

White Paper

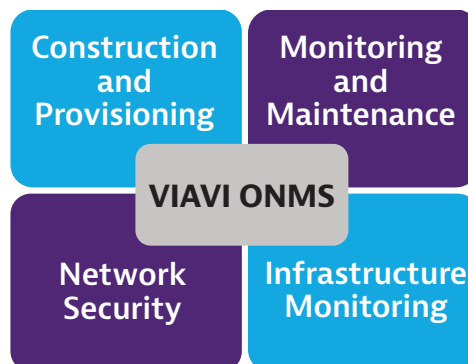
# Monitoring Raman Amplified Optical Links While In Service

## Introduction

Erbium-Doped Fiber Amplifier (EDFA) and Raman amplifiers are the two main solutions for optical signal amplification in long distance, optical communication systems.

While EDFAs are still the most deployed amplifiers, Raman-based solutions are gaining momentum in the metro/core transmission market. Some of the main benefits include the wider wavelength range than EDFA (limited to 1525-1565 nm and 1570 - 1610 nm) and the use of the transmission fiber as the amplification medium.

This paper explains how Raman amplified fiber can be monitored with the VIAVI Solutions Optical Network Monitoring System (ONMSi).



## Fiber Monitoring Principle

ONMSi automates the process of detecting and locating faults in fiber optic telecommunication networks by collecting and analyzing data from Optical Test units (OTU). ONMSi enables comprehensive fault diagnosis prior to dispatching repair crews in the field.

The OTUs are permanently deployed at strategic points of the network to test the optical cable plant with an Optical Time Domain Reflectometer (OTDR). Fibers under test are connected through an optical switch to allow monitoring of multiple fibers with a single OTDR.

