Automated defect detection and regulation in wind power plants based on CAN Network

M.Mohanraj[1], S.Nandini[2], Dr. Rani Thottungal[3]

Abstract— **Wind energy has emerged as one of the most important and economical renewable energy source. The generated electricity is from the air currents flowing across the earth's surface. Today, electricity generating wind turbines employ proven and approved technology, and provide a sheltered and reliable energy supply. Wind Turbines are located in remote areas mostly, where there are rigid environmental conditions. There is a great obligation to monitor the turbines to detect impending failures. This paper aims at monitoring the wind turbine parameters and intimation at the impending failure conditions. Wind turbine monitoring system collects the parameters such as Speed, Temperature, vibration, voltage and current from the essential components of turbines such as shaft, gear box, generator and nacelle by using respective sensors. The data are periodically updated to the control center. Depending on the data that has been collected from the monitoring system, manipulations are done and the fault control system makes the decision of location and the type of fault that has occurred in the wind turbine. In case of any abnormal conditions, we can automatically shutdown the turbine for a period of time, till the parameters become normal. We use CAN Network to communicate between the Wind turbine and the control center . PIC Mictrocontroller is used for monitoring and control operations and it uses a master-slave configuration.The GSM Module is used to intimate the owner with an SMS when abnormal conditions occur and indicate the fault type.**

Index terms—CAN protocol,GSM, PIC Microcontroller, Sensors, Wind turbine.

I. INTRODUCTION

Wind energy has undergone a remarkable expansion in modern times. As wind farms are aging, their operations and maintenance issues are gaining significance. The wind industry has been affected by failures in the main components of the wind turbine, such as main bearings, gearboxes, and generators. Electrical control, gearbox, yaw system, generator, hydraulic, grid and blades are considered as the most common failure components of wind turbines[1]. These operations provide high cost on emergency maintenance, component testing, physical designs and so on. High cost in replacing the components that have failed directly affect the energy cost.

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So, research in fault identification and condition monitoring is very much needed. Fault identification deals with with a fault which has occurred and identification of the type of fault. In monitoring system, parameters reflecting the component conditions are identified with the use of sensors and their changes are analyzed to detect an impending failure [2]. The major economical aspect that will be treated is the development of a cost/benefit analysis for the use of sensors as an efficient health monitoring system. Wind turbine monitoring system collects the parameters such as Speed, Temperature, vibration, power, voltage and current from the main components of turbines such as shaft, gear box, generator and nacelle .Depending on the collected data from the monitoring system analysis is done and the fault diagnosis system makes the decision of location and the type of fault to be occurs in the wind turbine. CAN(Controller Area Network) bus is one the Field bus control system used in automation, intelligence and networking. We use CAN to communicate between the Wind turbine and the control center and control the turbine automatically during failure conditions.

II. FAULT DETECTION IN WIND TURBINE

Fault is defined as the conclusion of an object,without completing its task. When some failure occurs in the wind turbine,such as high oil temperature in gearbox, the control unit interprets the failure and identifies the consequences of the fault, and responds according to the type of the flaw. Sometimes, in order to avoid dangerous catastrophes or main system failures, the turbine has to be shut down.

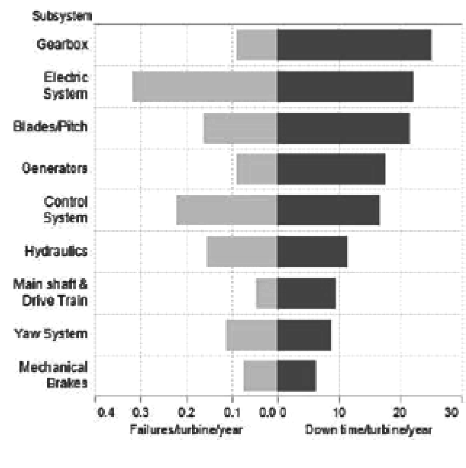

Fig. 1 Typical Faults in various Wind Turbine Parts

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They are frequently restarted due of wrong failure detection, which could be originated by noise within the system, and therefore these faults are not considered as crucial problems[2]. The proposed system helps to identify the flaw that has occurred and also control the wind turbine based on the identification.

