

Study of fiber Bragg grating reflection spectrum signal denoising

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Abstract: Using WDM technology to solve the problem of the reuse addressing the fiber grating sensing network, the system USES a reference grating for temperature compensation, the reference grating was put in the same temperature field as the measuring grating array, but does not suffer the effect of strain, reference grating principle and method of signal processing and measurement of grating is completely consistent. Because of fiber Bragg grating strain and temperature response is linear, so there is no difference between both in terms of signal demodulation, directly from minus the reference grating demodulation measuring grating demodulation results as a result, thus realized the reference grating is used to compensate temperature disturbance to the influence of strain measurement. Using empirical mode decomposition (EMD) method for fiber Bragg grating sensor signal de-noising.

Introduction

Fiber Bragg grating since 1978 after 30 years of development, optical fiber grating sensor has been used in Bridges, petrochemical, aerospace and other large-scale structure engineering, dangerous flammable and explosive occasions and strong electromagnetic interference environment has been widely used, popular. Optical fiber Bragg grating is made use of optical fiber photosensitivity, temperature and strain is fiber Bragg grating sensor detection of two of the most basic physical quantities, other physical quantities of sensors are the two most indirect derived on the basis of the basic physical quantities. Fiber Bragg grating sensor has a sensor head of simple structure, small volume, light weight, appearance is variable, can measure structure of internal stress, strain and structural damage, etc.

Distributed fiber Bragg grating strain sensor system design

The change of temperature, strain and stress will cause fiber grating lattice spacing and the change of the refractive index, so that the fiber Bragg grating reflection spectrum and transmission spectrum of the change. Through detection of fiber Bragg grating reflection spectrum or the change of the transmission spectrum, can get the corresponding information of temperature, strain and stress, which is measured with fiber Bragg grating temperature, strain and stress the basic principle of. Because of the fiber grating is sensitive to temperature and strain at the same time, so how to distinguish between temperature and strain is fiber Bragg grating sensor signal a problem must be solved in the practical application.

The structure of the fiber Bragg grating is shown in Fig.1:

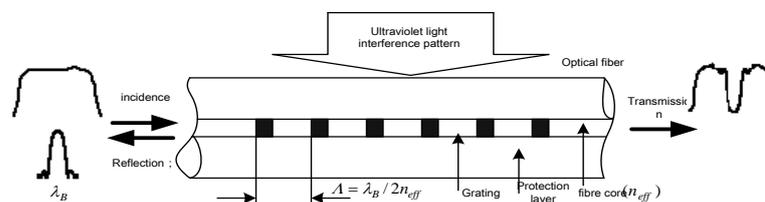


Fig.1 Fiber grating structure diagram

By the coupled-mode theory, the Bragg wavelength of fiber grating

$$\lambda_B = 2n_{eff} \Lambda \quad (1)$$

Where n_{eff} was an effective refractive index of fiber core; Λ was the grating period. Visible changes over and the Bragg wavelength, and the change of related to strain and temperature. Strain calculated by photosynthetic efficiency should change impact and length, and temperature through hot with thermal expansion effect and light efficiency, and then make the move.

One mechanical structure strain testing system based on fiber Bragg grating sensor is shown in Fig. 2, a number of different grating center wavelength FBG sensors on a single fiber series multiplexing, constitute a sensor array, when optical fiber broadband light irradiation, each of the FBG sensor grating reflected back to a change of center wavelength of the narrow-band light waves. Photoelectric coupler to separate the reflected light, the wavelength demodulation system of reflected light wavelength demodulation detect each grating wavelength offset. Distribution on the structure of multiple grating wavelength change can reflect the whole structure of the distribution of strain field. Reference grating and at the same temperature and there is no strain sensing grating changes.

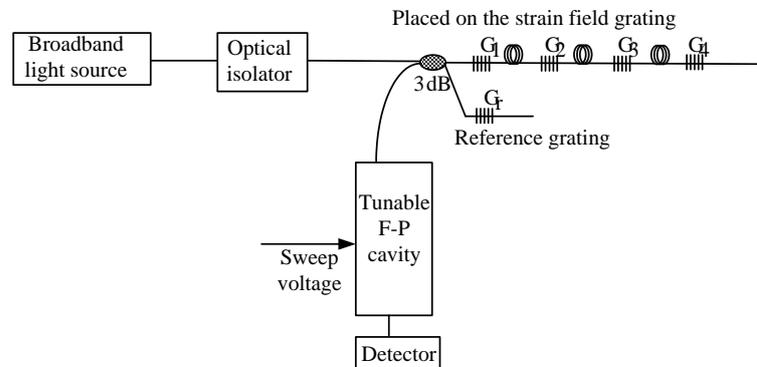


Fig. 2 strain testing system based on fiber Bragg grating sensor

Study of FBG test signal de-noising

In FBG sensing system, the reflection spectrum of the signal often contains a lot of noise, to the follow-up work of reflection spectrum of center wavelength of accurate positioning has brought a lot of difficulty, influence the accurate measurement of physical quantities to be measured. Therefore, for the FBG sensing signal denoising is crucial.

