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Research paper

Data Monitoring System for Micro-Wind Turbine Experimental Set Based on LabVIEW

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Abstract

The Wind Turbine Energy System (WTES) was applied to a micro-scale laboratory experimental set. Thus, there is a need to develop a data monitoring system in order to be applicable with the Wind Turbine Energy System. The aim of this study is to design and develop the data monitoring system for the Micro-Wind Turbine (MWT) experimental set, and to test the real time output and analyse the obtained results. The MWT output power is 100 watts 12 VDC with the cut-in speed is 3 m/s. The WTES consists of MWT, DC converter, and a Grid-connected inverter. This data monitoring system will be based on LabVIEW environment. The NI-9215 NI-9226, NI 9203, NI 9225, NI 9401 with chassis NI 9178 data acquisition devices were applied. The data monitoring program was developed by LabVIEW2013. The LabVIEW based data monitoring system has successfully met the objective of this study. It is capable of providing real time acquisition of the wind speed, electrical current, voltage and power of the Micro-Wind Turbine Energy System. Moreover, the software can generate a report from the MySQL data based via Microsoft office automatically.

Keywords: *Data Monitoring System; LabVIEW; Micro-Wind Turbine; Experimental set*

1. Introduction

Energy from the wind is a highly valuable type of alternative energy that is widely used for electrical energy production around the globe. The energy conversion process involves using the wind turbine generator to convert wind energy to mechanical energy, and eventually being converted to electrical energy. The Global Wind Energy Council reported that the total energy produced by wind turbine generator installed globally to be about 432.9 GW. [1]

Nowadays, the Micro-Wind turbines are widely used in the urban areas because of their ease of installation, low cut-in wind speed, low noise, and low maintenance cost. Understanding the operating characteristics of the MWTES is important due to the fact that people who work with the MWTES need to have the experiences and skill from the MWTES. Lastly, the MWTES basic design skill is also a necessity in order to develop other skills future usage. We need to study the MWTES on the real equipment under different patterns of the wind distribution.

In our case, the wind turbine is operating on the actual wind and thus, the wind energy will varies all the time due to the wind speed and direction resulting in dynamic variation. This causes the voltage, current and power flowing through the MWTES to be varied according to the wind speed as well. The measurement system that is appropriate for MWTES must be able to quickly acquire data from the wind speed and from the others parameters.

The special data monitoring system can also be applied. The system will then be able to acquire the wind speed signal, current and voltage signal from AC/DC parts. Moreover, it can analyse and determine all parameters to display in the graphical and numerical mode. Lastly, it can store the measurement data into the database system, and can generate the report in the format of Microsoft Office automatically. LabVIEW programming is a high performance of PC based measurement and data acquisition. It offers easy-to use construction of graphical user interface. The program is also applicable for the analysis and processing of signals, controlling, simulating, report creation and data base connection.[2] The objective of this study is to design and development the data monitoring system for the MWT experimental set, and test the real time output and results analysis. This system will be based on LabVIEW environment, with the DAQ hardware from National Instruments.

2. Literature Review

Jagathdarani was reported a process to elevate the efficiency of the solar G2GPVT system by inherent cooling method and monitoring using LabVIEW with the NI hardware. The experimental real time results monitored showed that performance and efficiency of the G-G solar PVT panel is higher when compared to the conventional (G-T) solar PV panel. [3]

Khera presented LabVIEW with a microcontroller based data acquisition system which can be used to acquire electrical parameters like voltage and current, active power and energy of real time remote monitoring system for the resistive load supplied from a 1-phase 220V/50Hz.[1]

Chabchoub developed a biomedical monitoring system based on LabVIEW FPGA. This system has the advantage of acquiring and analysing several physiological signals which were recorded from the heart, the brain and the muscle respectively.[4]

Karar developed a LabVIEW interface with Arduino Uno, current and voltage sensors, relays and controller. Monitoring interface uses real time measurement results to prepare the power, current

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and voltage graphs. It is also possible to analyse history of data. [5]

Ahmed presented the online performance, characteristics evaluation and parameters estimations for stand-alone PV panel via LabVIEW. The hardware interface used in that study was a NI-DAQ. Finally, the online monitor system was display weather data, electrical data, and determines the V-I and V-P characteristic of the PV panels via the internet. [6]

Kumar used the LabVIEW build-in web server application to monitor and control the PMDC motor. It can monitor and control (closed/open loop) the speed of PMDC motor over the internet perfectly. [7]

Yu reported the LabVIEW-based synchronized high speed multi-channels data acquisition card and some photoelectric conversion module. This system was controlled via a PCI bus interface. The system has high computational efficiency, high precision, which can be efficiently utilized in experiments relating to the measurement system. [8]

