

## Design of Wind Turbine Vibration Monitoring System

Shoubin Wang<sup>\*1,2</sup>, Chengwei Li<sup>2</sup>, Wei Gong<sup>1</sup>, Gang Su<sup>1</sup>, Hongyue Sun<sup>1</sup>

<sup>1</sup>School of Control and Mechanical Engineering, Tianjin Institute of Urban Construction, Tianjin 300384, China

<sup>2</sup>School of electrical Engineering and Automation, Harbin Institute of Technology, Harbin 150001, China

\*Corresponding author, e-mail: wsbin800@163.com

### Abstract

In order to ensure safety of wind turbine operation and to reduce the occurrence of faults as well as to improve the reliability of wind turbine operation, a vibration monitoring for wind turbine is developed. In this paper, it analyses the enlargement of all the parts of the structure and the working mechanism, the research method of wind turbine operation vibration is introduced, with the focus being the use of the sensor principle. Finally the hardware design and software of this system is introduced and the main function of this system is described, which realizes condition monitoring of the work state of wind turbines.

**Keywords:** wind turbine, gearbox, piezoelectric acceleration sensor, condition monitoring

### 1. Introduction

Energy is the material basis of human survival, but is now facing energy crisis, environmental crisis, renewable energy development and utilization of the major difficult problem. The current situation of the development of the wind of the word China, the United States, Germany, Spain and India ranked in the top five of the global total installed capacity of wind power in 2010. The installed capacity and growth percentage of 2006~2011 in the world is shown in Figure 1. Wind power project in China is developing rapidly, which is the first in the world beyond for the first time in 2010. The United States ranked second. The United States, China, Germany, Spain four wind power installed capacity of total have occupied 70% of the global total wind power. The world wind power unit installed capacity is 238 million kW by the end of 2011, with 20.6% growth than ever after statistics.

According to the global wind energy council (GWEA) statistics, The new installed wind power unit is 12904 in china (including Taiwan), the installed capacity is 18927.99 MW, year-on-year growth of 37.1%, which is the first in the world in 2010. 2001-2011 China's total installed capacity of wind power is shown in figure 2. The accumulative total installed wind power unit is 34485, the installed capacity is 44733.29 MW, year-on-year growth of 73.3%, which is also the first in the world. The new installed wind power unit is 11409 in China (including Taiwan) in 2011, the wind power installed capacity is 17630.9 MW, the total installed wind power unit is 45894, installed capacity is 62364.2 MW, an annual increase of 39.4%.

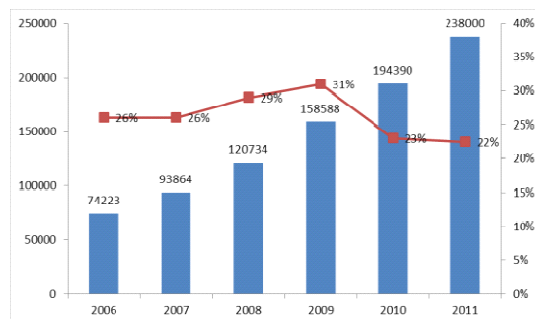


Figure 1. The Installed Capacity and Growth Percentage of 2006~2011 in the World

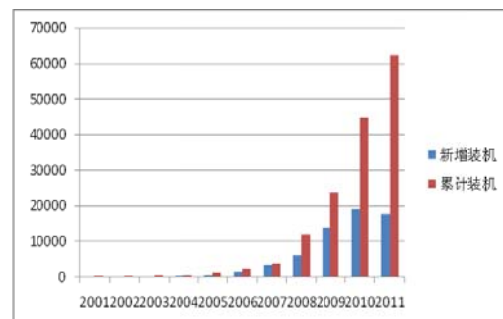


Figure 2. 2001-2011 China's Total Installed Capacity of Wind Power

In this paper, the wind turbine vibration monitoring system is proposed. The paper is organized as follows. Section 2 presents the working principle of wind generator. The design of hardware circuit is presented in section 3. Section 4 presents the design of software circuit. Section 5 presents the design of the system object.

## 2. The Working Principle of Wind Generator

The wind generator is included by rotor, variable pitch system, coupling, structure (engine, foundation and tower), gear, gear box, bearing, generators, electric system, control system, sensor, braking system, hydraulic system and yaw system composition. The wind generator can generate electricity by wind, which is in the use of wind power to drive the impeller rotation, which is changed into mechanical energy, again to improve the running speed of the impeller through the drive systems, and then the cabin of a generator transforms mechanical energy into electrical energy, and so on. Driving system consists of main shaft, gear box and part.

From the whole structure, the wind power unit can be divided into two classes: gear box acc type generator, direct drive type generator, and gear box acc type generator is in actual production of gain greater use of space. the structure of direct drive type wind power generation unit is shown in Figure 3.

