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# 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 likes 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 eeconomical 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 which is located in wind farm to monitor the structures to present models of wind turbine.

**KEYWORDS**: Wireless sensor, structural health monitoring, condition monitoring, wind turbine, supervisory control and data acquisition.

## I. INTRODUCTION

**T**he different types of renewable energy sources are available but most economical and flexible form of energy generation is windmill. Now days, burden on traditional non renewable energy source increase and non renewable energy source available in small quantity. Non renewable energy source create pollution and produces more waste which is difficult to recycle. Renewable energy sources are clean and do 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, hardware and software, the different factors are taking into consideration. Developing sensors networks is based on growth in acquisition from sensors, communications, data processing domains (data organization algorithms, hardware and software).

Figure 1 shows general block diagram of data transmission process which illustrate the monitoring and controlling of windmill [3].The block diagram shows that windmill equipped with different sensor like temperature, voltage, speed and vibration sensor.

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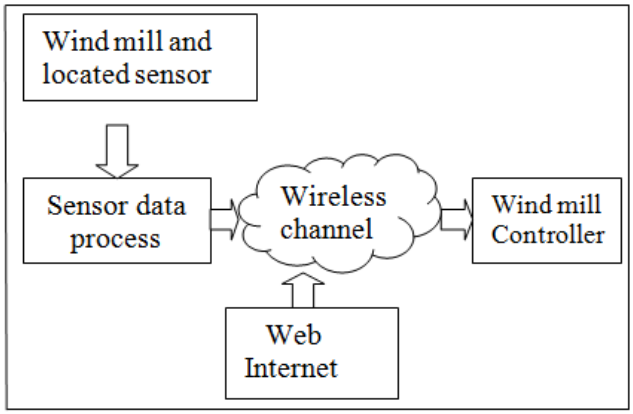


Figure 1 General Block diagram

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 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.

## II. RELATED WORK

We performed literature survey of online monitoring and controlling of wind farms. Using Unique Identification number we identify the windmill and monitor parameter to that windmill.There have been different approaches evolved for monitoring Wind farm [1], [3]. Other data acquisition technique also discuss in [2].SCADA (supervisory control and data acquisition) most reliable and fast technique. SCADA is used with neural network but it has some limitations[1].They used mathematical data analysis by calculating MSE(Mean Square Error) they calculate and defined threshold and make control chart and observed data[1].In this technique data monitoring is perform for only limited windmills. Monitoring performed for whole day and after data calculation is done and Error detected. But it is not continuous system. This technique only power is calculated and reference model was used for calculations which make confusion matrix for errors. Existing system mainly concentration only wind turbine blades,[7][9].but we concentrate on WT as well as other parameters.

This paper is organized as follow as: section II is proposed algorithm consist of WSN and SCADA which our main aspect. Hardware environment presents sensor with their interfacing, also section consist Software environment which provides interfacing of parameters. Section III shows pseudo code. Section IV gives results and VII defined conclusion and future work.

## III. PROPOSED ALGORITHM

A. *Design Considerations:*

- WSN AND SCADA

WSN is wireless sensor network in that sensors data wirelessly process monitor and control, Wireless includes internet network, GSM (Global positioning system) and Bluetooth. WSN has number of application and it is transducers which convert one quantity into another form of quantity. It is a group of spatially single and dedicated sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. WSNs measure environmental Conditions like temperature, sound, pollution levels, Humidity, wind speed and direction, pressure, etc.WSN includes thousand number of sensors node. Every sensor node is equipped with a sensor, microcomputer, and transreceiver with antenna and power source.

- 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

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temperature sensor LM35, voltage sensor, speed sensor, vibration sensor, and relay card as well as Pentium P4 processor for web page access.

1. Sensors

Sensor is basically transducer they convert one form signal into another form. For example electrical signal are converted into mechanical signal or movement or vice versa. A sensor gives real time signal interfacing.

**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 Vibrations 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. Using (Infrared) IR pair speed measurement is done.

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

2. 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 include simple robots, thermostats, and motion detectors. Arduino boards are available commercially in preassembled form, or as do-it-yourself kits.

- Software environment:

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

1. 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.

2. PC Remote software:

I. 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 RBDMS, 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.

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II. 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.

B. *Description of the Proposed Algorithm:*

Step 1: Architecture

Figure 2 and 3 shows diagram of proposed scheme.

Step 2: Block diagram

The figure3 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.

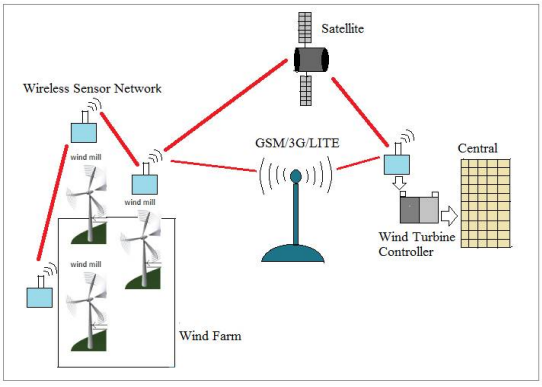


Figure 2 Diagram of proposed scheme

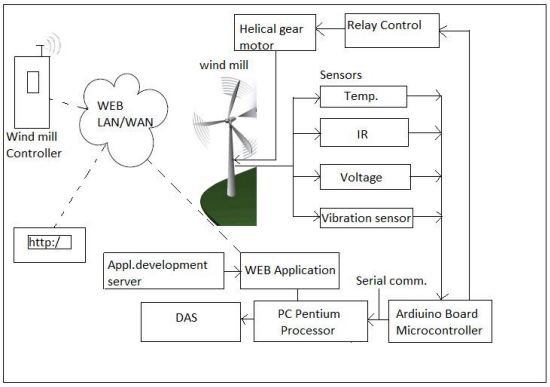


Figure 3 General Block diagram of Proposed Scheme

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 ash 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. 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 conditions. The gateway is the central node.. 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 with help of an ADC.