A. SCADA Based Monitoring System

A Supervisory Control And Data Acquisition (SCADA) -data based wind turbine monitoring system utilises the parameters which have been collected priorly gathered at the wind turbine controller. SCADA data caters data collected by continuous time observations, which can be accomplished for complete turbine operation monitoring[3]. With relevant methodologies, performance monitoring can be sophisticated into individual component fault segregation schemes.

B. Disadvantages of the Centralized SCADA

Communication between different computers in the network is not apparent , resulting in disposition problems. Data processing and directories have to be imitated across all computers in the system, resulting in low efficiencies. There is no regularized approach to collection of data from the plant locations– if two operations require the same data, the central system is inquired twice. With number of sensors, there will be lot of wires to be contracted. The operations are also affected by slow data rate.

III. CAN BASED MONITORING SYSTEM

CAN (Controller Area Network) bus is a network protocol which is used for communication between the microcontrollers or any other devices without the intervention of any master/central computer. CAN is basically designed for automobile applications but in the present scenario, it finds broad range of applications in automation, mobile machines, military and even harsh environment monitoring application. The bus does not influence any address between the transmitter and the receiver elements. In preference,it holds the unique identifier which is a numeric value used to tag the respective message throughout the network.

The devices that are connected by a CAN network are typically sensors, actuators, and other control devices. These devices are connected to the bus through a host processor, a CAN controller, and a CAN transceiver. CAN data transmission uses a lossless bit-wise arbitration method of contention resolution. This arbitration method requires all nodes on the CAN network to be synchronized to sample every bit on the CAN network at the same time. CAN Bus is used to communicate between the Wind turbine and the control center and control the turbine automatically during failure conditions [4].

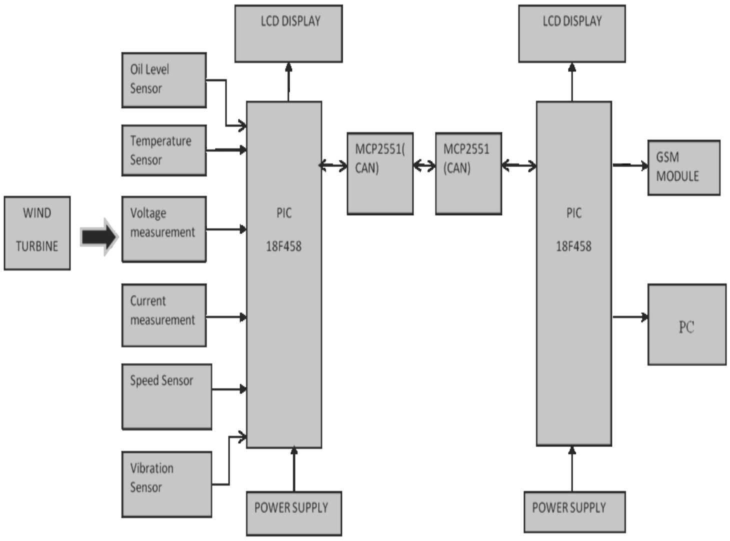

Fig. 2 Block Diagram of Proposed System

A. PIC 18F458

PIC 18F458 is an 8-bit microcontroller which has a performance capability of 10 MIPS.It has 8 channel,10-bit resolution Analog to Digital Converter (ADC).It has a built-in CAN Module within itself. PIC 18F458 controller1 is placed at the wind turbine unit.It collects the data from the corresponding sensors. PIC 18F458 controller 2 is placed at the control station.CAN Network is used for communication between them. For every particular amount of time, microcontroller preprocesses the sensed data and it will update the parameter values to the central database.

