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An Efficient Approach to Monitor Wind Turbines Using Zigbee Network

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ABSTRACT: This paper interprets the enhancement of the mechanical vibration of temperature from small wind turbines. The aim of this research proposes a new technique and protection method through verifying and monitoring signals from wind turbines, and the necessity of protective measure avoids catastrophic failures. The proposed system consists of a triple axis accelerometer which will identify vibration, thermocouples to indicate the temperature of wind turbines, acquisition and processing of signals using zigbee technology. The software interface has the functionality of received data and reports the data rates during monitoring. Hence, the model of the hardware and software results gained through experimental evaluation.

KEYWORDS: Small wind turbines, Accelerometer, Thermocouple, Wireless network.

I.INTRODUCTION

Wind turbines are the system that harnesses the kinetic energy of the wind for useful energy resources. Wind flows over the rotor of a wind turbine, tends to rotate a shaft. The resulting energy from the shaft can be utilized for mechanical work such as pumping water, or to produce electrical energy by turning on the generator. In addition, there are various designs of wind turbine; they are broadly categorized into two types, based on the orientation of the axis of rotation:

- Horizontal Axis Wind Turbines (HAWTS), the most common type of wind turbine, and
- Vertical Axis Wind Turbines (VAWTS).

World wind energy potential has been estimated at 10 million megawatts (10,000 GW). Necessities for the scaling of economical utilization in wind energy are as follows:

- Consistent wind speeds are greater than six meters/second.
- Access to electric power grid.
- Large capital investment.
- Power markets that can adjust to wind supply variations.
- Ability to produce power at costs equivalent to competing technology (diesel).

In previous work, developing the operating costs are generally lower for wind farms than diesel plants; there are no fuel costs, improving performance and reliability of equipment. Wind turbines can be added to wind farms one by one, for the requirement of increasing the capacity.Recently, there are about 30,000 wind turbines are manufactured in the world which are capable for installation in the order of 13,500 MW and in the future, the Committee of International Climate Change is aimed to construct the installation of 30,000 MW by the year of 2030. The rest of the paper is organized as follows. Section 2 narrates about small wind turbines, Section 3 depicts the mechanical vibration and temperature, Section 4 features about the accelerometer, Section 5 briefs about thermocouples, Section 6 shows the

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wireless technology, Section 7 describes the standard zigbee wireless, Section 8 proposes about proposed model, Section 9 depicts result and Section 10 concludes the paper.

II.SMALL WIND TURBINES

The necessity of electricity increases in day to day life due to the increased population growth. The constant level to minimize the environment impacts and the decreased level of greenhouse effects were rapidly results in utilizing the expansion of alternative energy sources and magnifying the Brazilian energy matrix. Besides the inclusion of wind energy results in low environmental impact and the wind generation possess alternative characteristics. By defining wind energy is the generation of electricity through wind turbines connected to generators which will convert the kinetic energy to mechanical energy by the method of displacing the blades and the usual turning of the rotor [1]. The wind turbines are categorized according to their size and dimensions as shown in Table I [2].

TABLE I-CATEGORIES OF TURBINES

Classes	Diameter Class Rotor (m)	Height Cube (m)	Potency (kW)	Application
Turbine Industrial	> 45	> 50	> 45	Generation
Turbine Average	< 45	< 50	<45	Generation
turbine Small	<20	<35	< 20	use domestic / generation
Mini Turbine	< 15	< 25	< 15	Use domestic
Micro Turbine	< 3	< 10	< 3	Use domestic

III.MECHANICAL VIBRATION AND TEMPERATURE

Rotating machines are ideally transforming their energy experimentally, but not producing any kind of energy for destructive purposes. Rather, the interaction of many elements of a machine under cyclic eliminates in the disperse of energy in the form of vibration, noise or temperature [3]. There are various methods for performing the controlling of mechanical vibration. In accordance, these methods are utilized for analyzing instrumentation and implementation of algorithm, which is given by:

a) Global vibration measurement,
b) Measurement vibration with frequency analysis, and
c) Measurement of vibration with frequency analysis by Fourier transforms [3].

