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FBG wide-range and high rate interrogation method

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Abstract— **A FBG sensor interrogation method for measuring applications requiring a wide wavelength range and a high rate interrogation is presented. An optical intensity transfer with a cosine-like shape is obtained by a fiber interferometer, which is periodically changed to a sine-like transfer by a phase modulator. The FBG sensor reflected light, after propagated through the interferometer, is detected. A tracking algorithm is used for determining the central wavelength of the FBG sensor. An analysis of the involved systematic measuring error is carried out which illustrates the method feasibility.**

Resumen— **Se presenta un método de interrogación de sensores FBG apto para aplicaciones que requieran de amplio rango en longitud de onda y una alta frecuencia de obtención de datos. Se basa en una transferencia óptica cosenoidal generada mediante un interferómetro en fibra el cual es periódicamente conmutado a una de tipo senoidal utilizando un modulador de fase. La luz reflejada por el sensor FBG es propagada a través del interferómetro y luego detectada. De esta manera con un algoritmo de seguimiento la longitud de onda central del sensor es determinada en forma dinámica. Se presenta un análisis del error sistemático del método que evidencia la factibilidad del método.**

I. INTRODUCTION

The growing applications of the fiber sensors based on Bragg gratings (FBG) motivate the search and development of new and efficient sensor interrogation schemes. Nowadays, two well known developed techniques are based on the use of laser scanning and monochromator. The common feature lies in a spectral measurement of the light reflected by the sensor and a signal processing to find the Bragg wavelength from each multiplexed sensor (in a WDM configuration). Clearly, the sensor flexibility is improved since the system response does not depend on the shape, spectral position or reflectivity of the FBG. However, the main limitation arises from the rather low interrogation speed which is limited to some kHz [1].

On the other hand, some interrogation methods have been developed based on edge filters, power methods [2] or matched FBG [3]. These methods share a higher interrogation speed but they are limited in the useful spectral range. Generally, the sensor and the interrogation system should be jointly designed so diminishing its versatility. Alternative system architectures allows to reach a wide spectral range and high interrogation rates [4] [5] [6] but they are complex or expensive.

In this paper we propose a new sensor interrogation method having high measuring rate and large measurement range. Neither dispersion compensation fiber (DCF) modules, nor ultra-short pulse sources are used, so resulting in a more compact device with lower costs.

The paper is organized as follows. In Section 2 a shortly sketch of the proposed technique is shown together with some operation aspects. The error estimation of the method is exposed in Section 3, including an example using typical values. Finally, conclusions are presented in Section 4.

II. DESCRIPTION OF THE METHOD

The method is based on sinusoidal functions identities. If the following optical transfers were implemented

$$_{C}(\lambda) = cos(\lambda)\,,\ I_S(\lambda) = sin(\lambda), \qquad (1)$$

and the intensity of the light reflected by the sensor was measured after crossing them, the sensor central wavelength could be inferred by applying the arctangent function as $\lambda = \operatorname{atan}(I_S/I_C)$.

The before mentioned intensity optical transfers are impossible to be implemented. A feasible alternative based in a similar approach is shown forward. Instead of using two devices to implement each optical transfer, the proposed method switches a feature of an interferometer in order to obtain both optical responses. It avoids the need to construct two interferometers with a specific relation between them, which would demand a very high fabrication precision and a high demanding thermal stabilization.

The proposed scheme is schematically shown in Fig. 1. light reflected from the FBG sensor is splitted in two signals transmitted by fiber arms L1 and L2 which, after recombination, are detected by a photodetector (PD). In this interferometric arrange, the length of one branch (L1) is controlled by a phase modulator (PM). For the case of zero phase delay (no PM action), the device intensity transfer function is given by Eq. (2), being n the mean refractive index of the fiber and L the interferometer optical branch length difference.

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