Turnkey Fibre Bragg Grating Interrogator for Real-Time Static and Dynamic Monitoring Applications

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Abstract

Fibre Bragg Grating (FBG) sensors have been widely known for the capability of per-forming static and dynamic measurements. However, the commercially available interrogators have several limitations such as low sampling frequency, lack of complete product that is ready for immediate use and the need of highly skilled FBG experts to interpret the readings. Therefore, this study demonstrated on the improved FBG interrogator known as Universiti Malaysia Pahang-Fibre Bragg Grating Interrogator (UMP-FBGI). Prediction of flexural load on composite beam is carried out for static monitoring. The results revealed that UMP-FBGI possessed good repeatability with the highest percentage of error at 7.51%. For dynamic monitoring evaluation, natural frequency of the composite beam is determined. From the comparison with accelerometer, the highest percentage of error is obtained at 9.82%. All in all, the developed FBG interrogator is a complete product with real-time monitoring graphical user interface (GUI) ready for immediate use.

1 Introduction

Fibre optic cable was first invented in mid-1960s for use in telecommunication industries [1-3]. The main attractions of optical fibre are lightweight, miniature size, low cost, electromagnetic interference immunity and many more [4-6]. Realizing these advantages, Hill et al. [7] inscribed a Bragg grating inside the optical fibre to form the optical based sensor known as fibre Bragg grating (FBG). Over the years, FBG sensors have been widely used in monitoring of various fields such as biomedical, aerospace and engineering structures [8].

FBG sensors can be used for static or dynamic measurements and required different configuration of devices in order to record and interpret the reflected wavelength readings. The device configuration is known as interrogation system. Broadband light source, optical circulator, optical spectrum analyser (OSA) and photodetector are the example of devices required to read the FBG's wavelength. The commercially available OSA capable to retrieve both the measurements. However, the sampling frequency was available only in the range of 1 Hz to 5 kHz [9]. This has limited for utilization in acoustic emission (AE) measurement that ideally should have the sampling frequency range of 1 Hz to 500 kHz [10].

Even worse, according to the market survey by Mendez et al. [11], most of the manufactures only provide one piece of the equipment rather than a complete turnkey device. This required highly skilled FBG experts to configure and operate the devices. This limitation has also created a barrier for on-site monitoring. According to the same author, another hurdle is the lack of knowledge in utilizing the technology for monitoring applications. This is due to the lack of real-time graphical user interface (GUI) that can instantly display the information.

Therefore, this work aims at developing a turnkey FBG interrogator complete with LabVIEW based GUI. The interrogator is known as Universiti Malaysia Pahang-Fibre Bragg Grating Interrogator (UMP-FBGI). The interrogator can be used for monitoring of static and dynamic measurements. In order to evaluate the feasibility of UMP-FBGI, static monitoring of flexural load on composite beam was performed. For dynamic evaluation, natural frequency of the composite beam was determined. Both the measurements were performed in real-time.

2. Working Principle of UMP-FBGI

The fabricated UMP-FBGI comes with a rugged storage case for heavy duty shockproof as shown in Fig. 1. In general, the interrogator consists of an AC power rocker switch for connection to the AC power supply. The temperature inside the case was kept ventilated by using dual DC fans. The temperature inside the case can be monitored from the digital thermometer. Two USB ports were also included for connection to any USB devices. Three fibre adapter ports were included where one for sensing FBG and two for filter FBG.

Fig. 2 shows the interior circuit of the UMP-FBGI. The interrogator can be operated for static or dynamic measurement or simultaneously. For static measurement, a sensing FBG or array of sensing FBGs (λ_1, λ_2, λ_3, λ_n…) were connected to the sensing FBG port. The circuit started with