UltrUltrasound measurements using optical fiber sensors under varying environmental conditions: Application to passive guided waves SHM

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Optical fiber sensors draw an increasing interest for structural health monitoring applications due to their low intrusivity, their capacity to be embedded in material such as composites or concrete and their adequation for many harsh environments: extreme temperatures, ionizing or electromagnetic environments… Many industrial applications of such sensors exist for the monitoring of low frequency physical quantities such as the temperature or the shape of a structure. Recently the use of Fiber Braggs Gratings (FBGs) as ultrasonic sensors has been demonstrated but the use of these sensors for ultrasound measurements outside a controlled environment remain a challenge due to the sensitivity of the sensor to environmental conditions hindering the ultrasound measurement capability. We present here the design of an optoelectronic system able to measure ultrasonic signals under varying environmental conditions using FBGs on optical fibers. The system is based on the so-called edge filtering technique, for which the wavelength of an optical source must be set on the edge of the reflection spectrum of the FBG. The environmental condition variations will induce a shift on the wavelength position of the reflection spectrum. Thanks to a control loop, the wavelength of the optical source follows the low frequency shift of the reflection spectrum, allowing to keep the sensitivity of the system to ultrasounds. This setup was tested during a 4 points bending test with steps of increasing speed to assess its performances in terms of tracking speed and sensitivity. The proposed setup, integrated in a multiple channel system, enables the simultaneous measurement by several sensors distributed on the inspected structure. Such system opens the way to the implementation of passive guided waves techniques relying on the cross-correlation of ultrasonic ambient noise signals acquired simultaneously by several sensors. Previous studies have shown the potential of passive technique for SHM applications and we demonstrate here the potential of using solely FBGs for such applications.