Condition Monitoring of Arrow Dynamic and Drive Train in Wind Turbine using Artificial Intelligence

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Abstract: In order to be economically competitive, various control systems are used in Wind turbine. These systems makes the wind turbine to work efficiently and produce maximum output at different speed. In this paper an adaptive control based on radial-basis function neural network are used for different operation of variable speed wind turbine including torque control at lower speed, pitch control at higher speed and smooth transition between these two modes. The adaptive neural network control approximates the nonlinear dynamics of wind turbine based on input/output measurement. One of the most important features in the smart gird is to integrate the state-of-the-art communication technologies to increase the electrify generation. In offshore wind farms, data communications would rely on wireless techniques. The wireless communication technology has several advantages over the wires or meter counterpart. However, the impact of atmospheric turbulence on wired must be well understood first. In this project, the performance of wireless links subject to weak influence in generator, turbine is monitored. The metrics are analytically and numerically evaluated.

Keywords:Adaptive control,Generator torque control, MAX232, Tarang Processor,ZigBee wireless network

I.INTRODUCTION

Wind power has become the world's fastest growing renewable energy resource. The worldwide wind capacity is increased upto 120 GW.Wind power becomes as a major utility source, it is complex to understand the operation of power system in order to improve both quantity and quality of wind power generation. In Wind turbine there is a different types of failure. Therefore, before exploring condition monitoring and fault diagnostic methods in wind turbines, the different kinds of failures, as well as their downtime consequences, are reviewed [2-7]. Of course, obtaining high power from wind turbine is complex it requires high performance monitoring-.

Monitoring systems collects data from the components of Wind turbine such as Generator, gear box, main bearing, shaft, yaw system.

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The purpose is to minimize downtime and maintenance cost while increasing energy availability and extending the lifetime service of wind turbine components. Condition monitoring system monitors all the components with a minimum number of sensors. Manufactures and operators are working hard to develop the advanced condition monitoring system to develop the efficiency and prevent from failures.

A wind turbine consists of many components that causes different types of failures, in which some of the them will frequently occurs that can be identified by comparing among them,it is necessary to know downtime. The resultant economic loss which is caused by the downtime of a particular component in this work, the economic losses caused by wind turbine subassemblies are approximated by the downtimes caused by failures. Figure 1.1 gives the annual average downtimes of major wind turbine subassemblies according to the LWK survey of more than 2000 wind turbines for 11 years [10].Neural networks are powerful methods for approximation of input output mappings. Many works [6],[7] suggested that the condition can be monitored by integrating both Trend master Pro and Snapshot offerings is signal processing technology, which can be particularly beneficial. The remainder of this article explores the technology and its benefit in more detail to relate wind turbine. Condition monitoring of Wind turbine frequently gives better maintenance management and increased reliability[2]

Vibration Sensor Equipment

In the wind power vibration monitoring is used to detect faults in mechanical components such as the bearings and gears.

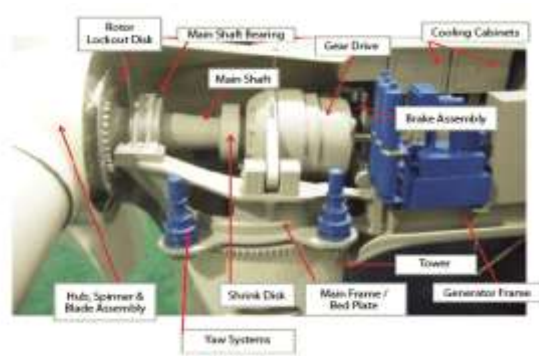


Figure 1.1.Major components of Wind turbine.

The monitoring and fault prediction functions of a condition based monitoring system are based on robust sensor equipment for continuous measurements, and this system performs online evaluation of characteristic fault indicators by use of modern digital signal processing methods. Modern type wind turbines are mainly based on rotational components. Therefore, measurement of vibration on component housings and structural oscillation will yield data for calculating characteristic values by means of advanced condition monitoring and fault prediction algorithms. The vibration signature from different kind of fault is same and depends on the geometry, load, and speed of the components. Figure show the configuration of sensors.

