Pipeline Infrastructure Monitoring System for Third Party Interference Detection

About Optellios, Inc.

Optellios Inc., is an American owned, U.S. based manufacturer of fiber-optic security technologies located in Newtown, Pennsylvania. Since 2000, the company has been a security market leader delivering technologically advanced hardware and software solutions for perimeter and pipeline security applications.

Beginning as scientific "think-tank" focused on the development of advanced technology for the Telecom Industry, Optellios continues to generate industry leading technologies garnering multiple patent awards in the area of fiber-optic sensing, polarization control, and light management for the delivery of national high-security grade technologies to the physical security industry. Recognized and awarded as an innovative provider of quality products and services by governmental entities ranging from the U.S. Government N.I.S.T program to our own F.A.A Homeland Security Reports as a part of the Safe Skies Program, Optellios continues to provide and drive innovation.

INTRODUCTION

Third-Party Interference (TPI), including unauthorized excavation in a pipeline's right-of-way, is the leading cause of pipeline accidents and loss. A single pipeline incident can have devastating effects, causing deaths, property destruction, service interruptions, environmental damage, and often costing the pipeline operator millions of dollars in financial losses. Further, incidents involving oil theft can go unnoticed for long periods of time causing serious economic issues. The Optellios FiberPatrol FP6100X advanced intrusion detection system is specially designed to promote physical security of buried pipelines and in-ground infrastructure. Minimal in required design and component infrastructure, the FP6100X system uses fiber-optic cable, buried along a pipeline, to detect and locate ground vibrations and acoustic signatures associated with third-party interference activity.

TECHNOLOGY

Patented Optellios' technology is based on an enhanced version of Coherent Optical Time-Domain Reflectometry (COTDR). This technology is extremely sensitive. Optellios' ECOTDR technology is then used to detect only the dynamic changes in the refractive index of the fiber caused by acoustic vibration (intrusion). Optellios' technology can measure not only the dynamic changes in the fiber but also quasi-static changes, such as temperature or strain. This approach allows that the phase change in the backscattered light, caused by the change of temperature/strain in a fiber, can be replicated by the change of wavelength of the interrogating light signal, as the measured phase change depends on the wavelength as well as the refractive index of the fiber. The deterministic relationship between wavelength change and temperature/strain change can thus be used to quantify a minute change in temperature or strain. A pulsed interrogating light signal at one wavelength is sent into the sensor cable, and the back scattered light is measured at that wavelength of the interrogating light signal from the entire fiber. This wavelength of the light is tuned to capture a wide spectrum of the back scattered light at each location in the fiber. The wavelength dependence of the back scattered light remains the same if the fiber property is unchanged. Any ground vibration due to a third-party interference source will alter the property of fiber, which will, in turn, alter the wavelength dependence of the back scattered light signal. The wavelength dependence of the back scattered light is changed in such a way that it is shifted along the wavelength axis because the phase change (due to TPI) can be compensated by the change in wavelength. The amount of the wavelength shift is an indication of the amount of change in phase and can be used to measure minute acoustic vibrations in the ground. A fiber-optic cable installed next to a pipeline can detect acoustic signatures caused by third-party interference. Optellios' system is cost effective and provides TPI protection up to 50 km range from one unit and typically locates within 10 m of the event.

FP6100X FEATURES FOR THIRD PARTY INTERFERENCE DETECTION

The detection of third party interference near a buried pipeline, such as, unauthorized mechanical or manual digging, is provided by the FiberPatrol Model FP6100X's capability and feature set. FP6100X detects excavation activity long before the digging equipment can reach the sensing cable and the pipe itself. By providing an early warning and the precise location of an incident, a FP6100X system can help responders prevent costly damage.

The monitoring system consists of two (2) primary elements:

