

Design of Monitoring System and Fault Diagnosis in Wind Turbine Based On Can Bus Using ARM

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ABSTRACT: Wind energy is the most widely used natural resource for the production of electrical energy. Presently wind energy is used to reduce the emission of carbon dioxide. During the transmission of data from one node to another, node disturbance occurs. To avoid these disturbances, to monitor and to detect the fault, CAN protocol is used. CAN is a Message based protocol designed especially for Automotive, later Aerospace, Industrial automation and Medical equipment's. CAN interfacemodule is used to communicate the monitored parameters between the wind turbine and the control centre.

Earlier, the vibration analysis, vibration signals produced by the rotating components in Wind Turbine's whose current health conditions need to be diagnosed are commonly analyzed either by broad band based methods or spectral line analysis methods. In our paper we declare the system with ARM and CAN protocol to monitor and diagnose the problems in the wind turbine application. The project deals with the data transmission between two units in the exact time without any disturbance. The data transmission time is increased with the CAN protocol. ARM core1 runs with CAN and LPC2148 as wind turbine unit to which sensors are connected and ARM core2 as Fault diagnose and monitoring section. Data acquisition node collects the sensor data through CAN protocol. The basic view of this technique is to reduce the possibility of fault diagnosis and increase the monitoring of wind turbine.

Index Terms - Wind turbine, ARM processor, monitoring parameters, Controller Area Network, Fault Diagnosis.

I. INTRODUCTION

Wind turbine is a rotating mechanical device that converts wind energy into mechanical energy resulting in the production of electricity. Wind turbines are fault prone, that is they are deployed in harsh environment such as desert, plains apart from that they are complex electromechanical system that are located far away from the control center. So the chance of fault occurrence and the side effects will be more, even it leads to power off. It is necessary to develop the remote monitoring and fault diagnosis system to monitor the run time status and the diagnosis of fault to improve the efficiency and the life time service of the wind turbine.

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. This analysis is uploaded to the mobile web server and an SMS is sent if there is chance of fault occurrence.

The advantage of using CAN bus in the automation is an added value to the system and increase its reliability. The purpose of using CAN bus is to enable any system to communicate with other system without putting too much load to the main controller. CAN bus is a fast serial bus with the speed of 1 Mbps that is designed to provide an efficient, reliable and economical link between various CAN systems, sensors and actuators. We use CAN to communicate between the Wind turbine and the control center which adopts client/server frame works to implement the monitoring and fault diagnosis system.

II. RELATED WORK

Maintenance activities for WT's can be broadly classified into two categories namely corrective maintenance and preventive maintenance. Corrective maintenance is carried out after a failure event whereas preventive maintenance is done before the occurrence of a potential failure (Nielsen and Sorensen, 2010). Preventive maintenance can be further classified into scheduled maintenance and condition based maintenance (CBM). Scheduled maintenance is carried out as per on fixed scheduled times and it can be done in as minor and major scheduled maintenances. Some examples of minor scheduled maintenance in WT's include change of filters, lubrication etc. (Nilsson and Bertling, 2007).

CBM is a form of preventive maintenance that involves continuous health monitoring of a WT unit. Currently the most common practice of maintenance activities in wind farms is scheduled maintenance. However with latest developments in the field of sensing and signal processing techniques, CBM has been gradually adopted into maintenance decision making of wind farms (Byon, Perez, Ntamo, and Ding, 2010). In CBM, condition monitoring systems are installed on different system components, such as gearbox, bearing, drive train and generators, to record various sensory signals in order to determine physical states of these components. Different types of sensory signals can be used for condition monitoring purposes, such as vibration and electrical signals. Usually CBM in WT's can be executed based upon vibration monitoring (Shi, Wang, Zhuo, and Liu, 2010, Gebrael, Lawley, and Liu, 2002, Randall, 2011, Randall and Antoni, 2011, McFadden and Smith, 1984, Antoni, 2002, Harris, 2001, Lebold, McClintic, Campbell, Byington, and Maynard, 2000), oil analysis (Lu and Chu, 2010), or electrical signature analysis (Yang, Tavner, and Wilkinson, 2008). With the help of WT health information provided by condition monitoring systems, optimal OandM planning strategies can be ascertained to prevent system failures and improve turbine availability.