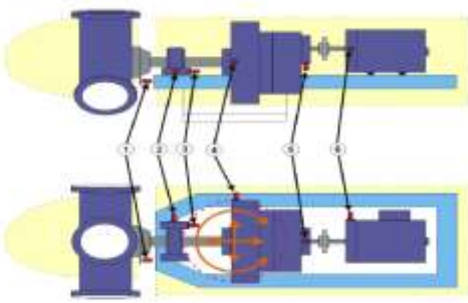


Figure 1.2 Common sensor configuration for horizontal wind turbine

It allows oscillation in both axial and transverse direction. By using two transverse directed sensors in front and back torsional oscillation can be measured. These can be measured at very low frequency. Internally the sensors will measures the force applied to probe . The monitoring and fault predict current in analog conditional circuit. The mounting positions of sensors are indicated in label 2,3 and 4.To monitor the generator and gear box, vibration sensor uses frequency range from 1Hz to 20,000 hz. Label 5,6 shows the position of generator and gear box. For the large turbine additional sensors can be used. The vibrational sensors can be mounted with glued sockets on every plane surface of gear box. The area needed is about 5cms.Installation of these sensors can be done after construction.

II.METHODOLOGY

This fault monitoring system is based on the study of vibration analysis. The vibration produced from the wind turbines are sensed by using ADXL330 MEMS Accelerometer. The vibrations under different load conditions like on load, no load and abnormal conditions are observed and the corresponding voltage produced is added as a reference value to MSP430.The MSP430 an advanced 16-bit microcontroller, which is used to analyze the data obtained from wind turbine via MEMS.

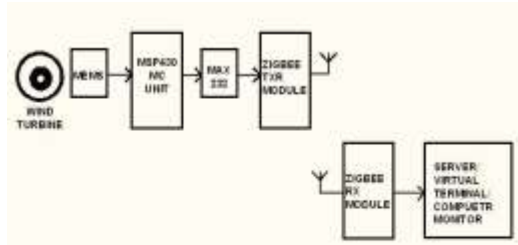
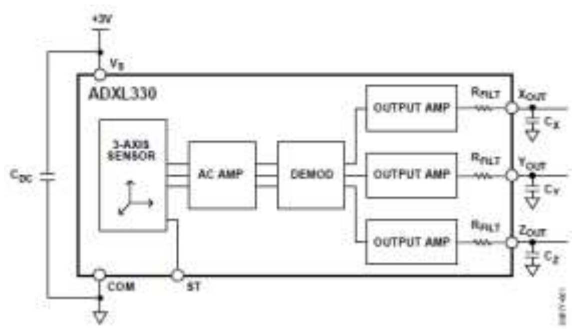


Figure 2.1 Block diagram

III.HARDWARE IMPLEMENTATION

3.1.ADXL330 MEMS Accelerometer

The ADXL330 is a three-axis acceleration measurement system on a single monolithic IC. The ADXL330 has a measurement range of ±6g. Figure shown above. It consists of sensor and signal conditioning circuit to implement the open loop acceleration measurement . The output signals are proportional to acceleration. The accelerometer can measure acceleration of gravity in tilt sensing applications as well as dynamic acceleration it results from motion, shock, or vibration. Deflection is measured using a differential capacitor that consists of independent fixed plates and plates attached to the moving mass. The fixed plates are driven by 180° out-of-phase square waves. Acceleration deflects the moving mass and it will not balance differential capacitor it results sensor output whose amplitude is proportional to acceleration. Phase-sensitive demodulation techniques are then used to determine the magnitude and direction of the acceleration.

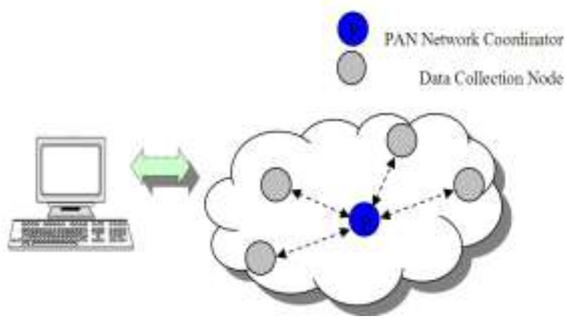


Block diagram of ADXL330 MEMS Accelerometer

The demodulator output is amplified and gets off chip through a resistor. Then we have to set a bandwidth by adding capacitor. The filtering helps to save aliasing. We should set bandwidth by using CX, CY and CZ capacitor in XOUT,YOUT and ZOUT pins.

