Wind Characterization By Three Blade Savonius Wind Turbine Using IoT

H F Liew 1, Abd R Rosemizi 2, M. Z. Aihsan 1, I Muzamir 3, and I Baharuddin 3

1 Department of Electrical Engineering Technology, Faculty of Engineering Technology, University Malaysia Perlis, Sungai Chuchuh, 02100 Padang Besar (U), Perlis, Malaysia.
2 School of Computer and Communication Engineering. Universiti Malaysia Perlis, Pauh Putra Campus, 02600, Arau, Perlis, Malaysia.
3 School of Electrical System Engineering, Universiti Malaysia Perlis, Pauh Putra Campus, 02600, Arau, Perlis, Malaysia.

Abstract. Fuel has become one of the vital energy in our life and reserves on the earth is lessened years by years. However, still wind that is renewable resource which is clean energy that can replaced a fuel. In this paper, novel idea to monitor the environmental condition and working conditions are characterized by using the small three blade Savonius wind turbines with Internet of Things (IoT) is proposed. Therefore, in terms of characterization, controlling and monitoring the status of wind turbine systems are recommended from anywhere in the world using Internet of Things (IoT) technology. In all repair work, this system is declared with IoT application and ESP 8266 to monitor, capture and diagnose problems in wind turbine. This allows the user to have a remote control mechanism remotely via secure internet web connection. This system helps users control energy sources, manually and remotely using smartphones or personal computers. This work is related to the transmission of data between two units in a timely and fast time without any disturbance. Wind turbine performance has a number of factors which determine its reliability. Next, a system for analyzing the data resulting from the rotation of the wind turbine from a distance is needed so that the study can take place at any time. The parameters that been measured using ESP8266 is voltage, current, power and wind speed. When turbine generate electric, it will display the output by thinkspeak. Various challenges, material of wind turbine and methods for condition monitoring were discussed and the results were analyzed with statistical measures and compared with its standard values.

1. Introduction
Nowadays, fuel has become one of the vital energy in our life even in Malaysia. Based on the fact however, that the earth's reserves of fossil fuel are reduced by years. But the use of this type of fossil fuel as energy requires many processes and requires high cost. Alternative development of wind power is encouraged as it offers natural resources, economy, clean and safe. Since the wind energy system has a superior advantage over the solar system, the monitoring of the wind turbine system is very important. Wind, which is a renewable energy resource that can replace fuel, is still clean [1-2]. Wind energy is a source of renewable energy from air flowing on the surface of the earth. Renewable energy, often called clean energy, comes from natural sources or from constantly refilled processes.
Wind energy has attracted much attention from research and industrial communities. One of growth areas is thought to be in the offshore wind turbine market. The ongoing effort to develop advanced wind turbine generator technologies has already led to increased production, reliability, maintainability and cost-effectiveness. The development of wind power is one of the highest power generating sources in the world today. Proper utilization renewable energy is one of the most important issues to solve the energy shortage and to control environmental pollution as the growing use of fossil fuel is leading ourselves to rapid climate change and global warming. In spite of its rising cost and detrimental environmental effects fossil fuels are still considered as the major source of power generation which indicates global warming will be inevitable if alternate sources of energies are not prioritized. Green energy technologies like wind is the most appropriate solution to this problem to meet the production and demand of electric energy on commercial and industrial applications, since it is a clean, economic and renewable energy source with a great availability in the environment.

Wind turbines converts the kinetic energy available in the wind to produce electricity. Hence, the necessary operating and maintenance requirements are mandatory to provide prolonged, reliable and cost-effective green energy to other users [3-4]. Therefore, observation and diagnosis are important to reduce maintenance costs and ensure the continuity of production, due to the winding down of an unexpectedly functioning failure system can cause expensive repairs and loss of production [5-6]. This operating system ceases to be expected and becomes critical and causes significant loss, therefore there is an increase from time to time necessary to perform efficient surveillance measures. This online surveillance allows for early detection to be detected by mechanical and electrical parts; it must be able to produce an early signal to avoid failure of the major component of wind turbine to be an important topic in scientific and industrial research [7-8].

Condition monitoring and inspection of wind turbines is a universally used tool for early detection of failure and reducing time and increasing productivity [9-10]. With an increasing number of offshore wind power plants, if there are commercial maintenance requirements, forecasts and proactive steps can be taken and mitigated immediately. Due to the environmental conditions, the location of extremely remote wind farms, and over-vertically elevated nacelle, expensive to physically examine wind turbines for maintenance and repair problems. Small three blade Savonius wind turbines are efficient in power generation for small industries and individual houses. It has been noticed that previous wind turbine critical components such as blades, gearbox (wheels and bearings) is most responsible for the downtime of the wind turbines [11-13]. The main objective of this project is to study the design of monitoring and the real-time control system for the characterization of the state of the turbine system by using IoT technology.

