Advantages of Fiber Optic Splitters in Key Applications

Increase the Efficient Use of Optical Infrastructure with These Passive Components

Overview

Fiber optic splitters play an increasingly significant role in many of today's optical network topologies. From FTTx systems to traditional optical networks, splitters provide capabilities that help users maximize the functionality of optical network circuits. This paper will explore a handful of the different types and functions of splitters, with an emphasis on two key applications – passive circuit monitoring and FTTx/PON architectures.

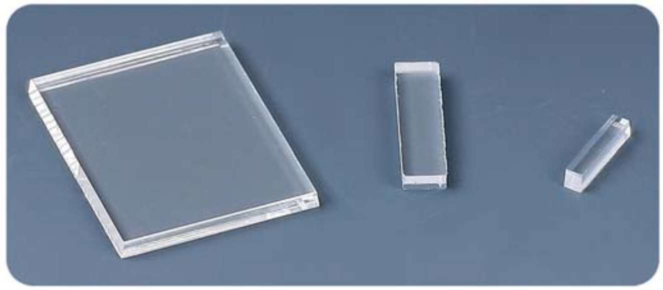

Figure 1: Sample of a PLC-style splitter chip. (Photo courtesy of The Blue Shift.)

In simple terms, a fiber optic splitter is a passive optical device that can split, or separate, an incident light beam into two or more light beams. These beams may or may not have the same optical power as the original beam, based on the configuration of the splitter. By means of construction, the outputs of a splitter can have varying degrees of throughput, which is highly beneficial when designing optical networks, whether the splitter is used for network monitoring or for a loss budget in a passive optical network (PON) architecture.

Splitter Types

Although technology continually evolves and there are variations of existing splitter types, the two most commonly deployed splitters are planar lightwave circuit (PLC) and fused biconical taper (FBT). Here is a brief description of each:

PLC-Style splitters use an optical splitter chip to divide the incoming signal into multiple outputs. The chip is either silica- or quartz-based, and is available in varying polished finishes. It consists of three layers – a substrate, the waveguide, and the lid. The waveguide layer accepts the incoming optical signal and passes it through to the outputs. The physical appearance of the splitter varies depending on final assembly.

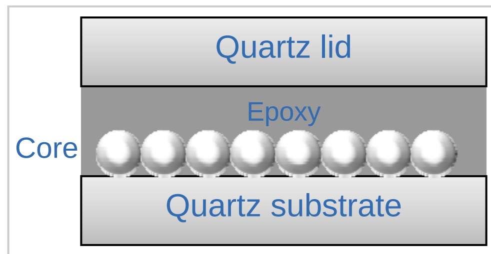

Figure 2: Cross-sectional representation of a PLC-style splitter. (Graphic courtesy of The Blue Shift.)