1. **FiberPatrol FP6100X System Controller**

   This is a rack-mounted unit that monitors the buried fiber optic sensor cable using an enhanced version of coherent optical time-domain reflectometry (COTDR). The System controller continually monitors two sensing cables of up to 25 km each, both cables attached to one controller, for a total cable distance of up to 50 km.
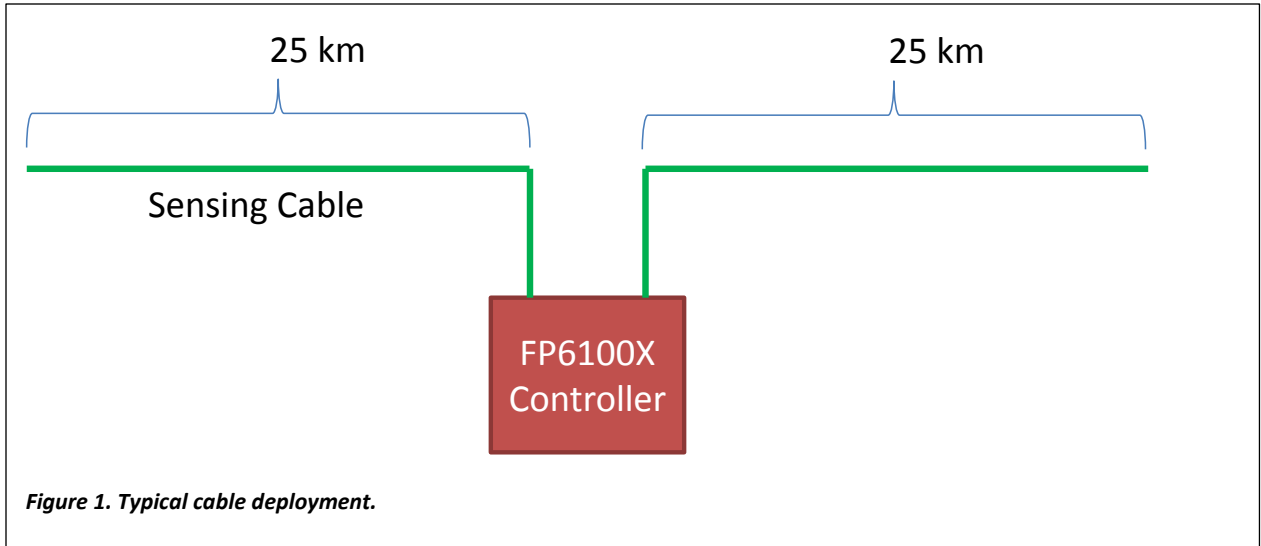
Figure 1. Typical cable deployment.

2. **Fiber optic sensor cable**, buried along with the pipeline. The cable is an armored, multi-fiber, single mode, telecommunications-type of cable suitable for direct burial. Standard cable deployment for third party interference detection purposes for the FP6100X is directly above the buried pipeline, at a depth approximately 20 – 30 cm (8 – 12") above the pipeline. The recommended cable deployment is shown in Figure below.
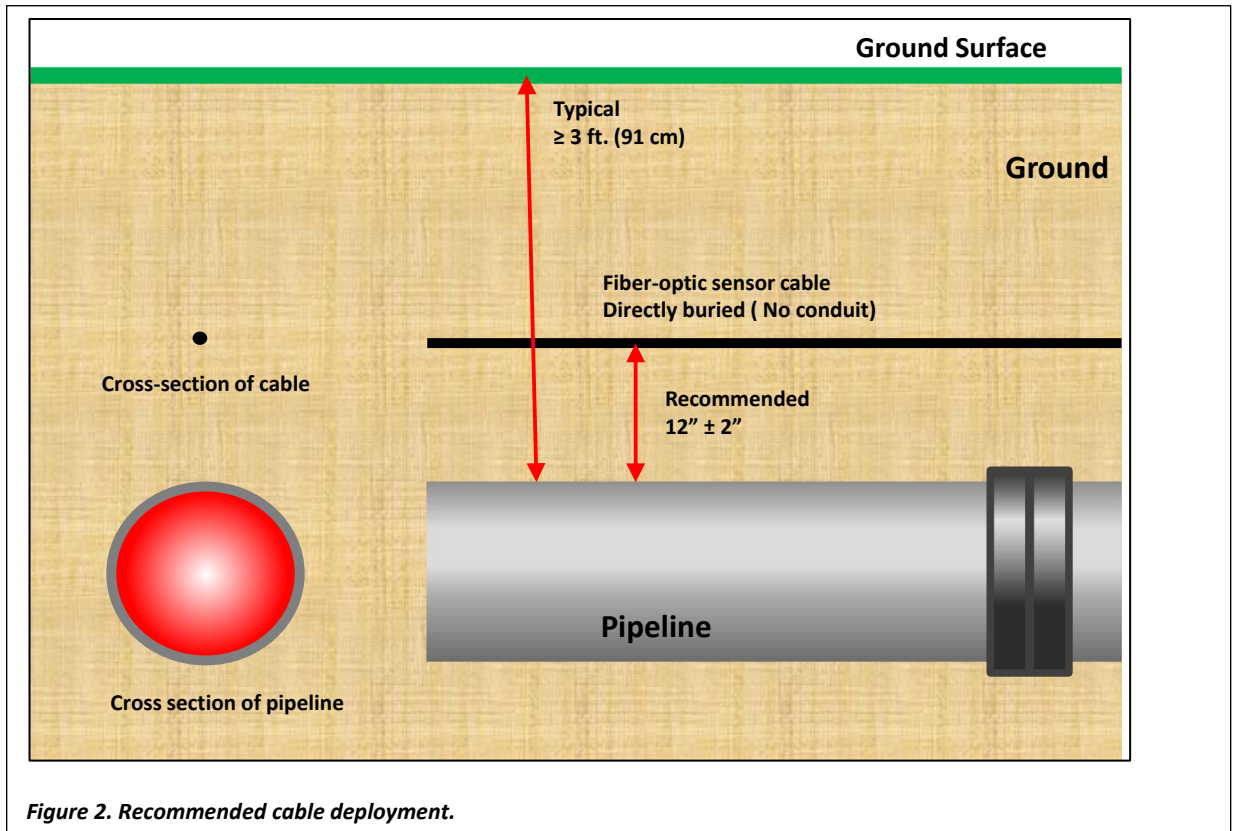

