WindSTAR
Wind-Energy Science, Technology, and Research
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Low Cost Optical Fiber Strain Sensor Interrogator for Wind Turbine Blades

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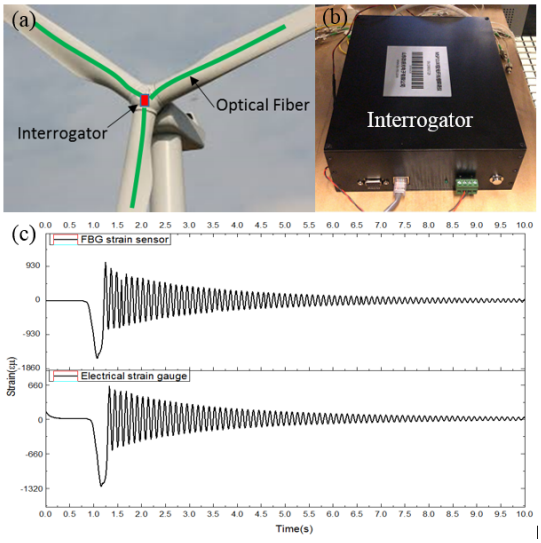
Sensing and control improvements in the blades of wind turbines plays a vital role in improving their power production efficiency and reliability. However, the blades suffer from exposure to harsh environments and continuous dynamic loads. It is important to utilize structural health monitoring sensors for operation monitoring and condition based maintenance and repair.Fiber Bragg grating (FBG) technology has the potential to be being widely used in wind turbine structural health monitoring. It has several advantages compared to other incumbent technologies, due to its small size, distributed sensing properties over long distances (20-120 km), immunity to electromagnetic interference, resilience to harsh environments, and capability of monitoring structural behavior of new composite materials in bending loads. To perform demodulation of FBG sensors, optical fiber sensor interrogator technology has been used for many years. In this project, a low-cost self-powered interrogation system that can be simultaneously operated by multiple optical fiber strain sensing elements is proposed. The interrogator dimensions are smaller than conventional systems (i.e. ~6" by 6" in size). The interrogation system being developed includes a low power-consumption tunable laser, photodiodes, controller and integrated data storage. The Field Programmable Gate Array (FPGA) technique is applied to conduct the high-speed scanning for the FBG wavelength. Vertical Cavity Surface Emitting Laser (VCSEL) is utilized for reducing power consumption. The 24 channels are divided from a laser source using a 1-24 optical splitter. 24 FBGs were mounted on three fiberglass panels to test the performance of the interrogator in the detection of strain and temperature. The electrical strain gauges were used as a reference during testing in operation. The results indicate the successful validation of interrogator in the laboratory and this optical fiber strain sensor methodology is found to be promising for detecting dynamic strain and temperature on utility-scale turbine blades.



The low cost optical fiber strain sensor interrogator for wind turbine blades: (a) the schematic of strain detection using FBG interrogator. (b) FBG interrogator. (c) The FBG strain sensors vs electrical strain gage.

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