RENEWABLE ENERGY (WIND POWER) MINI PROTOTYPE

PLANT WITH SCADA SYSTEM

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Bachelor of Industrial Power Engineering

May 2010

"I hereby declare that I have read through this report entitled "Renewable Energy (Wind Power) Mini Prototype Plant With SCADA System" and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

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RENEWABLE ENERGY (WIND POWER) MINI PROTOTYPE PLANT WITH SCADA SYSTEM

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering (Industrial Power)

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2010

I declare that this report entitle *"Renewable Energy (Wind Power) Mini Prototype Plant With SCADA System"* is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……..

Name : AHMAD SUZAIMY BIN SUKOR

Date : 12th MAY 2010

To my beloved mother and father

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ABSTRACT

This FYP report presents the purpose of research about the application of renewable energy as alternative energy to generate electricity. The motive of this project is to analysis the usage and advantages of renewable energy to replace fossil fuel as the energy to generate electricity. This project uses wind as the energy to rotate a wind turbine for this mini prototype plant to generate electricity. Wind energy is use to rotate the wind turbine system which will convert mechanical energy produce from a rotor rotation to electrical energy. The electrical energy generate from wind turbine system were supply to an inverter circuit. This inverter circuit will convert the electricity produce from wind turbine system as require whether AC or DC. SCADA system ensures this mini prototype plant operation fluent and very well. The functions of SCADA system are monitor and control this plant operation.

ABSTRAK

Laporan FYP ini membentangkan tujuan kajian berkenaan aplikasi sumber tenaga yang boleh diperbaharui sebagai tenaga alternatif yang boleh digunakan untuk menjana tenaga elektrik. Matlamat projek ini adalah untuk melakukan analisis berkenaan penggunaan dan kelebihan-kelebihan sumber tenaga yang boleh diperbaharui untuk menggantikan sumber tenaga fosil untuk menjana tenaga elektrik. Projek ini menggunakan angin sebagai sumber tenaga untuk menjana elektrik bagi prototaip loji janakuasa mini yang ingin dibangunkan. Tenaga angin digunakan untuk memutar sistem turbin angin di mana ia akan menukarkan tenaga mekanikal yang dihasilkan oleh putaran rotor kepada tenaga elektrik. Tenaga elektrik yang dijana oleh sistem turbin angin akan dibekalkan terus ke litar *inverter*. Litar *inverter* ini, akan mengubah jenis tenaga elektrik yang telah dijana oleh sistem turbin angin kepada jenis tenaga elektrik yang dikehendaki samada AC atau DC. Untuk memastikan projek ini beroperasi dengan sempurna, prototaip loji janakuasa mini ini juga dilengkapi dengan sistem SCADA. Sistem SCADA ini akan berfungsi sebagai sistem kawalan dan pengawasan untuk pengoperasian loji ini.

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KE	-	Kinetic energy
m	-	Mass
v	-	Velocity/ speed of wind
A	-	Area
δ	-	Air density
t	-	Time
P	-	Power
ρ	-	Wind power density
pr	-	Standard atmospheric pressure at sea level (101325 Pa N/m^2)
T	-	Air temperature (Kelvin)
g	-	Gravitational acceleration (9.8 m/s^2)
h	-	Elevation of wind above sea level
π	-	pi = 3.142
r^2	-	$(\text{Foot blades})^2$

LIST OF ABBREVIATION

C	-	Capacitor
R	-	Resistor
D	-	Diode
Q	-	Transistor
T	-	Transformer
V	-	Voltage
I	-	Current
AC	-	Alternating Current
DC	-	Direct Current
WEC	-	Wind energy converter
HAWT	-	Horizontal-axis wind turbines
VAWT	-	Vertical axis wind turbines
PLC	-	Programmable Logic Controller
SCADA	-	Supervisory control and data acquisition
I/O	-	Input/ Output
RTU	-	Remote Terminal Unit
FYP	-	Final Year Project
UTeM	-	Universiti Teknikal Malaysia Melaka

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

This chapter will discuss the overview of project background, wind energy, problem statement, the aims and specific objectives of the project, and the project scope. The end of this chapter will list the thesis outline.

1.1 Overview of Project Background

Today most of the countries began investing in renewable energy through various programs that promote the development and testing of reliable alternative energy resources. Renewable energy resources include wind, solar, hydroelectric, tidal, and geothermal. The advantages of renewable energy compare to fossil energy are producing much less pollutions than burning fossil fuels and are constantly replenished. This project basically is to design and develop one type of renewable energy mini prototype plant with SCADA system. Renewable energy resource that has been chose to generate this mini plant is wind energy. The operation of this project is wind energy are use to rotate the generator which will convert the mechanical energy that produce by the rotation to the electrical energy. Next, the voltage produce by wind turbine will be converting to require type of voltage use power electronic circuit (inverter). The operation of this mini prototype plant can be monitor and control through SCADA system.

1.1.1 Wind Energy

The wind energy is converted through friction into diffuse heat throughout the Earth's surface and the atmosphere. The origin of wind is complex. The Earth is unevenly heated by the sun resulting in the poles receiving less energy from the sun than the equator does. The dry land heats up (and cools down) more quickly than the seas. The differential

heating powers a global atmospheric convection system reaching from the Earth's surface to the stratosphere which acts as a virtual ceiling. There are the main advantages and disadvantages of wind power on the surrounding environment and the general reliability of wind turbines [3].

