Smart Monitoring and Controlling of Wind Farms based on WSN

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Abstract— As we know that energy is important part of our life. Energy available in different form like heat energy, solar energy, wind energy, etc. In our day to day life importance of alternative and renewable energy source increases year by year because of limited availability of non-renewable energy source. Hence it is necessary to take preventive action and increase the use of renewable energy source. Renewable energy source includes mainly solar energy, wind energy, vermin-composing, etc. For that purpose we address the issue related to renewable energy source like windmills. In this paper we present maintenance related to wind farms which consist of number of windmills using wireless technique. We used economical and flexible wireless sensors networks can be installed within a large structure to evaluate the response and performing monitoring algorithms. In this paper, wireless sensors are located on a wind mill farm to monitor the structures to present models of wind turbine.

Keywords— Wireless sensor, structural health monitoring, condition monitoring, wind turbine.

I. INTRODUCTION

The different types of renewable energy sources are available but most economical and flexible form of energy generation is winmill [1]. Now days, the burden on traditional non-renewable energy source increase and non-renewable energy source available in small quantity. on renewable energy source create pollution and produces more waste which is difficult to recycle. Renewable energy sources are clean and does not produce waste. It necessary to used renewable energy in our day to day life. At some places it replaces non-renewable energy sources by renewable energy source for electricity generation, but due to some maintenance problem it has some limitation. Hence we address maintenance problem of non-renewable energy source windmill.

In this paper maintenance is performed using wireless sensor network (WSN). wireless sensors network presented in, both hardware and software, the different factors are taking into description: the large amount of network nodes; for example on a wind mill structure approximately 50 nodes are installed to be managed by the method of addressing; large data flows, data partial or despoiled completely, preinclination to malfunction of nodes, weakness to interferences, power supply restrictions, restricted computing power, etc. multiple hops topology. Developing sensors networks is based on growth in acquisition from sensors, communications, data processing domains (data organization algorithms, hardware and software)[2].

![Fig.1 General Block diagram](image)

Fig.1 General Block diagram

Fig.1 shows general block diagram of data transmission process which illustrate the monitoring and controlling of windmill [3].

There are [3] are three monitoring including:
1. Reactive Maintenance (run to failure)
2. Preventive Maintenance (time-based)
3. Predictive Maintenance (condition-based)

The block diagram shows that windmill equipped with different sensor like temperature, voltage, speed and vibration sensor. A sensor produces analog data and this data is applied to controller which process data coming from sensor. In that,
First perform analog to digital conversion by ADC and then it applied to controller controller process that data and take necessary action and data transmitted wirelessly using LAN, WAN. Using web page of internet we accessing data is performed.

Using this technique we performed on line monitoring and controlling of wind farms. Using Unique Identification number we identify the windmill and monitor parameter to that windmill.

II. HARDWARE ENVIRONMENT
The complete system is developed around arduino microcontroller which is developed by Atmel Technologies in 2005 year to perform control action. Arduino microcontroller ATMEGA328P interfaced with different sensor like temperature sensor LM35, voltage sensor, speed sensor, vibration sensor, and relay card as well as Pentium P4 processor for web page access.

A. SENSORS
Sensor are basically transducer they convert one form signal into another form. for example electrical signal are converted into mechanical signal or movement or vice versa. Sensors gives real time signal interfacing. Windmill consist of special sensors like temperature for yoke or motor temperature LM35, IR pair for speed of rotating windmill blades or rotating shaft, voltage required by windmill and generating, vibration sensor MES sensor for sensing condition like any mining work, lighting stroke,strom, flood etc. like disaster situation. It also provide bending moment which avoids dangerous situation due to disaster. We used following different sensor:

1. Temperature Sensor: The temperature sensor is used to monitor the temperature of windmill in Degree Celsius. The 3 pin LM35 sensor is used for temperature measurement.

2. Vibration Sensor: The Vibration are measured using the MEAS sensor and the vibration sensor is measured to protect the windmill against mechanical stresses.

3. Voltage Sensor: The voltage generated by the windmill generator is directly measured from generator terminal by using potential divider.

4. Speed Sensor: The tacho principle is used for the speed measurement of the windmill. The voltage sample from the windmill is taken from the windmill and converted to speed using a lookup table which consists of voltage–speed relation.

5. Relay Card: Relay card converts electrical signal into mechanical signal and provide physical movement to windmill up down.

