

# WHITE PAPER

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## Fibre Channel Technology: Understanding Fiber Cabling and Connecting to Building Infrastructure

*Fibre Channel storage solutions will shatter distance, connectivity, capacity and bandwidth limitations of SCSI. Fibre Channel allows highly scalable, high-performance storage solutions for the most demanding applications. While SCSI technology continues to satisfy the needs of many applications, inherent I/O and physical limitations prevent SCSI technology from satisfying all of the expanding needs of enterprise storage. Compaq believes Fibre Channel is the best interconnect technology choice for future storage solutions and is committed to delivering enterprise storage solutions based on this technology.*

*This paper describes fibre channel transmission and the cabling and components used to assemble the Compaq Fibre Channel Storage System. It also describes how and when infrastructure cabling might be used. If plans for a fibre channel storage solution include using infrastructure cabling, a company that provides installation and testing services can be helpful, if not necessary, to determine appropriate cabling to meet data transmission rate and distance requirements. (See the section, "Acknowledgments and References," page 10.)*

NOTE: Not all fibre channel configurations require connection to infrastructure cabling. It is not uncommon to have all system components located near each other, eliminating the need for infrastructure cabling. This paper includes examples of Fibre Channel Storage System configurations with and without infrastructure cabling.

*For more information on Fibre Channel Technology, go to  
<http://www.compaq.com/products/servers/storage/fibre.html>*

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## UNDERSTANDING FIBRE CHANNEL TRANSMISSION

Fibre Channel uses lasers to achieve gigabit data transmission rates. The ones and zeros used to convey information digitally are generated by turning a laser on and off. The receiver detects these bursts of light and converts them to electrical signals. Lasers used in Fibre Channel transmit light in two wavelengths: 770–860 nanometers (short wave) and 1270–1355 nanometers (long wave).

Optical fiber cable (fiber) is the primary medium used in Compaq Fibre Channel solutions. Fiber has significant bandwidth, transmits data over long distances, and transports data more reliably than copper cable. It is also immune to electronic noise and does not radiate energy.

Fiber is categorized as either multimode or single mode; “mode” means path. In Figure 1, the diameter of multimode fiber is large enough to allow multiple streams of light to travel different paths from transmitter to receiver. Short wave lasers are used with multimode fiber. In Figure 2, the small diameter of single mode fiber allows one coherent stream of light to travel a single path. Long wave lasers are used with single mode fiber to transmit data over long distances.

**NOTE:**

This paper includes the terms “fibre” and “fiber.” Fibre is the international spelling that refers to the Fibre Channel standards for both optical and copper media. Fiber refers to the optical media used to implement Fibre Channel.

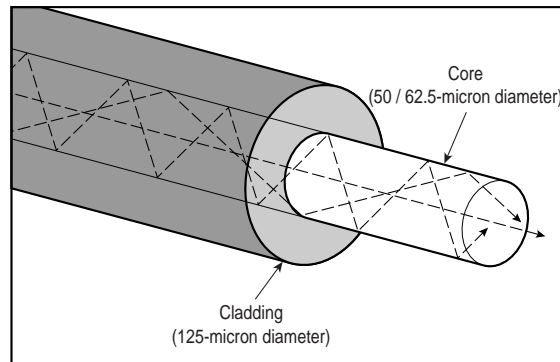


Figure 1. Multimode fiber

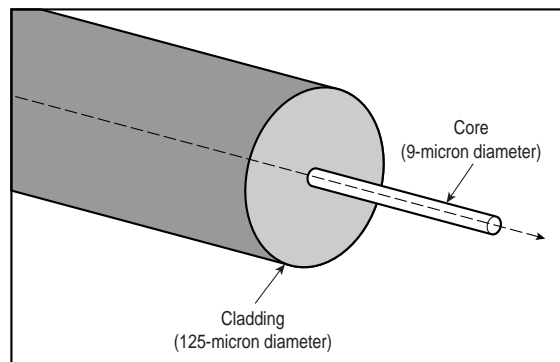


Figure 2. Single mode fiber

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## UNDERSTANDING FIBER TYPES

Multimode fiber includes two fiber types: 62.5-micron multimode and 50-micron multimode. Single mode has one fiber type: 9-micron single mode. The fiber types are distinguishable by their data transmission rates and distance capabilities.