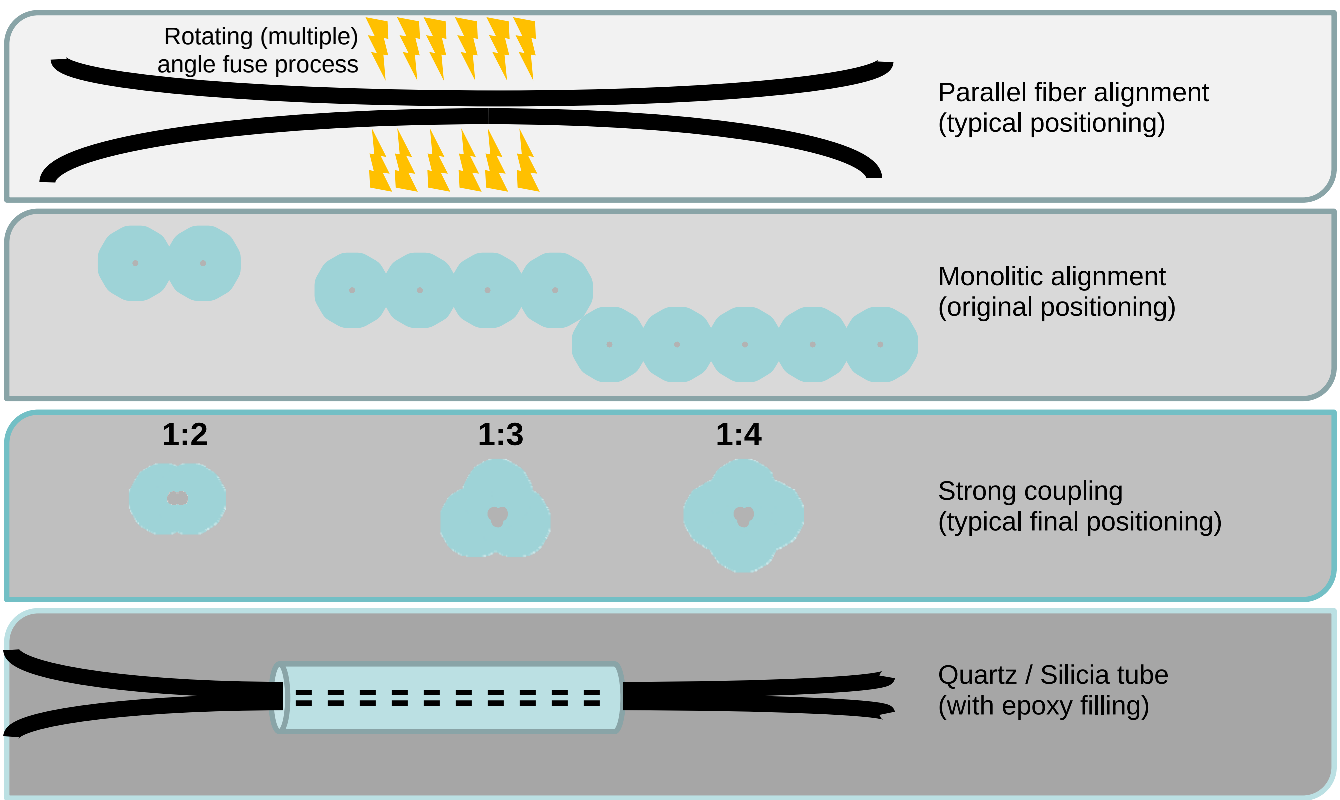

Figure 3: FBT-Type splitter fusion process, showing a symmetrical splitter. (Graphic courtesy of The Blue Shift.)