From the literature, several studies have been carried-out in recent years in order to improve its Savonius wind turbine performance [14-17]. For example, D’Alessandro et al. [18] developed a mathematical model of the interaction between the flow field and the rotor blades. The aim of this research was to gain an insight into the complex flow field developed around a Savonius wind rotor and to evaluate its performance. They validated the model by comparing it with data obtained at Environmental Wind Tunnel (EWT) laboratory. Altan et al. [19] introduced a new curtaining arrangement to improve the performance of Savonius wind rotors. The curtain arrangement was placed in front of the rotor preventing the negative torque opposite to the rotor rotation. The rotor performance was compared with that of the conventional rotor power coefficient of the Savonius wind rotor is increased to about 38.5% with the optimum curtain arrangement. Irabu and Roy [20] improved and adjusted the output power of Savonius rotor under various wind power and suggests the method of prevention the rotor from strong wind disaster. Driss et al. [21] studied the turbulent flow around a small incurved Savonius wind rotor. Experimental results are also conducted on an open wind tunnel to validate the numerical method. Al-Bahadly [22] determined and designed a suitable wind turbine which could be employed for rural homes or other small-scale applications.
A variety of horizontal and vertical axis wind turbines exist, each possessing a number of advantages and disadvantages which needed to be taken into account before a basis for the design is selected. A small prototype 1.5 m tall with a rotor diameter of 0.65 m is designed and built. Dobrev and Massouh [23] used CFD to study the behaviour of a Savonius wind turbine under flow field conditions and to determine its performance and the evolution of wake geometry. The flow analysis helps to qualify the design of the wind turbine. As the summary of the review on the existing technique, most of the researchers are focusing in improving devices which cause lack of studies in monitoring of wind characterization using this IoT devices. This technique has the advantage of avoiding disturbance and by using ESP 8266, wind characterization can be determined by sending to webserver to display by Thinkspeak. It is to ensure an original research after all possible similar studies have been investigated.

In addition, Simley et al [24] propose that a characterization of wind velocities in the stream induction zone using scanning continuous-wave lidars. A wind turbine generates power, induced velocities, lower than the freestream velocity, will be present upstream of the turbine due to perturbation of the flow by the rotor. Fernando Carbajo Fuertes et al. [25] demonstrated that a measurement campaign dedicated to the characterization of full-scale wind turbine wakes under different inflow conditions. The measurement of wind turbine wake characteristic for analytical wake model validation using nacelle-mounted wind lidars. Valerie-Marie Kumer et al. [26] demonstrated that Wake characteristics are of great importance for wind park performance and turbine loads. While wind tunnel experiments provided a solid base for the basic understanding of the structure and dynamics of wind turbine wakes, the consequent step forward to characterize wakes is full-scale measurements in real atmospheric boundary layer conditions under different stability regimes.

However, the definition of the Internet of Things is generally referred to as scenarios of network connectivity and computing capabilities extending to objects, sensors and everyday items that are not usually considered a computer tool, allowing the device to continue to generate information exchange and using data with minimal human intervention. This includes IP-Based Network Dissemination, Computing Economics, Miniaturization, Progress in Data Analytics, and Cloud Computing Reports. IoT commonly refers to the shared network of data and connectivity between devices, things (objects like buildings and structures). Unlike light switches failure which occurs in remote location such as wind turbines results in interrupted power generations and decreased productivity which results in high downtime and costs.

Through the concepts of IoT, connection between bridges the gap and the wind-turbines located far away from the control center through a software or new tool. IoT provide a monitoring and control platform with a remote application for the operator who is deputed especially for wind turbines maintenance. This paper has provided an overview of wind characterization by three blade wind turbine generators monitoring using IoT. Despite continued research and development effort, however, there are still numerous technological, environmental and economic challenges in the wind power systems. The choice of complex wind turbine systems is largely dictated by the capital and operational costs because the wind market is fundamentally cost-sensitive.

2. Proposed of IoT System

In order to save costs, avoid economic problems and provide more ease of use to consumers, microcontroller has been considered as a major system in data acquisition and recording. As always, everything about the process of control and monitoring will be controlled by a microcontroller. Software part includes web server for real-time monitoring of the entire system. Part of programming applications is easier when compared to using other tools. Sensor detection will be used to collect various information and send it to the controller if there is a change. The sensor will be used to
measure is current sensor, voltage sensor, vibration sensor and humidity sensor. Using Universal asynchronous receiver or interfacing that connects between PIC Microcontroller and IoT consists of one of the microcontroller types used to control relays.

