# Optical Switch Applications

Optical switches are an integral part in fiber optic transmission systems and contribute to the development of the “all-optical” network. The AV market can adapt these telecom components to enhance the capabilities of the overall AV transport system. There are two basic types of optical switches – the O-E-O (Optical to Electrical to Optical) and the O-O-O, or all-optical switch. Each has its place in fiber optic systems with their unique features and capabilities.

The fiber industry’s first optical switch was a simple mechanical 1x1 on-off switch using a moving fiber typically activated by a small DC control voltage. Since then a number of switch variations have evolved including the more popular and versatile 1x2 switch. This switch is used as a building block to develop more complex switching systems for optical routing and broadcasting.

**NxM Matrix Switch -** One of the most common switches for the AV market is the OEO switch. This switch uses standard telecom optical SFP (Small Form Pluggable) transceivers on the inputs to convert the incoming optical signal to its native electrical digital data stream. Similar optical transceivers are used on each of the corresponding outputs to convert the switched electrical data stream back to an optical signal for further transmission. The switch matrix is electrical and includes other functions such as reclocking and retiming to help clean up the signal and return it to its original condition, discounting any conversion-related anomalies. Most of these switches are multi-rate and can support a wide variety of data rates from approx 5 Mbps up to 4.25 Gbps, and some even higher. However, the reclocking functions are generally performed at very specific data rates, namely 270Mbps, 1.485Gbps, 2.97Gbps and 4.25Gbps. Other data rates are simply passed through the switch and regenerated without any retiming, reclocking and reshaping of the electrical signal.

These OEO switches have several features worth noting including the following:

- Point-to-Multipoint (broadcasting) capability
- Fully non-blocking
- Uses Optical I/O (SFP devices) with electrical switch engine
  - Electrical “3R” functions at selected data rates (Recovery, reclocking and regeneration)
- Does not degrade optical signal strength
- Available up to 4.25Gbps (Fiber Channel) data rate
- Available in configurations up to 1024 x 1024

The all-optical switch was introduced in the telecom market some years ago and has evolved to encompass the AV market. Products such as matrix and protection switches in addition to ROADM (Reconfigurable Optical Add Drop) and other function-specific optical switches are becoming staples in the AV market. The key feature of an all-optical switch is, as the name implies, that the signal is kept in the optical domain throughout the switching and routing process. This has clear advantages over the OEO switch in that the all-optical switch is data rate and protocol agnostic, in the AV market space. That is, any of the standard AV signals (video, audio & data) can be passed through the switch in any format (analog or digital). In addition, these switches can also send bi-directional data on the same port – something the OEO switch cannot do. In other words, bi-directional data on a single fiber (one port) can be easily routed in all-optical switches.

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Table 1 highlights some of the main characteristics of both the OEO and all-optical matrix switches.

| Table 1 – Matrix Switch Characteristics | |
|---|---|
| Electrical-to-Optical-to-Electrical (OEO) | All-Optical (OOO) |
| Converts signal to electrical for switching | Keeps signal in optical domain |
| Lossless switching – Retimes, reclocks & regenerates signals (at specific data rates) | Lossy switching – Optical insertion loss from input to ouput |
| Unidirectional switching | Bidirectional switching |
| Point-to-point & broadcast modes | Point-to-point & broadcast mode (using photonic multi-casting architecture) |
| Specific digital date rate formats | Data protocol & rate agnostic |
| Available up to 1024x1024 (and higher) | Max input/output typically 256x256 |

**1xn Optical Switches –** Many people consider fiber a simple replacement transport infrastructure to copper. This represents only one aspect of the overall capabilities of a fiber system. Once the signal is in an optical format a number of other switching and routing capabilities exist. As an example a simple 1x4 or 1x8 optical switch provides routing and broadcast capabilities very easily and much less expensive than an OEO equivalent. Just as with the all-optical matrix switch, these optical broadcast switches are signal type, data rate and format agnostic. Any signal that can be transported over fiber can be routed through one of these switches. An alternative to this is the 2x4 or 2x8 all-optical switch which provides additional capabilities. Figures 1 & 2 show an example of such switch designs.