**Table 1: Data Transmission Rates and Distance Capabilities of Fiber Types**

	Supported by Compaq	62.5-micron	50-micron	9-micron*
100 MB/sec	Yes	175 meters	500 meters	10,000 meters
200 MB/sec	Future	150 meters	300 meters	2,000 meters
400 MB/sec	Future	90 meters	150 meters	2,000 meters

\* Future

### Distance Limitations

Two factors can limit the distance capability of a fiber:

1. Data transmission rate. As shown in Table 1, the distance capability of each fiber type tends to decrease as the data transmission rate increases.
2. Attenuation. Attenuation is a reduction of the signal strength as it passes through fiber. Signal strength is also reduced by connectors and splices. The number of connectors and splices used will affect the distance capability of the fiber.

Formulas are used to calculate the distance limitation based on these factors. A company that provides fiber products and installation and testing services can help determine distance capabilities and limitations for a particular installation. (See the section, "Acknowledgments and References," page 10.)

## CONNECTION COMPONENTS

To build a storage system that uses Fibre Channel Technology, it is necessary to understand the use and function of Fibre Channel cables (FC cables) and connectors, hubs, and GBICs in Fibre Channel configurations. Briefly:

- FC cables and connectors join system components and connect to infrastructure cabling.
- Hubs accept different cable types simultaneously, allowing for intermixed cable types within a topology, and use port bypass circuitry to keep a Fibre Channel loop topology intact.
- GBICs convert electrical signals to optical signals (and vice versa) at the point where fiber cables connect to copper-wired components (hubs, controller cards, host adapters, etc.).

### FC Cables and Connectors

Typically, FC cables are a pair of fibers with connectors on each end. The fibers in an FC cable cross so that the input at one end of the FC cable becomes the output at the other end. The connectors are keyed to ensure proper orientation for connections. FC cables are available with different connectors and in different lengths and fiber types. Compaq supplies 50-micron FC cables in fixed lengths of two, five, and 15 meters, all with SC connectors. Compaq system components currently interconnect using 50-micron FC cables; support for 9-micron FC cables will be available in the future.

FC cables that connect to infrastructure cabling must match the fiber type of the infrastructure cabling. For example, if a 50-micron FC cable connects a server to a wall outlet, the infrastructure cabling that runs to that wall outlet must also be 50-micron. A mismatch (connecting a 50-micron FC cable to 62.5-micron infrastructure cabling) can cause severe degradation of the optical signal and could result in marginal operation or an unreliable connection. Cable assembly suppliers can provide custom cables with unique combinations of length, connector type, and fiber type to mate with infrastructure cabling. (See “Acknowledgments and References,” page 10, for suppliers.)

FC cable types are labeled at one-meter intervals on the cable. An FC cable labeled, “50/125,” indicates a 50-micron inner core with 125-micron outer cladding. Cables are also color-coded:

**Table 2: Standard Color Codes to Identify FC Cable Types**

62.5-micron	50-micron	9-micron
Slate gray or orange	Orange	Yellow

Compaq system components currently interconnect using 50-micron FC cables; support for 9-micron FC cables will be available in the future. Compaq has tested and qualified 62.5-micron cables but does not provide them; customers can acquire these cables from other sources.

## Hubs

An important feature of using hubs in a fibre channel solution is the ability to intermix different media types on the same loop to accommodate a different type of infrastructure cabling (for example, 62.5-micron multimode and 50-micron multimode as shown in Figure 3). Another feature of hubs is the ability to detect and bypass non-operational ports, keeping the loop intact.