ESP8266 module is used to transmit and receive the electrical data wirelessly, which is collected from internet through designed website and the control system. The ESP8266 transmitter is interfaced with various sensing devices and reliable data reception at a receiver side of ESP8266 module. The ESP8266 receiver has been interfaced through router which is connected to the internet. The load can be monitored and controlled remotely. The controlling operation is performed in two ways. Those are manual controlling and remote controlling.

When module is interfaced with internet, it generates a unique IP address. The webpage is designed so that when IP address is provided in the URL to the control page opens and user can control power supply by selecting buttons wind on or off. When power supply is cut off, person can switch power to another power supply (either solar or wind, which is more feasible). With just a single click the whole system could be controlled. The operating time from Virtual button to output is minimum 3 seconds. By using the module to ESP 8266 module, more energy sources could be added. By using relay, system can be used in houses for the controlling of power supply in Figure 1.

![Figure 1: Receiver Section of smart controlling system](image1)

2.1. **Objective of Project**

The main objective of this project is to use the maximum amount of wind energy from surrounding environment and vehicle running on road. The unused considerable amount of pressurized air used to drive the Savonius wind turbine from which the kinetic energy of turbine is converted into electrical energy. The main aim of this project to reduce the pollution produced burning of fossil fuel. The generated energy by Savonius Wind Turbine system are stored in a battery and this stored energy which can be used street lighting, toll gates or in future to provide the charging node to the electrical vehicle.

2.2. **Proposed Model for Wind Turbine with Sensor**

Here new model for the environment and condition monitoring is proposed of the wind turbines with an application support given by IoT In this model the following parameter values are monitoring like turbine speed, output power, phase voltage, vibration, and blade damage of the wind turbines. The various sensors types are listed for monitoring the above parameters and standard values recommended by the experts and organization. The coin position of the sensors in wind turbines is needed. The exact position is calculated and fixed, so that no misplacement happens during the working condition of wind turbines. The following Figure 2 represents the exact position of the sensors in the working model of wind turbines. Savonius turbines are one of the simplest turbines. Aerodynamically, they are drag-type devices, consisting of three blades (vertical – half cylinders). A three blades savonius wind turbine would look like an “S” letter shape in cross section (Figure 2)
3. Methodology
In this research, the simulation by Proteus is used to design the variety of monitoring parameter for IoT Arduino system. The simulated circuit are important to be analyzed because the best design for prototype fabrication of monitoring circuit can be determined.

3.1 Circuit Design Using Proteus Software
The purpose of the simulation to identify the suitable parameter of each component used in IoT system. Proteus 8.1 software was used to design the footstep generation system circuit before going through the hardware. The output result and data of the circuit can be analysed and it was more accurate than the analytical model. If the circuit is successful on Proteus, the circuit can easily proceed on the hardware design. Figure 3 shows the monitoring IoT system power generation circuit designed using Proteus software. This project used Arduino Uno software to programme the command into processing the value of voltage from the output voltage sensor and output voltage display on the 16x2 LCD. Figure 4 shows the complete circuit setup and the simulation was compiled, uploaded and exported to the Arduino component on Proteus software to test with the circuit. The simulation will be run between Arduino coding and Proteus software. The output voltage result will be displayed on LCD.
3.1. Hardware Implementation

After the software simulation done, the hardware design takes part in next step. The circuit of the project was carried out using a breadboard testing before doing a real circuit on PCB. The circuit that design in the simulation is connected on the breadboard, their result were small different compare with the simulation that because the real component may had some losses. The value and quantity of component must be alert to avoid any error on the circuit. To avoid this, every component should be test before construct the circuit on breadboard. The necessary calibrations need to be conducted each time measurement was carried out.

Figure 4 shows the full prototype of Savonius wind turbines that has three blade with IoT circuit system. Wind turbine were design in vertical axis with three blade made of aluminium. Aluminium were chose because it is lighter compare than to other material. In prototype set up a Savonius wind
turbines were made. The parameters include voltage, current, power and temperature output from wind turbine connection was generated and been characterized.

In Figure 5 is construction circuit to measure the output data which is voltage, current, power and temperature. Current and voltage sensor are used in this circuit. Voltage sensor used to detect the presence of voltage in circuit and current sensor used to detect electric current in a wire, and generates a signal. Meanwhile, the temperature sensor is used to detect the temperature of surrounding and corresponded to wind speed. The LCD was interfaced to the tile by using Arduino UNO to display the value of parameters generated across the wind turbine.

For this part, coil were used to create a generator to produce an electric current or call as electromagnetic generator. This coil were placed under the wind turbine and arrange side by side to form circle shape in Figure 6. The wind turbine system consist of ten circle magnet which is arranged within opposite pole. The coil need to be placed very near below of wind turbine. When turbine are rotate within presence of wind, the coils produce a magnetic field it will induced the magnetic field and produced the current. The Savonius wind turbine is one of the simplest and cheapest wind with
coil as rotors which was developed. It features advantages like low starting torque, relatively low operating speed and Savonius wind turbine convert wind energy into mechanical energy ability to capture wind in all directions etc.