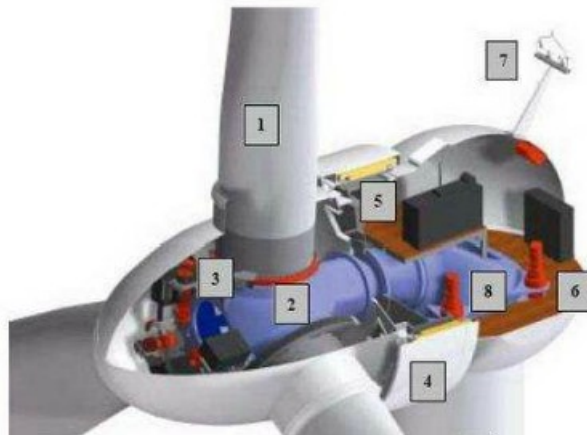


Figure 3. The Structure of Direct Drive Type Wind Power Generation Unit

The gear box is the key part to a reliable operation of wind power unit, whose main function is to realize the transformation of the low speed to high speed. Wind power unit gear box structure is used mostly two forms: planetary wheel form and planetary wheel and parallel shaft form. Big twisting torsion load is generally installed in the low speed shaft gear box, which can transmit to the high speed shaft through the level of planetary gear two stage parallel shaft cylindrical gear, which is transformed into high speed low torque, so as to improve the form of the generator to absorb energy.

Gear box may produce various types of fault in use process, Duing to its under static and dynamic load and its structure and the complication of stress situation. the gear box may produce possible fault in all respects, including the extent of the damage, from the initial production to finished product installation, and the process to the equipment operation and use of different. Gear box of common fault occurs in gear and bearing.

## 3. Design of Hardware Circuit

This paper constructs the wind power generation unit vibration testing system design, to detect wind unit key parts of the gear box operation condition. Wind power unit vibration detection system including vibration sensor, data acquisition circuit and A/D converter, microcontroller, display, and so on. It realizes wind power unit vibration testing system design

completed. Among them, the vibration sensor will change mechanical vibration quantity into the corresponding charge quantity.

Data acquisition circuit will charge for charge conversion and the amplifier amplification, low-pass filtering, and with analog signal output; A/D converter change analog signal into the corresponding digital signal, and finally output in the form of digital signal by single-chip microcomputer and its connections LED digital tube. The wind power unit vibration testing system diagram is shown in Figure 4. The system chooses the piezoelectric acceleration sensor, the sensor is installed in the wind generator in position, and gear box is affected the largest one by vibration relative influence. Charge amplifier circuit is shown in Figure 5.

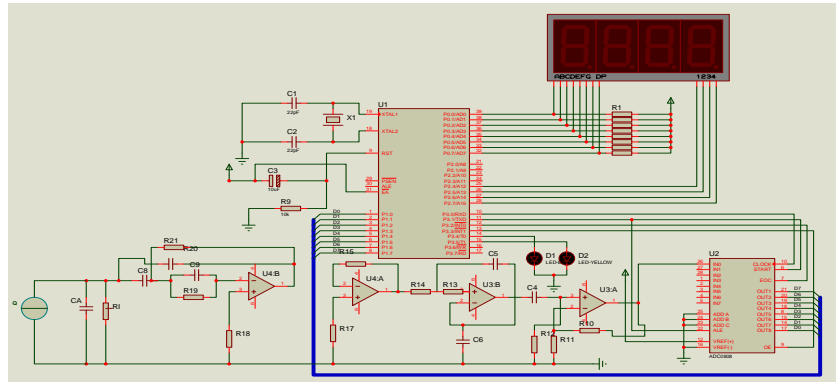


Figure 4. Wind Power Unit Vibration Testing System Diagram

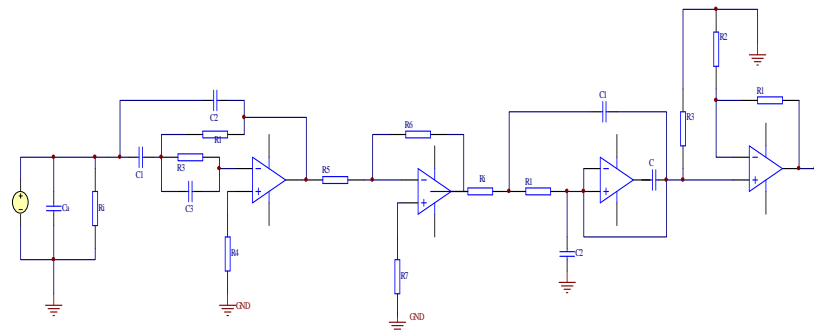


Figure 5. Charge Amplifier Circuit

It can realize the supply requirements to the circuit operational amplifier, chip and MCU power by the following circuit. We need to transform the normal 220 v alternating current (ac) into 20v. The voltage regulator circuit is shown in Figure 6.