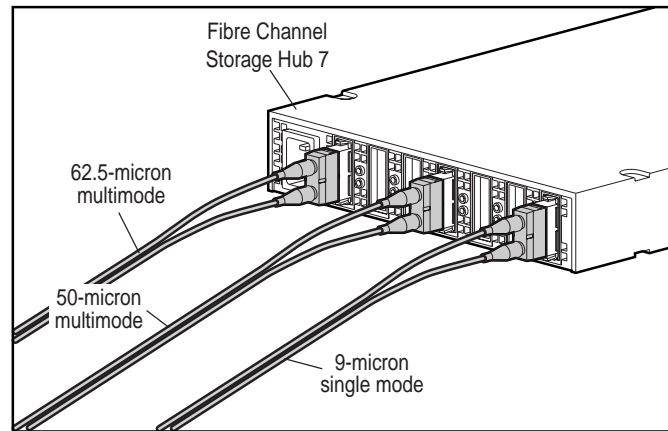


Figure 3. Using a hub to intermix fiber types

## GBICs

GBICs plug into ports of all fibre channel system components (host controllers, hubs, arrays) and convert electrical signals to optical signals (and vice versa). A short wave GBIC must be used with a multimode (short wave) FC cable and a long wave GBIC with a single mode (long wave) FC cable. Compaq GBICs currently use short wave lasers for multimode fiber; a long wave version for 9-micron single mode fiber will be provided in the future.

A label describes the GBIC and distinguishes it as short wave or long wave. The description may spell out a GBIC's characteristics or may use the Fibre Channel standard convention for labeling: SPEED-MEDIA-TRANSMITTER-DISTANCE. An example would be 100-M5-SN-I, where 100 denotes 100 MB/s, M5 denotes multimode, SN denotes short wave laser, and I denotes intermediate distance. Table 3 lists standard abbreviations for GBIC labeling.

Table 3: Fibre Channel Standard Abbreviations for GBIC Labels

Speed	Media	Transmitter	Distance
100 = 100 MB/s <sup>1</sup>	SM = single mode	LL = long wave laser (1300 nanometers)	L = long distance (2 to 10 kilometers)
200 = 200 MB/s	M5 = 50-micron multimode	SL = short wave laser with OFC (850 nanometers) <sup>2</sup>	I = intermediate distance (100 meters to 2 kilometers)
400 = 400 MB/s	M6 = 62.5-micron multimode (A cable labeled M6 can be used with an M5 GBIC)	SN = short wave laser without OFC <sup>1</sup> (850 nanometers)	S = short distance (0 to 100 meters)

<sup>1</sup> 1063Mbd is the data rate measured in megabauds and is equivalent to 106.3 MB/s, or 100 MB/s nominally.

<sup>2</sup> Compaq only supports short wave lasers without open fiber control (OFC), the SN version. OFC limits the amount of light transmitted when the fiber is broken to prevent eye injury. Improvements in technology and relaxed specifications have eliminated the need for OFC.

## INTERCONNECTING SYSTEM COMPONENTS

This section discusses interconnecting primary storage system components, using the Compaq Fibre Channel Storage System as an example.

### Overview of System Components

The Fibre Channel Storage System uses the components described in Table 4 below.

**Table 4: Fibre Channel Storage System Components**

Component	Description
Fibre Channel Array	An external storage cabinet that houses the Fibre Channel Array Controller and up to 12 1-inch or eight 1.6-inch Wide-Ultra SCSI disk drives
Fibre Channel Array Controller	An intelligent Fibre Channel to SCSI array controller with 32-MB cache (Contained within the Fibre Channel Array)
Fibre Channel Storage Hub 7	Supports up to seven devices on a Fibre Channel Arbitrated Loop (FC-AL)
Fibre Channel Host Controller	An EISA or PCI to Fibre Channel host adapter
Gigabit Interface Converter (GBIC)*	Converts optical signals to electrical signals (and vice versa)
Multimode Cable	2m**, 5m*** or 15m 50-micron fiber optic cable. All cables are available as separate options.