B. Arduino Microcontroller ATMEGA328P
Arduino is 8 bit and an open-source computer hardware and software microcontroller, user that designs and manufactures microcontroller-based kits for building digital devices and interactive objects that can sense and control objects in the physical world. The project is based on microcontroller board designs, manufactured by several vendors, using various microcontrollers. These systems provide sets of digital and analog I/O pins that can be interfaced to various expansion boards and other circuits. The boards feature serial communications interfaces, including USB on some models, for loading programs from personal computers. For programming the microcontrollers, the Arduino project provides an integrated development environment (IDE) based on the Processing project, which includes support for the C and C++ programming languages. The first Arduino was introduced in 2005, aiming to provide an inexpensive and easy way for novices and professionals to create devices that interact with their environment using sensors and actuators. Common examples of such devices intended for beginner hobbyists include simple robots, thermostats, and motion detectors. Arduino boards are available commercially in preassembled form, or as do-it-yourself kits. The hardware design specifications are openly available, allowing the Arduino boards to be manufactured by anyone.

III. SOFTWARE ENVIRONMENT
Software is divided into two parts as control system and PC remote software.

A. Microcontroller programming:
In that we programmed inbuilt ADC and microcontroller with sensor output. At initial state we defined input output port of microcontroller. Then using C or C++ language coding is performed. In this microcontroller, there is no need to generate hex file separately like 8051 microcontroller. Code directly burned into microcontroller. We used port PC0-PC4 As input port and port PD6 and PD7 as output port.
B. PC REMOTE SOFTWARE:

1. Data acquisition
Microsoft SQL Server is a relational database management system developed by Microsoft. As a database server, it is a software with the main function of storing and retrieving data as requested by other software applications which may run either on the same computer or on another computer across a network (including the Internet). Microsoft has at least a dozen different editions of Microsoft SQL Server, intended at different audiences and for workloads ranging from small single-machine applications to large Internet-facing applications with many concurrent users. SQL Server is Microsoft's relational database management system (RDBMS). It is a full-featured database primarily designed to fight against competitors Oracle Database (DB) and MySQL. Like all major RDBMS, SQL Server supports ANSI SQL, the standard SQL language. However, SQL Server also contains T-SQL, its own SQL implementation. SQL Server Management Studio (SSMS)(previously known as Enterprise Manager) is SQL Server's main interface tool, and it supports 32-bit and 64-bit environments. SQL Server is sometimes referred to as MSSQL and Microsoft SQL Server.

2. Web Application Design
A development server is a type of server that is designed to facilitate the development and testing of programs, websites, software or applications for software programmers. It provides a run-time environment, as well as all hardware/software utilities that are essential to program debugging and development. A development server is the core tier in a software development environment, where software developers test code directly. It is comprised of the essential hardware, software and other components used to deploy and test the software under development, including bulk storage, development platform tools and utilities, network access and a high-end processor. Upon testing completion, the application is moved either to a staging server or production/live server.

IV. PROPOSED SCHEME

A. Architecture

FIGURE 2 AND 3 SHOWS DIAGRAM OF PROPOSED SCHEME

B. Block diagram

Fig. 2 Diagram of proposed scheme

Fig. 3 General Block diagram of Proposed Scheme

The figure 3 shows that architectural views of the project were and the system implementation is discussed below. The main Systems to be implemented are the interface of the circuit with the arduino development board microcontroller and WSN to it. The other interface would be the retrieval of the information from the device and then system and system gives remote processing of data.

There are three main component on which system depends,
1. WSN
2. Controller
3. PC or Laptop

1. WSN
The Wireless Sensor Network is a low-cost, low-power, wireless mesh network standard. Low power-usage allows longer life with smaller batteries or renewable energy. Mesh networking provides high reliability and more extensive range.
The chip vendors typically sell integrated radios and microcontrollers with between 60 KB and 512 KB flash memory. The network operates in the industrial, scientific and medical (ISM) radio bands; 868 MHz in Europe, 915 MHz in the USA and Australia, and 2.4 GHz worldwide. Data transmission rates vary from 20 to 900 kilobits/second. The network plans support are based on layers for the first plan, generic mesh networks for the second plan with a gateway node and for the third plan is a hybrid star wireless sensors network based on RFID tags. Every network must have one gateway device, tasked with its creation, the control of its parameters and basic maintenance. Within star networks, Windmill consist of different sensors like temperature for yoke or motor temperature, IR pair for speed of rotating windmill blades or shaft, voltage required by windmill and generating, vibration sensor for sensing condition like any mining work, lighting storm, flood etc. like disaster situation. It also provide bending moment which avoids dangerous situation due to disaster. The gateway is the central node. In first and second plan the nodes can play the routers role to extend communication at the network level. The protocol in the gateway plan is the responsible for a number of tasks, which include keeping of device roles, management of requests to join a network, device discovery and security. Specially, for this application the online maintenance of the network is done very rarely since the nodes are static. A sensing node has 3 basic components: a CPU, a radio transceiver, and a sensor array. Any kind of sensor, interfaced CPU through an ADC.