B. CAN MCP 2551

The MCP2551 is a high-speed CAN, fault-tolerant device that obliges as the ally between a CAN protocol controller and the physical bus. The MCP2551 device administers differential transmit and receive competence for the CAN protocol controller, and is fully complies with the ISO-11898 standard, including 24V requirements. It will act at speeds of up to 1 Mb/s. CAN controller is used to transfer data between the wind turbine unit and the control unit. CAN transceiver is utilized to alter the voltage levels of the microcontroller to those standardised for the CAN bus[4].

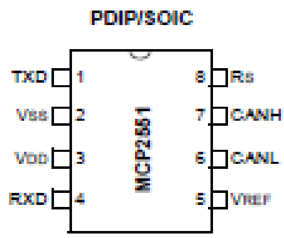

Fig. 3 Pin Diagram of MCP 2551

C. GSM Module AND PC

The GSM Module(SIM300) is used to provide information about the conditions prevailing in the turbine to the keeper.It

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sends SMS to the keeper in case of any abnormal situations. It has been built up with a standard RS232 interface which can be used to conveniently interface the modem to micro controllers and computers..This is a plug and play GSM Modem with a simple to interface serial interface. We accomplishes tasks like sending SMS, make and receive calls, and perform other GSM operations by controlling it through simple AT commands from micro controllers and computers. The parameters which have been manipulatedd can be displayed in the PC placed at the control center and these real time values can also be sketched against time.

D. Sensors Unit

Temperature Sensor

The LM35 series are high precision integrated-circuit temperature sensors, which afford output voltage that are linearly proportional to the Celsius (Centigrade) temperature scale. The LM35 does not require any apparent calibration to contribute suggestive accuracies of ±1⁄4˚C at room temperature and ±3⁄4˚C over a full −55 to +150˚C temperature range. Low cost is guaranteed by precision and calibration from the bottom level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. The LM35 is graded to operate over a −55˚ to +150˚C temperature scope.

Vibration Sensor

The Vibration is measured with the help of piezoelectric sensor .A piezoelectric sensor is a device that uses the piezoelectric effect, to measure changes in pressure, acceleration, strain or force by converting them to an electrical charge. Piezoelectric technology is unresponsive to electromagnetic fields and radiation, enabling measurements under severe conditions. Whenever a structure moves, it experiences acceleration. A piezoelectric sensor, in turn, can produce a charge when physically accelerated. This combination of properties is then used to modify the response or reduce noise and vibration, which can be employed in monitoring vibration effect in the turbine.

Oil Level Sensor

Level sensors recognize the level of elements that flow, such as, liquids, slurries, granular materials, and chalky substances . The fluid to be measured can be placed inside a tub or can be in its characteristic form. Continuous level sensors manipulate levels within a desired range and calculate the definite amount of substance in an area of consideration, whereas point-level sensors only pointout whether the substance is above or below the point of reference. Ultrasonic level sensors are utilized for non-contact level sensing of highly viscous liquids, as well as bulk solids. They are also broadly used in water treatment functions such as pump control and open channel flow measurement. The sensors exude high frequency (20 kHz to 200 kHz) acoustic waves that are reflected back to and observed by the emitting transducer.

Speed Sensor

The speed/RPM sensors are built,based on various determining principles – Hall effect, magneto resistive, inductive – to detect without getting ahold of the rotary movement of phonic or toothed wheels and usually of any rotative device fabricated in a ferrous material and provided with slots or obstrusive parts. They provide a frequency output signal which is digital in nature – for the Hall effect or magnetoresistive versions – or a sinusoidal signal – for the inductive versions – that pursue exactly the alternating sequence of presence and absence of ferrous material presented by the rotative device.