Research on real-time failure diagnosis which interprets data acquired by smart sensors and utilizes these data streams in making critical decisions provides significant advancements so that early awareness of the WT health condition before unexpected failures are developed becomes possible (Tamilselvan, Wang and Jayaraman, 2012; Tamilselvan and Wang, 2012; Tamilselvan and Wang, 2013; Byon et al., 2010). Among many others, vibration-based health monitoring system that detects the faults of WT components based on the vibration signals produced by the rotating components during operation is one of the most vastly used mechanisms for WT condition monitoring. Although effective health diagnosis of WT's provides various benefits, such as improved reliability and reduced costs for turbine maintenance, analysis of massive heterogeneous vibration signals leading to accurate detection of failures of WT components in an early stage remains as a challenge problem.

FAULT DETECTION METHODOLOGIES

The most common faults that can occur within the system and the current methodology for the inspection:

1. Negative sequence over current fault Protection

Rotor thermal protection of directly connected wind turbines is provided through monitoring of negative sequence current, which is a significant contributor to the rotor heating to ensure it does not increase above the generator's capability limits. The scheme provides a negative sequence over current element that can be configured to trip instantaneous upon reaching predefined levels of negative sequence current or have delayed tripping.

2. Abnormal voltage fault Protection

Over voltage and under voltage elements are provided to ensure that the generator is providing power at nominal voltage levels as well as to isolate the generator when system instabilities are causing the abnormal voltages to be induced upon the generator.

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3. Voltage unbalance fault Protection

The scheme has a definite time voltage unbalance function, operating on the ratio between negative and positive sequence voltage. The voltage unbalance elements can be used to protect directly connected turbines from excessive unbalance voltage and associated unbalanced currents that lead to damaging rotor heating. For electronically regulated wind turbines, the voltage unbalance element can act as a back up protection for malfunctioning voltage regulators in the turbine.

4. Over current fault Protection

Instantaneous and time over current functions are available for phase neutral, ground and negative sequence currents. The phase time over current elements have a voltage restrained feature that when enabled can be used for providing more sensitivity under conditions that cause the measured voltage to drop to below nominal levels.

5. Directional current fault Protection

Directional elements are provided to detect the direction of current flow and supervise or block the operation of overcurrent elements thereby allowing for proper coordination between internal and external faults. Directional overcurrent elements are available for phase, neutral and ground currents.

6. Reverse Power fault Protection

The directional power element detects reverse power conditions on directly connected wind turbines thereby preventing cases of generator motoring and associated turbine damage. Two levels of settings are available providing differentiation between low forward power and reverse power conditions.

PROBLEM STATEMENT

The system is automatically monitored and it avoids the automatic power off system and also gives indication before any weather condition is changed and it will send the SMS to the control section using ARM LPC2148 microprocessor.

In our paper we declare the system with ARM and CAN protocol to monitor and diagnose the problems in the wind turbine application. The project deals with the data transmission between two units in the exact time without any disturbance. The data transmission time is increased with the CAN protocol. ARM core1 runs with CAN and LPC2148 as wind turbine unit to which sensors are connected and ARM core2 as Fault diagnose and monitoring section. Data acquisition node collects the sensor data through CAN protocol. The basic view of this technique is to reduce the possibility of fault diagnosis and increase the monitoring of wind turbine.

III. SYSTEM HARDWARE DESIGN

The system consists of microcontroller, GPRS module, CAN controller, and parameters of wind turbine. Microcontroller is the key element in processing module which keeps on monitoring the wind turbine parameters. The block diagram of processing module is shown in Figure. 1.

CAN controller is used to communicate between the wind turbine and the database. For every particular amount of time, microcontroller pre-processes the sensed data and it will update the parameter values to the central database via GPRS module. Memory module is also provided for future references. RS232 is used for serial communication between the Simulink and the CAN Bus.