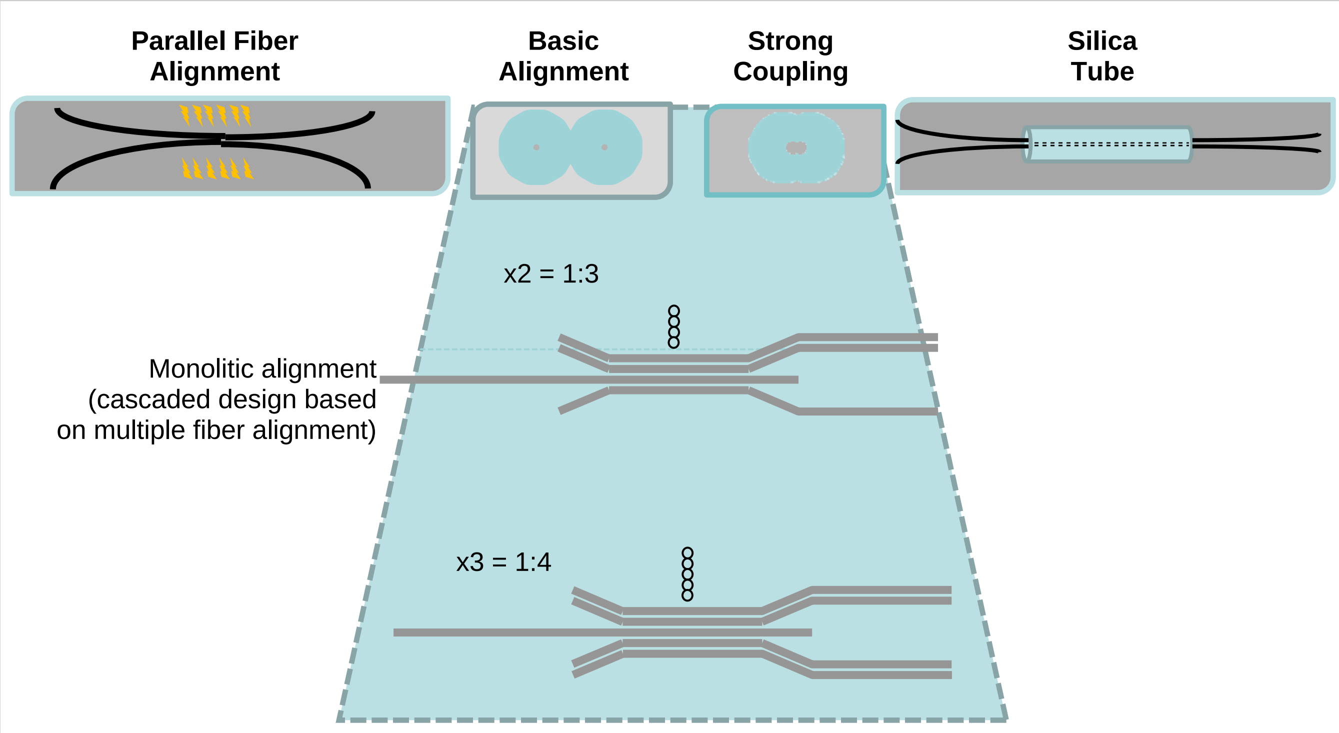

Figure 4: FBT-Type splitter fusion process, showing a non-symmetrical splitter. (Graphic courtesy of The Blue Shift.)

FBT Splitters are fused with a heat source similar to a one-to-one fusion splice. The fibers are aligned in a group to create a specific location and length. Heat is applied to the aligned fibers while the fibers are monitored for polarization-dependent loss (PDL), split ratio and insertion loss (IL). Once the desired parameters have been met on all fibers, the fusion process stops. Fused fibers are placed in a V-shaped groove and fixed in a silica tube with a mix of epoxy and silica powder to attain the proper heat characteristics. The silica tube is assembled into a stainless steel tube and sealed with silicon. Return loss (RL), pulling test, PDL, split ratio and IL measurements are taken at this point.

Split Ratios

As mentioned briefly above, there are a multitude of split ratios available, including a varying numbers of inputs and outputs. With most networks migrating toward optical connectivity (if not already there), the uses for splitters continues to grow. How they are used in networks varies considerably based on the technology being deployed.

In a service delivery application, PON architectures utilize splitters to split a single fiber into multiple fibers to feed residences and businesses. The use of splitters in this application allows the service provider to conserve fibers in the backbone, essentially using one fiber to feed as many as 64 end users. A single fiber accommodates more than ample capacity for this functionality. A typical split ratio in a PON application is 1:32, or one incoming fiber split into 32 outputs. See image above.

Passive monitoring is another key application for splitters. By using a varying split ratio, users can insert a splitter into an optical signal path and tap into a small percentage of the signal to perform nonintrusive monitoring. This enables testing of the circuit without impacting service.

We'll cover each of these applications in more detail later.

Typical Form Factors

Splitters vary in form from a module that resides in a standard bulkhead-style patch panel, completely enclosed in a metal or plastic housing, to a bullet-style splitter that is small enough to fit into a splice tray. This latter configuration is typically deployed in an outside plant splice case for distributed splitting in a PON application.

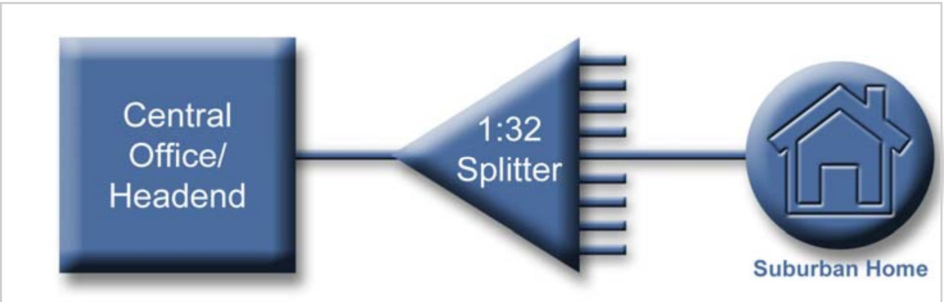

Figure 5: Typical PON architecture, with a 1x32 splitter represented in the center.