- The advantages of wind energy:
    1. Wind energy is extremely friendly to the surrounding environment, no fossil fuels are burnt to generate electricity.
    2. Wind turbines are great resources to generate energy in remote locations from example mountain community. The turbines can be a range of different sizes in order to support varying population's level.
    3. Another advantage of wind energy is when combined with solar electricity; this energy source is great to provide a steady and reliable supply of electricity.
    4. New technologies are making the extraction of wind energy much more efficient. The wind is free, and able to cash in on more and more of this free wind power.

- The disadvantages of wind energy:
    1. The main disadvantage regarding wind power is down to the winds unreliability factor. In many areas, the winds strength is too low to support a wind turbine and for this the use of solar power is great alternative.
    2. Wind turbine construction can last over a year, be very expensive and costly to the surrounding nature environment during the build process.
    3. A wind turbine can only support a specific population. Wind turbines aren't like power stations, where just burn a bit more fuel to generate more energy when need it.
    4. The noise pollution produces from the rotation of wind turbine.

1.2 Problem Statement

Nowadays, most of the power plants use fossil fuels as the energy to implement the operation to produce electricity to customer. As known, the capacity storage of fossil fuel energy is decreasing and its price is unstable and increases frequently. Furthermore, this energy has disadvantages by producing pollution to the environment. For example, the burning coal process, which is to generate energy to operate the power plant, will cause the air pollution.

A safe and clean alternative energy is required to replace the fossil energy. This project uses renewable energy which is wind as an alternative energy to generate and produce the electricity, since it is clean and safe for environment. Besides that, with the implementation of this project, it also helps in teaching and learning development because an educational plant that being interfaced with SCADA system.

1.3 Project Objectives

The main objectives of performing this project are:

- To implement the research base on wind energy as an alternative to support electricity generations.
- To comprehend and develop SCADA system to monitor and control the operation of a teaching and learning mini prototype plant.
- To construct the proper hardware system (include generation system and power electronic circuit) that can be well interface with SCADA system.

1.4 Project Scope

1. Inverter circuit
    - Construct an inverter circuit appropriate with data specification required for this project.

2. The Turbine Fixture and Selection of Generator/ Motor

    - Search the types of generator or motor that compatible function as a generation system for an inverter circuit.

3. Develop Project Circuit Board

    - Develop complete project circuit board from a several types of circuit such as strip board or PCB.

4. SCADA System Development
    - Develop proper SCADA system use CX- Designer software to monitor and control a circuit operation.

1.5 Thesis Outline

Chapter one present an introduction, overview of project background, problem statement; project objectives, project scope, and the thesis outline.
Chapter two covers the literature review. In this chapter will discuss about wind turbines, wind turbine system speed and energy calculations, power electronic circuit (inverter), PLC, and SCADA system.
Chapter three covers the methodology of the project. In this chapter the project workflow and schematic block diagram of the project will be shown.
Chapter four presents the results and discussion.
Lastly chapter five discusses the conclusions and stated recommendations for the future works.

CHAPTER 2

LITERATURE REVIEW AND THEORETICAL BACKGROUND

2.1 Introduction

This chapter will explain in detail wind energy as one type of renewable energy sources that worldwide use at this moment to support electricity power generation.

2.2 Wind Turbines

A wind turbine is a machine that can convert the kinetic energy of the wind into electrical energy. Blowing wind rotates the blades of the turbine and the mechanism in it can generate electricity upon this rotation [9]. All wind systems consist of a wind turbine, a tower, wiring, and the "balance of system" components: controllers, inverters, and/or batteries.

Rotors can have two or three blades, with three being more common. The best indication of how much energy a turbine will produce is the diameter of the rotor, which determines its "swept area," or the quantity of wind intercepted by the turbine [4]. The frame is the strong central axis bar onto which the rotor, generator, and tail are attached.

The tail keeps the turbine facing into the wind. Wind turbines have mainly two types. Horizontal axis wind turbines (HAWT) and vertical axis wind turbines (VAWT). The horizontal axis wind turbines shows in Figure 2.1 and the vertical axis wind turbines

shows in Figure 2.2. Both have advantages and disadvantages but horizontal axis ones are more common due to higher efficiency [9].

- HAWT Advantages

1. High efficiency because the blades always move perpendicularly to the wind, receiving power through the whole rotation.
2. Variable blade pitch, which gives the turbine blades the optimum angle of attack.
3. Most are self-starting.
4. The blades of turbine are at the centre side of gravity, so this ensure for it stability.

- HAWT Disadvantages

1. HAWTs require an additional yaw control mechanism to turn the blades toward the wind.
2. The height can create local opposition based on impacts to view sheds.
3. Downwind variants suffer from fatigue and structural failure caused by turbulence.

Figure 2.1 – Horizontal axis wind turbines

- VAWT Advantages

1. Easier to maintain because most of the main component parts are located near the ground.

2. A wind start up speed for VAWTs is lower than HAWTs. Generally, the electricity starting generate at 6 mph.
3. VAWTs may have a lower noise signature.
4. Vertical wind turbines have a higher airfoil pitch angle, giving improved aerodynamics while decreasing drag at low and high pressures.

- VAWT Disadvantages

1. Having rotors located close to the ground where wind speeds are lower due to wind shear, VAWT may not produce as much energy at a given site as a HAWT with the same footprint or height.
2. Most VAWT have low starting torque.
3. Most VAWT need to be installed on a relatively flat piece of land and some sites could be too steep for them but are still usable by HAWT.

Figure 2.2 – Vertical axis wind turbines

2.2.1 Wind Turbine System Steps of Installation Amongst Industrial and Domestic (Small Wind Generation System) [9]

- **Industrial**

1. **Wind Measurement**: As annual electricity generation depends mainly on wind speed, this step is of vital importance to be able to forecast the energy production.
2. **Feasibility studies**: This will be a detailed study to let know whether a proposed system will be a feasible project or not.