that use these extreme temperatures are hold-overs from the early days of fiber optics when a mated pair of connectors was another form of fiber splicing.

Laser Safety. For the vast majority of workstation networks, the optical sources will be LEDs or low-coherence lasers which minimize risk of eye damage. For the uncommon situations where the optical sources are high-coherence lasers, the dust doors of the VF-45 connection provide excellent protection. The dust doors provide automatic, built-in protection for plugs and sockets. Exposure can only occur if a person holds open the dust door on a patch cord with an active link and looks directly into the opening from less than a half-inch (12.5 mm) away.

Adaptable to Modular Faceplates. All field-mounted connectors (electrical as well as optical) are attached to the cabling outside the outlet box. This means that there must be cable between the box and the field-mounting wallplate, and this excess (slack) cable must be stored somewhere. Fiber optic cable has minimum bend radius requirements of 1.18" (30 mm) diameter, which means the slack could be stored in a 2" X 4" electrical box. However, most of the available space with a 2" X 4" electrical box is typically taken up by the outlet connector. Therefore, most fiber optic connection systems (including the Volition VF-45 system) provide some kind of outlet fixture that mounts on the common-sized boxes and provides appropriate slack storage along with the connection hardware. Experience with other fiber optic connectors and electronic telecommunications connectors shows that many in-field failures occur because the projecting connector has been broken. Learning from this experience, the VF-45 connector is designed to lay parallel to the wall or partition, which is a more rugged position.

Protrusion from Faceplate. Volition socket faces are flush with faceplates; therefore, unmated sockets have no protrusions to be damaged.

Performance

The major focus of VF-45 interconnect development has been for the multimode application of fiber, and testing shows that the VF-45 interconnect meets or exceeds all the specifications for the ISO/IEC and TIA/EIA requirements (listed in Table 2). Early testing of single mode performance indicates that the VF-45 design also exceeds ANSI/TIA/EIA-568-A and ISO/IEC-11801 for this application of fiber.

Requirement	TIA/EIA Specification	TIA/EIA Fiber Optic Test Procedure (FOTP)	Related IEC Test Method
Attenuation	<0.75 dB	171	1300-3-4
Return Loss Multimode Single mode	-20dB min -26 dB min	107	1300-3-6
Mating Durability	500 <.75 dB loss; -20 dB return loss min	21	1300-2-2

Impact	8 drops @ 1.5m <.75 dB loss; -20 dB return loss min	2	1300-2-12
Cable Retention	66N @ 0° 6.6N @ 90° <.75 dB loss; -20 dB return loss min	6	1300-2-4
Coupling Strength	33N <.75 dB loss; -20 dB return loss min	185	1300-2-6
Flex	0.5 kg <.75 dB loss; -20 dB return loss min	1	N/A
Torsion/Twist	15 N <.75 dB loss; -20 dB return loss min	36	1300-2-5
Cold	-10°C for 96hr., Active <.75 dB loss; -20 dB return loss min <.3 dB change	188	1300-2-17
Heat	+60°C for 14 days, Active <.75 dB loss; -20 dB return loss min <.3 dB change	4	1300-2-18
Humidity	+40°C, 90-95% RH for 96 <.75 dB loss; -20 dB return loss min <.4 dB change	5	1300-2-19
Thermal Cycling	TIA/EIA - none 3M criteria: <.75 dB loss; -20 dB return loss min <.3 dB change	N/A	1300-2-22
Vibration	TIA/EIA - none 3M criteria: <.75 dB loss; -20 dB return loss min <.3 dB change	N/A	1300-2-1

Table 2 — *ISO/IEC and TIA/EIA fiber optic performance requirements. The VF-45 interconnect is compliant with these requirements.*

Ease of Installation

The VF-45 design, which is significantly different from ferruled connectors, not only provides a plug and socket with low cost and low complexity, it also results in a simpler, faster installation procedure:

1. Remove the outer cable sheath.
2. Remove the Kevlar™ strands.
3. Put the boot on the cable.
4. Remove the buffer tube.
5. Strip the fiber coating.
6. Wipe off any residual coating.
7. Place the fiber in the socket fiber holder.
8. Move the holder through the automatic scribe-and-cleave slot.
9. Polish the fibers.

10. Clean the fibers.
11. Inspect the fibers.
12. Snap the fiber holder into the socket, and snap the socket base onto the socket housing.
13. Seat the boot on the socket.

