DUNAY – DISTRIBUTED ACOUSTIC SENSOR
Extended objects security zones monitoring system
VIBROACOUSTIC SENSOR OF NEW GENERATION
DUNAY SOFTWARE AND HARDWARE COMPLEX

Distributed acoustic sensing (DAS) uses standard single-mode optical fiber (G.652) as highly-effective distributed sensitive element detecting soil vibrations (acoustic vibrations) at a distance of several dozens of kilometers along the optical cable. Dunay system hardware detect, localize, classify and alert on activity along the entire length of the cable. It offers cost-effective method of around-the-clock automated environment activity monitoring over long-distance linear objects.

Dunay allows to detect various events with 10 meters accuracy throughout monitored zone: approach to a guarded zone, movement along the border or trespassing the monitored zone border. Detection accuracy is increasing greatly if several monitoring zones are arranged. If any person or car approaches to guarded zone or any active process starts near protected object, Dunay system generate and send alarm event to the operator’s computer indicating the source location. The system permits to detect any kind of activity that is causing water or soil vibrations. When installing the system with a client T8 specialists set the system individually by taking into consideration the particular features of every facility.

Physical working principle

The system operation is based on physical principals of coherent reflectometry. Coherent reflectometers differ from common reflectometers by using highly stable and coherent laser sources. Optical pulses are repetitively launched into the fiber and during their propagation along the line a small portion of light is scattered backward. This back reflection occurs both from fiber local defects and also from random microscopic fiber index of refraction non-uniformities (sometimes called “scattering centers”), uniformly distributed over the fiber length. The backscattered optical waves are summing up coherently, with fixed yet random phases thus forming a chaotic intensity signal. This signal is well reproduced from pulse to pulse, as long as the fiber and laser remain intact.

Event recognition

A highly essential component of Dunay system is its embedded signal recognition algorithm. Signal processing is performed by using a convolutional neural network. Each signal acquired from a specific fiber segment by the optical equipment is then assigned with a “probability vector” which is compared to the etalon reference signals. Having performed analysis of the acquired information over the whole line the recognition module algorithm aggregates probabilistic events into an object or set of objects. At the final stage, specific object characteristics (trajectory, velocity, etc.) are determined.

Implementation of neural network, capable of learning to new types of events, allows to widely expand a range of classifiable objects and solvable tasks. The
EARLY DETECTION IS THE BEST PROTECTION

- Integration with video monitoring and security systems.
- Hidden operation of the system - there are no visually detectable sensors and radiation.
- Insensitivity to electromagnetic impact and interference.
- The sensing element is a standard G.652 optical fiber.
- Stable operation of the system regardless of weather conditions: fog, rain, snow, wind, etc.
neural network software can run either on the built-in computer of Dunay module or on the external server. In case when multiple Dunay modules are operating the software is deployed on the external server.

**Purpose of the system**

Areas of application of the system:

- **Pipelines monitoring and diagnostics:**
  - Routine works monitoring.
  - Protected zone monitoring.
- **Perimeter guarding.**
- **Transportation infrastructure objects monitoring:**
  - Rail tracks.
  - Landing strips.
  - Highways, bridges, tunnels.
- **Communication lines guarding.**

One of the main Dunay system applications is early detection system for critical infrastructure. Since an acoustic sensor allows to detect signals from sources located at dozens or even hundreds of meters from a source. A system operator gets an alarm signal before a trespassing.

Dunay system is designed in 3U chassis to be installed in standard 19" telco rack. Chassis has three slots for: receiving/transmitting unit (coherent reflectometer), amplifier module, and industrial computer for data processing and transmission to remote server. Dunay system can operate independently or may be integrated to any exiting security system. Open API allows developers to connect Dunay system to all modern security applications using Ethernet channels.

**Future opportunities**

Our company is also researching possibilities to use Dunay as a distributed temperature sensor. Such sensors have extremely wide areas of applications: temperature monitoring of power lines, detection of pipeline leakages, exploration of oil and gas fields.

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### Sensor parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of optical fiber</td>
<td>G.652</td>
</tr>
<tr>
<td>Fiber length (sensing element)</td>
<td>50 km or 75 km with ROPA *</td>
</tr>
<tr>
<td>Accuracy of determination</td>
<td>up to 10 m</td>
</tr>
</tbody>
</table>

### Optical parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wavelength</td>
<td>1550 nm</td>
</tr>
<tr>
<td>Scan frequency</td>
<td>0.5 - 1 kHz</td>
</tr>
<tr>
<td>Deformation sensitivity</td>
<td>up to 0.14 nanostrain (up to 75 km)</td>
</tr>
<tr>
<td>Dynamic range</td>
<td>30 dB</td>
</tr>
<tr>
<td>Maximum power</td>
<td>10 mW</td>
</tr>
<tr>
<td>Connector type</td>
<td>LC/APC</td>
</tr>
</tbody>
</table>