3.2 ZigBee /IEEE 802.15.4 Standard

ZigBig defines the protocol and interconnection of devices via radio communication in a personal area network (PAN). It operates in the ISM (Industrial, Science and Medical) radio bands, at 868 MHz in Europe, 915 MHz in the USA and 2.4 GHz worldwide. It is used to provide a stability for ultra-low complexity, ultra-low cost, ultralow power consumption and low data rate wireless connectivity among expensive less devices. ZigBee technology used in many applications like industrial controls, embedded sensors, medical devices, smoke and intruder alarms, building and home automation and others. This network is designed with low power only then the devices will work more than one year with a single alkaline battery. Due to this ZigBee technology is used for this project. The ZigBee network supports star, tree and mesh topologies. In a star topology, the network is controlled by a single device called the ZigBee coordinator (as master node). Master node is responsible for initiating and maintaining the devices within the same network, and all other devices known as end devices (slave nodes), directly communicate with the ZigBee coordinator.



The structure of Wireless sensor network is shown above. It consists of PAN network coordinator and Data collection node. Network node can be connected with nearby collection node. ZigBee is made up of data collection node. The node consists of current signals, signal quantizing,, simple processing and Zigbee network. It receives data from other nodes also and it adds multi-hop information, packing framing, and it transfer data to network coordination. The base station will upload the incoming data to computer for processing and analysis. An advanced algorithm is used to check the status of machine. The data can also be transferred through Internet.

3.3 Tarang

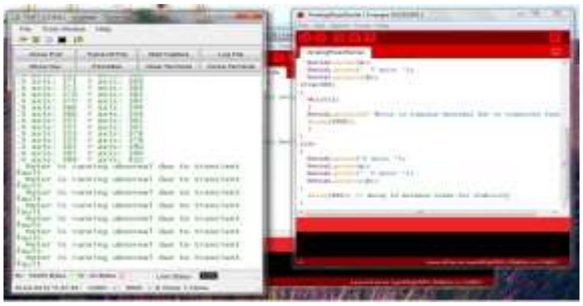
Tarang wireless modules are used to add wireless capability with serial data interface. The modules require minimal power and provide reliable delivery of data between devices. The I/O interfaces provided with the Module help to directly fit into many industrial applications. Tarang operates within the ISM 2.4GHz frequency with 802.15.4 base band.

3.4 MSP430 Microcontroller

MSP430 is a family of ultra-low-power microcontrollers ,it consists of several devices and it has the features like different sets of peripherals.. The architecture, combined with five low-power modes, is optimized to achieve extended battery life in portable measurement applications. The device features a powerful 16-bit RISC CPU, 16-bit registers, and constant generators that contribute to maximum code efficiency. The digitally controlled oscillator (DCO) allows wake-up from low-power modes to active mode in less than 1µs. The MSP430G2x13 and MSP430G2x53 series are ultra low-power mixed signal microcontrollers with built-in 16- bit timers, up to 24 I/O touch-sense-enabled pins, a versatile analog comparator, and built-in communication capability using the universal serial communication interface. In addition the MSP430G2x53 family members have a 10-bit analog-to-digital (A/D) converter.

IV.RESULTS

Motor vibration measured by MEMS accelerometer with help of Hyper Terminal software. MEMS sensor need 5V supply it is taken in MSP430 launchpad. The Hyper Terminal measured the signal by using Energia software (C compiler).



V.CONCLUSION

The most important problems in Wind turbine is the machine fault like gears, generators etc. Since the wind turbine has to be monitored continuously. So we are using wireless sensor to monitor the condition of wind turbine during operation, sensor will detect the fault by vibration in turbine. The mechanical fault detection through vibration have to be analyzed and assessed based on their ability. By using a MEM sensor a vibration detection method is proposed in this dissertation. MEM sensor is low cost, light weight, small in size and it requires log power. Vibration in turbine has to be analyzed in time and frequency domain, and the severe technique is used.

These are the important component for machine Health monitoring system and it is an advanced technique. The implementation of mechanical fault monitoring system can be used to estimate the range of severity levels, which makes it possible to detect the abnormalities before failure. It is very useful part of the condition based predictive maintenance. This control technique works for both normal and disturbance operation. Implementation of the vibration suppression capability opens up the windmill. This will surely improve the power generation quality and reduces downtime, when there is wear and tear on the mechanical component, like shaft, gear box and rotating plates.

REFERENCES

[1] Y. Amirat, M. E. H. Benbouzid, B. Bensaker, and R. Wamkeue, "Condition monitoring and fault diagnosis in wind energy conversion systems: a review", in Proc. 2007 IEEE International Electric Machines and Drives Conference, vol. 2, May 2007, pp. 1434-1439.

