

# Understanding Fibre Optic Network Tapping

Cars today contain diagnostic ports, which provide visibility into complex mechanical and electrical systems. Medical science relies upon high-tech imagining probes to gain visibility into the inner human body. Similarly, as data-management technology advances, transparent, reliable visibility into sophisticated, heavy-traffic data networks becomes essential for diagnostics and maintenance.

For many businesses, networks – particularly Storage Area Networks – are the mesh that interconnects all servers, switches, and storage arrays, carrying critical business information and data in constant heavy traffic. With ever-increasing growth and change, these complex multi-vendor virtualized networks are prone to infrastructure clogs and failures. This makes real-time network monitoring vital for business success.

However, to be effective, network visibility must satisfy two basic requirements: it must provide accurate, high-granularity information suitable for diagnostics and maintenance, and it must not alter or interfere with the operation of the system.

## Optical TAPs

Optical TAPs - Traffic Analysis Points (TAPs) provide accurate real-time access to traffic flowing on a physical connection (link) between two or more points within a network. Optical TAPs provide the exact duplicate of the signal on the network link without any disruption to the network activity, for most accurate real-time and proactive monitoring and analysis. The TAP normally resides in the link between network devices (Figure 1).

Optical TAPs meet and exceed the two basic requirements of network visibility. The TAP continually passes data on its Network Ports, without either modifying or degrading the signal passing on the tapped network link. And the TAP provides output that is an exact copy of the real-time data, by splitting a small amount of light flowing on the tapped network link.

There are two types of Optical TAPs – Active Optical TAPs, which use electricity for operation, and Passive Optical TAPs which do not. Active Optical TAPs are primarily used for applications that require manipulation of the signal sent to the monitoring port. This is required only for very specialized applications, such as switching TAPs or Aggregation TAPs. Passive Optical TAPs are much more common in enterprise data centers and are used for applications that require simple monitoring, as in the case of storage-infrastructure monitoring

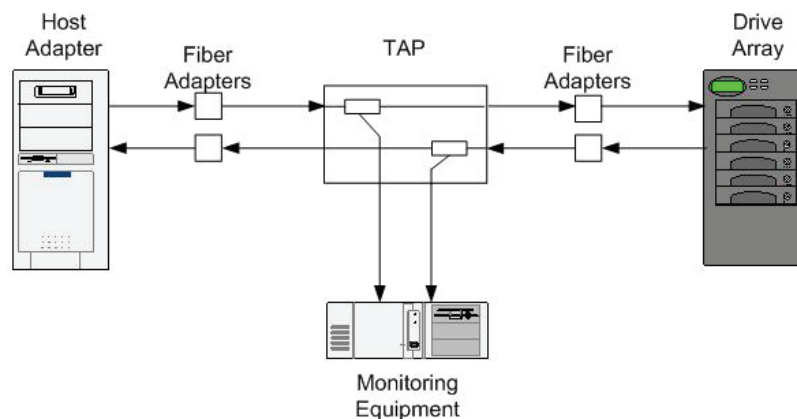


Figure 1: Typical Network with TAP

## Passive Optical TAPs

Passive Optical TAPs provide a simple and powerful way to monitor optical networks. Passive Optical TAPs require no power and have no electrical components (Figure 2), making it impossible for them to be a point of failure when deployed in a production network. Passive Optical TAPs are highly reliable and require no maintenance.

Light, the signal carrier for optical networks, has different properties from electricity, the signal carrier for copper networks. Light travels in only one direction. This property allows Passive Optical TAPs to monitor by “splitting” the input signal’s light energy. Splitting the light in the TAP provides a monitoring point without the possibility of corrupting the original signal because light split in the TAP port has no effect on the input signal.

Passive Optical TAPs provide access to data flowing across a network, without creating either a location to corrupt data or a prospective point of failure.

## Key Considerations for deploying Passive Optical TAPs

Two key points illustrate what happens to the signal when it passes through TAPs on an optical network link.

- TAPs divert a small portion of the light in the fiber from the network receiving device to the monitoring equipment, which results in a slight dB loss in the optical signal strength on the network side. It is important to ensure that sufficient optical power is available for proper network operation with the TAP inserted on the link and that sufficient optical power is available on the tapped port to represent the accurate copy of the link traffic and for proper operation of the monitoring equipment.
- Some degradation of the quality of the optical signal is inevitable in monitoring, which results in a small increase in jitter of the signal, along with a decrease in the “eye” margin. TAPs must minimize jitter and decrease in the “eye” margin. This is vital, particularly at high link speeds such as 10Gb/s.