\* One pair ships with Fibre Channel Array and Fibre Channel Host Controller

\*\* Ships with Fibre Array

\*\*\* Ships with Fibre Channel Host Controller

### Typical Fibre Channel Storage System Configuration

In most cases, the server, the hub, and the storage arrays will be located close to each other, making interconnections easy to configure without using infrastructure cabling. If a storage component needs to be located across a greater distance (for example, you need to centrally locate storage across multiple floors from its associated server), the server may need to be connected via infrastructure cabling. The following section discusses infrastructure cabling.

In Figure 4, the Fibre Channel Host Controller connects to the Storage Hub 7; the Storage Hub 7 connects to the Fibre Arrays. A GBIC is installed at all fiber interconnections. Using custom-length, 50-micron fiber, interconnect distances between components can be up to 500 meters; so, Fibre Channel Arrays can be located up to a kilometer from the Host Controller.

*Note: In a Fibre Channel configuration with a single Fibre Array, the Fibre Channel Host Controller can connect directly to the Fibre Array.*

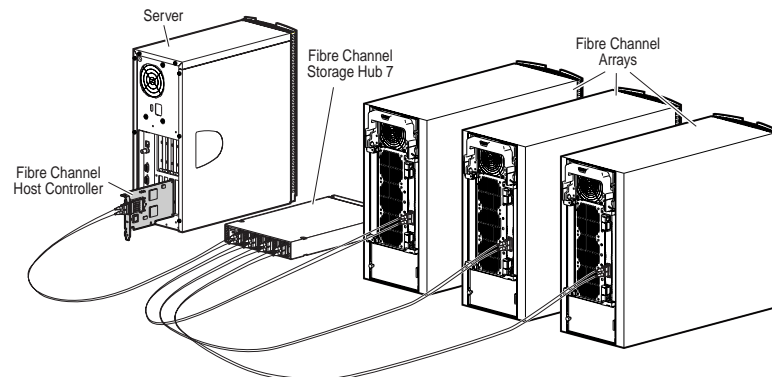


Figure 4. Typical Fibre Channel Storage System configuration

## USING INFRASTRUCTURE CABLING

Infrastructure cabling (or cable plant) refers to the complete cabling system within a building or buildings. This section includes a discussion of infrastructure cabling and includes a scenario in which a Fibre Channel Storage System uses infrastructure cabling to connect across multiple floors. This example should help answer the questions:

- Can I use existing infrastructure cabling?
- Do I install new infrastructure cabling?
- If I need new infrastructure cabling, what type do I install?

### Typical Fiber Infrastructure Cabling Scheme

Figure 5 shows a fiber infrastructure cabling scheme across three floors. A fibre channel cable (an FC cable or patch cable) connects servers to work area outlets. Horizontal fiber cable connects work area outlets to telecommunications closets. In the telecommunications closets, horizontal and backbone cables interconnect via FC patch panels. The fiber backbone cable connects telecommunications closets to the main distribution center.