In actual beta installations, newly trained technicians were able to install the VF-45 (two fibers in a duplex connection) within two minutes.

Cost Analysis

The installed cost of the VF-45 interconnect is expected to be about one-seventh the cost of standard SC duplex connectors. Several factors make the VF-45 a more cost-effective alternative. The individual component costs are lower, and there are fewer parts required. One VF-45 plug and socket replaces four SCs and two couplings. In addition, the installation process is much simpler, requiring a lower skill level and less time. The cost savings are demonstrated in Table 3.

	SC Connector	VF-45 Connector
Connector costs	2 plugs X $5 = $10	1 socket X $2.10 = $2.10
Installation cost (based on $60/hour labor cost)	15 minutes = $15	2 minutes = $2
Coupling costs	1X $5 = $5	None = $0
Total installed cost (per duplex connection)	$30.00	$4.10

NOTE: all costs are average approximations

Table 3 — *Comparison of the installed cost of VF-45 and SC connectors.*

Volition Media Converter and Optical Transceiver

The media converter required to interface fiber optic cabling with an electrical (copper) computer has been one of the more costly components of a fiber-to-the-desktop system. Nonetheless, it is a critical part of today's fiber optic installations because it allows customers to take advantage of high-bandwidth optical fiber cabling while continuing to use their existing electronics infrastructure, such as copper-based NICs and hubs.

Integral to the media converter are a set of custom ICs, which perform the media conversion function, and a transceiver, which provides the actual interface between system components. The Volition system provides improvements to both features.

Due to historically lower volume and premium pricing of fiber based systems, electronics integration in fiber components has lagged behind the integration found in copper systems. In the copper world, electronic integration to fewer and fewer ICs is a normal part of cost reduction and increased functionality. To address this issue, 3M has worked with an IC vendor to integrate the electronics on a single IC in order to provide the cost reductions required to compete with copper electronics. These components are used in the lower speed media converter (for 10 Mb/second Ethernet and Token Ring).

For higher data rates (100 Mb/second), 3M is aiming to remove the electronics and complexity in the optical transceivers by incorporating the electronics back into the physical layer ICs. By doing so, 3M will be able to provide higher integration for media conversion devices as well as for NICs and hubs.

On the transceiver technology, 3M and Honeywell, Inc. have jointly developed the VF-45 optical transceiver which, as with the VF-45 interconnect, uses V-groove technology to significantly reduce cost, size and complexity. The VF-45 plug with either a standard patch cord or hybrid patch cord inserts easily into the optical transceiver. A built-in dust cover provides inherent eye safety and protection from the environment, and it allows a simple cleaning procedure.

The VF-45 transceiver is available to end users as part of the VF-45 media converter which is used at the workstation and in the telecommunications closet. It is also available to networking vendors for integration into their products, providing a VF-45 fiber interface for next-generation NICs, hubs, switches, routers, etc.

The Volition media converter is available in a single-port configuration (for use at the workstation) and in a 24-port rack-mount configuration (for use in the telecommunications closet).

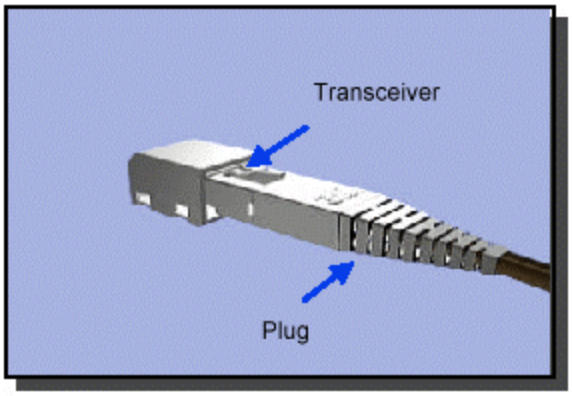

Figure 5 — *The VF-45 plug fits easily into the Volition optical transceiver, as shown here.*

Equipment Availability

3M is aggressively working with electronics manufacturers and other component vendors to assure that fiber-to-the-desktop products are enabled and broadly available for the market.

It is not 3M's intention to drive all aspects of a fiber-to-the-desktop solution. Instead, the company is:

- forming strategic partnerships to ensure interoperability and end-to-end connectivity for the Volition system
- working with component suppliers to ensure that necessary supporting technologies are available for equipment manufacturers at economical price targets

Strategic Partnerships

There are several areas where 3M has identified the need for further product development and has formed strategic partnerships to assure that these product needs are met. One example is development of the transceiver used with the Volition system to handle optical/electrical conversion.