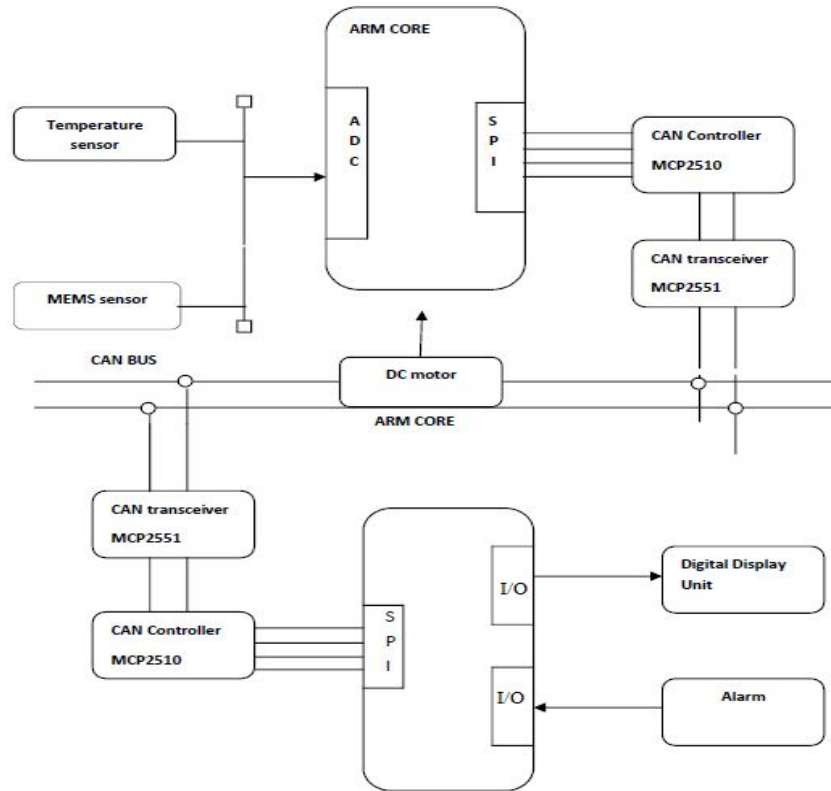


Figure 1. System Design Of Wind Turbine Monitoring And Fault Diagnosing

IV. CAN INTERFACE MODULE

A CAN bus automotive electronic control system, each controller through the CAN bus interconnected together to exchange information (such as speed, engine speed, etc). This mutual connection to the benefits of the sensor signal can be used for many controllers at the same time, and all controllers have the same information. The other hand, this connection can be increased throughout the system the new node, the development of updated features, and lower system cost. Electronic automotive instrument cluster node can fully reflect the car factor, product design and technical standards. Intelligent sensor nodes to accurately receive various types of sensor signals, at the same time to eliminate interference signals. Auto clock node for the entire system to provide the clock information.

NODE DESIGN

Each CAN node by the power supply circuit, a microcontroller, CAN controller, CAN transceiver (CAN Controller Interface), the watchdog reset circuit and peripheral circuits and other system hardware block diagram (electronic automotive instrument cluster nodes, for example) shown in Figure 2.

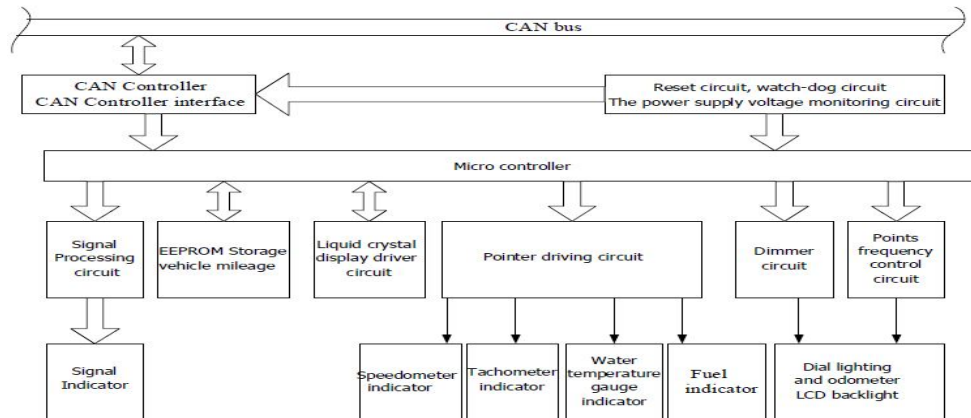


Figure2. Electronic Automotive Instrument Cluster Nodes

CAN interface module is used to communicate the monitored parameters between the wind turbine and the control centre. The CAN interface module consists of three components CAN Transceiver (MCP 2551), CAN Controller (MCP 2510), ARM LPC2148.

The MCP2551 is a high-speed CAN, fault-tolerant device that serves as the interface between a CAN protocol controller and the physical bus. The MCP2551 provides differential transmit and receive capability for the CAN protocol controller. It will operate at speeds of up to 1 Mb/s. MCP 2510 has two mode of operation: basic CAN which is a default mode and PeliCAN. CAN transceiver is required to shift the voltage levels of the microcontroller to those appropriate for the CAN bus. This will help to create the differential signal CAN High and CAN Low which are needed in CAN bus. This device must be able to withstand voltage tolerance which maybe caused by noise pickup.

