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Structural Health Monitoring For Wind Turbine System Using MEMS Sensor

A.Mariya therasa, Dr.L.Ranganathan

Abstract— Wind energy is a fast-growing sustainable energy technology and wind turbines continue to be deployed in several parts of the world. The structural health monitoring (SHM) and maintenance of turbine structures have become critical and challenging and at the same time essential as they develop into larger dimensions or located in places with limited access. Even small structural damages may develop ruinous find to the integrity of the system. So, cost-effective, predictive, and reliable structural health monitoring (SHM) system has been always desirable for wind turbines. A real-time nondestructive SHM technique based on multi sensor data fusion is proposed. The objective is to critically analyze and evaluate the feasibleness of the proposed technique to determine and localize damages in wind turbine blades. Based on the obtained results, it is shown that information from smart sensors, measuring strains, and vibrations data, distributed over the turbine blades can be used to assist in more accurate damage detection and overall understanding of the health condition of blades.

Keywords— wind turbine blade, MEMS sensor, MATLAB.

I. INTRODUCTION

Wind turbine manufacturers, owners and operators could benefit financially from structural health monitoring (SHM) technology, which provides an indication of the reliability of each wind turbine throughout its 10–30 year lifecycle. The term 'health' encompasses the loading, damage and operational capability of a turbine. Each turbine is comprised of subsystems such as the rotor, drive train, generator and tower, and components such as the blades, bearings, yaw joints and shafts. The operational reliability, and, more pertinent to operation and maintenance, the uncertainty in reliability of a complex system like a wind turbine is dictated by the loading and condition at the component level.

Whereas the discipline of design focuses on the loading, performance, failure modes and reliability of a population of wind turbines and its subsystems, the discipline of SHM focuses on individual wind turbines at the component level. If the loading and health of individual wind turbines could be quantized, the maintenance, operation and control of each turbine could be tailored to maximize uptime by increasing the mean time between inspections and other factors that influence uptime.

A.Mariya therasa PG Scholar, Department of Mechatronics, Jeppiaar Engineering College,Chennai.
Dr.L.Ranganathan , Professor, Department of Mechanical, Jeppiaar Engineering College,Chennai.

For instance, scheduled maintenance requiring approximately 24h per turbine is performed twice per year on most utility horizontal axis wind turbines. Unscheduled maintenance is approximately 500% more costly to conduct requiring 130h per turbine.

It is envisioned that SHM will provide maintainers with actionable information that they can utilize to schedule maintenance ahead of time to avoid more costly unscheduled maintenance actions. Furthermore, manufacturers could use health information about loads and the damage correlated with these loads to improve wind turbine designs, manufacturing and quality control processes, and shipping and installation methods.

For the wind farm owners and operators, knowledge of the health of the entire system of wind turbines as well as the health of the local electrical utilities could be of great economic benefit from an energy production and delivery point of view. SHM could also potentially enable designers to reduce the weight of rotors and drive trains by replacing conservative design assumptions with automatic state awareness and control measures.
As a specific example of a potential damage mechanism that SHM can address, consider a blade pitch actuator or bearing that exhibits unusually large amounts of hysteresis resulting in a bias error in the desired angle of attack for that blade. Such a blade's loading and health, as well as the health of the drive train with which that blade interacts, could be compromised. Wind farm operators could compare stored historical loads estimates of that individual turbine, particularly for severe loads, to the assumed design loads to assess the potential impacts on the turbine's life. If the mechanical defect in the pitch drive system could be detected, operators could also deploy maintenance resources in a proactive manner to correct the mechanical defect and avoid losses in energy capture or downtime because of more extensive unscheduled maintenance that could be required in the future

In addition, operators could pitch the other two blades to temporarily suppress asymmetric loads to the rotor and drive train that are partially responsible for causing the growth of fatigue damage to allow for the necessary parts to be ordered in a timely manner. Performance-based logistics could then be used by wind turbine maintainers to place orders for parts, which often have relatively long delivery lead times.

II. MEMS SENSOR

Micro-electromechanical systems (MEMS) are Freescale's enabling technology for acceleration and pressure sensors.

MEMS sensor products provide an interface that can sense, process and/or control the surrounding environment. Mems sensors are appropriately categorized as "transducers", which are defined as devices that convert energy from one form to another. In the case of micro sensors, the device typically converts a measured mechanical signal into an electrical signal.