Larger split ratios (1:32, 1:64) are typically found in some kind of housing. Due to the large number of fibers associated with these splitters, users should look for a platform that can handle the splitter modules, patch modules (for splitter inputs and equipment feeds), patch cables and slack storage. Most often this requires some type of high density fiber bay. This is typical of a centralized split architecture, where the splitters are all placed in a distribution site or a remote high-density PON enclosure, and all outgoing fibers from that location are "homerun" to the end user.

Figure 6: Telect's ADF, the ultimate high-density distribution frame. This system can house up to 1,296 splitter outputs, or a combination of splitters and patch terminations.

The Significance of Circuit Density

In all of today's applications, network engineers face the challenge of making the most of limited space, whether in a central office, a remote hut, a PON cabinet or an IDLCD. In high-capacity applications, when it comes to a high-density frame with varying split ratios and the potential for massive amounts of patch cords, the platform decision is critical. As an example, Telect's Advanced Distribution Frame (ADF™) houses up to 1,296 splitter outputs in a single side of the frame, allowing for inputs and distribution/drops on the other half of the frame and is unmatched for cable management.

Passive Monitoring Application

Whether you're maintaining a long-haul network, a cable TV ATM circuit, or a local area/metro area network, the ability to perform non-obtrusive monitoring is invaluable. Depending on the application, there is a best-fit splitter solution.

In passive monitoring applications, the splitter is used to tap into a small percentage of the optical traffic. The majority of the signal proceeds to its destination, while a small percentage is directed to a local access port. This can be done manually for troubleshooting purposes, or the splitter can be connected to a network monitoring system that constantly monitors the signal for ongoing maintenance and performance assessment.

The typical split ratio for this type of application is 90/10, 80/20 or 60/20/20. These numbers represent the division of the incoming signal into the outputs. In the 80/20 example, the single input is split into two outputs. The first output receives 80 percent of the original input strength, while the second output is set at 20 percent. In comparison, the 60/20/20 ratio has three outputs instead of two. This allows a constant monitor by the network management system or redundant monitoring for critical circuits. The additional 20% can also be used for local monitoring turn-up and circuit troubleshooting.

Sample splitter configurations can be seen below:

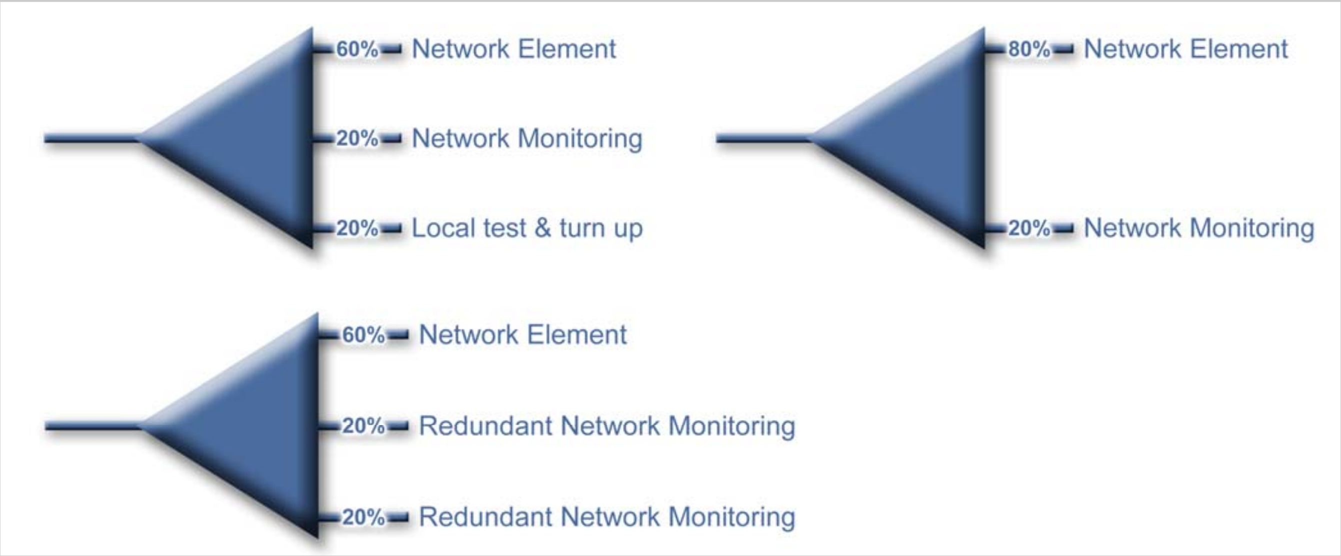

Figure 7: Sample splitter configurations utilized in passive monitoring application.

As mentioned previously, maximizing space is a significant challenge. The ability to reduce the number of rack units (RUs) occupied by the splitter system is a key value.

A typical scenario requires the termination of optical circuits prior to the splitter; these circuits must then be patched over to the splitter/monitor location, creating additional possible points of failure, along with additional loss in the circuit. Because it requires two separate panels or components for termination and splitting, this configuration also occupies more physical space.

High-density splitter solutions provide significant advantages in these scenarios. Telect's HDX offers some unique advantages. Each module accommodates 2 splitter circuits whether it's two 60/20/20 or 2 90/10's just about any combination of inputs and outputs with a maximum of 12 SC fiber ports (6 front and 6 back) or 16 LC fiber ports (8 front and 8 back) available per module.

Additionally the HDX was designed to fit in a standard equipment rack, which makes it extremely flexible when mounting it with a mixture of transport equipment. The 19" panel accommodates up to 24 modules, while the 23" panel accommodates 32. This unique high-density design allows for the connectors on each module to be spaced symmetrically or set up for duplex connections. The modularity of the system is both user-friendly and fiscally responsible; you can replace one module at a time for maintenance purposes and grow as required with one module at a time, as opposed to installing a more expensive "block" of splitters that may go unused.

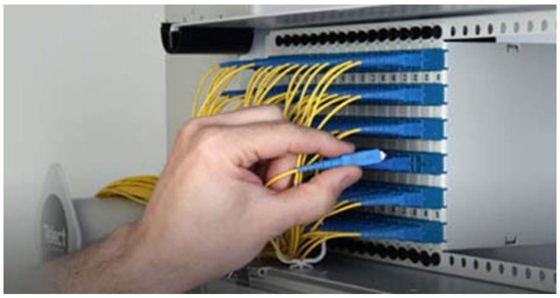

Figure 8: Telect's HDX splitter panel features a high-density design with easily accessible ports.

Figure 9: With Telect's HDX splitter panel, users can fit up to 128 splitters in a standard rack-mount panel.

Below and on the next page are two examples of monitoring applications utilizing splitter modules with a 60/20/20 ratio.

