Development of the LabVIEW Monitoring System for the Hybrid PV-Wind Energy System

N. Watjanatepin and C. Boonmee

Renewable Energy Research Laboratory, Faculty of Engineering and Architecture
Rajamangala University of Technology Suvarnabhumi Nonthaburi,Thailand
watjanatepin@rmutsb.ac.th

ABSTRACT

This paper presents the PC based monitoring system for the PV-Wind energy system project that supports the Renewable Energy Research Laboratory of The Faculty of Engineering and Architecture, Rajamangala University of Technology Suvarnabhumi Nonthaburi. The objectives of this project are to measure and monitor the performance of the 4.872 kW grid-connected PV systems and 1 kW wind energy system. It can measure, monitor and display the real-time data including wind turbine voltage, current and power, PV array voltage, current and power, grid voltage, current, power and energy, solar irradiance, wind speed and wind direction, ambient temperature, cell temperature and relative humidity. It is a PC-based monitoring system; it can display data and generate reports as tables and graphs. The user could monitor by using the local area network. Then the monitoring software was developed by LabVIEW. The system hardware consisted of weather station, sensors, converter devices, controlling and interfacing devices.

***Keywords**:* Monitor system, PV-Wind energy system, performance, LabVIEW

1 INTRODUCTION

This PV-Wind energy monitoring system does not have a fixed pattern. This depends on the objectives and the technologies used for that project. Normally, the PV-Wind energy system test and evaluate the capacity of the system by using sensors, along with proper software. Nowadays, the monitoring systems will measure and collect data in a digital form. Thus, hardware that can perform data acquisition with capability to do the remote monitoring is needed. A good design for this monitoring system should have minimum impact on the performance of the generating system and the monitoring system should not consume more than 5 percent of the total output of that PV Generating System[1].This monitoring system is used to observe whether the generating system is in normal condition or not. Generally, this monitoring system should monitor the system every day, and is able to report the result daily, monthly, or yearly. Thus, the computer measurement and monitoring system is now playing an important role, because it is a highly flexible system for installing new sensors, measuring instruments, and different types of hardware. Moreover, the software also should be flexible, can be use with many types of hardware, easily developed, or be the software that has a capability to program with modular graphical programming language. Lab VIEW, a program by National Instruments, is fitted to all these requirements and that is why it is widely used among researchers and engineers. Using the mentioned software to develop this monitoring system for PV-Wind energy system is a good option. The development can be done parallel with the generating process. The software can be easily edited. Also the system can be implemented on Microsoft Windows, which can work through internal and external network. Also, the data can be easily downloaded, which leads to less upgrading time in the future, and the improvement can be done without changing any hardware. [3] In order to create a highly reliable monitoring system, the researcher need to select a proper hardware that can be used with selected software. This includes all sensors, transducers, data loggers, receivers, distributors, or hardware interface via Ethernet network under TCP/IP. This should be standard equipment that is widely used. The Rajamangala University of Technology Suvarnabhumi (RMUTSB) Nonthaburi has worked on this research project on PV-Wind energy system, which was installed since 2004. The system is still in use until now. This system use amorphous silicon type photovoltaic module, the maximum power is 4.872 kW. It is equally separated into 3 sets. Each photovoltaic array provides DC current to 2.2 kW 220 V/50 Hz 1phase grid-connected inverter. These three inverters will then generate AC power and will directly send the energy to the distribution system, which also provide electricity to the research building. In 2008, two of 1 kW PMSG wind turbines were installed at the same place. Each wind turbine provides AC current to three phase rectifier and provides DC current to 550W 220 V/50 Hz 1 phase grid-connected inverter. Then each inverter supply AC power directly to the grid as shown in figure 1. Currently, this PV-Wind energy system does not have a full monitoring system. It can still measure and display only the average value of the output, and some parameters. The system cannot check other compulsory values that affect the process of this generating system. Therefore, this monitoring system is designed and created to fulfill the objectives to monitor and report data from this PV-Wind energy system effectively.

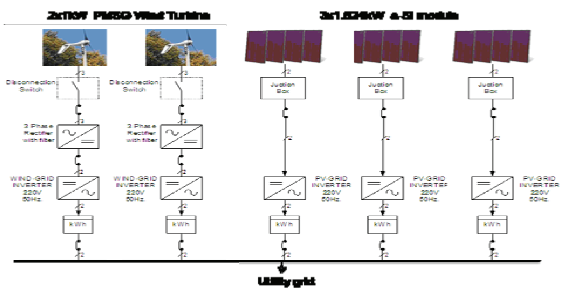

Figure 1: The diagram of PV-Wind energy system

2 SYSTEM DESIGN

2.1 Variables to Monitor

2.1.1 System Energy Information Technology

It is a standard for any electrical generating system. These data includes energy power generated (in kWh), DC power from a photovoltaic array, AC power from inverters, etc. This information can be acquired from the inverters, which normally have software to get this kind of data. Thus, this operation cost for this energy system technology is quite low.