Moreover, vibration measurement is the evaluation of wide frequency range (peak or rms), and the result of measurement yields the value from vibration in the frequency spectrum is analyzed in controlling of mechanical vibration. [3]. The same practical results illustrates that even with increases of 10 times (20dB) is based on a reference condition, defines the necessity for immediate intervention to preserve catastrophic failures [4]. Table II illustrates the range of vibration harshnesses the level of machines, the machines being small (Level I) medium-size machines (Level

II) machines large (Level II) and turbo machinery (Level IV) [4]. Temperatures in turn yielding high overloads in the wind turbines, and overheating bearings, refrigerants and lubricants [5].

TABLE II-CLASSIFICATION AND ASSESSMENT OF MACHINES UNDER VIBRATION SEVERITY LEVELS

Range of vibration severity		Example of quality for different machine levels			
Range	Velocity in limits (mm / s)	level I	level II	level III	level IV
0.28	0.28	A	A	A	A
0.45	0.45	A	A	A	A
0.71	0.71	A	A	A	A
1.12	1.12	B	A	A	A
1.8	1.8	B	B	A	A
2.8	2.8	C	B	B	A
4.5	4.5	C	C	B	B
7.1	7.1	D	C	C	B
11.2	11.2	D	D	C	C
18	18	D	D	D	C
28	28	D	D	D	D
45	45	D	D	D	D
71	Upper 45	D	D	D	D

Where:

A = Proper conditions;
B = Acceptable for continued operation;
C = Tolerable Limit;
D=Non-permissible

IV.ACCELEROMETER

The accelerometer transforms the energy of motion signal Electric am in accordance with the variation, acceleration signal is generated in the corresponding axis. This electrical signal produced by the accelerometer is related to variations in terms of an acceleration of gravity (g) Analog Volts (V) [6]. The function of an accelerometer (Fig. 1) is based on the working of micromachining capacitive as the force exerted along the axes of accelerometer will be a variation of capacitance and hence these changes will be reflected in the output signal [6].

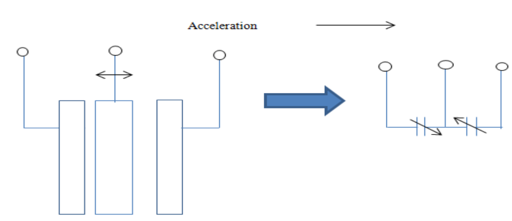

Fig.1 Physical Model of Transducer

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V.THERMOCOUPLE

The thermocouples are temperature sensors which has the as its terminals, an analog voltage in millivolts generated by the effect evaluated from thermoelectric materials. Seeback pointed that in 1821 a circuit Closed formed by two dissimilar metals, is traversed by an electric current when your joints are defined to a temperature difference [7]. Over time has combined the different elements. Thermoelectric aims to obtain sensors that can evaluate as possible in the increased temperature. Although there are various kinds of combinations thermoelectric, currently available in the market in series, are thermocouples or thermocouple shown in Table III.

TABLE III -VARIOUS TYPES OF THERMOCOUPLES

VARIOUS TYPE	RANGE IN USE
Type K thermocouples chrome – Album Nickel -Chrome (+) / Copper - Aluminum (-)	900 -200 ° C
Type R thermocouples 87% Platinum- 13% Rhodium (+) / Platinum (-)	0-1600 ° C
Type S thermocouples 90% Platinum- 10% Rhodium (+) / Platinum (-)	0-1600 ° C
Type B thermocouples 70% Platinum- 30% Rhodium (+) 94% Platinum- 06% Rhodium (-)	600 to 1700 ° C
Type N thermocouples Nickel -Chromium - Silicon (+) / Nickel - Silicon (-)	200 to 1200 ° C
Thermocouple Type E Chromes – Constantan Nickel -Chrome (+) / Copper -Nickel (-)	900 -200 ° C
Thermocouple Type J IRON – constantan Iron (+) / Copper – Nickel (-)	-40 To 750 ° C.
Type T thermocouple COPPER – constantan Copper (+) / copper - nickel (-)	350 -200 ° C

VI.WIRELESS TECHNOLOGY

Several ways of remote data transmission and it is composed of with or without physical performance. Wireless transmission is achieved by the data propagation between two points or devices. There are several technologies used from the wireless data transmission, and the various technologies are specified to the breadth (Figure 2), frequency, rates and transmission application [8].

