SelfAlign™AllOptical Switching

Better Technology…Better Performance…Lower Cost

Introduction

Since the bubble burst in the early 2000's technology companies have been pressured to do more with less in terms of resources and people. As a result, automation has become a key factor in test and monitoring environments where resource optimization is most vital. To address this need, various high-density, Layer 1 switching technologies with matrices above 128x128 have emerged on the market. Unfortunately, none of these switching technologies have offered a comprehensive solution that could be deployed in any network, regardless of the underlying technology, until now. Agiltron's SelfAlign™, switch is the first switch to combine the benefits of automated patch panels with all-optical switches to address the ever-increasing bandwidth needs of today's networks without regard for protocol, bandwidth, or fiber type.

Optical Switching Overview

The term optical switching has different meanings for different companies and market segments. True optical switching means that the data being transmitted over fiber never gets converted to electrons. In other words, switching from one port to another within a single network element is performed completely in the optical domain. As such, the optical switch is completely agnostic to the data rate or protocol being transmitted. This level of transparency makes optical switching ideal for single or multi-protocol environments and any amount of bandwidth.

Optical Switching Technology Comparison

There are various optical switching technologies deployed in the market today. The most common switches are micro-electro-mechanical (MEMs) driven in free space such as 3-D MEMs and Piezoelectric. Both 3-D MEMs and Piezoelectric high-density switches suffer from the same shortcomings. Neither technology is latching, which means that constant electronic control is necessary to maintain a stable light path. Furthermore, both technologies require single-mode fiber for high-density switches.

In addition to the technologies mentioned above, other new developments use robotic arms to physically move a fiber from one port to another; however, they are not suited for environments where frequent switching is required due to extensive connection times.

The information below covers each of these technologies as well as Agiltron's latest innovation, SelfAlign™, which is the only switch that addresses the entire market without regard for data rate, protocol, or fiber type, while providing fast, reliable connections, with fail safe latching and power-saving sleep mode.

3D MEMs

3D MEMs-based systems were the first large scale, all-optical switches to enter the market. The 3D refers to the gimbal-based mirror arrays and the input and output collimators. In a 3D MEMs optical switch, a collimator is used to align input fibers to a gimbal-based input micro-mirror array and output fibers to a gimbal-based output micro-mirror array. A micro-voltage is then applied to the hinges of the input and output mirrors forcing them to align. Once the alignment has occurred, light is then refracted in free-space from the input mirror to the output mirror.

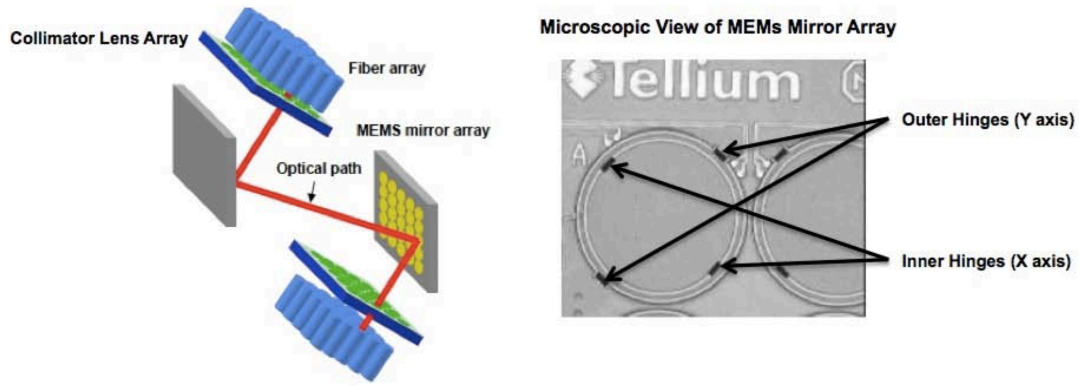

Figure 1: Example of 3D MEMs Switch

There are two techniques for achieving the lowest optical loss when switching the signal between the input and output mirrors. The first technique uses optical input and output power comparisons to more accurately align the mirrors. By rapidly measuring the difference in the optical power as an optical signal enters and exits the system, micro adjustments in the tilt of the input and output mirrors of a particular connection can be made to lessen the loss caused by the angle of diffraction. Some vendors refer to this process as dithering. In high-speed networks that are sensitive to optical power fluctuations, the bit error rate of the signal can increase due to the dithering process.