2.1. Benefits of Mems:

- Low Cost
- Low Power
- Miniaturization
- High Performance
- Integration

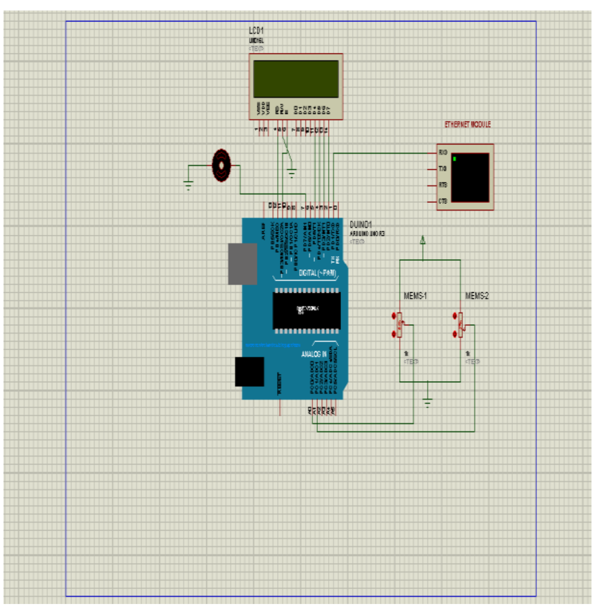
III. SOFTWARE

3.1. Arduino

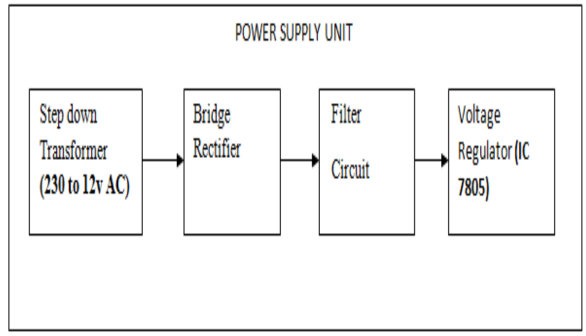
The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. . It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started."Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0. The Uno is the latest in a series of USB Arduino boards.

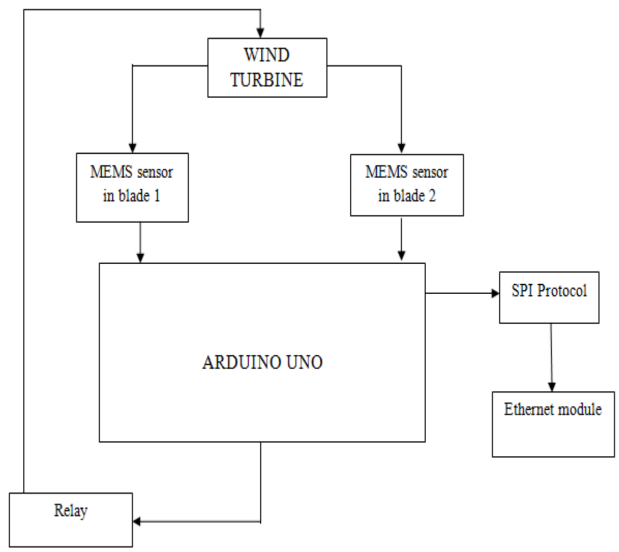
3.2 Proteus

Proteus (PROcessor for Text Easy to Use) is a fully functional procedural programming language. Its incorporates many functions derived from several other languages. Here C programming language is used to create a algorithm. All the typical control structures are available.

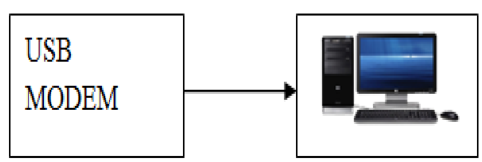


IV. BLOCK DIAGRAM





SHM System



V.IMPLEMENTATION

The proposed technique, using MEMS sensors, is shown to be effective in the damage prediction in the blades. The proposed damage detection method represents global monitoring approach where, as opposed to local techniques, the whole blade is under surveillance so that no defect is missed and damage development is detected at the initial stage before it becomes critical. This technique does not require direct human accessibility to the structure, is cost effective, easy to operate, and has the enhanced capability for real time damage detection. A major advantage of this method is that it uses one type of sensor, a MEMS strain sensor, to measure both vibration and strain signals and leads to accurate readings and much less noise.

VI. CONCLUTION

In this paper described the health condition of turbine blade. This system monitors the blade condition and updates the values. If any vibration occurs due to natural dissuaders in the plate Arduino will find out the vibration level using MEMS sensor. If the sensor value is greater than the threshold level means the system will intimate the owner through Ethernet.

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