Dynamic Characteristics and Response of Low Frequency Cantilever Beam-Based FBG Accelerometer Under Base Excitation

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Abstract. Cantilever FBG accelerometer for low frequency application is usually modelled by single-degree-of-freedom (SDOF) system which gives linear strain-curvature relationship along the beam, even when the curvature is not linear especially when the excitation frequency is greater than fundamental frequency. This inaccurate prediction can be overcome by modelling the cantilever beam using Euler-Bernoulli (EB) theorem which considers MDOF systems. Therefore, this paper presents: (a) the validation of analytical works using EB theorem for cantilever beam and its comparison with Timoshenko (T) theorem (*rotational inertia* and *shear force* are considered) obtained from finite element method and (b) initial analysis of strain developed on cantilever beam using EB theorem and SDOF model at low frequency range. Despite the fact that the work in (a) is inequitable comparison, yet it is valid for the case of slender beam structure at low frequency range in this study. The results show that the dynamic characteristic and vibration response of a simple cantilever beam structure is not significantly affected by both *rotational inertia* and *shear force* at low frequency excitation, thus proves that the EB theorem is valid to be used in representing cantilever FBG accelerometer. In the second work (b), the strain computed from the EB theorem gives significant discrepancy in terms of value and pattern compared to SDOF model.

INTRODUCTION

Recently, researchers have shown an increased interest in the development of fibre Bragg grating (FBG) accelerometer due to its capability to operate in harsh environmental conditions, invulnerability to electromagnetic fields, and ability to provide multiple sensing points in a single cable [1]. These criteria have enabled the FBG accelerometer to serve in many vibration monitoring systems such as in steel footbridge, military wheeled truck, gas exploration and ground motion [2-5]. The most common design of FBG accelerometer is based on cantilever beam mechanism [1, 2, 6-12] which could easily induce strain since FBG is more sensitive to strain and temperature due to the refractive index change and grating period variation [13]. Cantilever FBG beam mechanism basically consists of a single FBG sensor bonded on a thin cantilever beam, with or without tip mass. In this light, the presence of the tip mass improves the sensitivity of the accelerometer [1]. Furthermore, to serve as an accelerometer, this system is framed into a cubical space functioning as a housing, as shown in the close-up of cantilever FBG accelerometer in Figure 1(b). Due to the motion transferred from the housing to the beam at any point (x,t) along the beam, the strain of the FBG accelerometer is developed and it will proportionally shift the FBG wavelength.

With regard to cantilever FBG accelerometer, Peter *et. al* [14] have described that the strain of FBG can be computed by using pure bending theory [15] and have presented static relationship between variations of applied load, F and strain $\varepsilon(x)$. This approach was then adapted by other researchers [1, 2, 7, 9, 10, 16] for dynamic study where the static force (F) was replaced by base excitation force ($m \times a$), known as single-degree-of-freedom

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