

The Ten Commandments of Fiber Optics

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When planning for a successful fiber-optic network and cabling installation, several principles remain constant but often are overlooked. As a training manager, I see how easy it is to overlook some of these principles. Here are my 10 things to remember about fiber optics.

1. Consider the Nature of Thy Sandals When Thou Installeth Single Strand Fiber

You wouldn't buy two left shoes, but people often make a similar mistake when they're working with Single Strand Fiber (SSF). Single Strand Fiber technology allows for the use of two independent wavelengths, often 1310 and 1550 nm, on the same piece of cable. But the transmitters and receivers must be matched correctly. One unit must be a 1310/1550 device (transmitting at 1310 nm, receiving at 1550 nm) and the other must be a 1550/1310 device (transmitting at 1550 nm, receiving at 1310 nm).

The 1550 nm Single Strand Fiber transmitters are more expensive than the 1310 nm transmitters, thanks to the cost of their more powerful lasers. So network administrators may hope to save money by installing a pair of 1310/1550 devices. But, like mismatched shoes, it doesn't work.

Single Strand Fiber equipment is also more expensive than standard Single-mode. But there are situations in which Single Strand Fiber is well worth the investment. For example, if a strand of fiber is available in an existing bundle, deploying Single Strand Fiber products would be cheaper than digging up the cable run to add another bundle of fiber. And in applications where all of the available Single-mode fiber capacity is already in use you can double your fiber capacity by switching to Single Strand Fiber products.

2. Couple Not Thy Single-mode and Multi-mode Fiber Products, For Thou Will Surely Be Vexed and Tormented Thereafter

It may be tempting to try to make use of legacy cabling or equipment from an older fiber installation. But don't even think about it unless you know exactly what you've got, and what all the pieces are. Single-mode and Multi-mode fiber products are normally incompatible. Some of the major differences would include the wavelengths that the fiber cable can accommodate and the light sources that are being used.

Multi-mode fiber uses cable with a relatively large core size, typically 62.5 microns, with 50 microns still used in some installations. The larger core size simplifies connections and allows for the use of less powerful, less expensive light sources. But it also lends itself to modal dispersion – the light tends to bounce around inside the core. That limits Multi-mode's useful range to about 2 km.

Single-mode fiber combines powerful lasers and cabling with a narrow core size of 9/125 microns to keep the light focused. It has a range of up to 130 km, but it is also more expensive.

So let's say you tried to use Single-mode products over a Multi-mode cable run. The core size of the fiber cable would be far too large. You'd get dropped packets and CRC errors, and your customers would not be happy. Single and Multi-mode fiber may have many similarities – but they're not the same thing.

3. Fear Not the Short Single-mode Cable Run, for in Attenuation Lieth Thy Remedy

Networks designers don't always specify Multi-mode for shorter fiber cable runs. They may choose Single-mode instead, and their reasoning may be based upon issues like bandwidth or interoperability with large, complex systems. Depending upon the distances involved, a Single-mode fiber laser can sometimes be too "hot", meaning that it has a very powerful signal strength relative to the distance that is being covered. This can lead to oversaturation of the receiver at the other end of the connection.

The solution is attenuation: deliberately reducing the signal strength without impacting the integrity of the line or the throughput of data. Attenuators can take numerous forms. Examples include an O ring type that slips onto an ST connector interface, a coupler on the fiber line itself, and connector caps that clip onto a fiber interface connector. They are available with various dB values. Folks who don't want to perform heavy mathematical calculations often start with 10 dB.



4. Gaze Not Into Thy Fiber Ports, Lest Thou Be Blinded By Thy Folly

Fiber media converters normally use Class I, eye-safe lasers. And vendors will normally list all of the relevant specifications in their documentation or on their web sites. But why take any chances? More powerful lasers are often used in "Fibre Channel", medical and military applications, so it's best to avoid letting any lasers shine directly into your eyes at any time, even if it seems unlikely that they would be powerful enough to be dangerous. Better safe than sorry.

Figure 1. ST connector

5. Learn Thy Connector Types, Lest By Ignorance Thou Attempteth to Place a Square Peg in a Round Hole

Fiber transceivers use a variety of connectors, so familiarize yourself with them before you begin ordering products for a fiber installation. SC, "stick and click", is a square connector. ST, "stick and twist", is a round, bayonet-type. LC, or the "Lucent Connector", was developed by Lucent Technologies to address complaints that ST and SC were too bulky and too easy to dislodge. (LC connectors look like a compact version of the SC connector.) SFP, "small form-factor pluggable" transceivers use LC. Less common connectors include MT-RJ and VF.