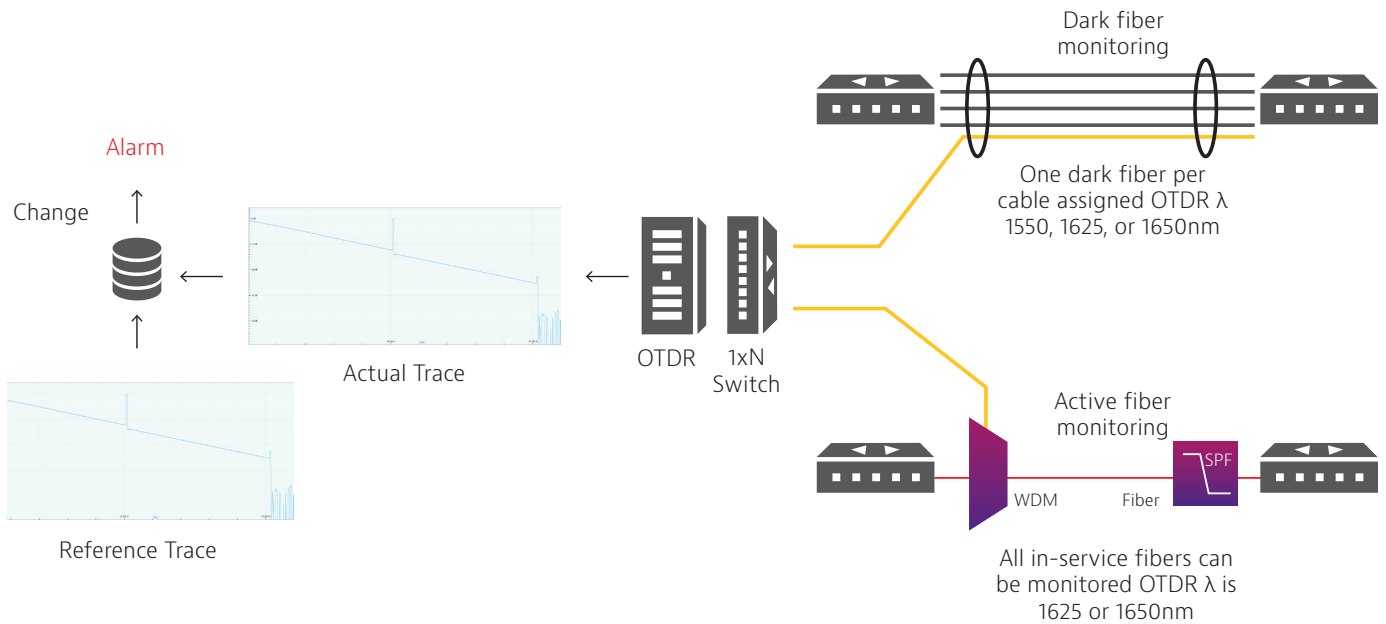


Figure 1: Fiber monitoring principle

## Monitoring In-Service Optical Fibers

Fibers under test are usually dedicated to monitoring. They do not carry data. The fibers within a cable are typically all affected by the same degradation event. Hence, monitoring a few spare fibers (so called witness fibers) in a cable is enough to gain good visibility to the health of the entire cable. This is a cost-effective strategy.

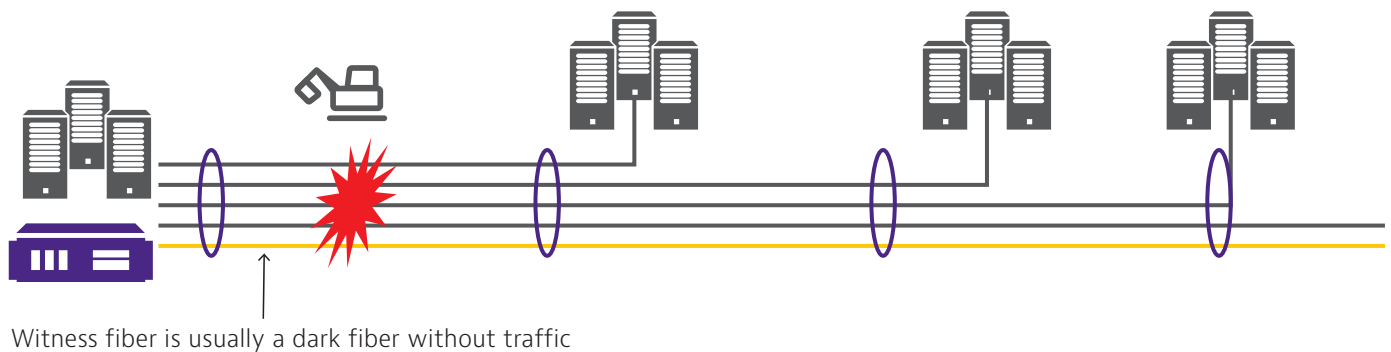


Figure 2: Witness fiber monitoring strategy over a dark or spare fiber in a cable

However, it can be required to monitor fibers carrying data, so called active or lit fibers, when:

- All the fibers in the cable are in-service. No spare, dark fibers available.
- A few fibers are leased from a dark fiber provider (3rd party company) who owns the cable.
- Fibers carry confidential data that must be protected against thieves (tapping).

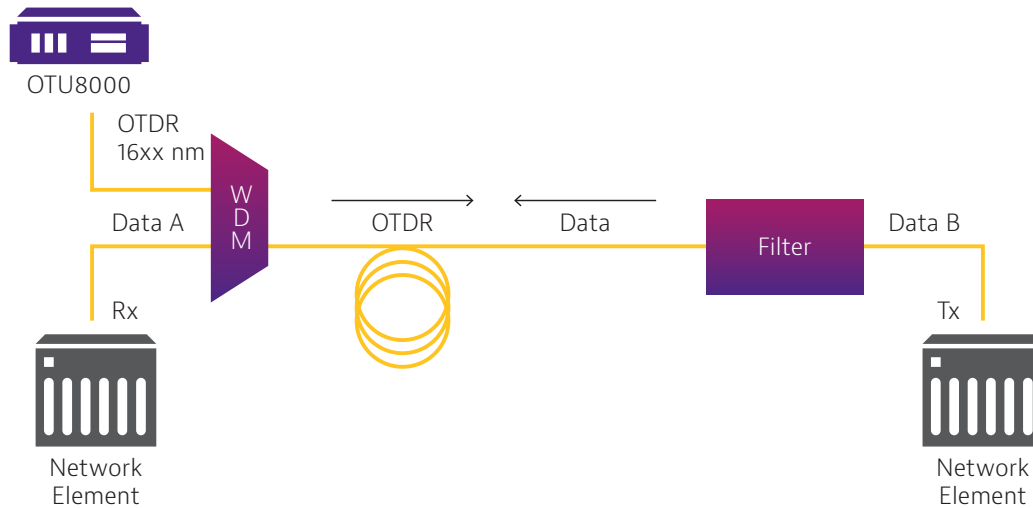


Figure 3: Principle of in-service fiber monitoring

## Non-Linear Effects and Optical Amplifiers

Non-linear effects depend directly on the light intensity travelling down the small effective area of an optical fiber. The non-linear effect affecting in service fiber monitoring is the Raman scattering effect. Raman scattering effect transfers the energy and consequently the wavelength between two signals travelling in the same fiber. This effect attenuates the data signal and degrades the OTDR signal.