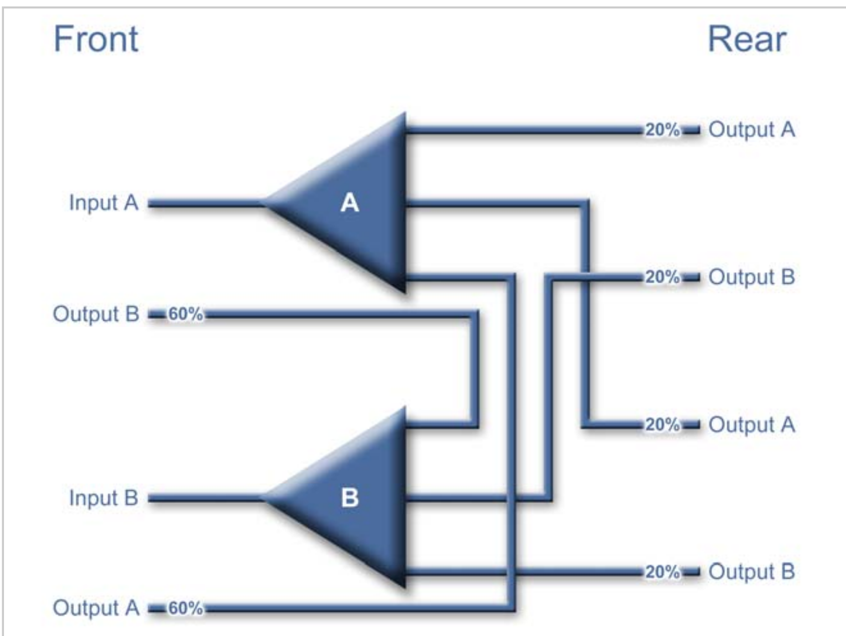

Figure 10: Example of a basic monitoring application using splitter modules.

Type: Dual splitter, single mode 1310/1550 nm
Split ratio: 60/20/20
Return loss: 60% < 55 dB; 20% < 55 dB

Connectors: SC/UPC
Insertion loss: 60% < 3.00 dB; 20% < 8.90 dB
Telect splitter part number: HD56-4862-6161-SOD