### Built-in PC

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Intel Core i5 or i7 *</td>
</tr>
<tr>
<td>Memory / Hard Disk</td>
<td>4 or 8 Gb / 2 Tb *</td>
</tr>
<tr>
<td>Protocols</td>
<td>TCP/IP, UDP</td>
</tr>
<tr>
<td>Interface</td>
<td>Ethernet, USB 2.0, DVI-D</td>
</tr>
</tbody>
</table>

### Execution

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power supply</td>
<td>220 V, 50 Hz</td>
</tr>
<tr>
<td>Energy consumption</td>
<td>300 W</td>
</tr>
<tr>
<td>Dimensions</td>
<td>482 x 415 x 140 mm (for 3U execution)</td>
</tr>
<tr>
<td>The weight</td>
<td>12 kg</td>
</tr>
</tbody>
</table>

* Depending on operating conditions, can be changed.
Dunay system is successfully operated in the perimeter security of the 1st and 2nd maneuvering area of Domodedovo International Airport in Moscow. The equipment is installed and operated at the international airports of Omsk and Tyumen. System has been successfully tested at the polygon of Research & Design Institute of Radio-Electronic Engineering (NIKIRET).
When organizing perimetral systems for monitoring of long-distance zones placed over dozens and hundreds of kilometers the main security goal is not to ensure the physical security but to detect trespassers on time. We offer developed in Russia the most cost-effective and best technical solution for long-distance objects security zones monitoring.

When any person or car, or any earthwork run activity near the protected object Dunay system generate and transmit alarm event to the operator‘s computer indicating the location of the source. It is possible to arrange several security zones for critical infrastructure and sensitive facilities in order to determine the exact direction and speed of trespasser’s movement.

The most important advantage of the Dunay system is its hidden operation, as monitored zone is not visually accessible. When dielectric cable is used the system cannot be detected in the ground even with special devices (metal detectors). The concealed location of the sensing elements allows to resolve several problems: impossibility of pre-reconnaissance, vandal resistance and preservation of the secured area landscape. The hidden operation of Dunay system prevents potential trespasser from performing preparation and workup activities, which increases the chance of detecting a trespasser.

Inconspicuous placement is crucial for remote areas, where equipment theft or damage is highly probable. Landscape preservation feature allows to use the system in specially protected cultural heritage areas.

Dunay all over the line does not require infrastructure and power supply units. Vibro-acoustic sensor allows to detect digging of underground tunnels and passages. Dunay system is indispensable for industrial and security-sensitive facilities as well as for various polygons.

Dunay system has an open API and allows developers to connect Dunay system to all modern security applications using Ethernet. Dunay system may be easy integrated to any existing security system. Video surveillance and Dunay systems can operate jointly, when alarm signal orients camera directly to relevant zone section, detected by Dunay sensor, thus, operator gets immediately alarm and event image on his monitor. Joint operation of Dunay and other security systems on the facility permits to decrease substantially the number of any false alarms.

System allows operators to detect, recognize and mask routine safety events, such as vehicles or people passing through permitted areas. Dunay system has proven it’s high efficiency in the airport perimeter guarding.
ONE DUNAY REPLACES THOUSANDS OF POINT SENSORS

- The system is in operation at the Gazprom Transgas Ufa JSC gas pipeline.
- Trials were carried out successfully on the Surgutneftegaz OJSC pipeline.
OIL AND GAS INDUSTRY PIPELINES MONITORING AND DIAGNOSTICS

Pipelines and communication lines monitoring always implies substantial expenditures for the security system infrastructure. If conventional solution is applied, the security zone would contain a lot of elements requiring regular maintenance and verification.

We offer our customers a unique solution that would allow zones monitoring of up to 75 km long per one device with the ROPA system. One fiber in the fiber optical cable substitutes thousands of sensors.

The Dunay system warns independently or within security complex about heavy machinery approaching a pipeline and allows to detect tie-ins and unauthorized works, Dunay system can be easily integrated into a video surveillance complex and provides video image of pipeline section where the alarm has been activated; it also generates an alarm event notification to security department employees via various channels.

Vertical seismic profiling system is being created. The system sensing element - fiber optical cable - requires no maintenance. According to the manufacturers the average fiber service life time is over 25 years and the Dunay system service life time is over 10 years. The possibility of system operation via Ethernet channels allows operator or dispatcher to monitor it remotely.

As the sensing elements are buried in the ground the probability of its malicious damage is minimized.

The detection zone for a person is several meters wide. Even before a person could get close to the facility the person will be detected by the system. It should be pointed out that Dunay also provides passage digging detection. Additional advantage of the system: it allows monitoring the passage of pig receivers (cleaning pigs) and defectoscopes in the pipes.

The Dunay system can be integrated into any security system which allows using of external API interfaces. The complete automation of the system is possible, e.g. integration with drones. Automatic issuance of coordinates to drone will allow you to quickly receive photos and video from the event location without additional participation of the dispatcher.
MONITORING ROADS IN REAL TIME MODE

- Russian Railways PJSC tests the system at several railroad sections.
TRANSPORTATION FACILITIES SECURITY

Railroads are the most important throughways of the country and they cannot operate without monitoring and control automation, same as any up-to-date transportation system. Railroads infrastructure operation requires real-time monitoring of trains movement and railtrack condition.