Figure 2. SC Connector

6. Thou Shalt Not Suffer Thy Connectors and Splices To Be Fruitful and Multiply

Although Single-mode fiber suffers from less signal loss per km than Multi-mode, all fiber performance is

impacted by connectors and splices. The signal loss at a single connector or splice may seem insignificant. But as connectors and splices become more numerous signal loss will steadily increase. Typical loss factors would include 0.75 dB per connector, 1 dB per splice, .22 dB attenuation per km for Single-mode fiber and .35 dB attenuation per km for Multi-mode fiber. Add a 3 dB margin for safety. The more splices and connectors you have in a segment, the greater the loss on the line.

If a line is too degraded there are some things you can do to try to resolve the problem. Installing a more powerful fiber optic device may compensate for signal loss. You may be able to shorten the length of the cable run. You may be in a position to reduce the speed, from gigabit to Fast Ethernet. (Lowering the speed extends range.) If none of these remedies succeed you may have to pull a new bundle of fiber, which is expensive and time-consuming.

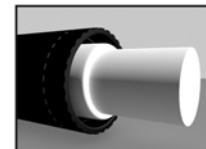
7. Trust In Thy Power Budget Calculations – But Use Thy Power Meter Anyway

In theory, subtracting minimum receive sensitivity from minimum transmit power should give you your power budget, the amount of light that is available to transmit signals over a specified distance. (Transmit Power - Receive Sensitivity = Power Budget.) And the vendor's spec sheet or web site should provide you with the relevant values. But splices, connectors and distance all affect the power budget as well, and there may be subtle differences between devices provided by different vendors. Use a power meter to verify and troubleshoot each segment of your installation.

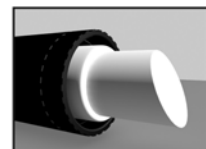
8. Thou Shalt Note That “Ferule” Rhymeth With “Peril’

Fiber connections may use Angle Polished Connectors (APC) or Ultra Polished Connectors (UPC), and they are not interchangeable. There are physical differences in the ferules at the end of the terminated fiber within the cable. An APC ferrule end-face is polished at an 8° angle, while the UPC is polished at a 0° angle. If the angles are different, some of the light will fail to propagate, becoming connector or splice loss.

UPC connectors are common in Ethernet network equipment like media converters, serial devices and fiber-based switches. APC connectors are typical for FTTX and PON connections. ISPs are increasingly using APC.



UPC



APC

9. Thou Shalt Fathom Thy Transceiver Acronyms

Small Form Pluggable (SFP) transceivers are more expensive than fixed transceivers. But they are hot swappable and their small form factor gives them additional flexibility. They'll work with cages designed for any fiber type and their prices are steadily dropping. So they have become very popular.

Standard SFPs typically support speeds of 100 Mbps or 1 Gbps. (One can also find a T1 SFP, although they are rare.)

Figure 3. Ferule Styles

XFP and SFP+ support 10 Gbps connections. SFP+ is the smaller of the two and allows for greater port density. But even if the modules were all the same size, you couldn't successfully connect XFP or SFP+ to a device that only supports 1 Gbps.

10. Separate Thy Sheep From Thy Goats, For They Be Different Beasts

Most fiber-based devices are defined by speed and protocol. If a gigabit network switch has a fiber interface on it, and it is labeled a GBIC, it must be connected to an Ethernet device that is capable of gigabit speed as well. Fiber devices are normally incompatible with equipment that is designed to communicate at a different speed.

Protocols matter, too. An Ethernet gigabit network device, for example, won't be able to communicate with a Gigabit Passive Optical Network (GPON) device, as the GPON is a point-to-multipoint access mechanism. It uses passive splitters and encryption to serve multiple locations. Both devices may be gigabit, but they won't be able to communicate effectively.

Mode converters can convert one type of fiber to another, and they are not confined by a protocol. But they are limited by a native speed range. A mode converter that supports up to 155 Mbps can't be connected to a gigabit mode converter. There are, however, fiber technologies like WDM (two channel fiber, passive optics), that can be connected at any speed up to 10 Gbps.



Figure 4. SFP and SFP+



Figure 5. XFP