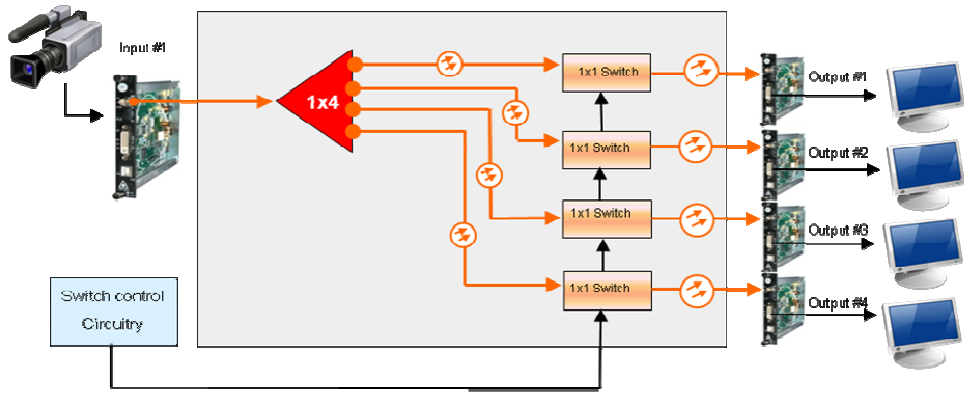


Figure 1

1x4 All-Optical Distribution Switch

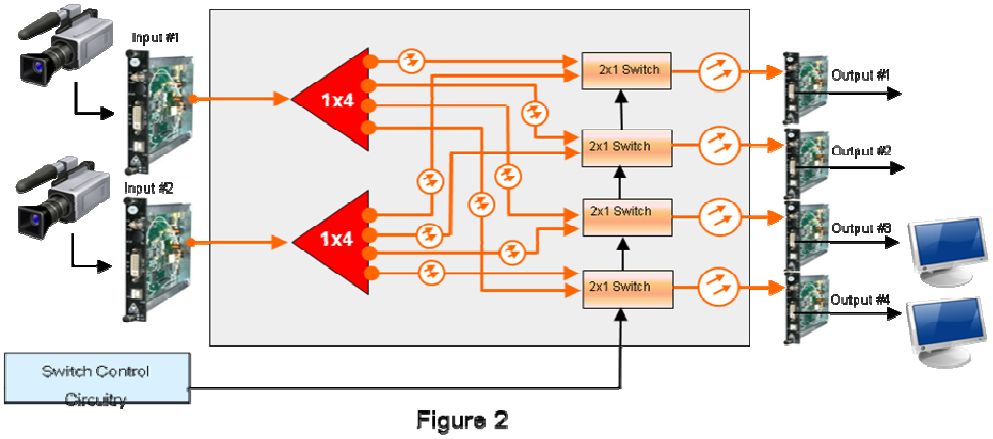


Figure 2

2x4 All-Optical Distribution Switch

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**Fiber Protection Switch** – This type of switch is ideal in mission critical applications where it's important to ensure fiber continuity between the transmitter & receiver units. At the transmit location the signal is split into two redundant signals and sent over two diverse optical paths. This switch design accepts these two optical signals from the same transmitter via the different fiber paths and will monitor the optical activity on each fiber. One path is set as the primary optical path and will automatically switch to the redundant fiber path if this primary path were to be interrupted or if the signal level falls below a pre-determined optical threshold.

Figure 3 illustrates how such a switch might be configured. At the transmit location the optical signal is split and sent over two diverse paths to the fiber protection switch, normally located near the receiver location. The optical signal from each fiber is monitored in the switch and is compared to preset thresholds. Once the signal in the primary fiber path falls below this threshold, the switch will automatically select the output from the redundant path and send that signal to the receiver unit. In addition, various alarms are generated to indicate a fiber has failed and the switch has activated.