To date, optoelectronics of active equipment has been the most costly portion of a fiber optic network. 3M, in alliance with Honeywell, has developed low-cost optoelectronic transceivers which, like the connector, use V-groove technology to eliminate the need for costly ceramic ferrules. In addition, the application of V-groove technology has simplified both the transceiver design and the manufacturing process, enabling lower cost transceiver components.

The VF-45 transceiver is manufactured and supplied by Honeywell for use in media converters, hubs, switches and other network electronic equipment. This technology is also available for licensing and, to date, several companies have announced their interest in licensing the VF-45 optical transceiver technology.

Supporting Technologies

In some instances, new technologies are needed to help enable fiber-to-the-desktop implementation. For example, there is a media conversion chip available for fiber systems that works at 10 Mb/second transmission speeds. However, at 100 Mb/second, media conversion currently requires several chips, which affects the size, cost and efficiency of the system.

To solve this problem, 3M is involved in the development of a new 100 Mb/second media conversion chip. This will ultimately lead to a lower cost copper-to-fiber media converter that can be interfaced with today's 10/100 Mb/second network interface cards(NICs). 3M is also involved in other chip development work to further reduce the cost of network electronic equipment such as hubs and switches.

Electronics Development Program

The Volition Electronics Development Program is an initiative undertaken by 3M to gain the acceptance and utilization of the Volition VF-45 technology within the electronics industry. The primary goal is to achieve momentum for the technologies which will enable fiber to the desktop by ensuring its widespread use in active network equipment. With the Volition Electronics Development Program, 3M will illustrate advantages of the VF-45 technology, demonstrate past and continued involvement in standards bodies, and integrate equipment developers into its dedicated sales effort and technology awareness campaign.

Along these lines, BATM Advanced Communications has announced a line of fiber optic hubs and switches, many of which will be available by the end of 1Q98, that will have a VF-45 interface.

Similarly, a leading backbone router and switch vendor has announced an I/O module for Token Ring access that will feature a VF-45 interface.

Licensing Strategy

The VF-45 interconnect licensing strategy is designed to widely license the Volition fiber-to-the-desktop interconnect technology. The objective is to move quickly to multivendor manufacturing so that the VF-45 connector is broadly available to support the 3M and other fiber-to-the-desktop solutions. Toward this end, both product pricing and royalties have been kept low and there are no upfront licensing fees.

3M is licensing all relevant patents to allow a company to manufacture a connector in accordance with the new Fibre Channel standard (which uses the VF-45 connector format).

In addition, Honeywell will grant licenses to third parties to design, manufacture, use and sell the optical transceivers.

As part of VF-45 interconnect licensing, 3M offers licensees the option to use the VF-45 trademark as part of their products' brand names. The VF-45 name is quickly becoming a valuable brand and will assist in creating recognition of the technology platform rather than for the 3M-specific system. Private label is available for companies pursuing this option.

Royalty Rates

The Volition interconnect is designed to sell at an average cost of $1.50 to $2.50 per piece (plug or socket), or $3 to $5 for the full interconnect. Royalties are 3% when the VF-45 trademark is used ($0.09 to $0.15 per duplex plug-and-socket combination), 4% when the trademark is not used ($0.12 to $0.20 per plug and socket). Although these rates may be higher than other connectors available, they are a higher percentage of a lower product price. On average, other fiber interconnects are selling at $8 to $10 with a royalty fee of around 2%. While the Volition connector requires only one factory-terminated plug and one socket to complete a duplex connection, others require four connectors and two couplings. (This mean royalties of $0.64 to $0.80 on the connectors required for a duplex connection — more than three times the cost of 3M royalties.)

Licensing Activities to Date

Licensing discussions for the VF-45 interconnect are currently underway with close to 20 companies and several have already been announced. Chicago-based Methode has announced it will be manufacturing and selling the VF-45 connector.

In the November 1997 Fibre Channel Forum Siemens, Berg Electronics and Sumitomo announced they are licensing the transceiver technology. These companies, along with Honeywell, are now working on a multisource agreement to assure that the pinout of their respective transceivers have the same functionality.

Additional licensing discussions are underway, but the companies have requested to remain confidential at this time.