The second technique rapidly takes a picture of where the optical signal "hits" the input and output mirror. The theory is that the dithering process can be accomplished quicker with more precise connections because the system can "see" exactly where the light is striking the mirror; therefore, it can more quickly determine what voltage to apply to the mirrors to decrease the optical loss. Interestingly enough, while this may be true, the first technique is more widely accepted due to an unexpected benefit: optical power monitoring. Optical power monitoring is a useful tool for isolating faults within a network.

Regardless of the technique used,in general, 3D MEMs switches cannot support asymmetrical switching because an input collimator connects to an input MEMs mirror array and an output collimator connects to an output MEMs mirror array. With that said, there is one exception to this. One vendor has successfully deployed a bounce mirror in the place of the output mirror array, which uses a single collimator for input and output fibers enabling true asymmetrical switching.

Another drawback to using 3D MEMs switches is their inability to adequately support multimode fiber. Since 3D MEMs-based optical switches, switch light in free space, multimode fiber is difficult to support with the same port density as single-mode fiber due to the higher dispersion in free space of the multimode signal.

Piezoelectric

Piezoelectric-based systems also use a collimator and switch light between fibers in free space. Similar to 3D MEMs, piezoelectric switches have difficulty supporting multimode fiber. Unlike 3D MEMs, a piezoelectric system makes minute adjustments to the tip of the fiber within the input and output collimators to align the fibers precisely. Then, the optical signal is passed directly between the input and output fibers in free space, so no mirrors are needed.

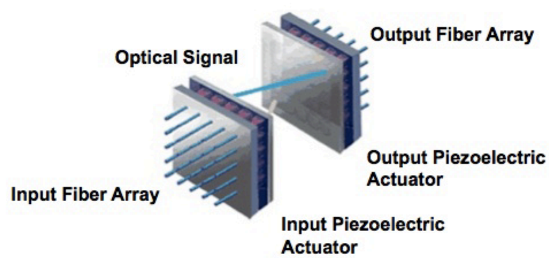

Figure 2: Example of Piezoelectric Optical Switch

As with the 3D MEMs switches, power monitoring measurements from both the inputs and outputs are used to more precisely align the switches. This allows the optical signal to propagate from the input fiber to the output fiber with minimal loss. In fact, the total loss including connectors is about 1dB. This is significantly better than 3D MEMs, which is typically around 2dB mainly due to the angle of diffraction required to make connections. Also, similarly to the 3D MEMs switches, Piezoelectric switches do not support asymmetrical switching without using the corresponding symmetrical port(s).

Robotic

Robotic solutions are typically referred to as automated patch panels. These switches use robotics to physically unplug a cable from one port, move the cable to the desired port, and plug it into that port. In essence, they replace the technician that normally performs this action.

The primary benefit for robotic switches is that they mimic the insertion loss of a traditional patch panel,which is nothing more than the connector loss(es). While this is a good trait, the downside for these switches is the actual switching time. A typical robotic switch takes 10-30 seconds to make a single connection. Since connections are made serially, this can result in extended waiting periods for multiple connections to be made. Furthermore, fiber management with robotic switches can become difficult as the number of ports increase because the fibers are being moved from one port to another, which could result in the fibers becoming tangled.

SelfAlign™

Agiltron’sSelfAlign™, switch is the first large scale switch to support latching, low insertion loss, power monitoring, both multimode and single-mode fiber, and parallel switching times of less than 1 second for all connections within a single switch. Furthermore, SelfAlign™, is cost competitive with even the least expensive layer 1 switches.

SelfAlign™, uses Agiltron’s patented V-groove technology to make ultra low-loss connections between fibers. Each fiber (simplex) or fiber pair (duplex) has a dedicated, servo-controlled rotor to connect to all the internal fibers. When a connection is made, the servo-controlled rotor of the input fiber aligns with the appropriate internal fiber(s) to connect to the desired output port. Then, the rotor associated with the output port aligns the internal fiber with the correct output port completing the connection. The following diagram shows the different switching methods supported by Agiltron’s SelfAlign™ switch.