D. Flow Of Operation

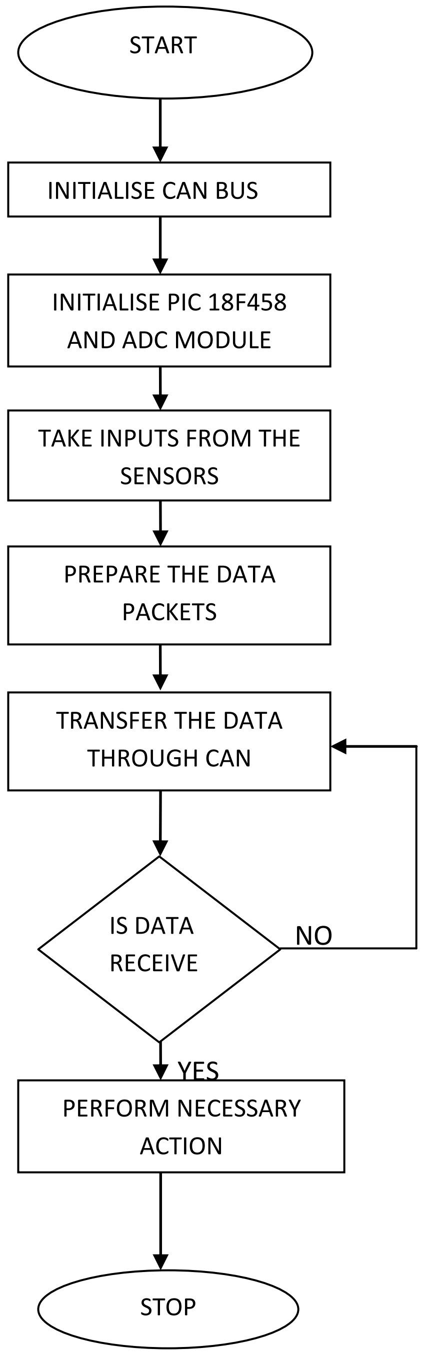

Fig. 4 Flow of Operation

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IV. PROTEUS SIMULATION RESULTS

A. Overall Simulation Circuit

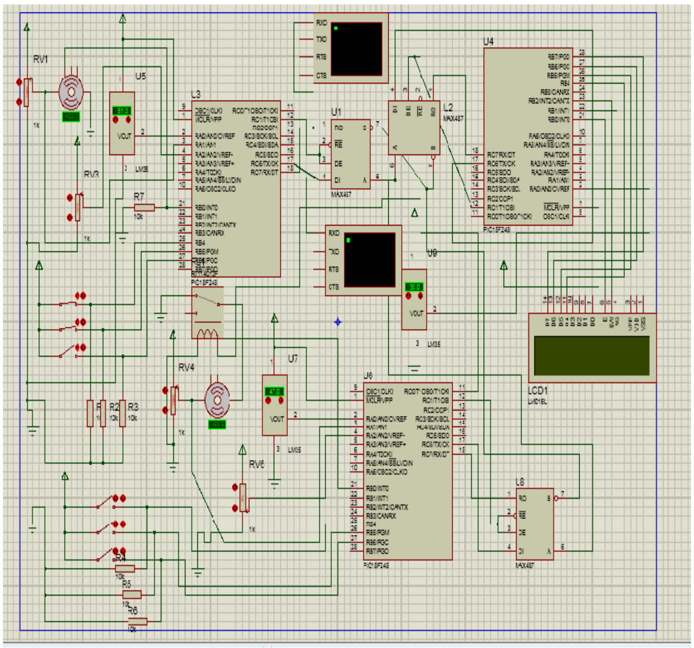

Fig. 5 Overall Simulation Circuit

The proposed system has been modelled using Proteus 8 Software.Here we have configured the system such that there are two wind turbines, which have been integrated.The microcontrollers placed at the wind turbines monitoring units act in slave modes and the microcontroller placed in the control end is said to act in master mode.It has been shown in Figure 5.