Figure 2. Recommended cable deployment.

Key Specifications

For detailed specifications, refer to the link for the datasheet on FP6100X at the end of this document. High-level specifications from the datasheet are shown below.

Specifications

Intrusion Detection

Max Sensor Length:	15 miles (25 km) per sensor, 30 miles (50 km) per head end
Alarm Location Accuracy:	Better than 100' (30 m) typical
Min Virtual Zone Length:	250' (75 m) recommended
Max Virtual Zone Count:	20 per mile (13 per km) recommended

Sensor Cable

Cable Type:	Gel-filled loose tubes, single jacket, unarmored
Fiber Count:	2 sensing, up to 70 spare
Sensing Fiber Type:	Corning SMF-28e+ or equivalent
Optical Loss:	< 0.40 dB/mi (0.25 dB/km) @ 1550 nm
Outer Diameter:	0.44" (1.1 cm)
Weight:	55 lbs/kft (82 kg/km)

Key features of FP6100X system:

- The sensor is a point locating distributed sensor, capable of identifying the exact location of activity to within 10 m along the sensor for most typical intrusions.
- The system is extremely sensitive to minute disturbances and has uniform sensitivity along the sensor, hence has a very high PD of > 95%.
- Sensors can be deployed to protect pipelines of any length. Each FP6100X system can protect up to 50 km and multiple systems can be daisy-chained to protect any length of a pipeline.
- The sensor can be deployed in any terrain or soil types.
- Requires no power in the field since it uses passive (all-dielectric) fiber-optic cable as a sensor in the field powered by laser light.
- The sensor is covert, which provides a significant advantage in detecting intruders by catching them off guard. The sensor is all dielectric, hence not detectable.
- Cost-effective solution especially for longer range.
- The location-sensing ability of the FP6100X system enables it to resolve multiple simultaneous disturbances, making it immune to defeat by coordinated attack.
- The FP6100X can be deployed in a configuration to provide cut immunity, which means the sensor remains fully functional even after the sensor is severed.
- The sensor is immune to RFI/EMI and lightning.

Location Sensing

FP6100X detects people activity, such as walking, a few meters from the sensing cable. The actual distance will vary depending on soil condition(s) that occur between summer, winter, and in rainy seasons. (Ex., FP6100X will detect a small/light vehicle, in driving mode, up to ≈ 150 feet away from the sensing cable in summer conditions, but the distance reduces to about 50 feet in wet conditions. The location sensing capability of FP6100X is summarized below.

Events	Typical detectivity range perpendicular from sensor* (in feet)
People Walking	3 to 15
Light vehicle	50 to 150
Heavy excavating machines	50 to 200

Figure 3. *Variation in detection range parameters in soil types and/or changes in soil characteristics due to extreme weather conditions.*

False and Nuisance alarm rates and Probability of Detection

The false intrusion alarms generated due to occurrences other than sensor cable motion / vibration are extremely low and have not been detected with FP6100X system. However, the system is specified to less than one false alarm per month.