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2. Controller

It is heart of system it controls different parameters like temp of yoke, rpm of rotating blades, and vibrations of motor, voltage used and generated. It also provides physical movement 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 windmills are rigid structure at high height which is affected by environment condition such as windstorms, rain and 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 port which is interfacing device. The LPT 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 move downward and when weather is clear again windmill is recovered to its original position by moving motor in upward shift.

## IV. PSEUDO CODE

Monitoring Module
Step 1: Start.
Step 2: Enter the url/link.
Step 3: Enter user ID and Password.
Step 4: Monitor the screen.
Step 5: Different values will be displayed according to the status of that parameter.
Step 6: If the value goes above set point, proper control is fired.
Step 7: Stop.

## V. SIMULATION RESULTS

The results produced with our implementation are very promising. First of all we have to read the sensor values accurately. Four sensors we are used-voltage sensor, Temperature sensor, IR sensor for speed, vibration sensor. All the four are producing the results but reading these values together and placing them in proper location in database in the computer is most challenging job. We checked whether the value is varying or not. In the same way we checked value of sensors are changing continuously compare with table 1 sensor data. The values are changing in the proper textboxes only as shown in figure 6. After that we do a microcontroller programming in Arduino ATMEGA328 microcontroller. Set points are defined as per requirement and the sensor values are compared with proper set points that are shown in figure 6 and figure 5shows that windmill pop up and pop down of windmill height.

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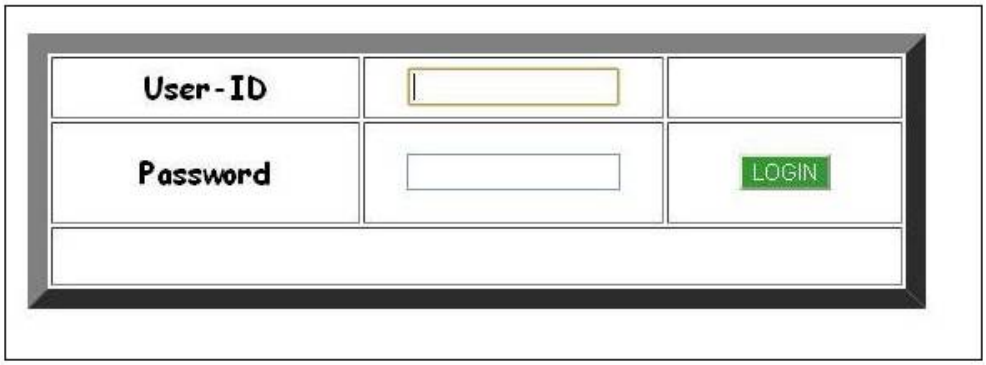


Figure 4 Web Login Form

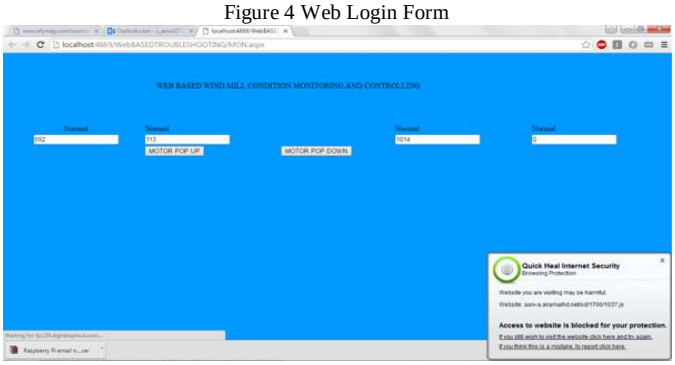


Figure 5 Control action of windmill height

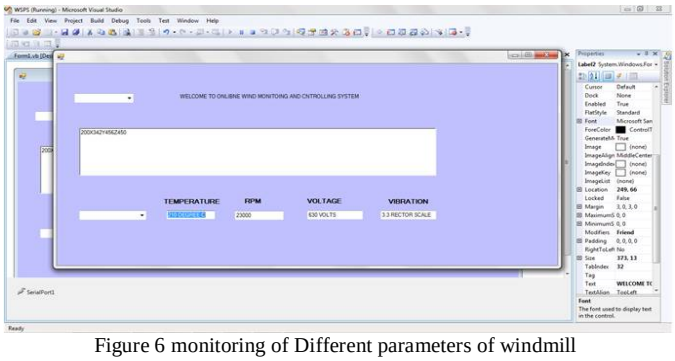


Figure 6 monitoring of Different parameters of windmill

As shown in figure 5 and figure 6 a central server on field is continuously fed with the sensor values in the database . It should be clear that for web monitoring this system is connected to the internet with any of technology. Here we are using static IP to do the server online. On web side administrator is provided with user admin authentication i.e. user-id and password which show in figure4. He can monitor any time on field using any device may be laptop or mobile phone connected to internet. All results of different sensors are accumulated in Table1.

| Sr.No. | Type of Sensor | Set point | Value read by Sensor |
|---|---|---|---|
| 1. | Voltage | 12Volt | 10Volt |
| 2. | Temperature | 40 Celsius | 37 Celsius |
| 3. | Speed | 5 Volt | 3.5Volt |
| 4. | Vibration | 500 | 300 |
| 5. | Displacement | 0 | 0 |

Table1.Sensor data

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## VI. CONCLUSION AND FUTURE WORK

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.

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## BIOGRAPHY

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