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### XXXIII Cycle - II year presentation

# Arrayed Waveguide Grating – Based Interrogation System for Fiber Bragg Grating Sensors

#### Fiber Bragg Grating Sensor

$\lambda_B = 2n_{eff}(\epsilon, T) \Lambda(\epsilon, T)$

$\Lambda$  modulation period  
 $n_{eff}$  effective refractive index

#### Interrogation System

How to sense?

Accuracy	Frequency	Application fields	Detection system
<math><math>100\mu\epsilon</math></math>	0	Strain, temperature; Surveillance monitoring for infrastructure.	OSA; Tunable laser & power meter.
<math>10\text{ne}</math>	1 Hz	Vibration monitoring in SHM.	FP tunable filter with piezoelectric actuator.
<math>1\text{ne}</math>	100 Hz	Seismograph; Vibration monitoring; Acceleration spectroscopy; Impact damage detection.	Interrogation system without mechanical moving parts.
<math><math>1\text{ne}</math></math>	1 kHz	Hydrophones; Acoustic emission spectroscopy.	
<math><math>1\text{ne}</math></math>	1 MHz		

Cost: \$0.1k, \$1k, \$10k, \$100k

#### Target

Development of an Interrogation System with:

- No mechanical moving parts;
- wide dynamic range;
- high accuracy;
- high resolution;
- low cost;
- high frequency bandwidth.

#### Analytical Simulation

- In linear dependence with interrogation function;
- Losses or noise on channel avoided;
- Immunity to source fluctuation.

$$\lambda_{FBG} = F\alpha + \beta$$

$$F_{m,m+1}(\lambda_{FBG}) = \text{atanh} \left( \frac{I_m C_{m+1} - I_{m+1} C_m}{I_m C_{m+1} + I_{m+1} C_m} \right)$$

$$I_m(\lambda_{FBG}) = \int_0^{\infty} S(\lambda) B(\lambda) A_m(\lambda) d\lambda$$

#### Circuitual Simulation

- Max  $V_{out} \rightarrow$  less than 1V, ok for ADC range;
- 12-bit ADC  $\rightarrow q = 0.244$  mV;
- 0.244 mV with a gain of 121k  $\rightarrow 2nA \rightarrow$  resolution below picometer.

#### Working Principle

#### Numerical Simulation

This system performs wavelength detection not only in the window between two channels, but, theoretically, in a wide range that is covered by AWG spectrum, without limiting the FBG sensing system in an environment where high strain or temperature stress must be avoided. As the previous case, the mean error value is in the range of sub-picometer.



#### Future work:

- Experimental analysis of the interrogation system;
- experimental analysis of the double stage Transimpedance Amplifier;
- development of the interrogation algorithm in FPGA environment;
- development of a new safety monitoring system for industrial application.