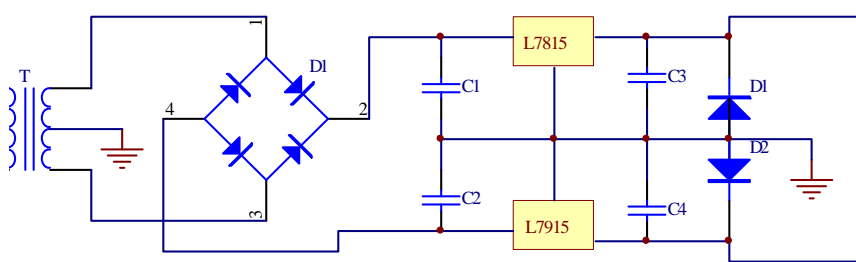


Figure 6. Voltage Regulator Circuit

ADC0809 is eight A/D converters, multiple switch and CMOS components of control logic of microprocessor compatible. It is successive approximation type A/D converter, and can connect single chip microcomputer directly. ADC0809 general requirements input of single polarity of analog signal for single polarity, and the input range of the voltage is 0~5v. In this system, the output signal of sensor will be small, which must carry on the amplification, and can be detected. If necessary, we can set sampling retainer in the front of the input, strengthening the preliminary, avoiding signal distortion.

The alarm display circuit is shown in Figure 7. We can display the voltage value converted through connection circuit by the single chip microcomputer with digital display tube. In this system, the gear box first limit: 7.5m/, the second limit: 10m/, so, take the gear box bear limit set to 7.84m/sensor output, thus the biggest voltage is 4v, the output voltage of wind generator can afford for 5v. It displays alarm through the control room when a certain range of numerical display beyond . This system sets respectively two lamp through the single chip P3.4, P3.5 mouth. It displays on blue flashing alarm through the P3.4 when the output voltage threshold 4v, however, it displays on the yellow flashing alarm through the single chip P3.5 mouth when the output voltage lower limit value 1v.

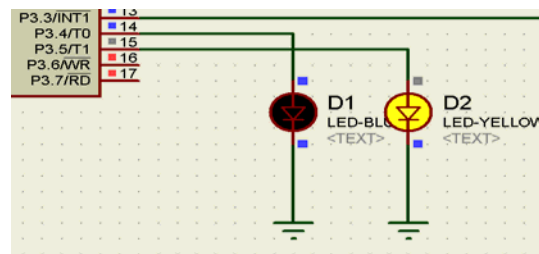


Figure 7. Alarm Display Circuit

#### 4. Design of Software Circuit

This system software program including the main program, T0 timer interrupt service routine, A/D data acquisition program, digital tube display program. Main program make a initialization to the system, and then set initially timer, high and low level alarm limit, A/D register, microcomputer A/D began to collect data, and make a comparison between the data and setting value, judging whether there is fault, if no failure, then continue display program, if there is A failure, then immediately alarm display, timely eliminate potential failure.

#### 5. Design of the System Object

The design of the system object is shown in Figure 8. In the real display of this system, power light is in red display. It simulation voltage amplitude converted by wind power unit vibration sensor using potentiometer, It increases four manual of high and low pressure alarm value, which can meet the wind power unit in the different situations of high and low voltage alarm value set demand, also increases the buzzer high pressure alarm.

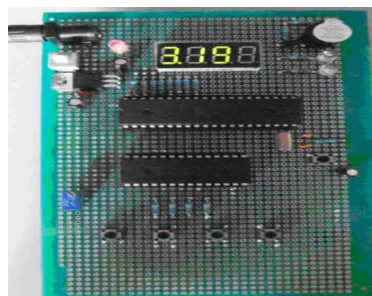


Figure 8. Design of the System Object

## 6. Conclusion

In this paper, the wind turbine operation vibration was introduced, with the focus being the use of the sensor principle. The hardware design and software of this system was also introduced and then the main function of this system was described, which realizes condition monitoring of the work state of wind turbines.

## Acknowledgement

This work was supported by the Tianjin Science and Technology Development Foundation for Colleges and Universities (No.20110713).

## References

- [1] Amirat Y, Bensaker Meh, Wamkeue R. *Condition Monitoring and Fault Diagnosis in Wind Energy Conversion Systems: a Review [C]//*. Proceedings of the International Electric Machines and Drive Conference. 2007: 1434-1439.
- [2] TANG Xinan, XIE Zhiming, WU Jinqiang. Fault diagnosis of gearbox for wind turbine. *Journal of Noise and Vibration Control*. 2007; (1).
- [3] Johan Ribrant, L Bertling. Survey of failures in wind power systems with focus on Swedish wind power plants during 1997-2005. *Energy Conversion*. 2007; 22(1): 167-173.
- [4] SONG Hua, ZHANG Hong-bin, WANG Xing-ren. Fuzzy Fault Tree Analysis Based on T-S Model. *Control and Decision*. 2005; 20(8): 854-859.
- [5] YAO Cheng-yu, ZHAO Jing-yi. Research on Fuzzy Fault Tree Analysis Method for Hydraulic System Based on T-S model. *China Mechanical Engineering*. 2009; 20(16): 1913-1917.
- [6] SONG Lei. Measurement and Statistical Analysis of Wind Turbine Failure. Baoding: North China Electric Power University. 2009.
- [7] Hameed Z, Hong Y, Cho Y, et al. Condition monitoring and fault detection of wind turbines and related algorithms; a review. *Renewable and Sustainable Energy Reviews*. 2009; 13(1): 1-39.
- [8] PJ Tavner, et al. Reliability Analysis for Wind Turbines. *Journal of Wind Energy*. 2006; 10(1): 1-18.