Stuchlý reported on a LabVIEW with DAQ multi-function card to monitor and control a system remotely. This LabVIEW program has been developed on physical platform of family house operated in Off-grid system. The report also mentioned post-processing of the measured database and long-time period measurement that will compile a standardized daily load curve, which will subsequently be implemented into Smart Grid system. [9]

LabVIEW is very powerful software for the control, monitoring of a system. It has friendly interface and compatibility with many type of the hardware. They also support the micro-controller, embedded devices, FPGA, Arduino, DAQ-card, c-DAQ, PCI-DAQ, low-cost DAQ and more. LabVIEW can adapt to any sensor including the physical or electrical parameters and weather

3. Material and Method

3.1. System Overview

The diagram of the LabVIEW-based data monitoring system for the MWT experimental set.(Figure 1) The sensors will detect the data from the MWTES and send them through the data acquisition(DAQ) devices. The LabVIEW program will save the measurement data to the database in the computer. Moreover, the monitored data will be interface to the user. This system could measure the wind speed, from the wind speed sensor model 6410 (DAVIS INSTRUMENTs). The output signal connect to a DAQ module is NI-9401. This is the 8-channel digital I/0 module with high speed acquisition. The DC current sensor used in the system is a current transducer model DK20C10U (LEM).

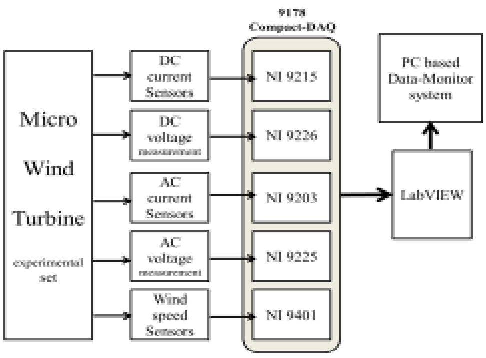


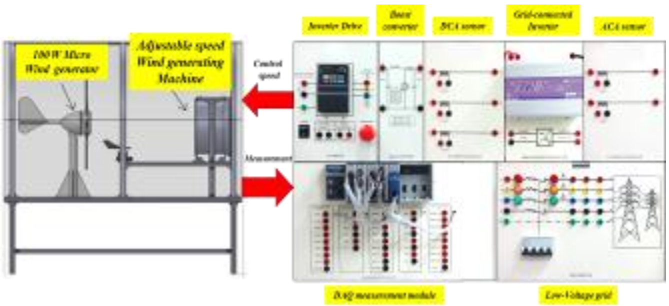
Figure 1: Diagram of the signal sensor and data acquisition module for MWT experimental set via LabVIEW

The purpose of the DC current sensor is to measure DC current and convert to DC voltage. The sensor output is connected to the DAQ NI-9215 which is a ±10V analog input module. There are in total 4 channels with 100 KHz sampling rate. The DC voltage measurement by DAQ model NI-9229. It is ±60V simultaneous analog input module with 4 channels, and has a data acquisition speed of 50 Ks/s. This data is based on the DC voltage from MWT experimental set based on a 12V system. This module is appropriate for DC low voltage measurement due to the fact that the DC voltage sensor is not required. The AC current sensor used is a transducer of model AK5B420L (LEM). It can measure RMS current from 0 to 5A and convert to 0-20mA signal. The AC current sensor was connected to the system by the DAQ module NI-9203. It is ±20mA, current analog input, and 8 channels with 200 Ks /s sampling rate.

Lastly, the author used NI-9225 DAQ module for the AC voltage (220Vrms 50 Hz) directly measurement. The input terminal supported 300Vrms, 3 channels analog input, and sampling rate 50Ks/s. All of the NI-DAQ module will be put on the slots of the chassis (cDAQ-9178, includes the DC power supply and USB interface cable.

3.2. MWT Experimental Set

The MWT experimental set comprises of six major parts.[10] (1) The wind generating machine. The axial fan motor (3 phase, 220V, 50Hz, 375W, 1450 RPM, Blade diameter 60 cm) with adjustable speed drive was applied. The frequency convertor drive DELTA VFD-EL 220V /50Hz /4.2A, was used for controlling the speed of the motor. (2) The Micro-Wind turbine generator that contains 6 blades (100 W, 12 V_{dc}). The blade diameter is 90 cm. (3) Boost convertor that can generate the maximum output voltage of 42V and maximum current of 6A.(4) Grid-Connecter inverter with the output of 190-260V, 45- 65 Hz and the input of 10V-