B. Data Received From Slave 1

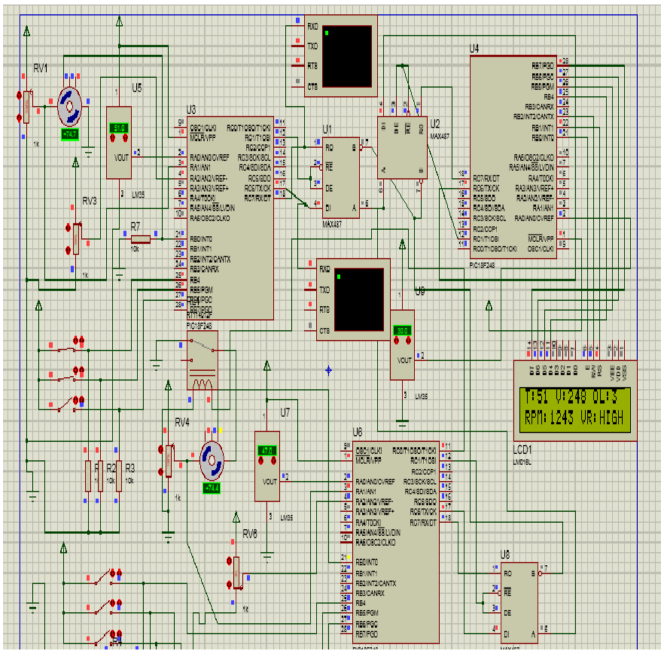

Fig. 6 Data from slave 1

The Figure 6 shows the data received from the wind turbine 1.

C. Data Received From Slave 2

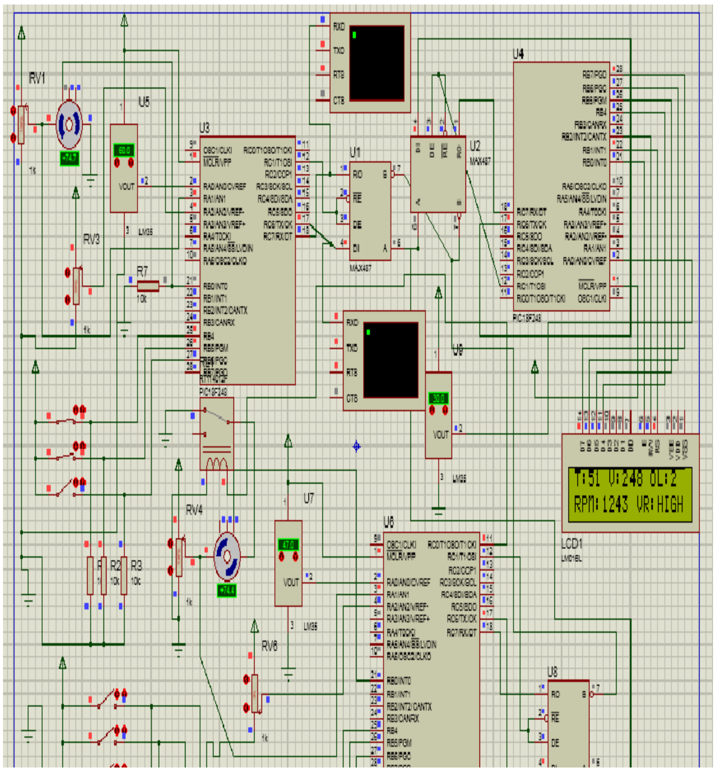

Fig. 7 Data from slave 2

The Figure 7 shows the data received from the wind turbine 2.

D. Virtual Terminal

The data communication between the master and slave microcontrollers can be viewed using the Virtual Terminal option.