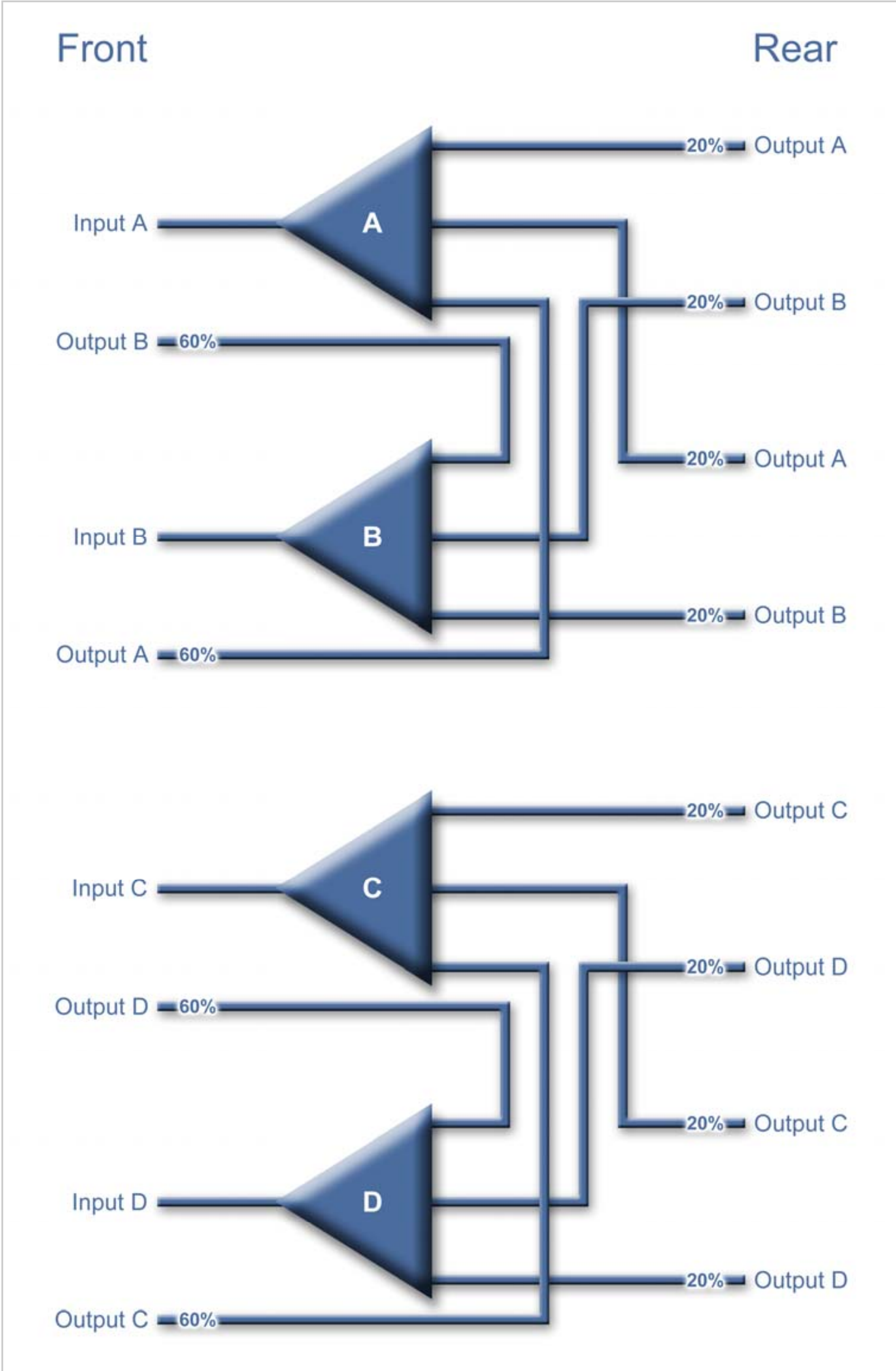

Figure 11: Example of a basic monitoring application using splitter modules.

Type: Quad splitter, single mode 1310/1550 nm
Split ratio: 60/20/20
Return loss: 60% < 55 dB; 20% < 55 dB

Connectors: LC/UPC
Insertion loss: 60% < 3.00 dB; 20% < 8.90 dB
Telect splitter part number: HD56-4Q62-5151-SOD

FTTx/PON Application

Passive splitters are the focal point of FTTx PON networks. The ability to reduce physical fiber usage, or the basic quantity of fibers required, is what makes these networks financially viable. Utilizing a single fiber to feed as many as 64 end users significantly reduces the strain on the fiber backbone.

There are many ways to deploy a PON network, and none of them are technically “wrong.” This flexibility is another strong asset of many types of splitters. Using a simplified example of a smaller city with one head-end and passive splitter locations in the field, it is fairly simple to display the theory behind PON (see diagram at right).

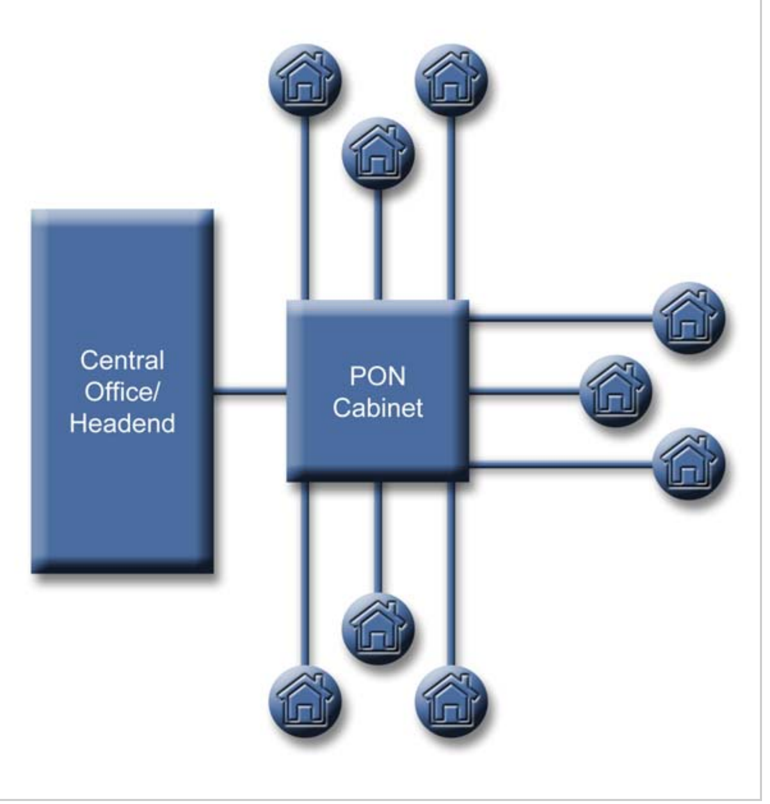

Figure 12: Sample FTTx/PON application. Splitters are located in the PON cabinet, a distribution point that delivers services to end users — in this example, residences.

