

What is the working principle of a circular fiber optic sensor



Overview

Optical fibers can be used as sensors to measure, , and other quantities by modifying a fiber so that the quantity to be measured modulates the,,, or transit time of light in the fiber. Sensors that vary the intensity of light are the simplest, since only a simple source and detector are required. A particularly useful feature of intrinsic fiber-optic sensors is that they can, if required, provide distributed sensing over very large distances.

Key Takeaways

Circular fiber optic sensors operate by detecting changes in light properties, such as phase or polarization, as light travels through a looped optical fiber, often exploiting the Sagnac effect for high-sensitivity measurements.

Basic Working Principle

Circular fiber optic sensors consist of an optical fiber arranged in a loop or circular configuration. Light from a source is split and sent in opposite directions around the loop. When the loop experiences a physical change—such as rotation, strain, or pressure—the phase, polarization, or transit time of the light traveling through the fiber is altered.

These changes are detected at the output, allowing precise measurement of the physical quantity affecting the fiber.



Sagnac Effect in Circular Sensors

A key principle in circular fiber optic sensors, especially for rotation sensing, is the Sagnac effect. When the loop rotates, the light traveling in the direction of rotation takes slightly longer to complete the loop than the light traveling against the rotation. This phase difference is proportional to the angular velocity, enabling the sensor to function as a highly sensitive fiber optic gyroscope.

Intrinsic vs Extrinsic Configurations
Intrinsic Circular Sensors: The fiber itself acts as the sensing element. Environmental changes directly modulate the light within the fiber, such as through strain-induced birefringence or temperature-dependent refractive index changes. **Extrinsic Circular Sensors:** The fiber transmits light to and from an external sensing element.

The circular fiber primarily guides light, while the modulation occurs outside the fiber, such as in a reflective or interferometric setup.

Advantages of Circular Fiber Optic Sensors

High Sensitivity: The looped configuration amplifies phase or polarization changes, allowing detection of very small rotations or strains. **Electromagnetic Immunity:** Using light as the signal carrier makes these sensors immune to electromagnetic interference, suitable for harsh environments. **Distributed Sensing Capability:** Circular loops can be integrated into larger networks for monitoring multiple points or extended structures.

Compact and Flexible Design: The circular geometry allows compact packaging and integration into devices like gyroscopes or vibration sensors.

Applications

Circular fiber optic sensors are widely used in: **Navigation Systems:** Fiber optic gyroscopes for aircraft, ships, and spacecraft. **Structural Health Monitoring:** Detecting strain or vibration in bridges, pipelines, and buildings. **Industrial Process Control:** Measuring rotation, torque, or pressure in machinery.

Seismic and Acoustic Sensing: Detecting vibrations or sound waves in geophysical applications. In summary, circular fiber optic sensors leverage the looped fiber geometry to enhance sensitivity to phase, polarization, or transit time changes, with the Sagnac effect being a central principle for rotation sensing. Their intrinsic or extrinsic configurations, combined with immunity to electromagnetic interference, make them versatile tools in precision measurement and monitoring applications.

Article Content

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Fiber-optic sensor

Optical fibers can be used as sensors to measure strain, temperature, pressure and other quantities by modifying a fiber so that the quantity to be measured modulates the intensity, phase, polarization, wavelength or transit time of light in the fiber. Sensors that vary the intensity of light are the simplest, since only a simple source and detector are required. A particularly useful feature of intrinsic fiber-optic sensors is that they can, if required, provide distributed sensing over very large distances.

Fiber Optic Sensors: Types, Working Principle

What is a Fiber Optic Sensor? A fiber optic sensor measures a physical quantity by modulating the intensity, spectrum, phase, or polarization of light traveling

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Fiber-optic sensors measure different light sizes such as wavelength and intensity in order to derive other measured values from them. In industrial automation, the energetic principle is often used. The

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When the incident light hits the core-clad interface at angles larger than its critical angle, the light is completely reflected and guided in the fiber. In contrast, the incident light which meets the

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Explore fiber optic sensors: their working principles, types (intrinsic, extrinsic, hybrid), and diverse applications in mechanical, chemical, and structural health

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Optical Fiber Sensors and Sensing Networks: Overview of the Main

Optical fiber sensors present several advantages in relation to other types of sensors. These advantages are essentially related to the optical fiber properties, i.e., small, lightweight,

Fiber Optic Sensor [Working Principle, Fiber Optic

One of the most widely used and unique sensors in the field of factory automation environments and electricity is the fiber optic sensor. Fiber optic sensors also

What is a Fiber Optic Sensor?

A fiber optic sensor operates with an optical fiber cable connected to a dedicated light source. These sensors offer great mounting flexibility and can be used in a variety of environments.

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