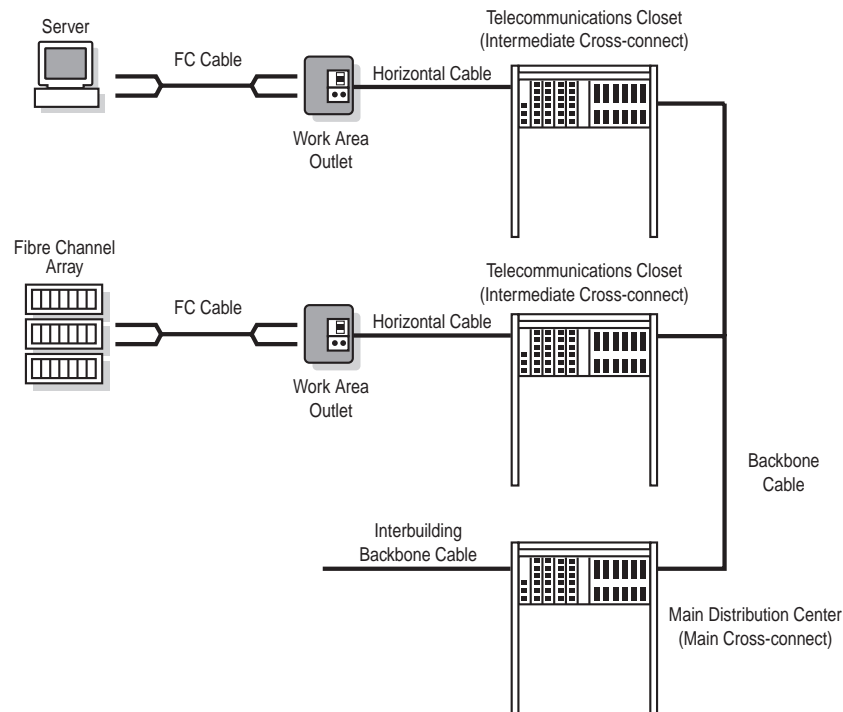


Figure 5. Infrastructure cabling across three floors



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## The Fibre Channel Storage System Using Infrastructure Cabling

Consider the scenario in which the server is located several floors away from its storage:

A server is located in the telecommunications closet on the n<sup>th</sup> floor of a building and will connect to a hub and storage arrays located in the basement. To connect the server to the hub requires infrastructure cabling. What type of infrastructure cabling will work?

To select an appropriate fiber type, measure the distance the backbone cable will span and determine the data transmission rate to be used. Remember, data transmission rates and attenuation limit distance capability. (See “Distance Limitations,” page 4.)

At 100 MB/s Data Transmission Rate	
If the total distance of between-floor connections is:	You can use:
<175 meters	62.5-, 50-, or 9-micron fiber*
>175 meters and <500 meters	50- or 9-micron fiber*
> 500 meters and < 10 kilometers	9-micron fiber*

\* Support for 9-micron fiber available in the future.

## Using Existing Cabling or Installing New Cabling

If you determine that 62.5-micron fiber will support your configuration and you have 62.5-micron installed in the building, you can use the existing fiber. Be sure to consider any additional plans for expanding the system and using increased data transmission rates in the future; 50-micron fiber may be required to support expansion and increased data transmission rates.

If you determine that 62.5-micron fiber will support your configuration and you have no fiber cable installed in the building, 50-micron fiber is the primary standard for Fibre Channel connections. It allows flexibility for system expansion and supports faster data transmission rates across greater distances than 62.5-micron fiber.

If you have no fiber installed, or if 62.5-micron does not satisfy distance requirements, the choice between 50-micron and 9-micron fiber depends on future configuration requirements and the use of faster data transmission rates in the future.

## Testing

Testing assures proper operation with a low error rate and is necessary for both existing and new infrastructure cabling. The power generated by the transmitter and the sensitivity of the receiver determine the amount of power available. This amount must be greater than the attenuation—reduction in signal strength—in a connection between two components.

Attenuation will always occur in the fiber, connectors, and splices. Other factors can cause attenuation. For example, a splice will always cause some amount of attenuation, but a poorly joined splice may go unnoticed and cause attenuation that exceeds expectations. This can be detected and repaired during testing.

Individuals experienced in installing and testing fiber-optic infrastructure should test existing or new infrastructure cabling. (See “Acknowledgments and References.”)

**HANDLING FIBER AND FIBER CONNECTORS**

Optical components should be protected from heat, contaminants, abrasion, axial or lateral movement, and mechanical hazards. Kinking or small-bend radiuses of fiber should be avoided. The rule of thumb is that the bend radius should be greater than 10 times the outside diameter of the cable. (For Compaq-supplied FC cables, the bend radius is 30 mm or 1.25 inches.) Heavy objects such as copper cable should not be placed on top of fiber cable because they can deform the fiber. All of these elements and actions can reduce the amount of light passing through a connection and can lead to degraded performance.

GBICs and FC cables ship with dust caps installed. These should remain installed until an optical connection is made and should be reinstalled when disconnected for any reason. Compaq products ship with instructions for making clean connections. Cleaning should be performed any time an open connection might have been exposed to dust or when there is any doubt about its cleanliness.

**ACKNOWLEDGMENTS AND REFERENCES**

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