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A CAN Bus Based System for Monitoring and Fault Diagnosis in Wind Turbine

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ABSTRACT:

Electrical energy can be produced using fossil fuels and also by natural resources. The production of electrical energy using fossil fuels is costlier when compared to natural resources. Solar, wind, thermal and tidal energy are most widely used natural resources for the production of electrical energy.

Presently wind energy is most widely used natural resources which could reduce the emission of carbon dioxide. The cost of the wind turbine is extremely higher and work in harsh and unattended environment. Hence the monitoring and the automation of wind turbine are necessary. This paper describes the monitoring and fault diagnosis system for wind turbine using CAN interface.

1. INTRODUCTION:

The wind power industry has experienced large growth in the past years. The growth mainly focuses on a growing market, wind power's better economic conditions (because of political decisions), and the development of large wind turbines and offshore farms. One of the goals is to increase reliability for turbines. The issue is even more important for offshore farms, where service is difficult and expensive. The industry has incentive to make maintenance more efficient.

In whatever way, Wind turbines are fault prone, that is they are given in harsh environment such as desert, plains apart from that they are difficult electromechanical system that are situated far away from the control centre. So the chance of fault happens and the side cause will be more, even it leads to power off. It is important to develop the remote controlling and defect diagnosis system to monitor the run time status and the identification of fault to improve the effort and the life time service of the wind turbine

Wind turbine monitoring systems could be the answer for better wind power industry maintenance management and increased reliability. Such systems are commonly used in other industries. This System continuously monitors the performance of wind turbine parts, e.g., temperature, weather, and transformer, and helps determine the optimal time for specific maintenance. This paper investigates these systems' support for the wind power user.The Health Monitoring of wind turbines, with the aim of diagnosing degradation in different structural parts in wind turbines, has seen its relevance boosted in the operation and maintenance plans for wind turbine industry. As a consequence many researchers are studying the relationship between structural deterioration and the change in different structural dynamics properties associated to some resonances.

In this context, wind turbine manufacturers are clearly increasing efforts in wind farm maintenance in order to achieve more robust and reliable wind turbines under any condition and under any operating regime. Needless to say, this requisite is even more demanding in offshore sites where the maintenance operations are challenging practices involving, in many cases, logistics or access difficulties. A defect is detected, the less impact it has in the wind turbine OPEX (operation expenditure) rate. Therefore, any tool devoted to the task of predicting a relevant structural change at early stage contributes to improve the market competitiveness for a particular wind turbine.

This paper provides an open-source literature survey on the emerging science of early detection of warranty and reliability issues - a topic that is becoming critical to product life management for the automotive, aerospace and energy industries [1]. an open-source literature survey from a variety of disciplines like reliability engineering, operations research, prognostic-health management, systems engineering, biostatistics, public health and epidemiology.

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These are areas that have seen significant recent research activity in the development of early warning systems and algorithms. This paper provides an overview of current and promising techniques with a focus on their underlying statistical theory and related system architecture issues. The concept of the project is to develop a system used to diagnose the fault and monitor the parameters in wind turbine. The project is a special one considering fact that we can monitor parameters and diagnose the fault in a wind turbine from the control station, this project is based on a CAN protocol (i.e. message based protocol). CAN connects the wind turbine with the control station using wires. This system requires minimal power and provides reliable delivery of data between wind turbine and control station.

2. SYSTEM ARCHITECTURAL OVERVIEW:

The overall block diagram of proposed system, An CAN bus based system for monitoring and fault diagnosis in wind turbine. This block diagram consists of two types of sensors, RPM counter, Microcontroller block, CAN, GLCD modules. The two types of sensors include temperature sensor, MEMS sensor. The inputs from the sensors are given to the ADC pins of LPC2148. Here the signals are converted into digital signals through analog to digital converter. These signals are sent to the serial communication block (SPI) where the input data is sent bit by bit manner. The serial communication block is connected to CAN controller module. The output signals of CAN controller are given to CAN transceiver module where the signal are converted into CANL and CANH i.e. data can be placed on CAN bus. These bus signals can be read by LPC2148 of Receiver. The receiver part is having GLCD for display purpose, Fan for temperature control purpose and toy car for fire. The sensor readings are collected and displays on the GLCD. Whenever the values of sensor exceed the threshold limit, corresponding action can be takes place and message is displayed on to the screen

A)Temperature sensor (LM35):

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Fahrenheit temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in degrees Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Fahrenheit scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1/2°F at room temperature and ±11/2°F over a full -50 to +300°F temperature range.

