FAULT DETECTION IN WIND TURBINES USING MEMS SENSOR

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ABSTRACT

Wind energy is fast-growing sustainable energy technology and wind turbines continue to be deployed in several parts of the world driven by the need for more efficient energy harvesting, the size of the wind turbines has increased over the years (several MW of rated power and over 100m in rotor diameter) for both off-shore and land-based installations. Therefore, Structural health monitoring (SHM) and maintenance as such turbine structures have become critical and challenging and at the same time essential as they evolve into larger dimensions or located in places with limited access. Even small structural damages may invoke catastrophic detriment to the integrity of the system. so, cost-effective, predictive, and reliable structural health monitoring (SHM) system has always been desirable for wind turbines. A real-time non-destructive SHM technique based on multi sensor data fusion is proposed in the project. The objective is to critically analyze and evaluate the feasibility of the proposed technique to identify 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.

INTRODUCTION

Wind turbines (also known as wind energy) considered to be one of the common source of wind power is being used in a large scale. MEMS sensor commonly known as Micro electro mechanical sensor is the high sensitivity strain sensor which can detect even a small vibration or crack. By fitting this sensor in the x, y or z direction of the blades it can easily detect the problem and updates it through the power supply. Structural health monitoring (SHM) is followed throughout the process to make sure that the wind turbine is working properly. Since it is a strain sensor it can easily be able to find even a small vibration caused during the power generation. The objective is to critically analyze and evaluate the feasibility of the proposed technique to identify and localize damages in wind turbine blades. Based on the obtained results, it is shown that information from smart sensors, measuring strains and vibration 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. Even small structural damages may invoke catastrophic detriment 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 non-destructive SHM technique based on multi sensor data fusion is proposed in this project.

WHY FAULT DETECTION MECHANISMS ARE SO IMPORTANT IN WTS?

Wind turbines (WTs) are unmanned, remote power plants. Unlike conventional power stations, WTs are exposed to highly variable and harsh weather conditions, including calm to severe winds, tropical heat, lightning, arctic cold, hail, and snow. Due to these external variations, WTs undergo constantly changing loads, which result in highly variable operational conditions that lead to intense mechanical stress. Consequently, the operational unavailability of WTs reaches 3% of the lifetime of a WT. Moreover, operation and maintenance (OM) costs can account for 10%–20% of the total cost of energy (COE) for a wind project, and this percentage can reach 35% for a WT at the end of life. A preventive-cantered maintenance strategy that avoids machine shutdown can considerably reduce these costs. Therefore, WTs require a high degree of maintenance to provide a safe, cost-effective, and reliable power output with acceptable equipment life. This is the main Reason for the introduction of Fault Detection Mechanisms in Wind Turbines.

EXISTING SYSTEM

FO (Fiber optic) strain sensors and particularly fiber Bragg gratings (FBGs) are currently the most widely used in wind turbine structural monitoring. In order to create the FO network, several interconnects are required, so implementation is challenging and probably requires surface treatment. Each sensor being wired to a central processing unit is also a drawback. First, strain sensors should always be attached to the materials being monitored (i.e., intrusive); otherwise, the measurements are not accurate. However, the deformation of the materials may lead to the separation of the sensors and the materials.

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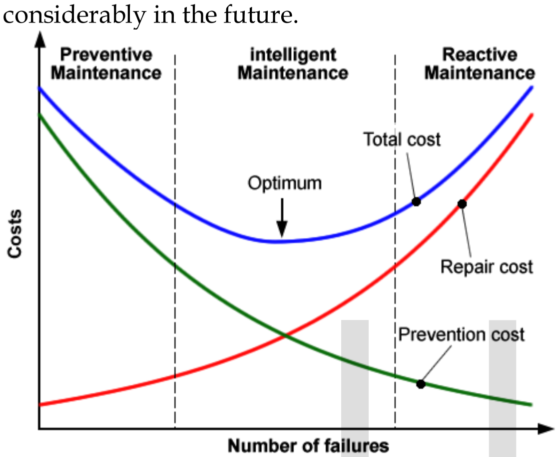
Moreover, the deformation level of the materials should not exceed the physical limitation of the sensors; otherwise, the sensors will not provide accurate measurements or even be damaged. The implementation of the strain monitoring requires additional capital costs, increases Wind Turbine system complexity, and is subject to problems or Sensor Reliability. The majority of this method has limitations with regard to large-scale sensing, difficult signal interpretation or have safety issues. The optical fibers must be mounted on the surface or embedded into the body of the monitored WT components. Therefore, OFM is complicated and expensive in real-world applications compared with other Condition Maintaining and fault detection method. However, due to technological progress, it is expected that the cost of OFM for Wind Turbines will decrease considerably in the future.



The Above Figure Shows the Costs associated with traditional maintenance strategies.

