INTERCEPTOR FOCUS Technology

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Published: January 2019

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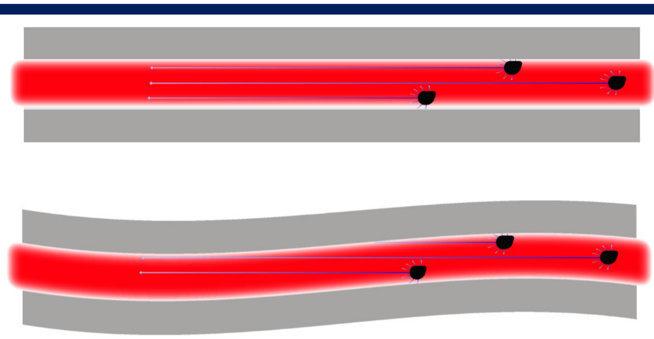
1. Introduction

Fiber optic cables have been used as sensors for more than three decades, and have long been recognized for their advantages in terms of electrical passivity and intrinsic safety when compared to other types of sensor systems. Also, thanks to the very low attenuation of optical fibers, measurements can be made over very long distances from the location of the active electronic equipment used for interrogation and interfacing to conventional monitoring and telemetry systems. Distributed acoustic fiber optic sensors in particular exploit this feature to permit operation over tens of kilometers, while also offering another unique advantage of spatially resolved measurements along the whole length of a fiber. Such sensors first became widely accepted for temperature measurement during the late 1980s and proved the feasibility of fiber optic sensing in challenging application environments. Today, the potential of distributed vibration sensing is becoming recognized as an even more valuable source of information for users in many sectors, ranging from Cyber Security to Critical Infrastructure such as Energy and Transportation. Systems can detect and measure strain, temperature, pressure, vibration, and even acoustics.

Rayleigh scattering: The parametric scattering of light caused by particles smaller than the wavelength of radiation.