30Vdc. (5) AC and DC current transducer measurement

Figure 2: MWT experimental set

3.3. Labview Based Data Monitor Program

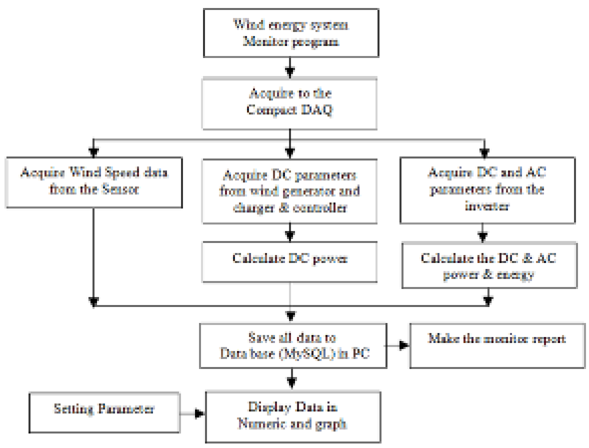


Figure 3: Diagram of LabVIEW based monitor program for WTES

The data monitoring program was developed by LabVIEW in order to acquire, calculate and store all measurement data to the MySQL, communicate with sensors, DAQ module and PC via USB interface. The sampling time that was set up to acquire the data can be adjusted at the default setting to be 60 s in the data logger mode. The user can display readings on the screen and make graphical representations. The program consists of 7 major sub programs with the following functions which are; (1) Acquire to compact DAQ (2) Acquire wind speed from a wind speed sensor. (3) Acquire and calculate data from a wind generator and a charger & controller. (4) Acquire and calculate data from an inverter. (5) Save to the database. (6) Display monitoring data, and (7) Make a measurement report. (Figure 3)The author could show some of the major VI blocks that were developed from LabVIEW. For example, the VI-blocks of function (2) which can acquire wind speed from a wind speed sensor (Figure 4). These VI-blocks will show how to retrieve and display the measurement data from wind speed sensor. The wind speed sensor is connected to the input of NI 9401 module. This VI can calibrate the offset and multiply value if the wind speed sensor is changed in the future.

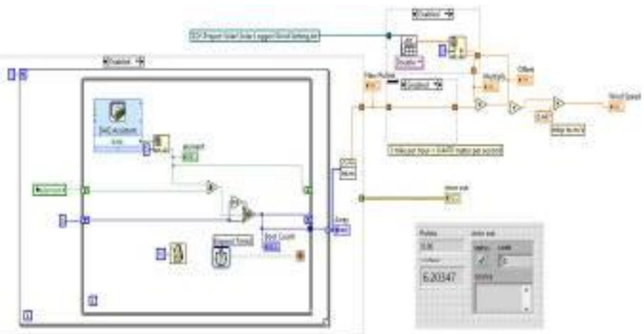


Figure 4: VI block and measurement test of the Wind speed.vi, sub-program (2)

4. Results and Discussion

4.1 Real Time Monitors Output

The experimental results were set up by LabVIEW-based data monitoring program for the operation of the MWT experimental set. The output of the inverter was connected to the low voltage grid. The experimental set was operated by the monitoring program in the numerical mode by adjusting the wind speed from 0 to 10 m/s. Subsequently, the electrical parameters and wind speed are recorded. Finally, the monitoring software is set up in the graphical mode and the wind speed command is sent as shown in the Figure 5.

The output from the MWT experimental set has been monitored for 43 minutes. The author made a wind speed command with the step function plus and linear function which was later sent to the invertor to control the speed of wind generating machine. The wind speed command showed in Figure 5. The output variations are due to the wind speed, the wind generation parameters (Voltage/V, Current/I, Power/P) and inverter electrical parameters (V, I, P, PF). Figure 5 shows the real time output with the X-axis of the graph indicating the V, I, P and wind speed while the Y-axis indicating the time. The real time data graph was show the wind generator voltage maximum of 28.52 V (no-load case), and the on-load case having the value between 11.85-12.55V. (Figure 5, a) The invertor output voltage is around 226.07 to 230.15 V when the inverter is connected to the low-voltage grid. (Figure 5, b) The output power and current from the wind generator and the inverter is in accordance with the wave form of the wind speed. (Figure 5, b, c,)