It is possible to eliminate the attenuation penalty on the data signal by applying one or more of the following rules:

- Use an OTDR in contra-propagation.
- Use an OTDR with limited output optical power.
- Use a short OTDR pulse.

The degradation of the OTDR signal occurs when the data signal is amplified. However, this degradation is limited if the OTDR, detecting the presence of Raman Scattering, automatically reduces its gain.

## Test Results of Monitoring Optical Links With In-Line Raman Amplifiers

The below results show that a fiber of 100km can be monitored in co and contra propagation when the data is amplified by Raman effect in contra propagation.

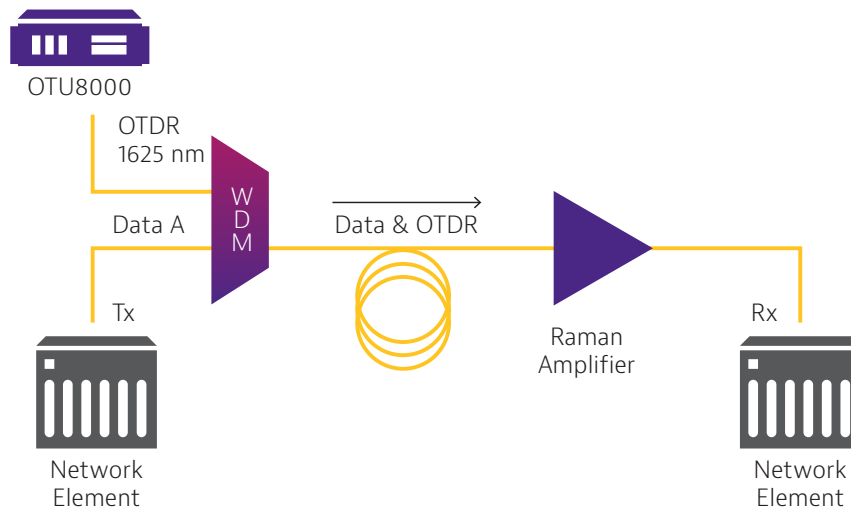


Figure 4: OTDR and data in co-propagation with Raman amplifier

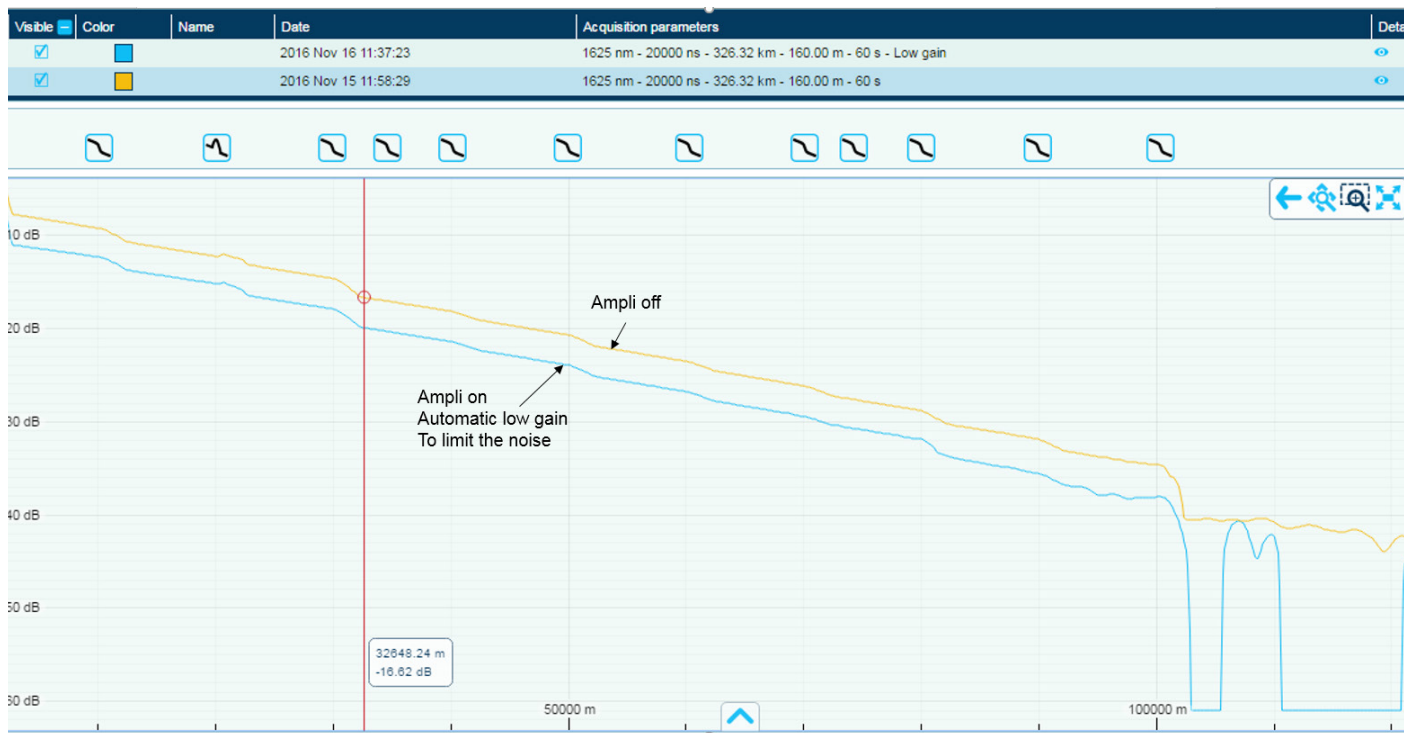


Figure 5: OTDR trace for co propagation with Raman amplifier

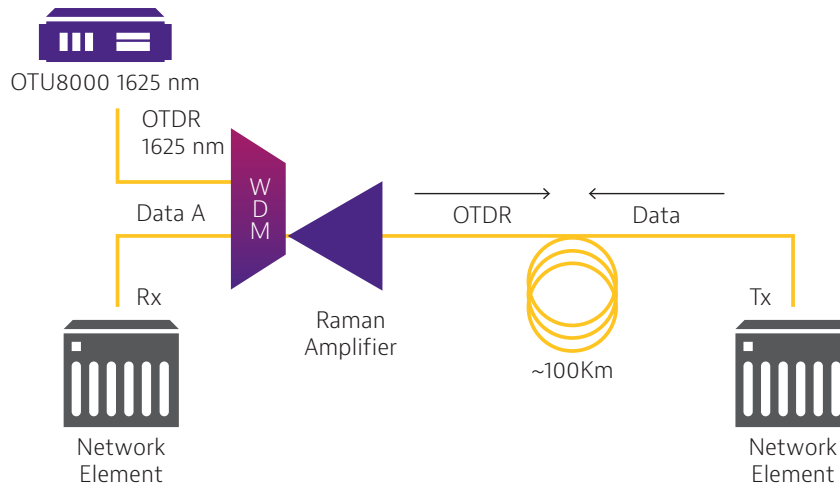


Figure 6: OTDR and data in contra-propagation with Raman amplifier



Figure 7: OTDR trace of contra-propagation with Raman amplifier

The Figures above shows that in both co-propagation and contra-propagation there is a penalty of about 4dB on the OTDR signal when the Raman amplifier is on, but it does not prevent successful fiber monitoring. The SNR at 100km is good enough to avoid a false alarm.

For these two propagation cases (co and contra), the Bit Error Rate (BER) was not affected by the OTDR.

## Conclusion

Monitoring optical links with in-line Raman amplifiers is possible and does not impact the ability for the OTDR to locate and identify faults or degradation. Prior to deploying such a monitoring solution, a few parameters need to be considered such as the impact on the dynamic range of the OTDR, and the loss induced by the passive components. These well understood parameters can be managed by an established calculation and planning process no matter what kind of amplifiers are present. This solution has been implemented in many network topologies successfully without impacting the transmission reliability.



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