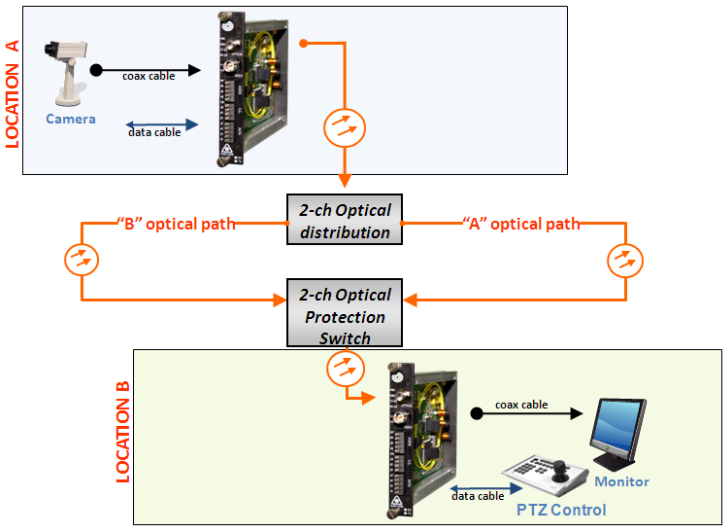


Figure 3
Redundant Network with Fiber Protection Switch

As with the other all-optical switches, this switch is data rate/protocol agnostic and will monitor and switch any optical signal presented to it. In addition, this switch design will also switch bi-directional information on the same fiber further increasing its flexibility and versatility for such applications as video conferencing, remote arraignment, video with PTZ control, HD video with audio talk-back, etc.

**Reconfigurable Optical Add-Drop Module** - One of the more unique optical routers/switches is the Reconfigurable Optical Add-Drop Module or ROADM. This device combines the features of wavelength multiplexing and demultiplexing with switching capabilities. In short, a ROADM can drop one or more wavelengths at a given location while the other wavelengths on the fiber continue down the fiber to the next location. One such application example is with digital signage systems. Since a number of wavelengths can be transmitted down one fiber, the signals associated with each of these wavelengths can be dropped at a particular digital sign location while the other wavelengths, and even the dropped wavelength, can be sent to all subsequent locations for similar wavelength/signal drops. In this way messages unique to individual signs can be associated with that sign while other signs can receive their specific message over the same fiber.

Figure 4 shows such an example of how this may be implemented. Associated with each digital sign (drop location) is a ROADM. Each of these ROADMs can be remotely addressed to drop a specific wavelength (and associated signals). This type of architecture provides exceptional flexibility to the fiber network. As with other all-optical devices, the signal stays in its optical format thus preserving signal quality without the need to down convert to its electrical signal and then back to an optical format for further transmission.

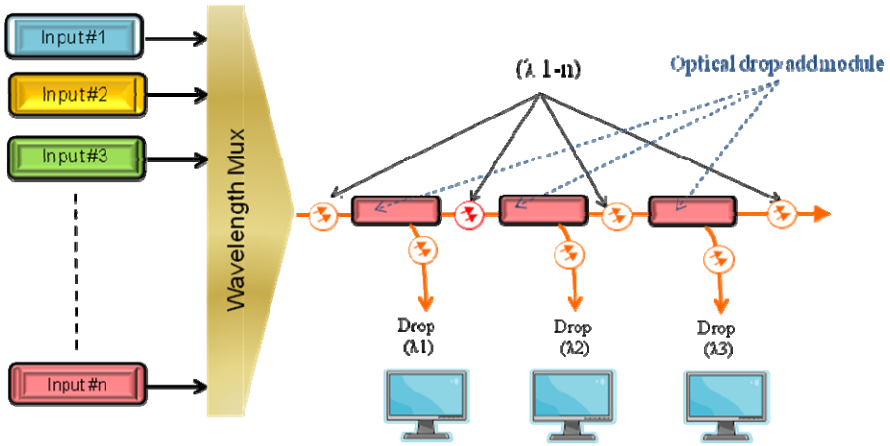


Figure 4
Reconfigurable Optical Add-Drop System

The OEO switch has its place in the AV market and is seeing increased use. As with any conversion process, there are always some artifacts or anomalies generated when converting from one format to another (optical to electrical and back) leading to increased errors and system degradation. All-optical switches to not have such anomalies and maintain the signals high quality throughout the switching process. They also have much higher potential since they are protocol, data rate and direction agnostic. As shown in this article, the all-optical switches help define the advanced role of fiber in the AV market and further illustrate the fact that fiber is significantly more than just a replacement for copper. Once the consultants better understand and accept the diverse capabilities of fiber, you will see increased and far-reaching AV applications using this technology and at a lower cost.

This article provides a high-level overview of some of the optical switch types and technologies available to system designers. Using these and other optical switch products, many other AV applications can be created to provide you with increased system versatility and help move to the holy grail of fiber systems – the *All-Optical Network*.

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