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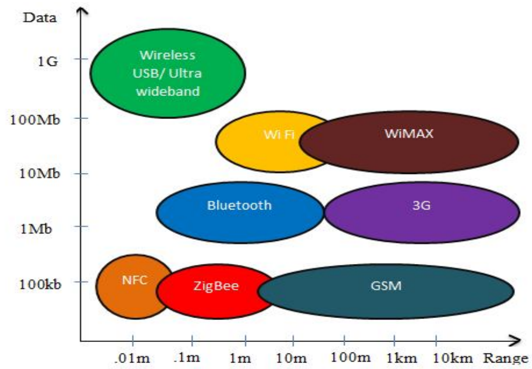

Fig.2 Wireless Technology

VII.STANDARD ZIGBEE WIRELESS (IEEE 802.15.14)

The ZigBee technology is evolved by ZigBee ™ Alliance, and it is a ZigBee mesh that enhances multiple paths between each device, allowing diversifying a potential failure point, via the “zig” and “Zag" of information over the network. This protocol is the organization of the bees that live in beehives, flying zigzag thus providing the information and the other members of the community and the direction location of food [9].

ZigBee Network Topologies

Communication methods for ZigBee assumed various features which are based on their configuration:

• CB - ZigBee Coordination: When the module is responsible for all communication as initialization, address allocation, maintenance and recognition of the whole network and other functions.

• ZR - ZigBee Routing: When a method is consumed initially as an operation which is responsible for routing and replay of transmission and reception.

• ZigBee Receiving Device: When a method is responsible by concatenating to the sensors and/or switching actuator.

Three different ways for interaction in ZigBee modules through various existing topologies for ZigBee network:

• Cluster Tree topology: In this topology, CB assumes the responsible of master node and communicates with or by ZED ZRS. This type of topology is ideal for applications in local necessity for communication with the distances larger.

• Star topology: In this type of topology, the ZC is the master node and interacts with the need of ZED

• Topology Mesh: This type of topology is unique for applications in expensed communication with the archived continuously communication.

VIII. PROPOSED MODEL

The proposed system has an accelerometer which creates the acquisition of the vibration signal and a thermocouple type J making to evaluate the performance of temperature of the turbine, these signals are performed by a plate that microcontroller sends the data and ZigBee to a remote computer and install the software application.

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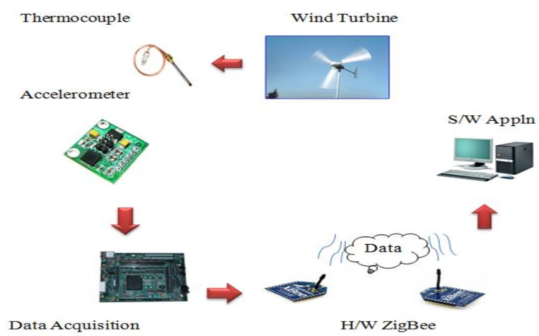


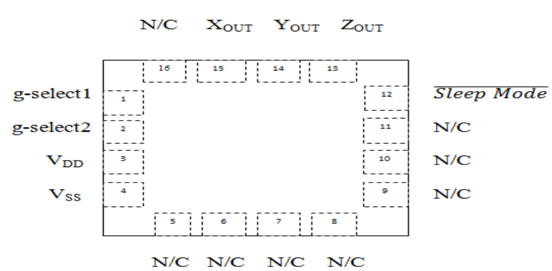
Fig.3 shows the Simplified working of the system

Vibration Measurement

Based on the measurement of the vibration component used is FREESCALE the MMA7260Q triaxial accelerometer (Fig. 3), which has the following characteristics:

• Adjustable Range: 1.5 g/2g/4g/6g,Maximum Acceleration: + / - 2000g,Sensitivity: 800mV / g @ 1.5 g,Supply Voltage: 3.6 Vdc

Top View



Pin Description

Pin No	Pin Name	Description
1	g-select1	Logic input pin to select g level
2	g-select2	Logic input pin to select g level
3	V_{DD}	Power supply input
4	V_{SS}	Power supply ground
5-7	N/C	No internal connection. Leave unconnected.
8-11	N/C	Unused for factory trim. Leave unconnected.
12	$\overline{\text{Sleep Mode}}$	Logic input pin to enable product or sleep mode.

