

Fiber Optic Grating Vibration Measurement Principle



Overview

Practical engineering applications have proven the high practicality of fiber Bragg grating accelerometers.

Key Takeaways

Fiber Bragg gratings (FBGs) measure vibrations by detecting shifts in the reflected light wavelength caused by strain induced by mechanical oscillations. Principle of Operation

Fiber Bragg gratings are periodic variations of the refractive index inscribed along the core of an optical fiber. When broadband light passes through the fiber, a specific wavelength, known as the Bragg wavelength, is reflected while other wavelengths are transmitted. The Bragg wavelength is determined by the grating period and the effective refractive index of the fiber core. Mechanical vibrations applied to the fiber induce strain, which changes the grating period and refractive index, resulting in a shift of the reflected wavelength. This shift is directly proportional to the applied strain, allowing precise measurement of vibration amplitude and frequency ().

Vibration Detection and Signal Processing

For vibration measurement, the FBG is either attached to or embedded in the structure of interest. When the structure vibrates, the FBG experiences dynamic strain, causing periodic changes in the reflected wavelength. These changes are captured using an interrogation system, which can include wavelength scanning devices, photodetectors, or CCD arrays. By recording the reflected power at different wavelengths over time, the time-dependent strain waveform can be reconstructed. Numerical methods and harmonic analysis are often applied to extract vibration parameters such as amplitude, frequency, and phase ().

Advantages of FBG Vibration Sensors

FBG-based vibration sensors offer several benefits over traditional electrical sensors:

- Immunity to electromagnetic interference, making them suitable for harsh environments ().
- Small size and lightweight, allowing integration into structures without affecting performance.
- Multiplexing capability, enabling multiple sensors along a single fiber.
- Long-term stability and minimal maintenance, as no electrical power is required at the sensing site ().
- High sensitivity to strain and vibration, capable of detecting microstrain levels and high-frequency oscillations ().

Practical Implementation

In practice, FBG vibration sensors are used in structural health monitoring, aerospace, civil engineering, and industrial applications. The sensor can be mounted on surfaces or embedded in materials. The reflected wavelength is continuously monitored, and the vibration spectrum is obtained by analyzing the periodic wavelength shifts. MATLAB or other signal processing software is often used to verify experimental data and extract frequency-domain characteristics, including natural frequencies and mode shapes (). In summary, FBG vibration measurement relies on the correlation between strain-induced wavelength shifts and mechanical vibrations, providing a highly sensitive, stable, and interference-resistant method for monitoring dynamic structural behavior.

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Fiber Bragg Grating

Fiber Bragg Grating (FBG) is defined as a sensing technology that utilizes gratings inscribed in optical fiber to enhance strain

Fiber Bragg Grating Based Sensors

A good solution for this problem is the measurement of parameters by optical fiber based FBG sensor. Fiber Bragg grating (FBG)

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