Dealing with Growth

Obviously, as the city grows and the network architect must deal with multiple distribution points and backhaul, the picture becomes less clear. Few networks are simple and straightforward in architecture, as most service providers are driven by the challenge of meeting subscriber requirements, which are often unpredictable. Taking these factors into consideration (random subscriber rates, loss budgets, etc.), the requirement for flexibility in head-end locations, distribution points and split ratios becomes even more significant.

In optical network splitter applications, capital expense considerations are noteworthy; however, the long-term operations costs are even more significant to the success of a network/service provider. PON Offers many advantages in the field from an operations perspective. An obvious consideration is the power consumption involved with placing actively powered cabinets in the field. Although point-to-point technologies and smart power systems are changing the way we consider and calculate the cost of active enclosures, nevertheless they do in fact consume power at a price per kilowatt hour.

Obviously, this is a running debate in communications network architectures. However your decision-making progresses, it is key to keep capital and operational costs in mind when making network architecture determinations.

The Significance of Split Ratios

Strictly focusing on the operational cost of a PON network, there are many steps that can be taken to prevent outages, ease maintenance and increase the flexibility for smaller split ratios, which leads to more bandwidth per subscriber. Having enough feeder fibers entering a remote splitter cabinet will enable maintenance crews to redirect fibers for maintenance or outages without interrupting service to end users. Along with maintenance concerns, the additional feeder fibers enable the service provider to reduce split ratios from 1:64 down to 1:4, which can increase the bandwidth in a GPON network from 39 Mbps per end user to 625 Mbps, as an example.

Of course, split ratios are never quite this simple in a real network. Most often, network architects end up with multiple splitters to carve up a particular optical line terminal (OLT) output. As an example, let’s use a network with fiber terminated to an OLT in a head-end/active distribution point. The service area features a mix of residential and business end users. The service provider likely would need to split the OLT with a 1:2 splitter, and adjust following split ratios from there based on delivery to residential (1:32 ratio) or business (from 1:2 to 1:32) customers. These multiple split ratios create flexibility in the network as long as close attention is paid to the utilization of transport electronics (such as an OLT) and the loss budget. Loss budget in particular is greatly affected by the use of multiple splitters.

Figure 13: Telect ADF splitter module.

Returning to our simplified PON network will help to explain the roles of the different types of splitters and splitter housings. In a distributed split architecture, it's possible to locate splitters in splice cases in the field, although this is not recommended unless you're utilizing connectorized splice cases and drop cables. The cost of rolling out a splice truck for every service turn-up would drastically affect operations costs.

A more common solution is to run dedicated fiber from the head-end to a local splitter distribution cabinet or PON enclosure. These devices terminate feeder fibers from the head-end and create a patch field for distributing the drop ends of a splitter to subscribers as they sign up for service. The result is a more flexible, easier-to-scale architecture.

Obviously, not all of these types of systems are equal, and users should focus on operational flexibility during the selection process. It's likely that the head-end or active distribution point will be a location that will need to accommodate multiple splitter types for varying network architecture demands. These will include feeds for remote splitter locations and drops located within close proximity to the head-end. Splitters can range from 1:2 to 1:64; due to the large quantities of fiber running in and through these locations, it's crucial to use a system designed for this volume of cable and components.

One such system is Telect's ADF™. Utilizing a modular structure, the ADF™ enables high-density fiber optic patching and splitting in a single frame. As a straight patch platform, the ADF™ accommodates up to 2,304 terminations; typical installations utilize one side of the frame for patching, and one side for splitting, essentially providing the capacity to serve large customer bases in a 26-inch frame footprint. Advanced cable management, laser safety protection, easy-to-install modules, and other user-focused features make the ADF™ an excellent choice for emerging applications.

Figure 14: Fully loaded Telect ADF.

Conclusion

As you can see, there are a wealth of technologies and architecture possibilities when deploying fiber optic splitters in the network. Making educated decisions regarding initial product selection and ongoing operational usage will play a major role in determining the long-term success and financial viability of a network build. Choosing fiber optic splitters to help increase the efficient use of optical infrastructure is key to developing a network architecture that will last well into the future.

A Note on Sources

Information found in this paper is based on research and interviews with staff of Telect, Inc. (www.telect.com) and The Blue Shift (www.tbsoptics.com). Document copyright 2010 Telect, Inc.