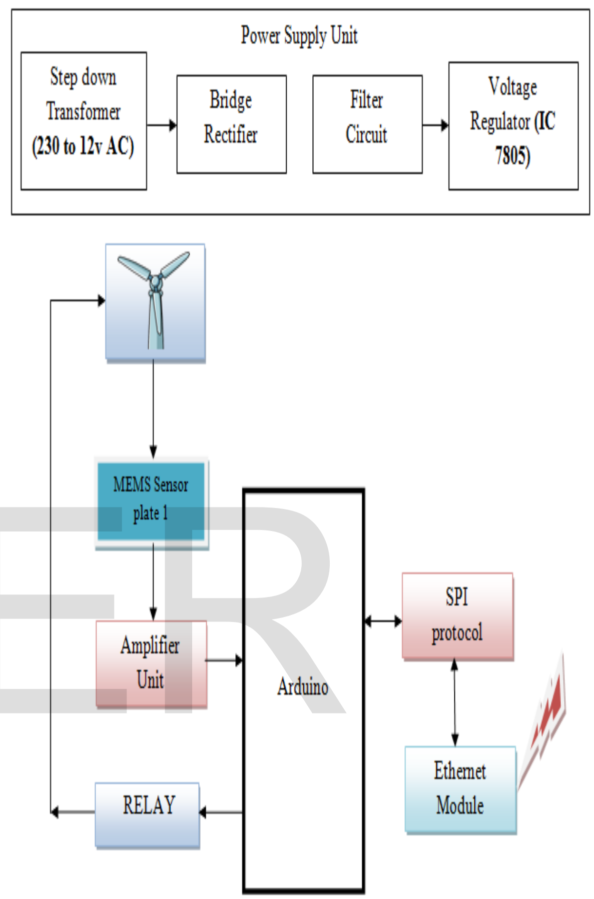
PROPOSED SYSTEM

In this work, a methodology for stress level sensing and detection of cracks for wind turbine blades is presented by analyzing the distributed strain fields along the blade and natural frequencies through finite element analysis for different damage scenarios. The proposed technique, using MEMS sensors is also 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. The proposed technique, in addition to detecting excessive strains, obtains strain distributions along the blade through multi-sensor data.

TECHNOLOGY BEHIND THIS PROJECT:

This Method Consists of Several Optimization changes over the Traditional FO method, the Fiber optics Sensor is replaced by MEMS Sensor. The Base of Our Project is the installation of MEMS sensor Module on Wind Turbine with the structural health monitoring (SHM) and Intelligent Damage Detection Systems. The SHS Comprises of Online Monitoring Module Pre-Installed in the computer, The IDDS Comprises of the Hardware Components Power Supply unit, Ethernet Module, Amplifier Unit, Relay and the Arduino Module.

BLOCK DIAGRAM



The power supply unit consists of a step down transformer (230 to 12v AC) followed by a bridge rectifier. The second part consists of a filter circuit and a voltage regulator (IC 7805). The turbine blades are fitted with a MEMS sensor connected to an amplifier unit which detects the vibration around the axis. There is a relay connected to the stepper motor of the wind turbine to rotate according to the power supply. The latest Arduino UNO board is used for the processing of values and uploading the status to the web page. Ethernet module is used for the connection between the Arduino and the system. structural health monitoring (SHM) is followed throughout the process to look after the uninterrupted power supply.

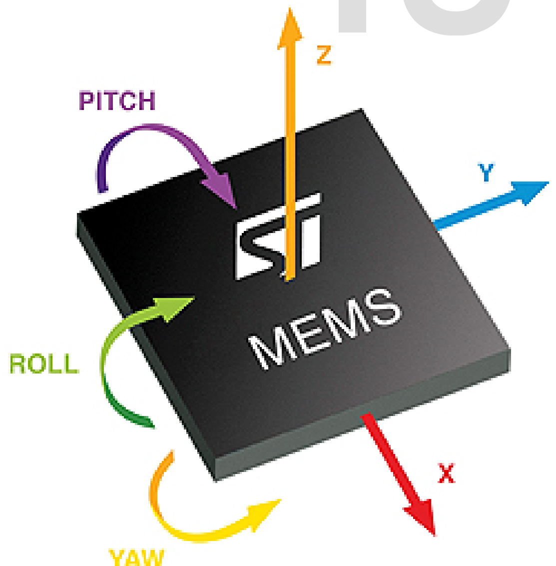
WORKING PRINCIPLE

To operate this project first, we have to check the

IP address of the corresponding LAN connection and replace that IP address in the program coding, then we have to upload the coding into the Arduino kit using the USB driver software. After the upload is done without any errors, required cables are connected into three axis such as x-axis, y-axis and the z-axis. If the direction in any one of the axis changes (i.e.) the set threshold value goes beyond the level means that the turbine is fault. This indication will be displayed on our HTML webpage as the status "WIND FAULT". But when the axis direction does not occur any changes or the threshold value is within the limit means the indication will occur as "no problem" so the turbine stops rotating automatically. The threshold value is set up to the value of 300.we can also manually stop the turbine using our control option in the webpage in case if there are any queries.