Given the current licensing activity, it is expected that multiple sources for the VF-45 interconnect and transceiver will come onto the market during the first six months of 1998. The transceiver product offerings are expected to cover 10 Mb/s to 1 Gb/s and include both 850 nm and 1300 nm solutions. Single mode options will be available later in 1998.

Conclusion

The 3M Volition Fiber Optic Cabling System is a robust, affordable fiber-to-the-desktop system that sets a precedent for ease of use and durability of fiber in the LAN. The full system includes all components required for a complete fiber optic structured cabling system.

Significant system innovations include the Volition VF-45 interconnect and optical transceiver. Through use of a proven V-groove technology, 3M has significantly lowered the cost, reduced the size and decreased the complexity of these two critical components. At the same time, the VF-45 interconnect maintains industry standards for system performance — meeting or exceeding all specifications for ISO/IEC and TIA/EIA requirements.

With active partnering programs and an attractive licensing package, 3M is working to ensure broad availability of equipment and technologies to the Volition — and other — fiber-to-the-desktop solutions.

Appendix A

Fibre Channel
SG Interface Specification

ZZ SG Optical Interface Specification

The primary function of the optical interface specification is to define mechanical alignment of the optical fibres to an optical port on a component such as a transmitter or receiver.

The objective of this section is to specify the optical interface sufficiently to ensure the following:

- Intermateability
- Mechanical/Optical Performance
- Maximum Supplier Flexibility

Note in this clause, only the dimensions necessary to specify the duplex transmitter and receiver are provided, hereafter referred to as the receptacle. All other dimensions are referenced in the TIA/EIA 604-7 standard. All dimensions for the optical plug are referenced in the TIA/EIA 604-7 standard.

ZZ.1.1 Relationship to other standard connectors

The optical interface connector defined by this document shall conform to:

- ANSI/TIA/EIA 604-7 (FOCIS 7), Fiber Optic Connector Intermateability Standard, Type "SG"
- ANSI/TIA/EIA-47500AC Detail Specification for Type SG Fiber Optic Connector

ZZ.1.2 Testing Recommendations

Supporting test information is contained in annex XX.

ZZ.2 SG Optical Receptacle

The SG optical transceiver is a ferrule-less optical design, and as such, there are numerous methods for accepting the bare fiber and guiding it to alignment. The TIA/EIA 604-7 (FOCIS 7) document defines one such method. The guidelines for mechanically controlling the optical fiber are giving in notes three through six below. Figure ZZ.1 dimensionally specifies the receptacle, with the following notes. Notes:

1. Unless otherwise specified, all dimensions ± 0.1.
2. Reference designators, denoted by a letter, are from the TIA/EIA 604-7 duplex SG socket interface (n=2, m=0) drawing.
3. Internal cavity to provide clearance for plug, including the latching mechanism, as defined in TIA/EIA 604-7 (d=1) plug interface. TIA/EIA 604-7 defines one method of fiber capture.
4. Fiber bend radius > 7.5mm
5. Fiber axial tip force > 1g
6. Length of fiber from mechanical reference plane, 18.2 ±0.1
7. Latching mechanism may protrude through outer portion of the housing.
8. SG plug is shown with the optional door in place.

Figure ZZ.1 - SG Receptacle

Dimensional Table:

Reference	Minimum	Nominal	Maximum	Notes
A		5.85		Note 1
B		2.8		Note 1
G		7.65		Note 1
H	12.02	12.1		Note 1
I		1.3		Note 1
J		0.9		Note 1
M		5		Note 1
N		4		Note 1
U	8	8.1		Note 1
X		1		Note 1
AA		25°		Degrees, Note 1
AB		30°		Degrees, Note 1

Note 1: Dimension referenced to the TIA/EIA 604-7 duplex SG socket interface standard (n=2, m=0).

ZZ.3 SG Optical Connector Plug

Figure ZZ.2 describes the SG duplex Connector Plug envelope dimensions. The following notes apply to figure ZZ.2.

Notes:

1. Unless otherwise specified, all dimensions ± 0.1.
2. Reference designators, denoted by a letter dimension, are from the TIA/EIA 604-7 plug interface (d=1) drawing.
3. SG plug is shown with the optional door in place.

Dimensional Table:

Reference	Minimum	Nominal	Maximum	Notes
B	11.85	11.9	12	Note 1
G	19	20	21	Note 1
U	7.85	7.9	8	Note 1

Note 1: Dimension referenced to the TIA/EIA 604-7 standard plug interface option (d=1).