Dunay system allows to record works progressing along railtracks, register trains speed, record cargo dragging in case of emergencies. The sensor allows to do the following in real-time mode: reveal wage wheels defects, find gripping brake boxes and determine worn wage wheels. Besides, the continuous data analysis helps to reveal on time any degradation or damage of the railroad tracks and to detect rockfalls.

A big advantage of the system is its immunity to electromagnetic disturbance. The sensor operates fault-free under lightning discharges, tolerates the vicinity to electric mains, and ensures sustainable operation under substantial electromagnetic disturbances.

DAS Dunay has the function of binding monitoring objects to geographic coordinates. This opens up opportunities for the integration of the Dunay with the existing information systems of the customer.

Example of recording trolley passage: horizontal axis — time, vertical axis — distance. In the image, one may see wage wheels clamoring.
Tests which carried out in urban conditions on the underground infrastructure of the largest operator in Russia showed the readiness of Dunay system for operation.
Monitoring and protection of sewage cable systems in a residential environment is a laborious and costly task. Theft of copper cables, vandalism, accidents and road crashes due to open hatches require conducting online state monitoring of linear-cable structures from the communication operator, including manhole covers. We should specially note commercial losses caused by unauthorized installation of the backbone cables.

There are not so many systems for monitoring underground communications and manhole covers on the market. Dunay advantageously differs from other proposed devices. The operation of the software-hardware complex does not require the installation of sensors in each manhole, and the length of the linear infrastructure per system can reach up to 50 km and more.

The tests taken in urban environment in the underground infrastructure of the largest operator in Russia have shown the readiness of software-hardware complex Dunay to operate. Dunay allows not only to detect trespassing into the manholes, but also informs the operator about the stage of exposure: the impact (opening) on the manhole cover, works in the manhole, pulling the cable. The system software is adapted to the operator’s tasks, the system is able to regulate the routine maintenance of the manhole.

Communication lines

During the operation of the cable infrastructure, one of the issues is to anchor point of the cable break to the terrain, as well as clarifying the route and the guard zone of the communication line in the area. Anchoring of the break point along the optical length to the terrain allows to reduce significantly the time of elimination of the malfunction. It is not uncommon for cases when it is not possible to detect the route using standard means based on the detection of metal parts. DAS Dunay allows to determine the route of laying the optical cable with an accuracy up to 1 m. The team works at a place to clarify the laying scheme, they literally knock the soil. The operator in real time reports the system’s data and remotely manages the route of the working team.

Specialized software from the DAS Dunay provides enhanced opportunities to anchor monitored objects to geographic coordinates. Mobile software allows not only to determine the coordinates at the moment of the binding of the monitored object on the terrain, but also automatically creates the database for correlating geographic coordinates with the optical length of the sensor element.

One of the most common causes of fiber optic communications failure is the breakage of an optical cable, which can be caused by accidental damage during works near the cable line or vandalism. Dunay allows to prevent an emergency situation by informing the operator systems about unauthorized works near the communication line.
RESEARCH, DEVELOPMENT, PRODUCTION, INSTALLATION
T8 SENSOR

About the company

T8 SENSOR, LLC is the leader of fiber optic sensor systems development in Russia and CIS countries. T8 SENSOR LLC is part of T8 Group of Companies and resident of Skolkovo Innovation Center.

The main areas of company activities: photonics and distributed acoustic sensors research and development. Doctors of science, Ph.Ds and several dozen qualified engineers perform innovation activity in T8 Group.

T8 SENSOR actively works on engineering research and development in the optical physics area in order to create innovative solutions and newest designs. All developments are covered by patents valid on Russian Federation and Eurasian Patent Convention territory. Lots of scientific researches are also made for Company T8, leading telecommunications manufacturer in Russia.

Optics laboratory of T8 Sensor Company is one of the best equipped in Russia. It is strongly organized by state-of-the-art equipment and tools for all kinds of photonics research and supports research and development services either for T8 Group of Companies or 3rd Party Companies.

Development of modern high-tech equipment and implementation of innovative technologies requires high professionalism and creative approach of all employees. Training and education center for young specialists has been created, company selects the best graduates from leading Russian universities such as MIPT, MSU, Bauman MSTU and others and force their professional growth.

The innovative distributed acoustic sensor system Dunay has been developed in company’s laboratory. System is intended for monitoring of protected zones of long-distance objects: polygons and perimeters, pipelines, railways and motor roads, communication lines, and so on.

Several first versions of Dunay system have already been installed at fuel and power plants and transportation facilities. Gazprom, Russian railways, Domodedovo Airport are among the system users.

The hardware and software system Dunay has all the necessary certificates and patents.
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