2.1.2 Engineering Information Technology

The desired data from the monitoring system that is suitable for engineering information technology generating system will normally take 2 to 5 years, and each data logging should take around 5 to 15 minutes. So, in order to get an accurate data that can show the trend of the actual system, such as number of shut downs, time period of starting and shutting down, etc, the operation cost for measuring will be quite high.

2.1.3 Research Information Technology

Information that will be used for research information technology is in-depth information that may need short sampling period from 1-5 seconds depending on the objective of the research, and of course, the cost for this information technology is much higher than the first two types mentioned earlier. In this project, the researchers have already assigned a total of 18 desired variables for the purpose of future uses. These variables are as followed: voltage, current and power of the photovoltaic array, voltage, current and power of the wind turbine, voltage output of the inverter, current output of the inverter, total energy output, date and time, solar irradiance, wind speed, wind direction, ambient temperature, PV module temperature, and relative humidity.

2.2 Hardware Design

This monitoring system is designed to acquire two parts. One is the weather condition at the research area consisted of ambient temperature, relative humidity, PV module surface temperature, wind speed, and wind direction. Another part is the data from the generating process, which is connected to an existed distribution system. The digital data is connected through inverter, and saved on the database. It can analyze and generate researched information report easily. The monitoring system for PV-Wind energy system consists of the following devices.

2.2.1 Sensors

1. Pyranometer is used to measure total solar irradiance (W/m^2). Researchers decided to use black and white pyranometer model 240-8102 from NovaLynx

2. Temperature sensors selected for the project is PRTD (Platinum Resistance Temperature Devices) manufactured by NovaLynx model 210-4470A.

3. Relative humidity / temperature probe for this project is a highly accurate type.The measurement is 1% RH /±20%, its stability is better than ±1% RH / year, the humidity range is 0-100% RH. The Rotronic Hygromer type sensor provides the output signal in current of 4-20 mA, temperature range of °C-50 to + 50°C, accuracy of ±0.3°C, and also provides the signal in 4-20 mA current output. The PRTD 100Ω Model 41382LC/LF was manufactured by NovaLynx is selected, since the system need to be installed in the open area,and the measurement might be wrong because of the solar radiation. Thus multi-plate radiation shield model 4100S is also used in the system.

4. Wind speed / Direction sensor this sensors sent the signal output type is 4-20 mA. The selected sensor is NavaLynx model 200-WS-22.

2.2.2 Data Acquisitions and Controller Interfaces

Data acquisitions and controller interfaces acquire data from its entire sensor, which is a analog signal. Then it will be converted into a digital signal, and it can control the data communication through a specific computer network by using connecting module used in the industry. Researcher chose National Instrument Distributed I/O product for this application. This is a small module with a capability to expand the system in the future without changing hardware. The detail for this distributed I/O is as shown below.

1. CFP-AI-110 8 Channel analog Input Module for Compact Field point programmed to acquire both voltage and current input.

2. CFP-2000 Ethernet Controller interfaces used to acquire data from analog input module, and sent the data to the computer used for database though the computer network (This module can be used with RS-232, RS-485, and TCP/IP).

3. CFP-CB-1 Connector Block

4. CFP-BP-4 4-Slot Backplane used to mount all the modules together. For this project, there are 3 backplanes used, and 1 for spare part.

2.2.3 Connection

Because the distance between the computer and devices is around 50 meters, the interface is divided into two parts. The first part is between interfaces and PC since there are 3 sets of PV inverters and 2 sets of wind inverters; each inverter has RS-232 output port, which is needed to be converting to RS-485 type by using ET-RS422/485 to increase the capability for long distance connection. The researcher used PCI-485/4 serial interface to acquire data from RS-485/4 into a computer used to analyze the data.

2.2.4 PC-based Monitor System

PC-based monitor system is an important device that plays a role as a database, displayer, and report generator. The PC acquires the signal that sent via RS-485 and TCP/IP. The acquired data will be displayed and saved to the database. Thus, the PC should have the capability to process data in high speed, as well as enough RAM. Thus, CPU speed about 3-GHz, Operating system is Windows XP or higher, Ram 2 GB, Harddisk 250 GB was selected. There must be programs installed in the system, which are;

- RMUTSB-H1
- Database program MySQL
- Microsoft Office

2.3 Developing RMUTSB-H1 program

When developing RMUTSB-H1 program, the constrain and functions into two parts.