2. Controller

It is heart of system it controls different parameter like temp of yoke, rpm of rotating blades, vibrations of motor, voltage used and generated. It also provides physical moment like be bending of windmill in uncertain condition. We used arduino microcontroller board.

3. PC or Laptop

It provides monitoring as well as controlling to remote terminal through web. It also provides the necessary information related to windmill or wind turbine. It also provides graphical display. PC is used for data acquisition and for web application design for user interface and for taking required control action.

The windmill are rigid structure at high height which are affected by environment condition such as wind storms, rain, snowfall for protection of windmill continuous monitoring is required. We protect the windmill by bending it at downward side using motor relay mechanism. The continuous data from windmill is taken for voltage, speed measurement by using sensors. Then using LM35 sensor senses the temperature and using MEAS sensor vibration are measured. This data is transferred to Arduino Board, act as the process controller and sends data to Pentium 4 processor which analyses data and the sort in various specified columns. This continuous data is transferred to operator has an authorize access through the web page. When abnormal condition is observed sends command for relay using Pentium 4 processor. Then to interface this software command to hardware we use LPT board which is interfacing device. The port has 25 pins out of which only 8 pins are used for data transfer and 2 control pins for relay circuit control. Then when relay receives command for operation the relay get energized and according to forward motion switch is operated, when abnormal condition occurs windmill is tilted downward and when weather is clear again windmill is recovered to its original position by moving motor in upward motion.

V. APPLICATION

- Location of any windmill could be found in all over world.
- Used for Offshore windmill monitoring and controlling.
- It is a useful for alert in emergencies in which consist of many windmill to identify which one is faulty.

Since many area which are having long coastal area facing lots of problems regarding the windmill, this system is made to identify the problem and to provide solution if needed.

VI. EXPECTED RESULTS

The trend of the actual and predicted generator bearing B temperature of Turbine. The temperature at the peak points is more than 90°C, which is above the specified upper limits for the generator bearings. Such temperature may cause damage to the bearing and can adversely affect operations of the wind
turbine; thus, the ability to predict this condition ahead of the time is desirable.

**Figure 4** Histogram of wind temperature

**Figure 5** Percentage failures of turbine components

Maintenance cost is still a major concern. Extent of maintenance, type of maintenance, and component’s age are the key factors discussed in operations and maintenance (O&M) related research and development (R&D). The maintenance cost comprises of the cost associated with scheduled maintenance, and cost associated with unscheduled maintenance. In order to better understand the maintenance related issues, fault analysis of wind turbines is essential. Gearboxes and blades are the most costly and fault prone components in the turbine, and therefore they have drawn the focus of researchers. Other fault prone components of the systems are electrical system and yaw systems. A graph showing the comparison of percentage failure is presented in Figure 5 Studies reveal that generator; turbine blades and gearbox are the critical components which contribute more than 85% of the maintenance cost as well as downtime of the whole wind energy conversion systems (WECS).

Additionally, with an aim to harvest more energy, several modifications in the turbine design has been done. Now-a-days turbine blades are about 40 meters long with the tower height being increased from 60 meters to 100 meters, whereas, rotor diameter has now increased to more than 100 meters. Modification in the tower height made the maintenance and inspection task difficult, whereas, modification in the rotor size made turbine blades more sensitive to wind speed.

**VII. CONCLUSION AND FUTURESCOPE**

The proposed monitoring and controlling system has the main possibility to reduce the damages motivated by unseen failures. The remote control is available only with help of the internet, from any place of world. With help of this technique not only monitors the structure health as well as condition monitoring. Wind power has a great possible to supply renewable energy without depend on traditional non renewable technologies. The monitoring of wind turbines informs the prevention of accidental situation due to component or structure failure.

The future steps will think on building a sample network to demonstrate its benefits. Due to its flexibility this network can be used in monitoring and control of different renewable power source farms, like solar power plants and also, for the old controversial green hydro power to monitor the dam structure. In future with internet in addition we used GPS and GSM we track the exact location of wind mill and take necessary control action on failures. Also, we increase parameter for monitoring and controlling by increase sensors.

**REFERENCES**


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