Couplers & Splitters

Fiber, connectors, and splices rank as the most important passive devices. However, closely following are tap ports, switches, wavelength-division multiplexers, bandwidth couplers and splitters. These devices divide, route, or combine multiple optical signals. Some of the most common applications for couplers and splitters include:

- Local monitoring of a light source output (usually for control purposes).
- Distributing a common signal to several locations simultaneously. An 8-port coupler allows a single transmitter to drive eight receivers.
- Making a linear, tapped fiber optic bus. Here, each splitter would be a 95%-5% device that allows a small portion of the energy to be tapped while the bulk of the energy continues down the main trunk.

For more information on switches and wavelength-division multiplexers see Fiber Optic Components.

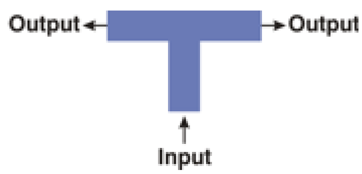
Couplers

Fiber optic couplers either split optical signals into multiple paths or combine multiple signals on one path. Optical signals are more complex than electrical signals, making optical couplers trickier to design than their electrical counterparts. Like electrical currents, a flow of signal carriers, in this case photons, comprise the optical signal. However, an optical signal does not flow through the receiver to the ground. Rather, at the receiver, a detector absorbs the signal flow. Multiple receivers, connected in a series, would receive no signal past the first receiver which would absorb the entire signal. Thus, multiple parallel optical output ports must divide the signal between the ports, reducing its magnitude. The number of input and output ports, expressed as an N x M configuration, characterizes a coupler. The letter N represents the number of input fibers, and M represents the number of output fibers. Fused couplers can be made in any configuration, but they commonly use multiples of two (2 x 2, 4 x 4, 8 x 8, etc.).

Splitters

The simplest couplers are fiber optic splitters. These devices possess at least three ports but may have more than 32 for more complex devices. Figure 1 illustrates a simple 3-port device, also called a tee coupler. It can be thought of as a directional couplerdirectional coupler. One fiber is called the common fiber, while the other two fibers may be called input or output ports. The coupler manufacturer determines the ratio of the distribution of light between the two output legs. Popular splitting ratios include 50%-50%, 90%-10%, 95%-5% and 99%-1%; however, almost any custom value can be achieved. (These values are sometimes specified in dB values.) For example, using a 90%-10% splitter with a 50 µW light source, the outputs would equal 45 µW and 5 µW. However, excess loss hinders that performance. All couplers and splitters share this parameter. Excess loss assures that the total output is never as high as the input. Loss figures range from 0.05 dB to 2 dB for different coupler types. An interesting, and unexpected, property of splitters is that they are symmetrical. For instance, if the same coupler injected 50 µW into the 10% output leg, only 5 µW would reach the common port. Click here to view the table of typical insertion losses for modern single-mode couplers. Adobe Acrobat Reader Required

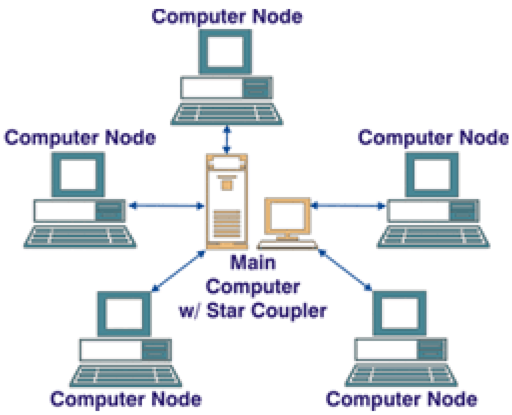
Figure 1 - Typical Tee Coupler



Coupler and Splitter Applications

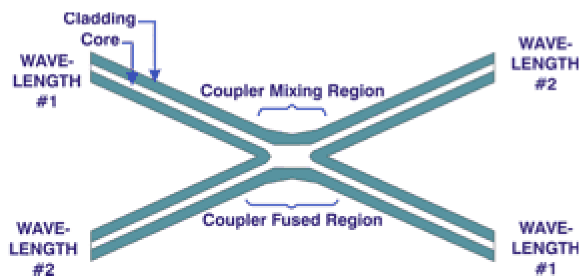
In applications that require links other than point-to-point links, optical couplers find the widest use. This includes bidirectional links and local area network (LAN). In LAN applications, either a star network topology or a bus topology incorporate couplers. Figure 2 illustrates a star topology, notice that stations branch off from a central hub, much like the spokes on a wheel. The allows easy expansion of the number of workstations; changing from a 4 x 4 to an 8 x 8 doubles the system capacity. The star couplerdivides all outputs allowing every station to hear every other station. Star couplers have many ports (usually a power of two), and couplers with 32 or 64 ports are not uncommon. One use of a star coupler creates a large party-line circuit. Many transceivers connect to the star coupler and can communicate with all other transceivers, assuming the network adopts a protocol which prevent two or more transceivers from communicating simultaneously. Large insertion loss, (20 dB typically for a 64-port device) creates the biggest disadvantage of the star coupler, as is the need for a complex collision-prevention protocol.

Figure 2 - Star Topology



Bus topology utilizes a tee coupler to connect a series of stations that listen to a single backbone of cable. In a typical bus network, a coupler at each node splits off part of the power from the bus and carries it to a transceiver in the attached equipment. In a system with N terminals, a signal must pass through N-1 couplers before arriving at the receiver. Loss increases linearly as N increases. A bus topology may operate in a single direction or a bidirectional or duplex transmission configuration. In a one way, unidirectional setup, a transmitter at one end of the bus communicates with a receiver at the other end. Each terminal also contains a receiver. Duplex networks add a second fiber bus or use an additional directional coupler at each end and at each terminal. In this way, signals flow in both directions. By far the most popular type of coupler in use today is a fused couplerfused fiber coupler. In this type of coupler, two or more fibers are twisted together and melted in a flame. Figure 3 shows the basic construction.

Figure 3 - Fused Fiber Coupler



This construction technique can be used to make 50%-50% couplers, 99%-1% couplers and even WDMs. The length of the coupling region (the fused region) as well as the amount of twisting and pulling done on the fiber while it is melted, determines the result. This coupler has grown in popularity because of the low cost of the basic materials needed for its construction: a few meters of fiber, a bit of potting compound, and a metal tube. The magic is knowing how to melt, twist, and pull the fiber. The most interesting type of fused fiber coupler is the WDM. It is only possible with single-mode fiber. An interferometric action forms the WDM within the fused mixing region. Like an interferometer, this causes a sinusoidal response as the length increases. WDMs operate at two specific wavelengths. Adjusting the minimum of the sinusoid to correspond to the first wavelength of interest and the maximum of the sinusoid to correspond to the second wavelength of interest forms a WDM. For More Information See "WDMs."

Source: http://www.fiber-optics.info/articles/couplers_splitters