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MEMS Multi Sensor Intelligence Damage Detection for Wind Turbines

Phatangare Abhishek Machhindra[1], Phatangare Pravin Bharat[2], Pawar Tejas Dilip[3], U. V. Kute[4]
[1,2,3]*Student, Department of Electronics and Telecommunication Engineering, Amrutvahini College of Polytechnic, Sangamner, India*
[4]*Professor, Department of Electronics and Telecommunication Engineering, Amrutvahini College of Polytechnic, Sangamner, India*

***Abstract*: Maintenance and repair of wind turbine structures have become more 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 been always desirable for wind turbines. A real-time nondestructive SHM technique based on multi sensor data fusion is proposed in this paper. The objective is to critically analyze and evaluate the feasibility of the proposed technique to identify and localize damages in wind turbine blades. The structural properties of the turbine blade before and after damage are investigated through different sets of finite element method simulations. 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*: Multi sensor, Wind turbines.**

1. Introduction

The evaluation and enhancement of wind turbine performance has become an essential requirement and highly demanded task due to the use of larger turbine rotor sizes, higher tower, heights, and the increased number of the wind turbines employed in renewable energy production. Furthermore, wind turbine systems located at remote and rural areas as well as offshore system offer limited and less frequent access thus add more challenging to the condition monitoring process.

Modern embedded systems are often based on a microcontroller that is central processing units with integrated memory and/or peripheral interfaces but ordinary microprocessors using external chips for memory and peripheral interface circuit are also still common, especially in more complex systems. In either case, the processor used may be types ranging from rather general purpose to very specialized in certain class of computations, or even custom designed for the application The evaluation and enhancement of wind turbine performance has become an essential requirement and highly demanded task due to the use of larger turbine rotor sizes, higher tower heights, and the increased number of the wind turbines employed in renewable energy production. Furthermore, wind turbine systems located at remote and rural areas as well as offshore systems offer limited and less frequent access thus add more challenging to the condition monitoring process.

An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is specifically designed for a particular function. Industrial machines, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines and toys are among the myriad possible hosts of an embedded system. Embedded systems that are programmable are provided with programming interfaces, and embedded systems programming is a specialized occupational hand. A common standard class of dedicated processors is the digital signal processor. Program memory in the form of ferroelectric random access memory or read only memory is also often included on chip, as well as a AVR small amount of random access memory. The key characteristic, however, is being dedicated to handle a particular task. Since the embedded system is dedicated to specific tasks, design engineers can optimize it to reduce the size and cost of the product and increase the reliability and performance. Some embedded systems are mass-produced, benefiting from economies of scale.

Physically, embedded systems range from portable devices such as digital watches and MP3 players, to large stationary installations like traffic lights, factory controllers, and largely complex systems like hybrid vehicles. An embedded system is some combination of computer hardware and software, either fixed incapability or programmable, that is specifically designed for a particular function. Industrial machines, automobiles, medical equipment, cameras, household appliances, airplanes, vending machines and toys are among the myriad possible hosts of an embedded system. Embedded systems that are programmable are provided with programming interfaces, and embedded systems programming is a specialized occupation. Modern embedded systems are often based on a microcontroller that is central processing units with integrated memory and/or peripheral interfaces but ordinary

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the embedded system is dedicated to specific tasks, design engineers can optimize it to reduce the size and cost of the product and increase the reliability and performance. 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 3 strain distributions along the blade through multi-sensor data.

2. System design and details

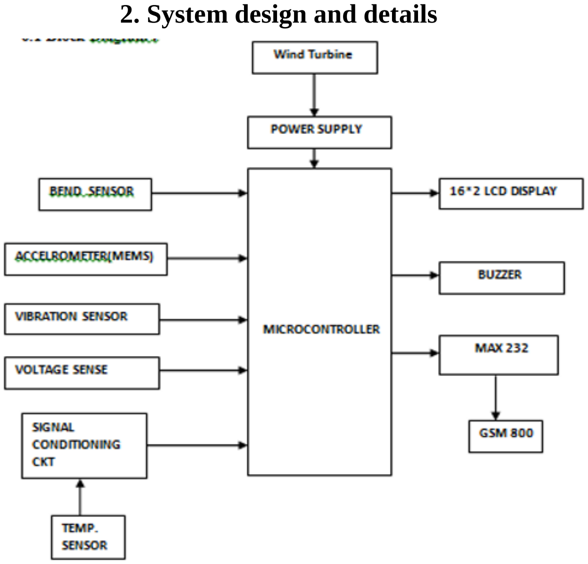

Fig. 1. Block diagram of system design

To identify and localize damage in wind turbine blades using multisensory for this, we are using components like microcontroller, sensors, wind turbine, power supply and buzzer. Here wind turbine is connected to power supply.PIC Microcontroller (18F4520) is used to perform operation. The 16*2 display is used to display temperature and also damage detection. Flex sensor is used for detection of bend in present in blade. Accelerometer345 are micro electro mechanical sensor. It checks the direction of wind turbine. The LM35 sensor are precision integrated circuit temperature sensor, whose output voltage is linearly proportional to Celsius temperature. Load cell is a transducer that is used to convert a force into electrical signal. This is used to measure the load of turbine. Here, vibration sensor 5W-18020P is used for vibration detection, when external force is acted upon either movement or vibration, the sensor two pin are closed and contact is made between the two pins. GSM is global system for mobile communication is used for sending receiving data such as message of wind turbine.