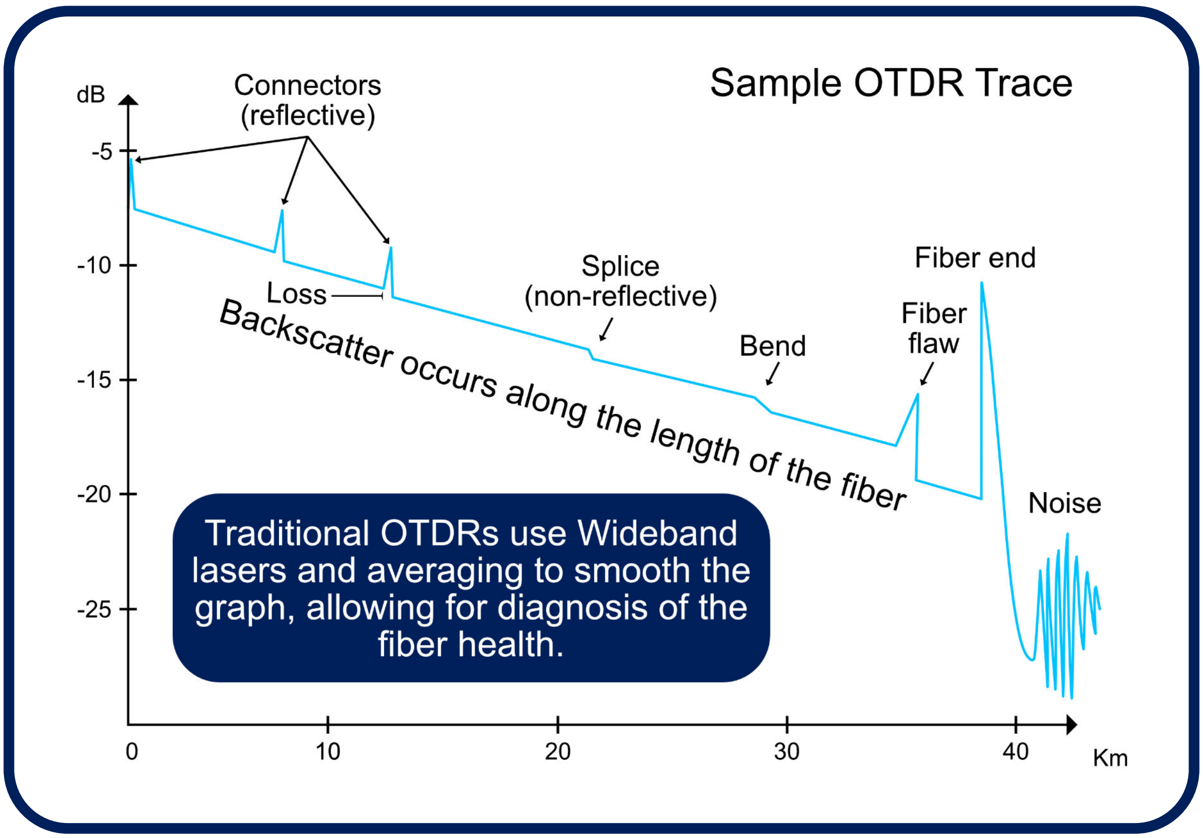


Any changes in the fiber environment modifies the backscatter signature

2. Optical Time Domain Reflectometry

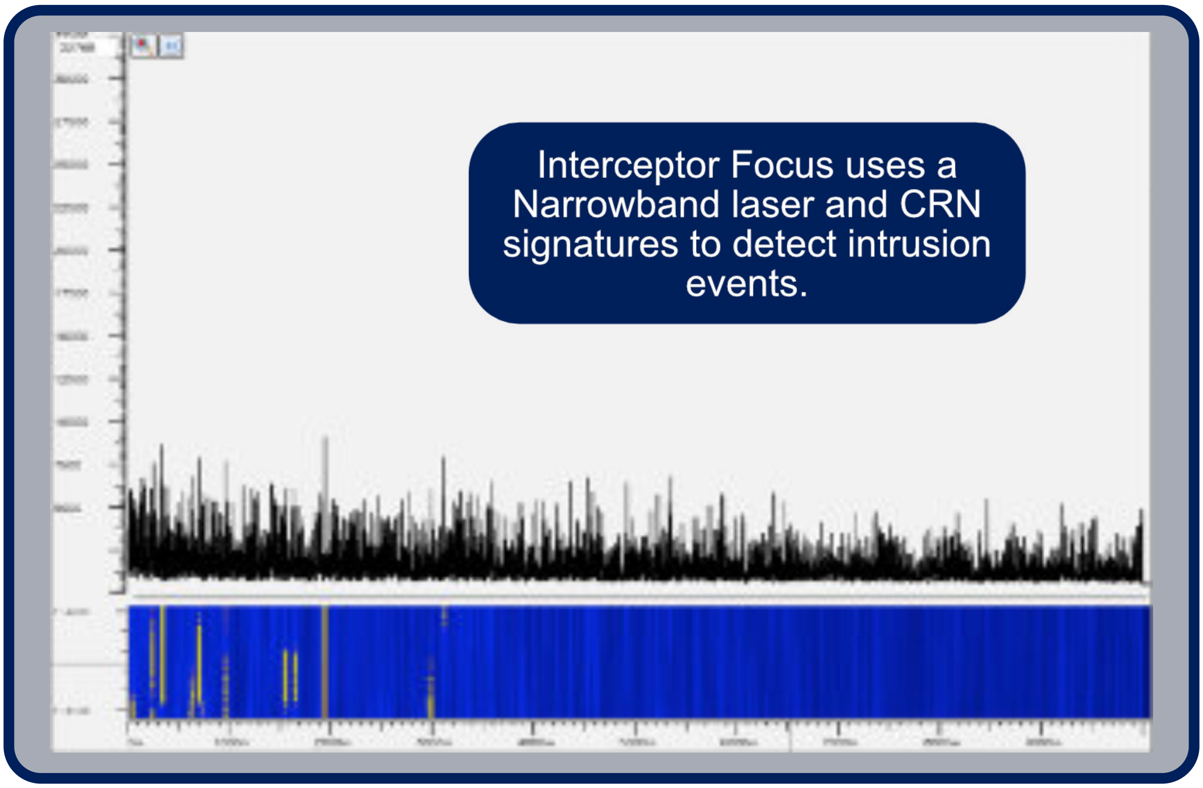
Distributed optical fiber sensors typically use a technique called Optical Time Domain Reflectometry (OTDR) to achieve the spatial resolving function mentioned above. This technique is very similar to radar, in that it uses variations in backscatter from intense, short pulses of radiation launched into an optical fiber.

Conventional OTDR instruments are commonly used to measure attenuation profiles of optical fibers in the telecommunication industry. Since optical attenuation does not change rapidly in a fiber, these instruments do not need to respond quickly. They are also optimized to read smoothly from point to point along the fiber under test. This latter aspect of performance requires low noise in the detection system. Instrumental noise arises from two main causes. The first is due to thermal noise in the electronics. The effects of this can be minimized by averaging the results from many interrogation pulses, as well as by increasing the sensitivity of the optical receiver to weak optical signals. The second source of noise that needs to be minimized in conventional OTDR systems is caused by the randomness of the molecular structure of glass fiber, in combination with the narrow relative frequency spread of laser sources. This type of noise is known as Coherent Rayleigh Noise (CRN) and repeats exactly between successive interrogation pulses when the laser and the fiber are stable during the interrogation period. This determinism in the noise precludes any improvement from averaging over repeated pulses and is instead overcome by employing lasers with Wideband optical emission.