B) MEMS technology:

Micro Electro Mechanical Systems or MEMS is a term coined around 1989 by Prof. R. Howe and others to describe an emerging research field, where mechanical elements, like cantilevers or membranes, had been manufactured at a scale more akin to microelectronics circuit than to lathe machining. It appears that these devices share the presence of features below 100m that are not machined using standard machining but using other techniques globally called micro-fabrication technology. Of course, this simple definition would also include microelectronics, but there is a characteristic that electronic circuits do not share with MEMS.

While electronic circuits are inherently solid and compact structures, MEMS have holes, cavity, channels, cantilevers, membranes, etc, and, in some way, imitate 'mechanical' parts. The emphasis on MEMS based on silicon is clearly a result of the vast knowledge on silicon material and on silicon based micro fabrication gained by decades of research in microelectronics. And again, even when MEMS are based on silicon, microelectronics process needs to be adapted to cater for thicker layer deposition, deeper etching and to introduce special steps to free the mechanical structures. MEMS needs a completely different set of mind, where next to electronics, mechanical and material knowledge plays a fundamental role. Then, many more MEMS are not based on silicon and can be manufactured in polymer, in glass, in quartz or even in metals... The development of a MEMS component has a cost that should not be misevaluated and the technology has the possibility to bring unique benefits.

The reasons that prompt the use of MEMS technology are for example miniaturization of existing devices, development of new devices based on principles that do not work at larger scale, development of new tools to interact with the micro-world. Miniaturization reduces cost by decreasing material consumption. It also increases applicability by reducing mass and size allowing placing the MEMS in places where a traditional system doesn't fit. A typical example is brought by the accelerometer developed as a replacement for traditional airbag triggering sensor also used in digital cameras to help stabilize the image or even in the contact-less game controller integrated in the latest hand phones. Another advantage that MEMS can bring relates with the system integration. Instead of having a series of external components (sensor, inductor...) connected by wire or soldered to a printed circuit board, the MEMS on silicon can be integrated directly with the electronics. These so called smart integrated MEMS already include data acquisition, filtering, data storage, communication, interfacing and networking. As we see, MEMS technology not only makes the things smaller but often makes them better.

C) ARM Microcontroller:

Microcontroller is a heart of this project. ARM 7 is suitable microcontroller for this proposed embedded system. LPC2148 is ARM 7 controller used in this project. The main feature of LPC2148are as follows,

• 16-bit/32-bit ARM7TDMI microcontroller.

• 8 kB to 40 kB of on-chip static RAM and 32 kB to 512 kB of on-chip flash memory.

• Two 10-bit ADCs provide a total of 14 analog inputs, with conversion times as low as 2.44 ms per channel.

• CPU operating voltage range of 3.0 V to 3.6 V (3.3 V ± 10 %) with 5 V tolerant I/O.

D) Power Supply:

A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones and rarely to others.

E) MCP2551:

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 MCP2551provides differential transmit and receive capability for the CAN protocol controller and is fully compatible with the ISO-11898 standard, including 24V requirements. It will operate at speeds of up to 1 Mb/s. Typically, each node in a CAN system must have a device to convert the digital signals generated by a CAN controller to signals suitable for transmission over the bus cabling (differential output). It also provides a buffer between the CAN controller and the high-voltage spikes that can be generated on the CAN bus by outside sources (EMI, ESD, etc.).

F) GLCD Display:

GLCD or Graphical Liquid Crystal Display unit is used to display the current status of system and it display the error message when the system behaves abnormally. JHD12864E (128X64) GLCD is used in this project.

3. Project Design And Implementation:

In this project we declare the system with ARM and CAN protocol to monitor and diagnose the problems in the wind turbine application.CAN is a message based protocol designed specifically for Automotive, later Aerospace, Industrial automation and Medical equipments. CAN interface module is used to communicate the monitored parameters between the wind turbine and the control center. The project deals with the data transmission between two units in the exact time without any disturbance, however CAN protocol is immune to noise.

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. A discussion about weather condition (WC) monitoring and generation voltage (GV) display is also added in this design. 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. Temperature sensor is used to measure the temperature. IR RPM is used to count the rotations per minute of the wind turbine. Alarm is placed on the monitoring section; it will alarm us when some fault is diagnosed. Digital display unit is placed to display the values diagnosed.The MCP2551 is a high-speed CAN, fault-tolerant device that serves as the interface between a CAN protocol controller and the physical bus.