## Analysis of the Tapped Link’s Power Margin

Before TAPs are integrated into a network, the link’s power budget between transceivers must be evaluated to ensure that sufficient margin is available for the TAP. If sufficient power margin is not available, tapping the link may result in performance degradation.

The simplest method for calculating the power margin is to subtract all of the line losses from the transmitter power, giving an excess above the required receiver power. This excess is the power margin.

It is important to note that each time the signal flows through a transceiver, the signal is regenerated to full strength. Thus, a link’s power budget analysis must take place between two transceivers, such as Initiator to FC Switch, target port to FC Switch, or, in the case of a local ISL, FC Switch to FC Switch.

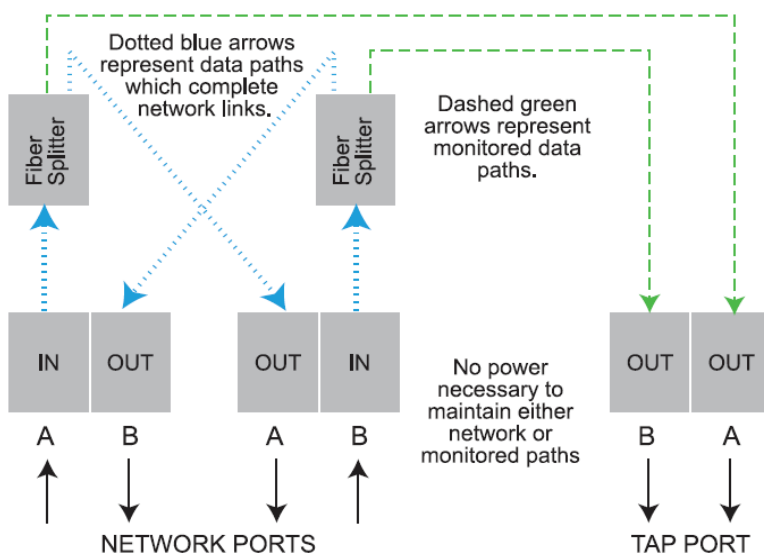


Figure 2: Passive Optical TAP

*Example***Finisar FTLF8524P2xNy 4.25 Gb/s Short-Wavelength SFP Transceiver for the network component:**

Transmitter Power (using 50 or 62.5 µm multi mode fiber)	-9.0 dBm minimum (-2.5 dB max)
Receiver Sensitivity @ 1.0625 Gb/s	-20 dBm
Receiver Sensitivity @ 2.125 Gb/s	-18 dBm
Receiver Sensitivity @ 4.25 Gb/s	-15 dBm
(Note: Receiver Sensitivity becomes more stringent with increased link speed)	
Power loss per connector	0.5 dB
Power loss per Kilometer of optical fiber	3.75 dB
A Typical Passive Optical TAP power loss	2.5 dB (Network) / 6.0 dB (TAP port)

**The following calculation is for a 4 Gb/s system with 2 connectors and 300 meters of fiber optic cable with a Passive Optical TAP inserted:**

$$\text{Power Margin} = 15 - 9 - (2 \times 0.5) - (0.3 \times 3.75) = 3.875 \text{ dB}$$

(This 3.875 dB power margin is well above the 2.5 dB drop that the TAP introduces. Therefore, the TAP can be deployed without any performance degradation)

This analysis is based on worst-case numbers for power loss on the link. Typical available power margins are generally better than those depicted. A detailed analysis of the power budget using a light meter provides much more accurate numbers for the link to be tapped. This analysis should be done while deploying any high speed (4G/s and above) optical infrastructure, even if installation of monitoring equipment is not under consideration.

**Analysis of Available Power for Monitoring Test Equipment**

It is also critical to ensure that the power loss on the tapped port is within the receiver sensitivity specification of the monitoring equipment. The monitoring equipment must correctly read link traffic from the tapped port. If a power loss causes the monitoring equipment to read information incorrectly, it may generate false alarms and errors.

Use the specified calculations to determine the worst-case power available for the monitoring test equipment, which is below that required for an industry-standard receiver.

With a TAP in the center of the network, the worst-case available power is:

$$-9.0 - (1 \times 0.5) - (0.15 \times 3.75) - 6.0 = -16.06 \text{ dBm}$$

The industry-standard receiver specification guarantees a sensitivity of -15 dBm at 4 Gb/s.

Received power does need to be above the actual sensitivity rating of the optical module in the test equipment in order to operate in satisfactorily. Finisar monitoring equipment is shipped with optical transceivers with at least 2 dBm higher receiver sensitivity than some competitors. This additional power margin enables Finisar monitoring equipment to read received information on tapped ports correctly.