The system is designed to reject nuisance sources such as those created by small animals, farm machinery, or nearby vehicle and train traffic. The system employs *adaptive filtering* and *pattern recognition algorithms* to minimize the rate of alarms induced by environmental factors and unwanted nuisance sources. The nuisance alarm rate depends on the sensitivity requirements for detection and rejection of nuisance sources, in addition to factors related to the ground type and condition, vegetation, environment, proximity to mechanical noise sources, as well as on configuration and depth of the buried sensor. FP6100X offers a variety of configuration settings to optimize the tradeoff between probability of detection requirements and minimization of nuisance alarm rate.

The system is immune to nuisance alarms and performance degradation originating from electromagnetic and radio-frequency interference in the field.

The system can detect isolated, non-stealthy excavation attempt in the area directly above the sensor cable with greater than 95% probability, before such excavation reach the cable. Such attempts include:

- Digging using excavation equipment
- Digging using manual tools

Cable Cut Detection and Cut Immunity

The system detects and locates a sensor cable cut with an absolute accuracy of better than 100' (30 meters). In the event of a sensor cable cut, the system retains detection and location ability in the portion(s) of the sensor cable that remain connected to the system controller.

The FP6100X system can also be installed in a configuration to provide cut immunity, allowing the system to continue full, normal operation even in the event of a cut/severed cable.

Cable specifications

The fiber-optic sensor cable is communication-grade single-mode optical fiber strands in in gel-filled loose buffer tubes. The FP6100X system uses 2 fibers to protect up to 50 km of pipeline. The cable is rated for buried deployments and has all dielectric construction with no conducting or emitting parts.

Simple Installation

FP6100X uses one Fiber-optic sensor cable in both directions, which can be easily deployed next to the pipeline using standard telecommunication methods. If the pipeline already has a single-mode cable installed alongside, in most situations the FP6100X system can be retrofitted to the existing cable to provide protection.

Protection for long pipelines

To protect long pipelines, multiple FP6100X systems can be daisy-chained and monitored from a central location either using FiberPatrol Remote Alarm Management System (FPRAMS) or similar 3rd party head end software.

Integration to 3rd party systems

FP6100X sensors may also be integrated with CCTV cameras and security systems to provide complete protection. FP6100X can also be integrated with other intrusion sensors from Optellios or 3rd party to protect pumping stations and other pipeline facilities.

Graphical User Interface

The FiberPatrol software is used for graphical user interface for calibration and configuration of the system. The software is designed to be intuitive and easy to use. As with all FiberPatrol systems, the alarm reporting methods offer ready and easy integration to a wide variety of PSIM, VMS, and ACS devices, or even direct interface to IP CCTV controllers. It also provides GPS integration.

Comparative Summary

FiberPatrol's implementation of (TPI) third party interference *differs significantly* from those implemented by other pipeline monitoring systems. Competitive fiber optic pipeline monitoring systems rely on complex analysis of acoustic signal for third party interference. This leads to performance issues and limitations for TPI applications:

- Extensive acoustic analysis to qualify and discriminate digging and third party interference detection leads to unavoidable and unpredictable uncertainty in event qualification, due to variations in environment, ground composition, pipeline condition, flow, and many other variables. This leads to erratic detection performance and excessive nuisance alarms from environmental elements.

By contrast, the FiberPatrol uses simpler but sophisticated measurement and analysis methods for **third party interference (***digging / tamper):*

- **The FiberPatrol's basic and well-proven vibration detection capability provides a very high level of reliability detecting ground-coupled vibrations due to digging attempts. Such vibrations are easily detected, and do not require complex and error-prone acoustic analysis, resulting in very high levels of detection but with minimal environmental nuisance alarms.**

<u>Why Choose Optellios?</u>

Unparalleled Protection Using Most Advanced Technology
The FiberPatrol® by Optellios line of systems from Optellios delivers the most advanced fiber-optic sensor technology available for perimeter and infrastructure protection and monitoring. FiberPatrol's field-proven, location-sensing fiber-optic security systems provide solutions for perimeter applications such as fence, wall, and in-ground perimeters and infrastructure monitoring of pipelines and data links. The company's security solutions offer industry leading, self-healing technology, simple installation methods, reconfigurable virtual detection zones, as well as many features specific to the application installation.

Low Cost of Ownership
Installation costs are drastically reduced when installing FiberPatrol's passive, all-optical fiber sensor that stretches up to 10 miles without using field repeaters, processors, or any other powered components. A typical installed system replaces the equivalent of 100s of legacy sensors while providing higher performance at a fraction of the cost. Using the same cable for fiber-optic video and data transmission further reduces the cost of infrastructure development.