2.3.1 Data Acquire and Save Program

This program is designed to connect with all hardware to acquire data and transfer it to PC including analog input from sensors that will be sent through data acquisition devices, and digital signal from five inverters. The main programs also have 4 subs VIs, which are; Data acquire and logging, Setting parameter Status Checking, and Report. The program will start to acquire the data in the following order.

- Solar Irradiance
- Wind Speed and Wind Direction
- Ambient Temperature
- Relative Humidity
- Surface Temperature on the front and back of the PV module
- Electrical parameter from inverter 1,2,3,4 and 5

The result will be displayed on PC monitor and saved to the database, and wait until the next acquisition (5 minutes per on iterations).The loops will continue until the user stops the program.

2.3.2 Report Generating Program

This report generating program will get data and generate a report from the database. LabVIEW was used to develop the program together with the toolkit from SQL to connect to database with ODC(Open Database Connectivity). In order to get LabVIEW to connect to Windows to the database, the researcher has to create a program that is able to create the database. The time for display is set to time standard; daily, monthly, and yearly average. The report will be display in Microsoft Office program.

3 SYSTEM INSTALLATION

Authors installed one PRTD temperature sensors on the front surface of the PV module, and another one in the back. Pyranometer was installed to measure the global irradiance in a closed area that will not create a shadow on the PV module surface. Inverter will be place inside the 5th floor of the research building. Wind Speed and direction sensors were installed at the same place as temperature/humidity probe but placed on a two meters long tower. These sensors are also place on the 6th floor. For the PC-based monitoring system, authors installed this at the research laboratory at the 1st floor of the same building. The installation diagram is as shown in figure 2.

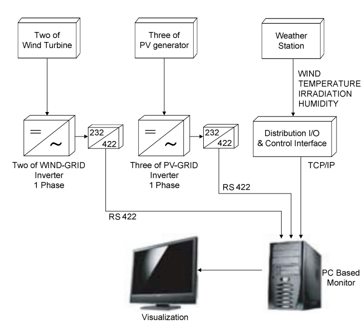

Figure 2: The installation diagram of PC based monitoring system

4 RESULTS

The PC based monitoring system that has been developed is complete on 2008.The system had been tested at the beginning of the usage, and had been improved until it can give satisfying results,as well as provides accurate data report. The program has been improved until the middle of 2008.

4.1 RMUTSB-H1 Program

The display of the program is as shown in figure 3. This shows real-time data, and can also set sampling time. Furthermore, the program can also select the data that will be analyzed and generated as a report. The visualization panel shows the energy generation from the PV energy system, and wind energy system. It represents daily real-time data and accumulation of the hybrid energy system, as shown in figure 4.

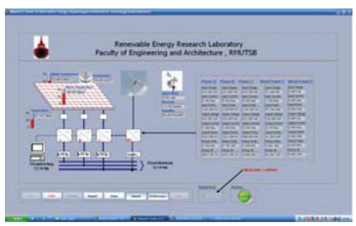

Figure 3: The display of the PC based monitor program

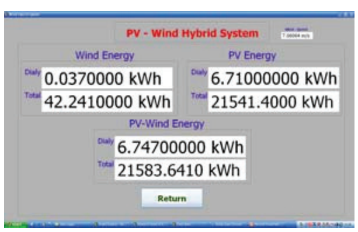

Figure 4: The display of the visualization panel

4.2 Observation Results

The analyzed data used for observation is acquired from 2008 to 2009. Author sampled the result of data on January 15, 2009 and August 30, 2008. The acquisition is processed every 5 minutes. The result of the solar irradiance in maximum is 697.972 kWh/m^2 at 12:25:56. This monitoring system (as shown) when it is cloudy, the solar irradiance will decrease, for example at 14:16:56 it is 364.162 kWh/m^2, and at 15:40:56 dropped to 158.632 kWh/m^2 as shown in figure 5. So, the output current of three inverters of the PV generating system is equal to 3.7A, 3.74A, 3.64A in order to phase A, B and C. Then the output current of three inverters will decrease when the solar irradiance decrease, to be harmonious with the global irradiance as shown in figure 6.