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13	Z_{OUT}	Z direction output voltage
14	Y_{OUT}	Y direction output voltage
15	X_{OUT}	X direction output voltage
16	N/C	No internal connection. Leave unconnected.

Fig. 3 Accelerometer MMA7260Q

Temperature Measurement

Based on the temperature measuring thermocouple was chosen Type J (Iron - Constant) for its characteristics of less cost and better linearity as shown in Figure 4. Illustrates view that the accelerometer using three analog channels, and this case the hardware consists of eight channels; measurement unit receive five more thermocouples.

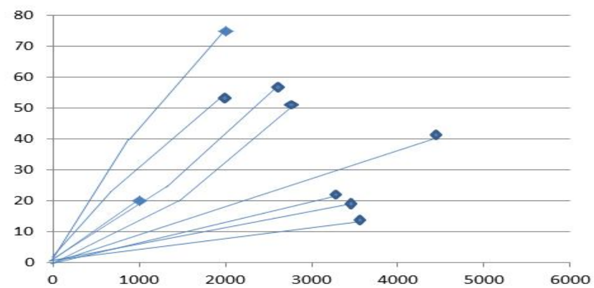

Fig. 4 Thermocouple Temperature Curves

IX. RESULTS

The system queries the concluding stages of module development still missed the compliance with the levels of measuring the system and validating results in a real wind turbine. The calibration level (next level) will be made by comparison with meters already on the market which will be implemented corrections needed to make the system more accurate. The completions of the project will occurred at the end of step validation where the system is applied in the generation of small wind turbine. Initial tests were resulted by the measuring of an electric motor and the condition was simulated and the simulation results are validated the values that are used to approach and innovating the developed operating system. Below is a screen monitoring of temperature and vibration results carried out from the simulation (Figure 5 and Figure 6).

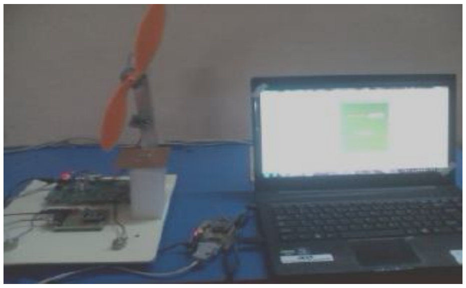

Fig. 5 Temperature Monitor Screen

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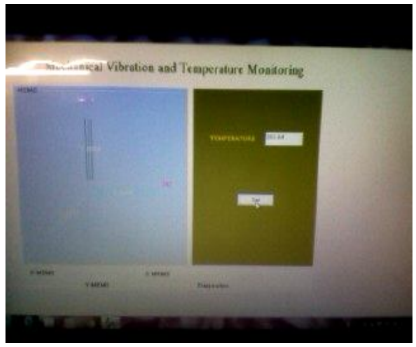

Fig. 6 Mechanical Vibration and Temperature Monitoring Screen

X. CONCLUSION

The proposed model enables the management of vibration as mechanical and the increase in temperature of the wind turbine using the methods developed. The software allows user interaction and the model proposed by a user interface, In assistance of the result making decision to avoid catastrophic effects on the vibration cyclic regime (Resonance effect), and excessive temperature the windings and rotating mechanical couplings (Effect Joule) can cause the small wind turbines. Future work of this paper consists of two stages for monitoring and controlling the wind turbine, while concerning the first stage the rapid increase in temperature upto the threshold value leads to automatically cooling and the fan also in ON stage.In stage two, increase in vibration causing the sms to be received to the user and the wind turbine set to OFF stage, by decreasing the threshold value.

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