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Pin Descriptions:

The 8-pin DIP and its pin configuration out is listed below

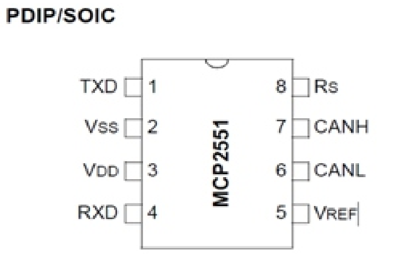

Fig : Pin Configuration of MCP2551

Features:

- Supports 1 Mb/s operation
- Implements ISO-11898 standard physical layer requirements
- Suitable for 12V and 24V systems
- Externally-controlled slope for reduced RFI emissions
- Detection of ground fault (permanent dominant)on TXD input
- Power-on reset and voltage brown-out protection
- Protection against high-voltage transients
- Automatic thermal shutdown protection
- Up to 112 nodes can be connected
- High noise immunity due to differential bus implementation

Mode	Current at R_s Pin	Resulting Voltage at Rs Pin
Standby	$-I_{RS} < 10\ \mu A$	$V_{RS} > 0.75\ V_{DD}$
Slope-control	$10\ \mu A < -I_{RS} < 200\ \mu A$	$0.4\ V_{DD} < V_{RS} < 0.6\ V_{DD}$
High-speed	$-I_{RS} < 610\ \mu A$	$0 < V_{RS} < 0.3 V_{DD}$

Table: Mode of Operation of MCP2551:

The project "CAN Bus Based System for Monitoring and Fault Diagnosis in Wind Turbine" consists of 4 modules listed below.

- Temperature Module
- MEMS Module
- Generation Voltage module
- RPM module

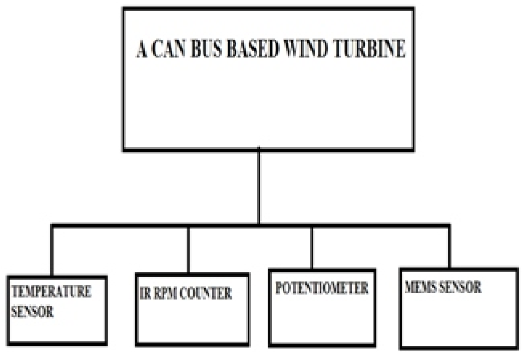

Fig : Block diagram of ProjectTemperature

When the process is started, the TEMP variable is declared globally. The microcontroller, ADC and CAN are initialized and the Temperature readings from the ADC channel are assigned to the TEMP variable. The CAN bus checks the busy flag if it is free or not. If the bus is free then the FORM_PACKET is sent to the receiver.

This process is repeated until the device is damaged. When the process is started, the ASCII_TEMP, TEMP variables are declared globally. The microcontroller, GLCD and CAN are initialized. If the CAN bus REC_BUF pin is enabled read the values from bus and assign to TEMP variable. The Ascii value of TEMP variable is stored in ASCII_TEMP variable. Depending on the ASCII_TEMP value the GLCD displays temperature value and its condition.

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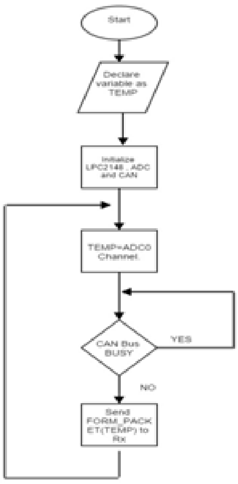

Fig Temperature TX module operation

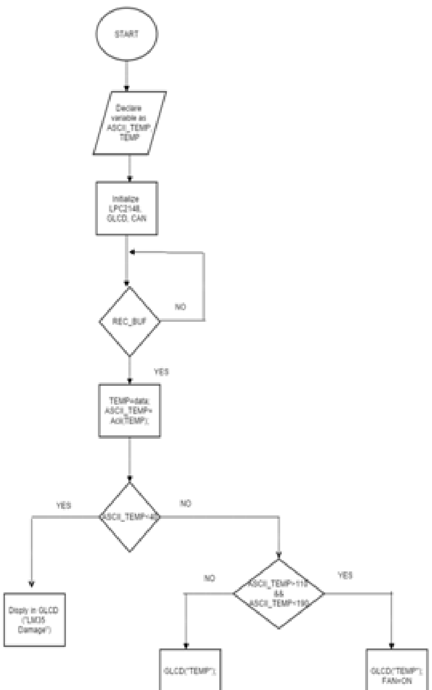

Fig Temperature Rx module operation

RPM Module:

When the process is started, the RPM variable is declared globally. The microcontroller and CAN are initialized and the digital output reading from GPIO pin is assigned to the RPM variable. The CAN bus checks the busy flag if it is free or not.

If the bus is free then the FORM_PACKET is sent to the receiver. This process is repeated until the device is damaged when the process is started the RPM variable is declared globally. The microcontroller and CAN are initialized. If the CAN bus REC_BUF pin is enabled read the values from bus and assign to RPM variable..