Scalable and Flexible
The FiberPatrol Remote Alarm Management Solution (FPRAMS), a network-based software platform for enterprise-wide security integration and alarm management, permits multiple protected sites to be monitored from one or several central locations simultaneously.

Cut Immunity
When an installed fiber-optic cable is cut, either in an attempt to defeat security or by accident, the FiberPatrol system immediately reports the incident, including its exact location. Moreover, the system can detect and pinpoint intrusion attempts up to the cut point.

True Integration with 3rd Party Systems
The FiberPatrol systems fully integrate with 3rd party systems to provide a total security solution. FiberPatrol is successfully integrated with the top PSIM, VMS, IP CCTV, Access Control, and Video Analytic platforms, and more. Through a range of integration modules and an open Software Development Kit (SDK), Fiber Patrol applications can be seamlessly integrated with most access control, alarm and building management systems and with more specialist systems.

User Friendly
The FiberPatrol Remote Alarm Management Solution (FPRAMS) is a database-driven Windows® service program that aggregates alarm reports from remote sites, defines and implements automatic alarm handling policies and issues notifications to client stations. The client station software is a standard Windows application that subscribes to the server and provides convenient graphical operator interface for alarm monitoring and system administration.

Service & Support
Optellios is 100% focused on delivering the very best customer service, and the company prides itself on the commitment it makes to both Partners and end users. Working by phone, e-mail and face-to-face, the company's representatives deal 24/7 with any questions or issues that arise during the specification, installation or maintenance of Optellios' solutions.

Authorized Partner Program
Optellios partners with authorized system integrators and installers to provide local system design, installation and service to end users. This means that end-users can be confident that there are many companies in their region that can service and support Optellios' systems.

FiberPatrol by Optellios protects applications including our nation's infrastructure for air, rail and seaports, high security government sites and agencies, power generation plants including nuclear, coal, gas and electric, refineries for oil, gas and chemical manufacturing, water supply, storage and treatment facilities, and other infrastructure sites critical to corporate and national security.

These enterprise class systems improve organizations' operational efficiency, enhance public safety, and enable timely emergency response. Optellios operates from its Newtown, Pennsylvania Headquarters as well as numerous regional offices globally. Optellios partners with numerous authorized system integrators to provide local system design, installation and service to end users.

Optellios is the Total Solution

The FiberPatrol® fiber-optic sensing and intrusion detection systems feature the most advanced fiber-optic sensor technology available for perimeter and infrastructure protection and monitoring. All of the FiberPatrol solutions have the ability to identify multiple simultaneous events, such as coordinated intrusions, which can be effectively detected and located. The system reports the coordinates of an attempted breach, which can be used for activating corresponding PTZ camera presets and for personnel dispatch. The location-sensing ability also enables the system to ignore non-localized disturbances, such as those produced by wind and rain.

FiberPatrol's passive, all-optical fiber sensors provide up to 10 miles for fence, in-ground, wall, and fiber data link applications on a single controller, and up to 30 miles for the pipeline application. Multiple controllers extend the systems' capability. All of Optellios' solutions require no electrical grounding in the field and are unaffected by lightning storms. Using the same sensor cable for fiber-optic video and data transmission further reduces the cost of infrastructure development.

FiberPatrol Distributed Sensing Technology

FiberPatrol by Optellios is the leading edge technology for long distance perimeter and infrastructure security.
The system transmits pulses of light to interrogate the fiber. Light from every point along the fiber is returned to the Head End. Then, each location along the fiber is analyzed individually and the returned light is analyzed for the presence of disturbances. Signals from different locations along the sensor are decoupled from one another and the sensing zones defined in software rather than with field components.

Market Expertise

FiberPatrol® Intrusion Detection Systems are deployed across a variety of industries and at facilities that include (among others):

Oil Refineries	*Airports*
Chemical Manufacturing/ Processing Plants	*Water/Wastewater Storage/Treatment Facilities*
Electrical Power Generation	*Transportation/Ports*
Electrical Switching Stations (and sub-stations)	*Nuclear Power Generation*
Data Centers	*Prisons/Correctional Facilities*
Military Bases & Posts	*Government Facilities*
Pipelines	*DoD Communications and Control Sites*
Sea Ports	

FP6100X Datasheet
http://www.optellios.com/pdf/FP6100-X_20130326_WEB.pdf