EMD de-noising filter from high frequency to low frequency filter out noise, and step by step the most If the IMF component is the trend of the original signal or average commonly, for the purposes of this system for high frequency signal, noise and effective signal the IMF components and noise of the IMF and frequency crossover will not happen, so remove high frequency signal directly, the rest of the low frequency signal superposition get the effective signal, this is the basic principle of the EMD filter. The EMD de-noising experiment was carried out on the grating reflection spectrum simContaining noise FBG reflective spectrum is shown in Fig. 3, you can see, a maximum of waveform by the interference of noise, with a maximum of waveform of FBG Bragg wavelength value is easy to cause measurement error, reduce the measuring accuracy of optical fiber sensing probe.

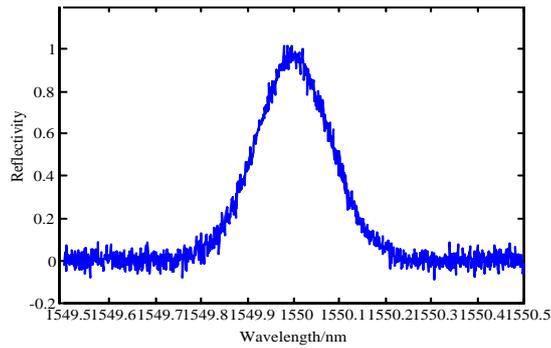


Fig.3 FBG reflection spectrum

For each of the original signal EMD decomposition of the IMF, known by the preceding analysis, for the purposes of this system directly to the high frequency filter the IMF components, the low-frequency IMF component and residual function which make effective signal. The real effective signal is:

$$x'(t) = \sum_{i=k}^n c_i + r_n \quad (2)$$

the EMD decomposition get seven IMF component ($c_1 \sim c_7$) and a residual function. See from diagram, 1 ~ 4 layer for high frequency signal is the noise signal, the signal containing noise was isolated, the residual signal component is the real effective signals, the ~ combination to get the real effective signal. The signal reconstruction as shown in Fig.4, apparently after the EMD de-noising, fiber Bragg grating reflective spectrum is smooth, be able to identify the location of the center wavelength, so that they can accurately get the Bragg wavelength drift.

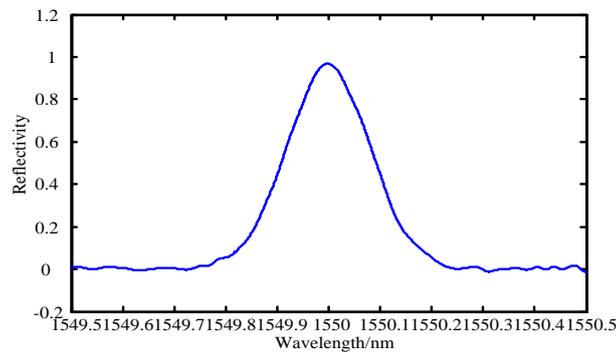


Fig.4 reconstruction signal spectrum

Conclusion

Based on the empirical mode decomposition (EMD) method for fiber Bragg grating sensor signal de-noising. This method is to get the empirical mode decomposition of intrinsic mode function, divided into the signal component plays a leading role modal modal, and noise component plays a leading role to remove noise components play a leading role modal, and use the reflected signal of main structural modal for implementing reconstruction signal denoising, get a smooth reflection spectrum after noise reduction.

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References

- [1]A.D.Kersey, M.A.Davis, H.J.Patrick, et al. Fiber grating sensors. *Journal of Lightwave Technology*,1997,15(8):1442-1463
- [2]DU Rong-jian, TIAN Nai-liang. The experimental study of C-waveband arrayed-waveguide grating. *Journal of Tianjin institute of technology*. 2004,20(1):32-34
- [3]JIAO Ming-xing, ZHAO En-guo. Solution of cross sensitivity of strain and temperature of fiber Bragg grating. *Journal of applied optics* , 2003, 24 (2):20-23
- [4]X.B. Luo, Z.X..Li,Z.Y. Guo,Y.J.Yang. Study on linearity of a micromachined convective accelerometer.*Microelectronic Engineering*.2003,65:87-101
- [5]K.C.Peter, W.Chan., M.S.Jin.“Demokan.Multiplexing of fiber Bragg grating sensors using subcarrier intensity modulation”.*Optical&Laser Technology*.1999,31:345-350.
- [6]A.D. Kersey et al..Dual wavelength fiber interferometer with wavelength selection via fiber Bragg grating elements. *Electron. Lett.IEE JNL*.1992,28(13):1215-1216.