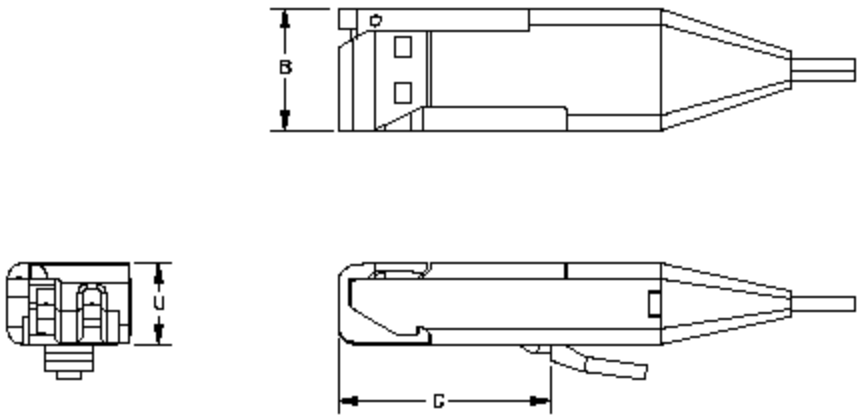

Figure ZZ.2 SG Connector Plug Envelope Dimensions

Annex XX
(Informative)
SG Optical Interface

XX.1 Combined Mechanical-Optical Requirements as defined by Detail Specification ANSI/TIA/EIA 47500XX

TESTS	Value	Test Method
Axial Pull Force (safety, latch retention force)	20 N Minimum 60 N Maximum 1.0 dB Maximum Variation	Annex XX.3
Insertion/Withdrawl Force	20 N Maximum	Annex XX.4
Single Plug Repeatability	2.0 dB Maximum (SM) 1.5 dB Maximum (MM)	Annex XX. 5
Cross Plug Repeatability	3.0 dB Maximum (SM) 2.0 dB Maximum (MM)	Annex XX.6
Off-Axis (Rotational) Pull	1.0 dB Maximum Variation	Annex XX.7
Cable/Connector Pull Strength (cable to connector retention)	90 N Minimum	Annex XX.8

XX.2 SG Optical Interface testing definitions and conditions

The product shall be defined as compliant when the following conditions are satisfied:
a) Meets the criteria stated in section XX.1.
b) No mechanical damage defined as splitting, cracking, pitting or galling is observed under 10X magnification unless otherwise stated.
c) Functional dimensions conform to Figure A requirements.

The application of a stimulus such as force or environmental condition shall be applied once to demonstrate compliance with the requirement unless otherwise stated. The following tolerances shall apply to all connector tests:

Table XX.2 - Connector test tolerances

Length	± 10%
Angles	± 3°
Rates	± 10%
Weights	± 10%

Note: Before each of the following tests are conducted, clean the ends of the optical fibers and ensure that optical reference conditions remain stable during testing.

XX.3 Axial pull test

Purpose: To ensure the receptacle is able to wi thstand an axial applied plug pull load without mechanical damage or exceeding permissible optical performance.

Test method: FOTP-185 is the recommended test method. The plug must be completely latched before the start of testing.

XX.4 Insertion/withdrawal force test

Purpose: To ensure the receptacle is designed to allow for easy insertion and withdrawal of the SG Plug.

Test method: FOTP-187 is the recommended test method.

XX.5 Single plug optical repeatability test

Purpose: Fibre to optical source alignment measurement.

Test method: FOTP-34 is the recommended test method.

A minimum of 25 single plug insertions should be repeated on a single receptacle. The insertions should meet the optical performance requirements stated in Table XX.1.

XX.6 Cross plug optical repeatability test

Purpose: Fibre to optical source alignment measurement.

Test method: FOTP-34 is the recommended test method.

A minimum of 25 different plug insertions should be performed on a single receptacle. The insertions should meet the optical performance requirements stated in Table XX.1.

XX.7 Off axis pull test

Purpose: Ensures that the cables can be dressed in any direction without loss in optical performance.

Test method: IEC 1300-2-35, Cable Nutation, is the recommended test method.

XX.8 Cable/connector pull strength

Purpose: Test integrity of the fibre to connector strain relief.

Test method: FOTP-6 is the recommended test method. The plug must be secured before the start of testing.