3. Distributed Optical Fiber Vibration Sensing

Vibration sensing can be achieved in OTDR systems by shortening the time needed to accurately record the optical backscatter signature of a fiber and by exploiting, rather than minimizing, the CRN signature. Ideally, the backscatter signature should be accurately recorded after a single laser pulse. A narrowband optical source is used to make CRN a large part of the response. CRN is produced by interference between the backscattered contributions from different parts of the traveling pulse of radiation. The received signal is stable if the fiber is undisturbed. INTERCEPTOR FOCUS measures changes in the CRN pattern. Detection noise is minimized by using optical amplification, narrowband optical filtering, and low-pass electronic filtering.

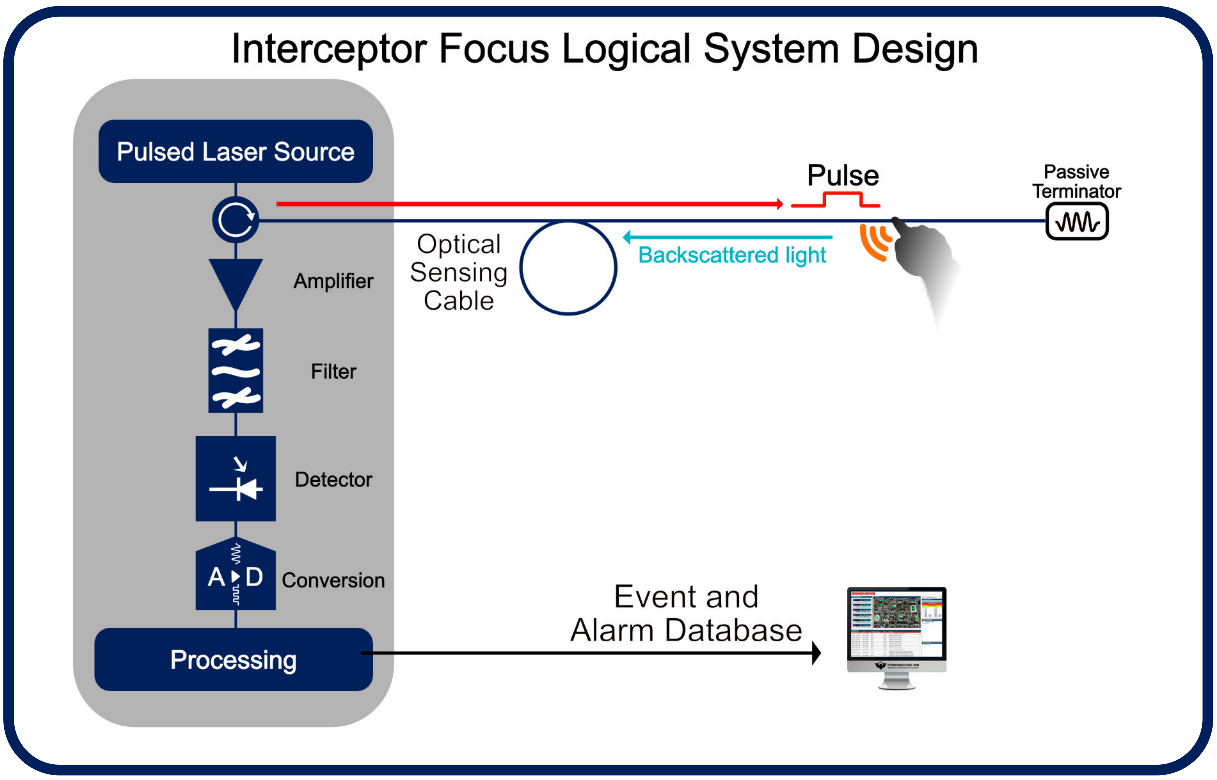


Any changes in the fiber occurring before the next pulse will then lead to associated changes in the backscatter signature from the fiber. The locations of these changes can then be identified in the time domain and converted to known locations. The magnitudes of the changes depend on the strength and type of disturbance acting on the fiber. In order to provide for discrimination of small changes in backscatter signature over distances shorter than the minimum practical pulse length, the data acquisition system in the