PIC Microcontroller: PIC microcontrollers are very popular and industrialists; this is only cause of wide availability, low cost, large user base & serial programming capability. In our project we are choosing a PIC18F4520 microcontroller because of its maximum speed, amount of RAM and sufficient number of I/O pins.

LCD Display: A LCD is kept so that if there is any danger and if the system finds the fault then the LCD will display “DANGER”. Buzzer-A buzzer is also used to spread alertness when the danger is detected.

GSM: The Wi-Fi modem is used to send the data to the server. Load cell-it is use to detect the weight of the system and indicate the corrosion of system.

Bend sensor: It is also called as flex sensor& detects bend in one direction.

Load cell: A load cell is a transducer that is used to convert a force into electrical signal.

Vibration sensor: It can be used in variety of vibration detection projects. To identify and localize damages in the wind turbine blades using multisensory. Initially the structural properties of the turbine blade before and after damage are investigated. This is done by different sets of finite element method simulations. Based on the obtained results, from the smart sensor we can measure the following. Strains and vibrations data, distributed over the turbine blades are detected. This can be used to assist in more accurate damage detection. A real- A load cell is a transducer that is used to convert a force into electrical signal. time non

A. PIC microcontroller (PIC 18F4520)

Fig. 2. PIC microcontroller

A microcontroller is a compact integrated circuit designed to govern a specific operation in an embedded system. A typical microcontroller includes a processor, memory and input/output (I/O) peripherals on a single chip. PIC microcontrollers are very popular and industrialists; this is only cause of wide availability, low cost, large user base & serial programming capability. In our project we are choosing a PIC18F4520 microcontroller because of its maximum speed, amount of RAM and sufficient number of I/O pins.

Features:

- Operating Frequency: DC – 40 MHZ
- Program Memory (Bytes): 32768
- Program Memory (Instructions): 16384
- Data Memory (Bytes): 1536
- Data EEPROM Memory (Bytes): 256
- Interrupt Sources: 20
- I/O Ports: Ports A, B, C, D, E
- Timers: 4

Capture/Compare/PWM Modules

B. Vibration sensor SW-18020P

Can be used in variety of vibration detection projects. The two contacts of sensor are not connected in idle condition. When external force is acted upon either my movement or vibration, the sensor's two contact pin are closed and contact is made between the two pins. When the force is removed the sensor terminals returns back to open contacts.

C. Testing with LED

Make a simple LED circuit to verify the working of Vibration sensors. Use Vibration Switch as an on-off switch. When vibration of above a threshold is present on the sensor, the LED glows while when there is no applied vibration LED does not glow.

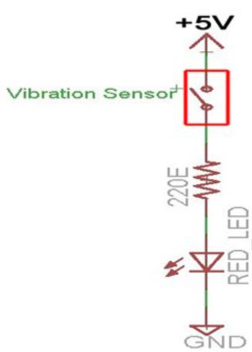

Fig. 3. Vibration sensor

D. Flex sensor (Bend Sensor)

Fig. 4. Flex sensor

Flex sensor also called as bend sensor detects bend in one direction. These sensors are easy to use, they are basically resistors that change value based on how much their flexed. If they're unflexed, the resistance is about ~10KΩ. When flexed all the way the resistance rises to ~20KΩ. Very easy to use just connect a pull up or a pull down resistor and you will get analog output which will vary according to how much they are bent. Can then be easily connected to Arduino or any other micro-controller.

E. GSM

Fig. 5. GSM

GSM (global system for mobile communications) is an open, digital cellular technology used for transmitting mobile voice and data services. GSM is a global system for mobile communication is mostly used for sending or Receiving data such as voice and message. In this security system GSM plays an important role. GSM supports voice calls and data transfer speeds of up to 9.6 kbit/s, together with the transmission of SMS (short message service).

F. Advantages

- To study of the effects of the wind turbine working conditions (i.e. blades speed, Pitch angle) on vibrations at different measuring points, generated torque, current and voltage signals of Spectra-Quest wind turbine simulator in both time and frequency domains have been investigated.
- This investigation forms a first step toward using of these parameters to diagnose the faults in various wind turbine components (i.e. blades, gears, and bearings) using multi-sensor (fusion sensors) health monitoring approach.

G. Disadvantages

- Initial cost and technology immaturity
- Wind facilities is extremely expensive
- Some Wind turbine tend to generate a lot of noise which can be unpleasant

H. Application

- Wind turbines
- Water turbines
- Monitoring the structural health of bridges, highways, and buildings.

3. Conclusion

- A new methodology to nondestructively locate and estimate the severity of damage in wind turbine blade structures has been presented. The method is based on strain field distribution analysis combined with natural frequency variation detection which provides global as well as local information on structural health condition. 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. From the simulation results, we demonstrated that the proposed technique was successful in the turbine blade damage detection under various scenarios. Another advantage of this method is that it can be implemented without the detailed knowledge of material properties or prior models and responses. One of the challenges of the technique is the ability to identify minor cracks or to differentiate the type of damages on composite structures.

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