[2] C. Hatch, "Improved wind turbine condition monitoring using acceleration enveloping," Orbit, pp. 58-61, 2004.

[3] R. W. Hyers, J. G. McGowan, K. L. Sullivan, J. F. Manwell, and B.C. Syrett, "Condition monitoring and prognosis of utility scale wind turbines," Energy Materials, vol. 1, no. 3. pp. 187- 203, Sep. 2006.

[4] D. McMillan and G. W. Ault, "Quantification of condition monitoring benefit for offshore wind turbines," Wind Engineering, vol. 31, no. 4, pp. 267-285, May 2007.

[5] L. M. Popa, B.-B. Jensen, E. Ritchie, and I. Boldea, "Condition monitoring of wind generators," in Proc. IAS Annu. Meeting, vol. 3, 2003, pp. 1839-1846.

[6] J. Ribrant and L. M. Bertling, "Survey of failures in wind power systems with focus on swedish wind power plants during 1997–2005", IEEE Trans. Energy Conversion, vol. 22, no. 1, pp. 167-173, Mar. 2007.

[7] P.J. Tavner, G.J.W. van Bussel and F. Spinato, "Machine and converter reliabilities in wind turbines," The 3rd IET International Conference on Power Electronics, Machines and Drives, Dublin, Ireland, pp. 127-130, March 2006.

[8] C. A. Walford, "Wind turbine reliability: understanding and minimizing wind turbine operation and maintenance costs," Sandia National Laboratories, Rep. SAND2006-1100, Mar. 2006.

[9] M. R. Wilkinson, F. Spianto, M. Knowles, and P. J. Tavner,"Towards the zero maintenance wind turbine," in Proc. 41st International Universities Power Engineering Conference, vol. 1, 2006, pp.74-78.

[10] M. R. Wilkinson, F. Spinato, and P. J. Tavner, "Condition monitoring of generators and other subassemblies in wind turbine drive trains", in Proc. 2007 IEEE International Symposium on Diagnostics for Electric Machines, Power Electronics and Drives, Sep. 2007, pp. 388-392.

[11] B. Boukhezzar and H. Siguerdidjane, "Nonlinear control with wind estimation of a DFIG variable speed wind turbine for power capture optimization," *Elsevier Ener. Conv. Manag.*, vol. 50, no. 4, pp. 885–892, 2009.

[12] B. Karimi, M. B. Menhaj, and I. Saboori, "Robust adaptive control of nonaffine systems using radial basis function neural networks," in *Proc.32nd Annu. IEEE Ind. Electron. Conf.*, Nov. 2006, pp. 495–500.

[13] C. L. Bottaso, *Wind Turbine Modeling and Control*. Milano, Italy:Politecn. Milano, 2009.

[14] J. Hui and A. Bakhshai, "A new adaptive control algorithm for maximum power point tracking for wind energy conversion systems," in *Proc. IEEE Power Electron. Special. Conf.*, Jun. 2008, pp. 4003–4007.

[15] S. Lang, *Real Analysis*. Reading, MA: Addison-Wesley,

[16] J. M. Jonkman and M. L. Buhl, "FAST user's guide," Nat. Wind Technol. Center, Nat. Renew. Energy Lab., Golden, CO, Tech. Rep. NREL/EL- 500-38230, Aug. 2005.

[17] J. Jonkman, S. Butterfield, W. Musial, and G. Scott, "Definition of a 5-mw reference wind turbine for offshore system development," Nat. Renew. Energy Lab., Golden, CO, Tech. Rep. NREL/EL-500-38060,Feb. 2009.

[18] J. Ehlers, A. Diop, and H. Bindner, "Sensor selection and state estimation for wind turbine controls," in *Proc. 45th AIAA Aerosp. Sci. Meeting Exh.*,Jan. 2007, pp. 1–10.

[19] K. Z. Ostergaard, P. Brath, and J. Stoustrup, "Estimation of effective wind speed," *J. Phys.*, vol. 75, pp. 1–9, Jun. 2007.

[20] P. Simoes, B. K. Bose, and R. J. Spiegel, "Fuzzy logic-based intelligent control of a variable speed cage machine wind generation system," *IEEE Trans. Power Electron.*, vol. 12, no. 1, pp. 87–95, Jan. 1997.

[21] B. J. Jonkman and M. L. Buhl, "TurbSim user's guide," Nat. Wind Energy Technol. Center, Nat. Renew. Energy Lab., Golden, CO, Tech. Rep. NREL/TP-500-39797, Sep. 2006.