Temperature sensor used here is Transformer probe which is used to monitor in low voltage transformer's windings. MEMS DC accelerometer is used to measure static, as well as dynamic acceleration. The DC-response device, it can handle static acceleration and produce accurate velocity and displacement data.

V. SOFTWARE REQUIREMENTS

Software and language used for programming the ARM microprocessor are shown below. The circuit design can be simulated using the Orcad software for the corresponding signal response of wind turbine.

KEIL IDE

We use KEIL uvision3 software for programming the LPC2148 microprocessor. The software solves the complex problems facing embedded software developers. While starting a new project, first we have to select the microprocessor, that we are going to use for our project from the device database and the μ Vision IDE sets all compiler, assembler, linker, and memory options.

FLASH MAGIC

Flash Magic is a PC tool for programming Flash based microcontrollers/microprocessors from NXP using a serial or Ethernet Protocol while in target hardware. The use of flash magic is to download the .hex file to the ARM processor.

MATLAB

MATLAB Simulink is a block library tool for modelling, simulating and analyzing dynamic systems. It supports linear and non-linear systems, modelled in continuous time; sample time is a hybrid of the two. The fault parameters such as voltage and current which are generated from the wind turbine is simulated using Simulink model. The figure 3 shows the MATLAB output of parameter measurement such as current, voltage, speed, pitch, power.

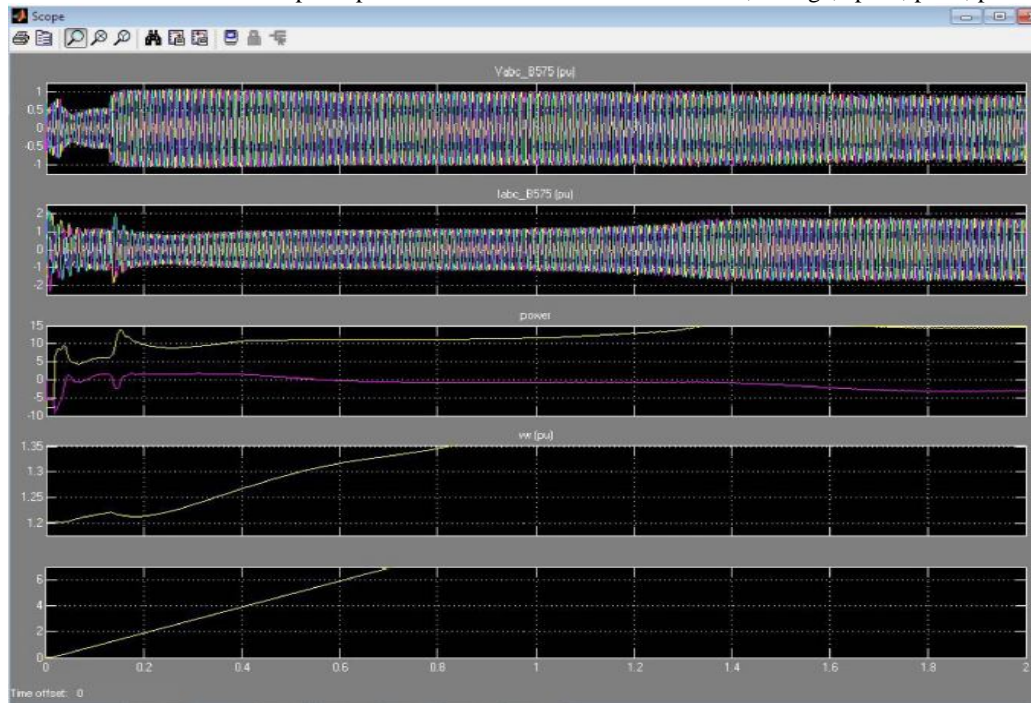


Fig. 3 MATLAB Output of monitoring the parameters

VI. CONCLUSION

The location and the type of faults are analysed before they occur and are transmitted from wind turbine to the control center through CAN bus. The fault identification is done using MATLAB and the parameters are measured through the CAN interface module. The monitored data is analysed using the neural network. The system scalability and flexibility to increase the number of nodes on the CAN bus and flexibility to increase or decrease the number of nodes on the CAN bus can be done accordingly. The CAN protocol which is used for serial communication provides high data transmission rate and reliability.

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