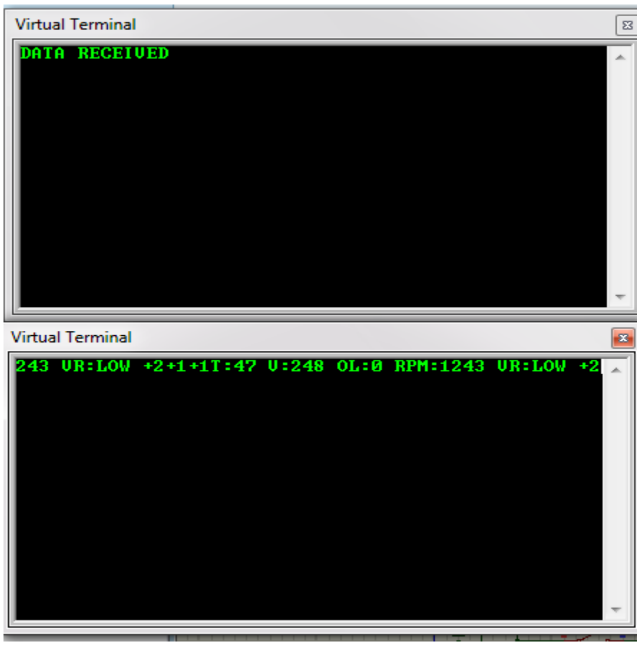

Fig. 8 Virtual Terminal-Turbine1

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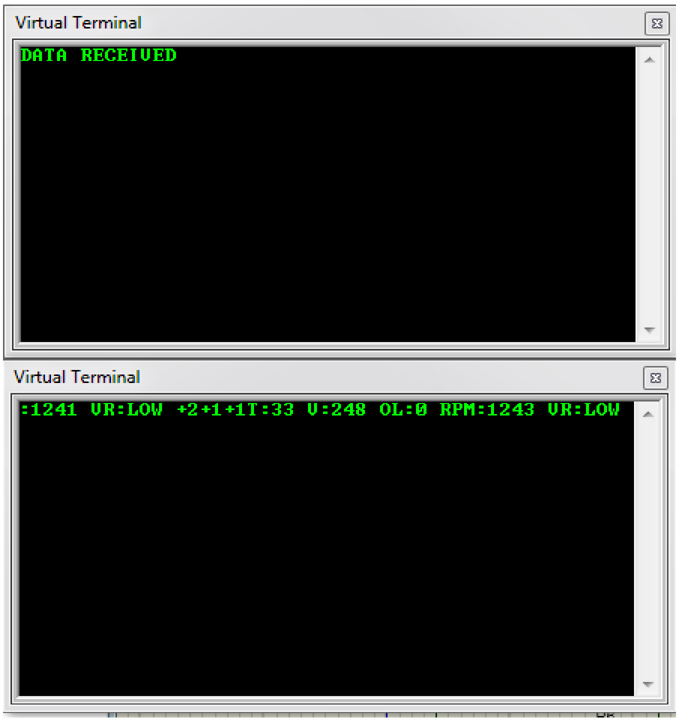

Fig. 8 Virtual Terminal-Turbine2

V. CONCLUSION AND FUTURE SCOPE

The proposed system enables the monitoring and prevention of abnormalities such as higher vibration, rise in temperature, higher speed as well as lesser lubrication of the Wind Turbine using the developed methodology to avoid failure of the turbines. The software used provides a friendly graphical interface.Simulation results give us a virtual view of the actual operations of the discussed system.This provides a simple, convenient, time saving and secure system for Wind Turbine.

REFERENCES

[1] Wang chuhang Network Center of ChanchunNormal University, Remote Monitoring and Diagnosis System for Wind Turbine.
[2] FU Zhixin and Yuan Yue(2012), ‘Condition Health Monitoring of Offshore Wind Turbine based on Wireless Sensor Network’ IEEE Transaction and IPEC.
[3] K. Kim, G. Parthasarathy, O. Uluyol and W. Foslien, l, S. Sheng and P. Fleming,’ Use of SCADA Data for Failure
[4] Detection in Wind Turbines’, 2011 Energy Sustainability Conference and Fuel Cell Conference.
[5] Mohanraj.M ,Dr.RaniThottungal, Jaikumar K(2013), ‘A CAN Bus based system for monitoring and fault diagnosis in Wind Turbine’, IEEE Xplore
[6] Analytical techniques for performance monitoring of modern wind turbines,20 12EWEA, Copenhagen.
[7] Arnt Ove Eggen,Olav Rommetveit,Andre Reitlo,Einer.O.Mitbo, ‘Handbook on Conition Monitoring of Wind Turbines’.
[8] R. W. Hyers, J. G. McGowan, K. L. Sullivan, J. F. Manwell and B. C. Syrett, ‘Condition monitoring and prognosis of utilityscale wind turbines’

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