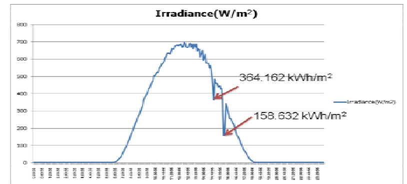

Figure 5: The solar irradiance on January 15, 2009

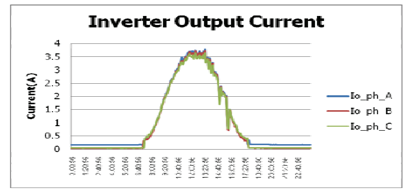

Figure 6: The output current of three inverters of the PV energy system on January 15, 2009

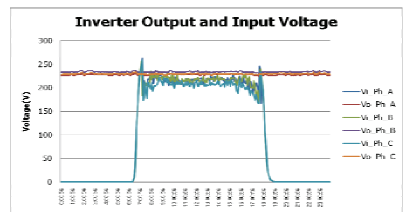

Figure 7: The output and input voltage of three inverters of the PV energy system on January 15, 2009

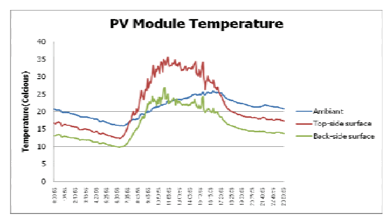

Figure 8: The ambient temperature, front surface and back surface of PV module on January 15, 2009

Figure 7 shows the output and input voltage of these inverters. The ambient temperature, front surface and back surface of PV module as shows in figure 8.This is to show the behavior of PV module when it had been operating all day. The difference of the maximum temperature between the front surface and back surface is 11.96˚C at 14.45.56, so, the difference of the average temperature is 9.618˚C. This point is very interesting to apply so that it can be use to convert temperature to energy.To monitor the behavior of wind energy system, authors choose data from August 30, 2008 (the acquisition is processed every 5 minutes). It was found that the average wind speed is 5.829 mph, and the maximum output power of wind-grid inverter (NO1) is equal to 90.015W at 15.148 mph as shown in figure 9. Figure 10 shows the input and output voltage of the same inverter, found that the average input voltage is 29.236V, and the average output voltage is 229.291V.

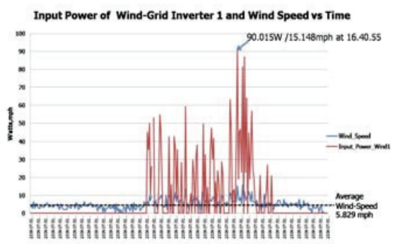

Figure 9: The input power of wind-grid inverter 1 and wind speed on August 30, 2008

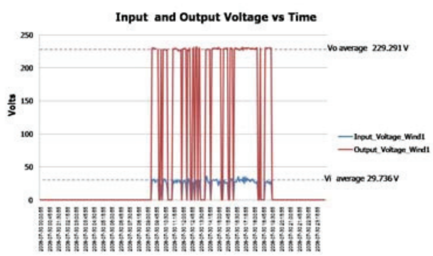

Figure 10: The input and output voltage of wind-grid inverter 1 on August 30, 2008

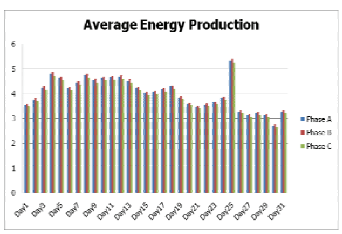

Figure 11: The daily energy production from inverter of the PV energy system on January 2009

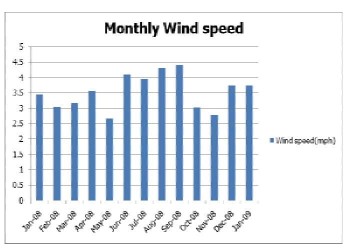

Figure 12: The monthly wind speed during January 2008 to January 2009

You can make a report that can compare the same parameter in difference day or month. For example the daily energy production from three inverters of the PV energy system in the whole month (January 2009) and the acquisition is processed every 5 minutes as shown in figure 11. It shows the maximum energy produced on January 25, which is equal to 5.34kWh, 5.4099kWh, and 5.25kWh arranged in order of phases. The monthly report of average wind speed during January 2008 to January 2009 as shown in figure 12. Its' average wind speed is 3.5322 mph, the maximum is 4.4034 mph on September 2008. And the minimum is 2.6735 mph on May 2008.

5 CONCLUSIONS

The monitoring system that the authors developed to monitor the PV-Wind energy system could be use to measure and correct the data according to the researcher's goals. It is able to generate report in order to research information from PC data-based Microsoft office. The research information could show the behavior of the operation of the PV-Wind energy system. This monitor could show the unusual operating condition of the system. Also, this system could be a remote monitoring system via the Internet network. It is easy and appropriate for the researchers. However, the monitoring systems need the assistant researcher to work with. Because he or she has to observe the monitoring data and analyze to maintain the energy system so that it can continue its operation. This means that we have the operating cost. If the system has a problem he or she has to fix it as soon as possible. It is very important for the large energy system. Next, authors have to develop this system so that it could warn when system errors occur. It can send the error message through the mobile phone network, and sent email to the researchers. Examples of the inverter malfunctions are PV array cannot supply the DC voltage, or wind generator fail, etc. That could decrease the error from the system shut down, which means that the energy production will increase.

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