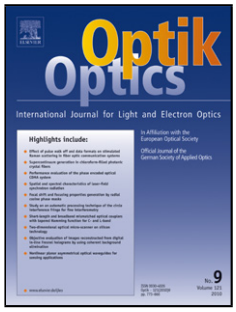

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Theoretical Approach to Optimize Fiber Bragg Grating Sensor Performance using an Automated New Code

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ABSTRACT:

In this work, we propose a novel theoretical model to optimize the window profile of Fiber Bragg Grating Sensor (FBGS) based on the sensing system requirement using an automated new code. The main objective of the proposed approach is to seek the higher Reflected power as long as side lobes are kept in the required level based on the design setting of FBGS. For this purpose, Coupled Mode Theory (CMT) and Transfer Matrix Method (TMM) have been programmed using new closed-form expressions to describe the light apodization in the FBGS. The proposed algorithm optimize automatically the FBGS window profile and calculate automatically its coefficients according to the required Side Lobe Level (SLL) and the allowable Full Width at Half Maximum (FWHM) of the FBGS reflection response. The proposed method has been compared with the state-of-art alternatives to prove how it helps to obtain better results. Comparison results demonstrate the efficiency of the suggested technique.

Keywords: Fiber Bragg Grating Sensor (FBGS), Coupled Mode Theory (CMT), Transfer Matrix Method (TMM), Side Lobe Level (SLL)

I- INTRODUCTION:

Fiber Bragg grating sensor (FBGS) is one of the most recent technologies adopted to detect temperature and strain changes as to monitor damages in composite structures in locations where electrical sensors are enable to give reliable information due to high electromagnetic field [1]. These damages take place among the structure plies or edges and occurs under different loadings such as impact and fatigue, which makes it more dangerous in critical structures such as aircraft and high-speed trains [2]. With this end in mind, Fiber Bragg Grating (FBG) is proposed to meet electrical sensors challenges because of its immunity to electromagnetic fields effects, its ability to be integrated inside the structure and its multiplexing capability to detect the damage in several locations along one single fiber [3]. Nevertheless, FBGS with uniform refractive index modulation amplitude shows reflection spectrum with large side lobes, as well as highly nonlinear dispersion characteristics which makes it unsuitable for high performance applications [4]. For this reason, apodized FBGS has been recently developed and optimized with a view to ensuring superior filtering performance and low side lobe level. The reflection spectrum of an apodized periodic grating follows closely the Fourier transform of the applied apodization profile, which means that a smooth apodization profile would result in low side lobe level and superior grating performance [5]. The choice of the apodization profile, however, has to be made carefully because strong apodizations result in low reflectivity level and waste an important amount of reflectivity power. Concordantly, the user of the FBG technology find himself obliged to choose between Reflectivity and SLL according to the sensing system requirement. In this work, we propose a theoretical approach to optimize the window profile of FBGS using a very fast algorithm with new closed-form solutions seeking the higher Reflectivity power as long as we respect the required SLL. The proposed algorithm optimize automatically the FBGS window profile according to the SLL of the FBGS reflection response. The rest of the paper is organized as follows: In Section II, we briefly describe the general theoretical model used for the calculation of the grating response. The main window profiles considered in literature are also presented in this section. In Section III, we compare our simulation results with the apodization profiles proposed by other authors [5][6][7] to prove how the proposed method helps to obtain better results. The conclusions are given in Section IV.

II- THEORY and MODELING:

A. Fiber Bragg Grating:

The FBG is completely characterized by its refractive index distribution $n_{eff}(z)$ along the fiber [8]