DESCRIPTION IN DETAIL

1) MEMS SENSOR: Micro-electromechanical systems (MEMS) are Freescale's enabling technology for acceleration and pressure sensors. MEMS based sensor products provide an interface that can sense, process and control the surrounding environment. Freescale's MEMS based sensors are a class of devices that builds very small electrical and mechanical components on a single chip. MEMS-based sensors are a crucial component in automotive electronics, medical equipment, hard disk drives, computer peripherals, wireless devices and smart portable electronics such as cell phones and PDAs.



Micro-Electro-Mechanical systems or MEMS is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements (i.e. Devices and structures) that are made using the techniques of microfabrication.

2)RELAY: A Relay is an electrically operated switch. Electric current through the coil of the relay creates a magnetic field which attracts a lever and changes the switch contacts. It consists of a coil of wire surrounding a soft iron core, an iron yoke, which provides a low reluctance path for magnetic flux.

3)SPI BUS INTERFACE: Serial to Peripheral Interface (SPI) is a hardware/firmware communications protocol developed by Motorola and later adopted by others in the industry. The Serial Peripheral Interface or SPI-bus is a simple 4-wire serial communications interface used by many microprocessor microcontroller peripheral chips. An SPI protocol specifies 4 signal wires, The Illustration of SPI interface is shown in Figure.

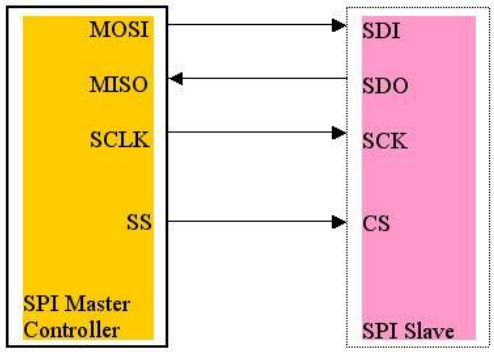
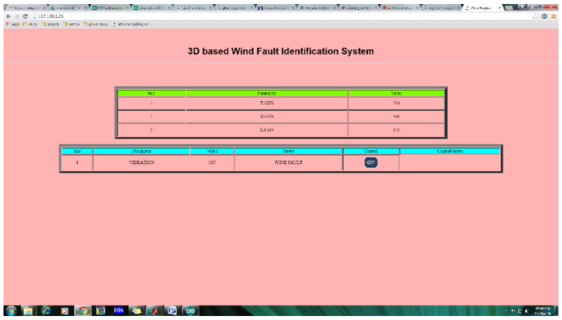


Fig-1 (Single master, single slave SPI implementation)

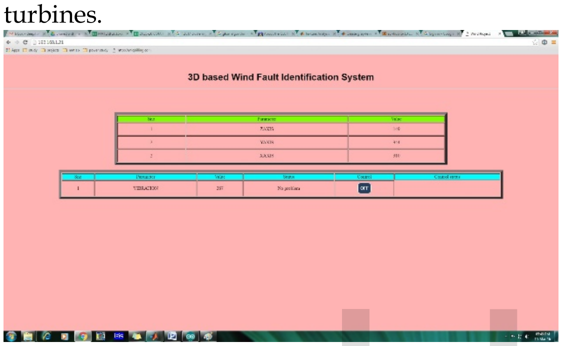
4)ARUDINO MODULE: The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable. The Uno differs from all preceding boards as it does not use the FTDI USB-to-serial driver chip. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform for a comparison with previous versions.

5)ETHERNET MODULE: Ethernet is a family of computer networking technologies for local area networks (LANs) and metropolitan area networks (MANs). The Hardware Module Communicates with the Computer Through the Ethernet interface.

SIMULATION AND OUTPUT



The Above figure shows that the control status of the Wind turbines in terms of x, y and z parameters displayed in a HTML page in comparison with the threshold values to the measured values. The output shown is fault in Wind turbines.



It shows the status of the wind turbines in working condition as comparing the values to the threshold values.

ADVANTAGES

The proposed 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 than existing Fiber optic Strain sensor.

While the functional elements of MEMS are miniaturized structures, sensors, actuators and microelectronics the most notable (and perhaps the most interesting) elements are the micro sensors and micro actuators. Micro sensors and micro actuators 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.

CONCLUSION

From the proposed technique, it concludes that it does not require any direct human access to the system. The MEMS strain sensor finally carried over by the turbine blades insists that the system processes in a good condition or whether the wind is fault. If it detects the fault, the direction of the x, y and z-axis will automatically change to the certain threshold values that is already set. The method easily makes the conclusions of the damage and the cause by simply stressing on the turbines and access to the network by the SHM System.

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