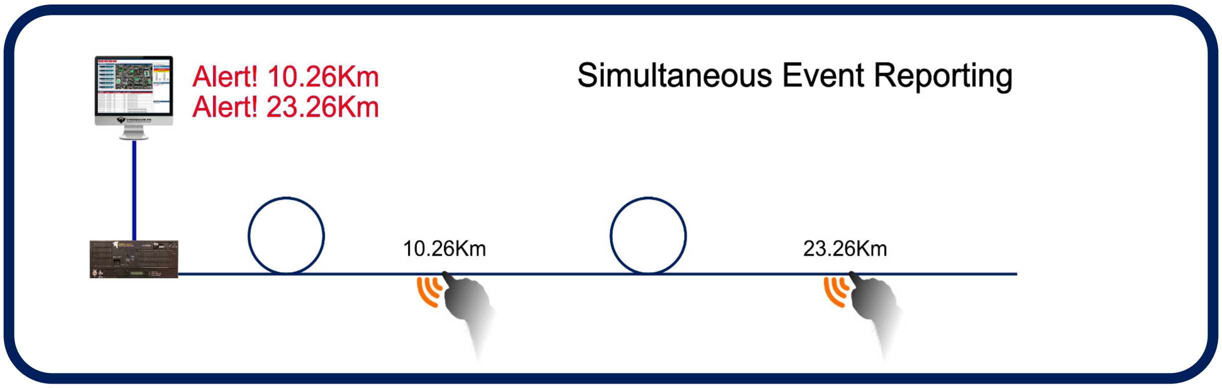
INTERCEPTOR FOCUS system provides 16-bit resolution and samples at a rate of 150 MS/s.

4. Spatial Resolution and Vibration Sensitivity

The instantaneous intensity of the CRN is generated by self-interference between all of the reflected signal components from every part of the propagating optical pulse, so the physical length of the pulse limits the spatial resolution of the system. The shorter the pulse is made, the finer the spatial detail. However, shortening the pulse also reduces the mean intensity of the backscatter, making it harder to record the backscatter signature without suffering from random receiver noise. This introduces a tradeoff between spatial resolution and vibration sensitivity. In practice, laser pulses only one or two meters in length can be used to detect mechanical vibrations having amplitudes much smaller than an optical wavelength, thus providing a very good combination of sensitivity and spatial resolution. Helios GS systems offer spatial resolution down to one meter by using optical pulses of only 10 ns duration.



One other advantage of adopting the OTDR method for distributed detection of vibration is that once the backscattered light has left the sensing region, no other vibrations can affect its value as it travels back toward the interrogator. This means that from an optical viewpoint, there can be no crosstalk between vibrations present at different points along the sensing fiber. Crucially, this means that even extremely large vibrations at a point close to the interrogator will not disturb signals arising from tiny vibrations far from the interrogator. This allows multiple events to be alarmed and recorded simultaneously.



5. Acoustic Bandwidth and Sensor Cable Length

Another key parameter of fiber optic distributed vibration sensors is their acoustic bandwidth. This is limited by the rate at which laser pulses can be launched into a sensing fiber without the echoes from successive pulses becoming superimposed on each other. Light takes approximately 10 ns to make a round trip through a meter of fiber. For example if a system employs fiber a kilometer long, then pulses cannot be launched more often than 10 μs apart (a maximum repetition rate of 100 kHz). In this case, the maximum acoustic bandwidth that can be reliably sampled is 50 kHz, since at least two samples per cycle are theoretically required to reconstruct the acoustic signal. The available acoustic bandwidth decreases linearly with increasing length, but since many practical cases only require bandwidths of a few kHz, tens of kilometers of fiber can be used without unduly limiting the available sensing bandwidth. In fact, thanks to the enormous speed of light and the minuscule attenuation of typical fiber, the maximum range of a distributed sensor can often be constrained only by more exotic considerations involving nonlinear optical effects. For the INTERCEPTOR FOCUS system operating with standard single-mode optical fiber, this limit can be up to 40 km.

Another consideration is that there is also a tradeoff between the maximum length of the sensor cable and spatial resolution, since the weaker backscatter from shorter pulses suffers more readily from detector noise. In order to exploit the maximum potential sensor cable length, good quality, low loss cable must be used and spatial resolution must be set to 10 or 20m.

6. Summary

INTERCEPTOR FOCUS utilizes state-of-the-art Distributed Acoustic Sensing (DAS) technology to provide long-range capability and pinpoint location of any physical disturbance to your classified communications cable up to 40km in length. The system continuously monitors the entire cable and pathway to immediately detect and report the most sophisticated intrusion attempts, or even the subtlest tampering conducted for the purposes of data theft (tapping) or denial of service.

Fully integrated with our proprietary CyberSecure software platform, the INTERCEPTOR FOCUS solution will centrally monitor and continually automate CNSSI 7003 required inspections and customized Standard Operating Procedures (SOP) for immediate response to any threat to your classified network. The INTERCEPTOR FOCUS can be rapidly deployed in new or existing network infrastructure to rapidly provide security to your physical layer.