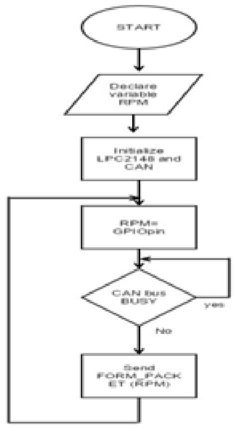

Fig RPM TX module operation

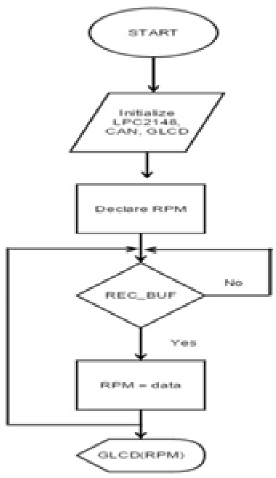

Fig RPM Rx module operation

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MEMS Sensor Module:

When the process is started, the MEM variable is declared globally. The microcontroller, ADC and CAN are initialized and the Level readings from the ADC channel are assigned to the MEM variable. The CAN bus checks the busy flag if it is free or not. If the bus is free then the FORM_PACKET is sent to the receiver.

This process is repeated until the device is damaged. When the process is started, the ASCII_MEM, MEM variables are declared globally. The microcontroller, GLCD and CAN are initialized. If the CAN bus REC_BUF pin is enabled read the values from bus and assign to MEM variable. The ASCII value of MEM variable is stored in ASCII_MEM variable. Depending on the ASCII_MEM value the GLCD displays temperature value.

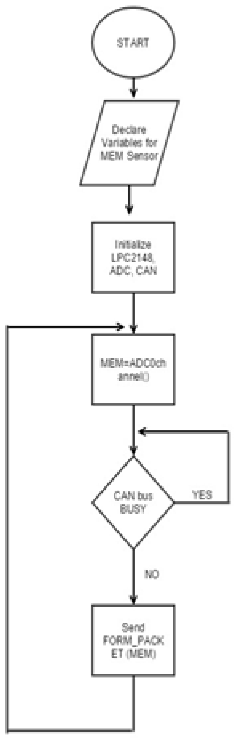

Fig: MEMS sensor Tx module operation

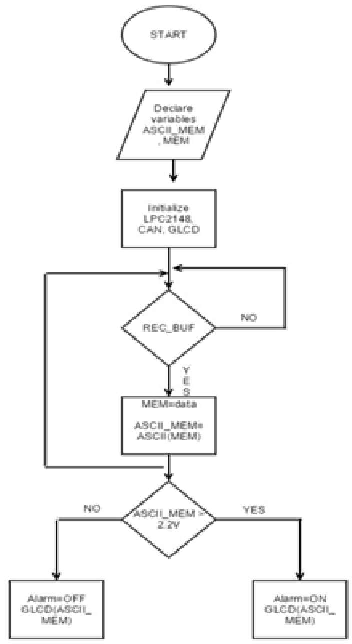

Fig: MEMS sensor Rx module operation

The CAN module handles all functions for receiving and transmitting messages on the CAN bus. Messages are transmitted by first loading the appropriate message buffer and control registers. Transmission is initiated by using control register bits via the SPI interface or by using the transmit enable pins. Status and errors can be checked by reading the appropriate registers. Any message detected on the CAN bus is checked for errors and then matched against the user¬-defined filters to see if it should be moved into one of the two receives buffers.The control logic block controls the setup and operation of the MCP2510 by interfacing to the other blocks in order to pass information and control.

Interrupt pins are provided to allow greater system flexibility. There is one multi-purpose interrupt pin (as well as specific interrupt pins) for each of the receive registers that can be used to indicate a valid message has been received and loaded into one of the receive buffers. Use of the specific interrupt pins is optional. The general purpose interrupts pin, as well as status registers (accessed via the SPI interface), can also be used to determine when a valid message has been received. Additionally, there are three pins available to initiate immediate transmission of a message that has been loaded into one of the three transmit registers. Use of these pins is optional, as initiating message transmissions can also be accomplished by utilizing control registers, accessed via the SPI interface.

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CONCLUSION:

The project uses two ARM core with a CAN bus communication. From the engine part ARM core, the sensor readings will be continuously transmitted to the monitor room part ARM core. In monitor room, the threshold comparison will be done and sensor failure can also be identified. Using fan rotation and the voltage generated, we can decide the functioning of Wind Turbine. If any hardware system is failed in the Wind turbine, from monitor room we can identify the fault. The monitor room display gives trouble shooting information to the user. By this project work we can monitor and detect the fault in wind turbine and prevent the major loss.

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