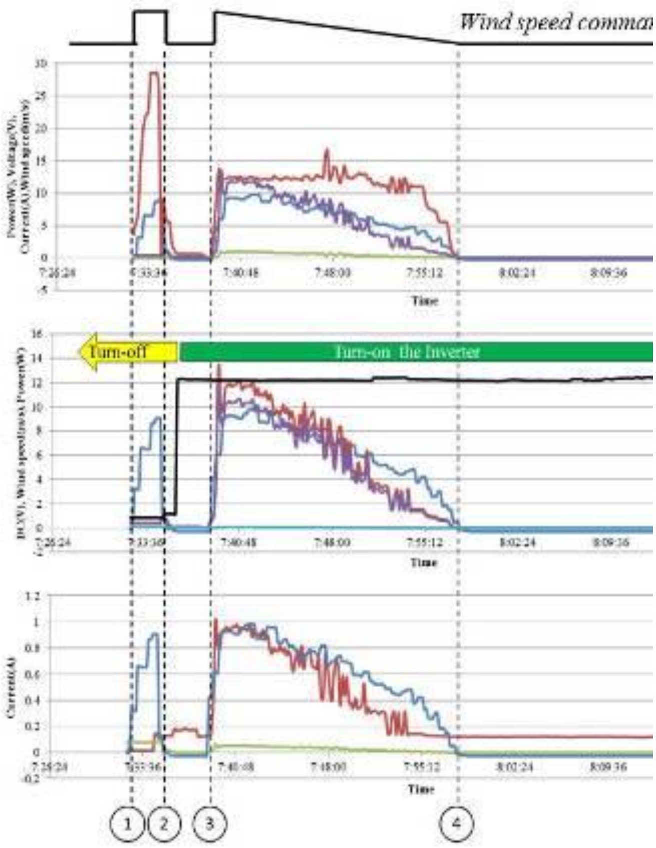


Figure 5: Real time output of MWT (on-grid system) by the Data Morning system via LabVIEW

4.2. Results Analysis

The author tested the real time electrical parameter test reading of the MWT experimental set (on-grid case) by adjusting the wind speed from 0 to 10 m/s. The data monitoring system was applied to measure and display reading from the numerical mode as shown in Figure 6. Table 1 shows that when the wind speed is lower than 4 m/s, no power flows in the MWTES. When the wind speed is higher than 4 m/s, the MWTES will be in operation. The power output of the wind generator and grid- connected invertor will increase linearly with the wind speed. The plot of wind turbine power curve from the experimental results is identical to the power curve from the wind turbine manufacturer.

4.3 Discussion

The limit of this study is the errors of measurement. From the results, found that the AC current may have some errors because the wide range of AC current transducer (CT) especially if the AC current is lower than 0.5A. In this case we can improve the measurement's accuracy by using non-CT current measurement. The NI-9227 module (4-
Channel AC current input, 5A, 50 kS/s, from National Instruments) could be used as an alternative to direct AC current measurement at the output of the grid- connected inverter. This setup will conform to the study of [3] that had obtained high accuracy of the AC current measurement.

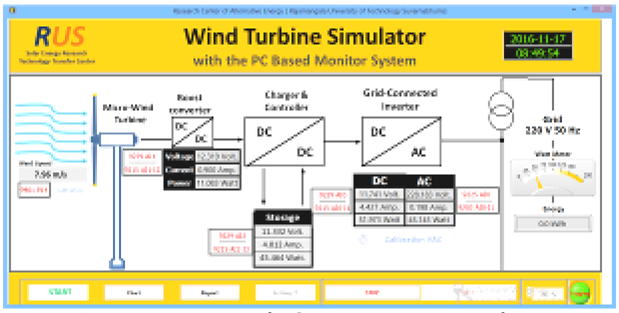


Figure 6: Font page of a data monitoring system for MWT

However, the LabVIEW-based data monitoring system that was applied to monitor the electrical parameter can still achieve targeted results which is in accordance with the study of [5] and [6], and [9].

Table 1: Electrical parameters test reading

Wind speed	Wind Turbine Generator			Grid-connected Inverter			
(m/s)	V(V)	I(A)	P(W)	V(V)	I(A)	PF	P(W)
0.00	0	0.00	0.00	224.30	0.00	0.28	0.00
1.57	4.69	0.00	0.00	224.50	0.00	0.29	0.00
2.35	7.84	0.00	0.00	224.00	0.00	0.28	0.00
4.05	11.73	0.00	0.00	224.30	0.00	0.28	0.00
4.73	14.99	0.03	0.49	224.60	0.01	0.16	0.41
5.45	16.58	0.04	0.66	224.00	0.01	0.16	0.44
6.68	18.71	0.04	0.65	224.10	0.02	0.16	0.55
7.50	21.75	0.07	1.50	223.60	0.02	0.16	0.68
8.05	23.87	0.17	4.08	224.10	0.04	0.20	1.57
9.32	24.07	0.25	6.07	223.90	0.04	0.32	3.08
9.90	24.21	0.37	8.98	224.50	0.05	0.40	4.72
10.29	24.32	0.42	10.31	223.90	0.06	0.43	5.61

5. Conclusion

In this paper presented a real time data acquisition and monitoring system based on LabVIEW 2013. The data monitoring system has successfully met the objective of this study. It was able to provide real time acquisition of the wind speed, voltage, current and power of the MWTES. The LabVIEW-based data monitoring system with the compact DAQ has a great benefit for the usage in the laboratory. The real time monitor data in graphical mode can support further studies. This system is easy to use and is capable of monitoring all electrical data. This system can reduce the experiment time and can be applied in research studies of the engineering students.

Acknowledgement

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