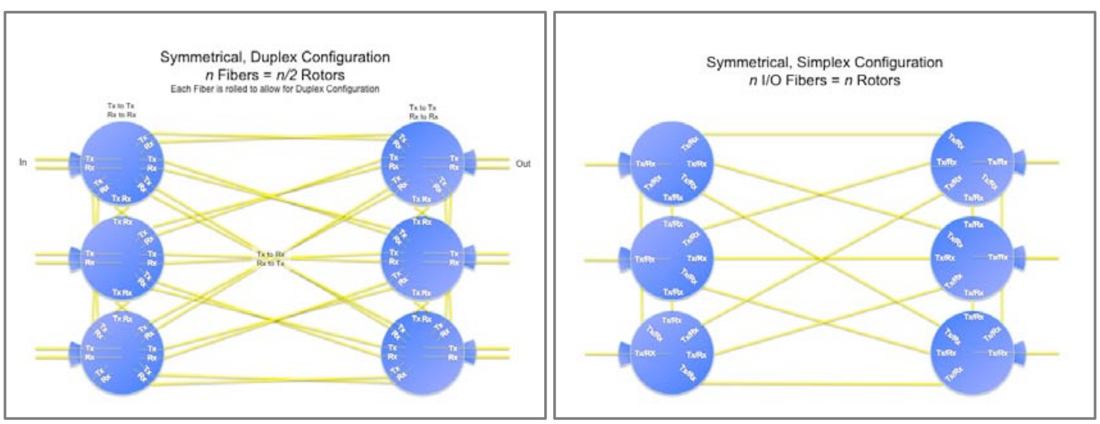

Figure 3: Symmetrical Configurations

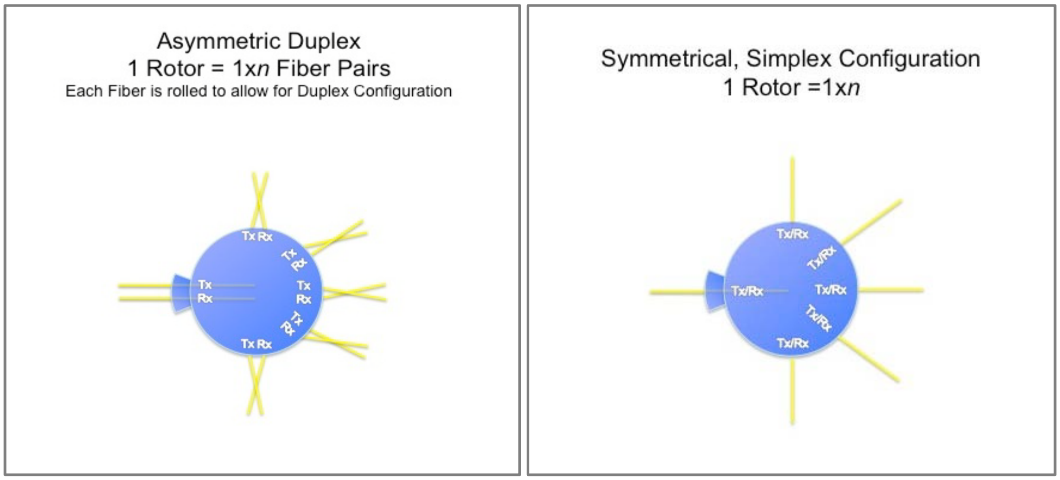

Figure 4: Asymmetrical Configurations

When you exam the advantages and disadvantages of each technology (see Table 1: Comparison of Optical Switching Technologies), it becomes clear that SelfAlign™ provides the best solution for the vast majority of applications requiring layer 1 switching.

Table 1: Comparison of Optical Switching Technologies

Feature	3-D MEMs	Piezoelectric	Mechanical	SelfAlign™
Switching Time	10-25ms	20-30ms	10-30sec	~1sec
Insertion Loss (max)	~3dB[1]	~1dB[1]	~.5dB[1]	~1dB[1]
Latching	No	No	Yes	Yes
Fiber Type	SMF only	SMF only[2]	SMF/MMF	SMF/MMF
Max. Matrix	320x320	192x192	1000x1000	288x288
Scalable	No[3]	No[3]	Yes	Yes
Asymmetric	No	No	Yes	Yes
Cost	$$$	$$$	$	$

[1] *Includes connector loss*
[2] *MM can be supported but only up to 16x16 in a separate, dedicated switch*
[3] *Limited by the collimator or the MEMs mirror chip size, neither of which can change*

Conclusion

In locations where many fibers are terminated, all-optical switches can be used as an effective tool for automation, remote reconfiguration, and disaster recovery applications. While each of the technologies discussed in this paper are viable technologies, only one, Agiltron's SelfAlign™, is capable of supporting any fiber type using asymmetrical or symmetrical, latching switches. In addition, the ultra-low loss of the SelfAlign™ switch and the ability to support multimode or single-mode fiber makes it the best choice for layer 1 switching. Call Agiltron today to learn more.