![Figure 7: Three cup anemometer to measure wind speed](image)

This is three cup anemometer in Figure 7 with wind speed sensor, it is a device used for measuring wind speed from surrounding and is a common weather station instrument. This well-made anemometer is designed to sit outside and measure wind speed with ease. The arms are attached to a vertical rod. As the wind blows, the cups rotate, making the rod spin. To use a device, connect the black wire to power and signal ground, the brown wire to 7-24V DC (we used 9 V with success) and measure the analog voltage on the blue wire. The voltage will range from 0.4 V (0 m/s wind) up to 2.0 V (for 32.4 m/s wind speed).

4. Result and Discussion
The principal goal of this project was to test the performance of an innovative design of a proposed Savonius Wind Turbine monitoring based IoT system startup. In order to do so, first modeled the rotors on SolidWorks and then ran simulation on these designs.

4.1. Experimentation and Results data in Cloud as Statistical Analysis Tool
The simulations ran were done in the ANSYS workbench using Fluent. A wind turbine prototype as shown in Figure 8 is design using with Ansys and shows the simulation of rotation for wind turbine. This simulation shows the rotation based on velocity of wind. In this proposed model, we monitor four parameters such as temperature, voltage, speed and vibrations. The monitor these above said parameters and those monitored data were stored in cloud. From the obtained results, it is perform a statistical approach to determine whether the obtained values are within the normal range or exceed the threshold. Because of the blades curvature, the blades experience less drag force ($F_{\text{convex}}$) when moving against the wind than the blades when moving with the wind ($F_{\text{concave}}$). Hence, the half cylinder with concave side facing the wind will experience more drag force than the other cylinder, thus forcing the rotor to rotate. Similarly, the three blade savonius wind turbine is constructed from three half cylinders, they are arranged at (120°) relative to each other as shown in Figure 9.
4.2. Ansys Simulation
The 3D analysis is performed to characterize the performance of three blade wind turbine. The following curves describe the comparisons of the performance of some variations resulting from changing parameters like velocity of inlet air, angle of attack (AOA). Simulation is done by increasing inlet air velocity from 1 to 5 m/s with increment of 0.5 m/s for 0° and 180° angle of attack (AOA) for three blade wind turbine. Figure 10 describes the effect of tip speed ratio on torque and effect of velocity of inlet air on performance for three blade wind turbine. It is observed that for three bladed wind turbine the peak value of coefficient of the velocity of air increases, the rotor rpm increases and hence power drawn by turbine also increases; but after peak value, if velocity of air is increased then power drawn by turbine is decreased.
5. Conclusions

This application of this wind power source is highly effective in commercial areas, especially areas with high wind speed limit exposure. Wind power is a kind of environmentally friendly energy at the same time preventing pollution and clean energy. It is used to replace the non-renewable energy type and the use of short power charges. Furthermore, this wind energy system is low cost and no power cuts or shedding loads will occur at any time. In addition, this system is handled and monitored by internet of thing as a site manager that facilitates and receives detailed information on all site facilities and facilities, efficient maintenance for checks and common failures can be detect easily. It is the most reliable in cost efficient use. From this analysis data, the simulation result have same agreement with measurement result. In which a novel idea and a model for monitoring the various parameters of the wind turbines using the concepts of IoT are proposed. This monitoring covers both the characteristics environmental and conditional monitoring of the wind turbines. The analysis is done with help of statistical tool which uses store data into cloud Method for the obtained data. In this research, the future work of wind characterization of the Savonius wind rotor with using IoT as monitoring system to analysis at different parameter have been studies. Particularly, the goal of this work is to optimize and to improve the experimental conditions of the Savonius wind rotor into IoT system. In the future, to change others geometrical parameters were proposed to improve the Savonius wind rotor performance. More in-depth analysis should be carried out in the design, control and operation of the wind turbines primarily using numerical, analytical and experimental methods if wind turbine generators are to be further improved. Therefore, this idea can be extended by completing the monitoring of wind turbines with various scenarios and conditions and the real time data will be updated in cloud for various data analytics using IoT Controlled Application in future.

**Figure 10**: Effect of Tip Speed Ratio on Torque for constant AOA with three blade wind turbine
Acknowledgments
The authors would like to acknowledge University Malaysia Perlis and the Malaysian Ministry of Higher Education for providing the Exploratory Research Grant Scheme (ERGS Grant No: 9010-00028), which made this study possible to be conducted and successfully published.

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