Again, this analysis is based on worst-case numbers. Typical available power values are better than those depicted, resulting in better available power margin on the tapped port. A detailed analysis of the power budget using a light meter provides much more accurate numbers for the power available on the tapped port.

It is also best practice to replace aged transmitters with new modules, which gives an immediate boost to the power margin. When optical power is “low”, increased jitter is generated in the receiving module. Finisar recommends OM3 fiber, which is optimized for laser transmitters, where long lengths of fiber are used, especially at data rates of 4 Gb/s and higher.

**Signal Quality/Degradation**

The majority of optical TAPs today use fused biconic tapered coupler construction for Multimode 850nm data transmission. This is the most cost-effective method of construction available. In addition, the majority of optical module transmitters used for data rates of 4 Gb/s and higher are Vertical-Cavity Surface-Emitting Laser (VCSELs).

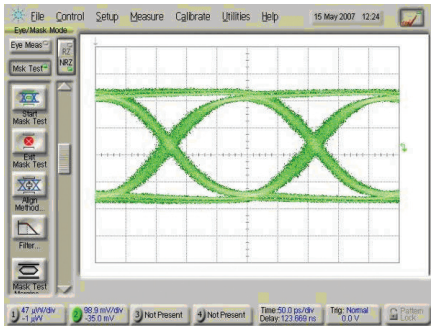


Figure 3A: 4 Gb/s input signal

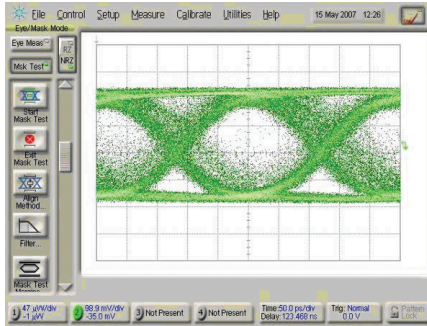


Figure 3B: 4 Gb/s TAP port signal (standard coupler)

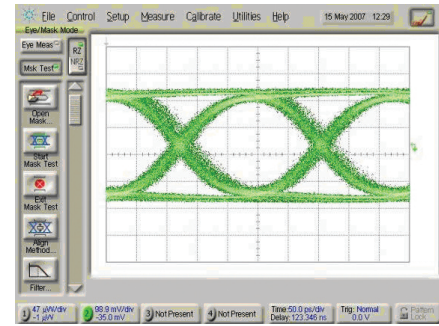


Figure 4: 4 Gb/s TAP port signal (Finisar coupler)

When VCSELs launch their light into the fiber, it can travel down the fiber in a number of different modes. However, the majority of available combinations of modes cause the asymmetric split couplers to behave in an aberrant way. By the very nature of the fused biconic tapered coupler, this manifests as extremely high jitter on the TAP port (Figure 3), which causes data to be unreadable by monitoring test equipment. It is very important to note that this jitter is seen on the TAP port and not on the Network port. These test results were collected in worst case conditions with specific SFPs, Cables and TAPs with worst couplers. It is interesting to note that better SFPs resulted in worse jitter on the TAP port. About 5% of the SFPs out of a large supply that we tested displayed this worst case jitter on the TAP port. These best SFPs transmitted the light into the fiber with only a very few “low order modes”. For a TAP to present a true copy of the network signal on the TAP port, we have to ensure that we get all of the phases of the light on the TAP port.

Finisar, the leader in providing high data rate asymmetric TAPs for the Multimode 850nm market, has developed proprietary (patents pending) techniques to eliminate this phenomenon while still providing low optical loss on the network side. Finisar technology advancements deliver much lower jitter and a much cleaner “eye” margin (Figure 4) on the tapped signal, for accurate reading by monitoring test equipment.

## Summary

With Passive Optical TAP technology advancements of highly sensitive monitoring equipment coupled with light budget analysis, it is possible to deploy TAPs for passive non-disruptive monitoring and analysis of storage infrastructure links. Transparent, reliable visibility into sophisticated, heavy-traffic data networks for diagnostics and maintenance becomes available. Real-time network monitoring provides accurate, high-granularity information suitable for diagnostics and maintenance, without altering or interfering with the operation of the system.

- TAPs are a simple, effective, and cost-efficient way to gain access to the data within switched networks.
- TAPs allow access to network traffic in real-time for troubleshooting, analysis, and monitoring without affecting network operation.
- Installing TAPs during deployment of a Storage Area Network allows future troubleshooting without bringing down the network or breaking links.
- Implementing a network Diagnostic Layer can make the difference between weeks of frustration or potential downtime, and proactive problem resolution before an event grows critical.

## Test & Measurement Regional Sales

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