Application of single chip processor in an interrogating system for fiber Bragg grating sensors with a fiber Fabry-Perot wavelength filter

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A novel interrogation system for fiber Bragg grating (FBG) sensors with a tunable fiber Fabry-Perot (FFP) wavelength filter is proposed. The system combines a feedback loop arrangement and micro control unit (MCU), which integrates the closed-loop tracking mode into the scanning mode by varying the process of sawtooth voltage. As a result, the wavelengths of fiber grating sensor arrays can be interrogated; moreover, the wavelength of arbitrary FBG under dynamic conditions in the arrays can be tracked and then be locked. A strain resolution of < 0.3-ustrain can be realized using this system.

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Fiber Bragg gratings(FBGs) have been intensively studied as optical sensors for many years owing to their fiber-based, wavelength-encoded characters. FBG is a periodic perturbation of the refractive index along the fiber length which will cause light reflected from this grating to be greatest at a particular wavelength λ_B, where λ_B is given by $\lambda_B = 2n\Lambda$ and n is the effective refractive index and Λ is the grating period. Since the wavelength λ_B is the parameter modulated by the measurands, any change in fiber properties, such as strain or temperature will change the Bragg wavelength[1]. So sensor interrogation can be reduced to simply detecting the shift of the Bragg wavelength. A number of suitable wavelength detection schemes have been introduced and developed in recent years[2,3]. One of the successful schemes is tunable fiber Fabry-Perot (FFP) which is swept in wavelength by a sawtooth voltage used to adjust the mirror spacing[4]. Consequently, the FFP control voltage is a measure of wavelength shift. Higher resolution to measurand-induced shifts in the wavelengths of the sensor FBG can be achieved using dither technology. The advantages of this method are simplicity and accurate measurement, however, the limitation is that this method can only operate either in a closed-loop tracking mode for use with a single sensor element or in a scanning mode for use with multiple sensors. Here we present a novel approach for integrating the closed-loop tracking mode into the scanning mode to improve it.

In order to realize both the working modes in an interrogating system, a chip of micro control unit (MCU) and a digital-to-analog converter may be used. Here, we choose MCS-51 series MCU such as AT89C2051 for its wide use and powerful function, moreover, it is easy to program. And, 8-bit (or $>$ 8-bit) input digital-to-analog converter is available, such as 16-bit serial input DAC8531. Generally, the more bit digital-toanalog converter(DAC) is adopted, the higher accuracy can be achieved.

As shown in Fig. 1, light from a wavelength-swept fiber laser which is composed of FFP and an erbium-doped optical fiber amplifier (EDFA) is input to the system[5], and the components reflected by several FBG sensor elements are directed via a coupler to the main part of interrogation system. The higher coupling ratio port of C3 connected with a feedback loop arrangement. The light in the low coupling ratio port of C3 detected by the photo detector would send a message generated by a voltage comparator to MCU when the laser wavelength came into the wavelength domain occupied by arbitrary sensor. As soon as MCU receives this message, the program of MCU will adjust the output voltage to DAC to keep fixed value for a moment as shown in Fig. 2(a). Here a single sensor element is locked and interrogation for this sensor FBG is completed. And then MCU continues the process of sawtooth at a higher voltage which will make the wavelength of FFP skip the wavelength domain occupied by that sensor. Similarly, MCU will adjust the output voltage when next message comes. By repeating this working process of MCU each sensor element will be locked for a short time in the scanning

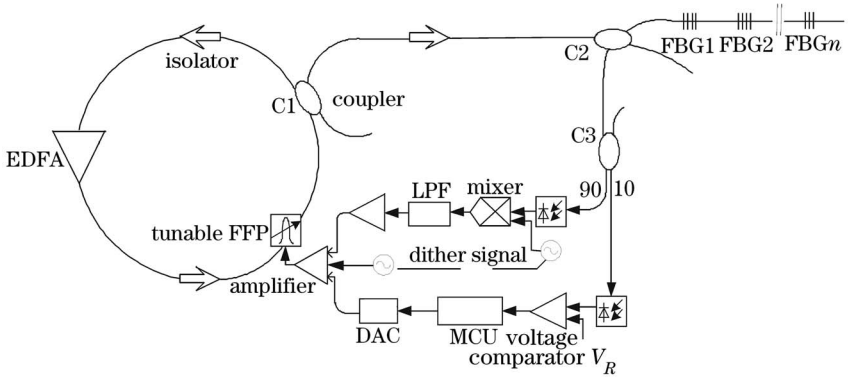

Fig. 1. Experimental setup of the proposed interrogation system for FBG sensors.

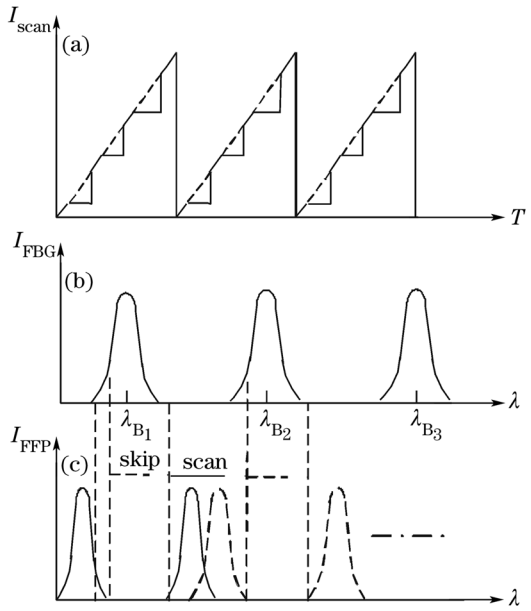

Fig. 2. Illustration of the proposed concept for FBG interrogation: (a) applied quasi sawtooth waveform adjusted by MCU; (b) reflection spectra of FBG arrays along a fiber path; (c) transmission spectra of tunable FFP corresponding to applied quasi sawtooth waveform.

mode for use with multiple sensors, higher resolution of < 0.3-ustrain will be achieved correspondingly[4].

Another potential advantage of this interrogating system is that the wavelength of arbitrary FBG under dynamic conditions in the arrays can be tracked and then be locked. To achieve this, we need only keeping the output voltage of MCU constant when the voltage comparator sends a message to MCU.

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