Design of a Remote Data Monitoring System for a Solar and Wind Based Renewable Energy Power Source:Application to a Water Delivery Project in a Rural Community.

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A large number of projects including analysis and design of renewable energy sources have been reported by several institutions. Particularly, solar and wind energy based power sources have resulted in a variety of interesting projects, including automatic control of solar tracking photovoltaic panels and solar wind combination sources for various applications. The current work illustrates the design of a computer controlled system for monitoring the power generated by a renewable energy power system under a recorded local weather condition. The monitoring system includes a web-based Labview power measurement apparatus as well as a complete wireless weather station. The power system consists of a solar tracking photovoltaic (PV) system and a Whisper H80 wind turbine. The power system generates up to 2KW of electrical power. The remote data monitoring system provides a round the clock information on the generated power, the wind speed, humidity, rain water level, outside temperature etc… The system is programmed to provide data logging for an assessment of the correlation between the local weather condition and the electric power generation. The remote system will also be equipped with a provision for switching to net-metering with an interface to the local utility company. The remote monitoring system is scheduled to equip a similar solar/wind hybrid power station recently inaugurated in rural Ethiopia.

Keyword: Stand alone PV systems, Water pumping, Hybrid, Monitoring

1 DESCRIPTION OF THE RENEWABLE ENERGY SOURCE

As depicted in **Fig. 1**, the renewable energy based electrical power source comprises:

1. A photovoltaic array of twelve (12) 80-Watt solar panels; and
2. A Whisper H80, 900-Watt wind turbine.

The electrical power generated by this combination of solar and wind power can reach up to 2KW. This source has provided power to a variety of projects undertaken by engineering and science students at UDC and elsewhere [1,2,3,7]. However, provision for monitoring the power generated by the source was not put in place. Also, provision for evaluating the correlation between the local weather condition and the power generated by the source was missing.

As described in **Fig. 2**, the power system can be configured to provide either DC output only or AC output only. The DC output configuration is obtained by connecting the Wind turbine's 3-phase output and the solar array's DC output directly into a Grundfos [5] IO102 switch box which is designed specifically for combining these two solar and wind generator outputs in order to provide a single DC output signal to be fed to a specified DC load.

Figure 1: Renewable Energy power source on the Van Ness campus of UDC comprising an H80 Whisper wind turbine and a sun tracking solar array

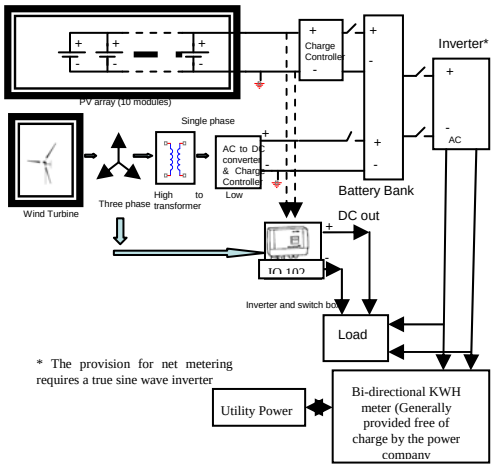

Figure 2. Diagram depicting the electrical connections of the power system

Power measurement procedure

Power measurement across a terminal load is typically made by evaluating with a voltmeter or a digital multimeter (DMM) , the voltage, V(t) across its terminals and by evaluating the current I(t) going into the load.. The obtained electrical signals, V(t) and I(t) are either constant values if a constant DC source is used or can be time dependent if the power source is time-varying.

The relationship between the power absorbed by the load and the power generated by the load depends on two factors: the nature of the signal applied to the load and the nature of the load itself. If the load is purely resistive, the power is simply the product between the voltage and the current If the load is capacitve or inductive, there appears a phase shift between the voltage and the current and a power factor needs to be evaluated as shown in equation 1, giving the general expression of power, where cosθ represents the power factor of PF of the load.:

$$P(t) = VI\cos\theta \quad (1)$$

Hence, a purely resistive load or a DC source would lead to a PF of zero.

In the context of the power system described earlier, there are several points in the diagram of the power source as shown in **Fig. 2**, where a power measurement could be effected.

2 LABVIEW POWER MEASUREMENT

Labview [4] is a very versatile software package capable of driving a multitude of computer boards. It uses the concept of virtual instruments or VI's for a variety of applications.

In particular it has capabilities for:

- Voltage and current waveform acquisition;
- Simultaneous acquisition of both measurement waveforms ; and
- Analysis functions (i.e. mathematical functions, transforms etc…).

These are essential capabilities for evaluating electrical power. The version of Labview used during the implementation of the project if version 7.1, The board which is used for acquiring the voltage and the current signals is the **NI-4060**, **5** ½ digit digital multimeter (DMM) board as shown in **Fig. 3**.

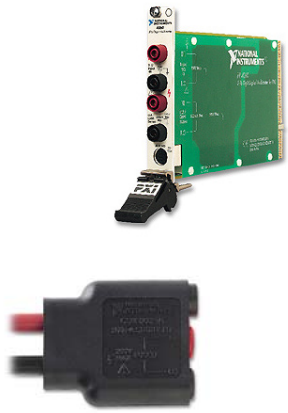

Figure 3. National Instrument's NI-4060 and the 10A current shunt module (Photograph courtesy of National Instruments, Inc.)

The system requires two DMMs:, one configured to measure voltage and the other to measure current.. A 10A current shunt module has to be used for measuring currents exceeding 200mA.

As shown in **Fig. 4**, the power measurement selected for the project is made at the output of the IO-102 switch box when the arrays and the wind turbine are disconnected from the battery bank. The output of the IO-102 represents the combined outputs of the solar array DC output voltage and the "rectified" three-phase AC output of the wind turbine. The load used is a 900 Watt submersible water pump, 11 SQF-2 from Grundfos.

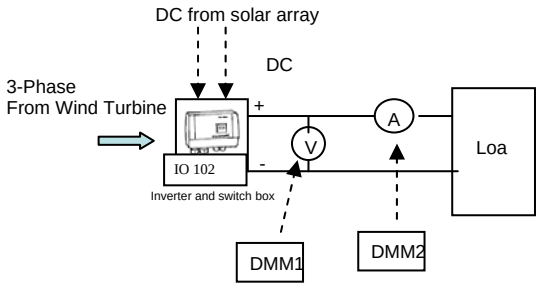

Figure 4. Power measurement tap points in the power system

The DMM1 operates as a voltmeter whereas the DMM2 is configured as a high current ammeter which is the equivalent of a voltmeter with a 10A shunt module.

The Labview program corresponding to this configuration is shown on Fig. 5 with the corresponding front panel display.

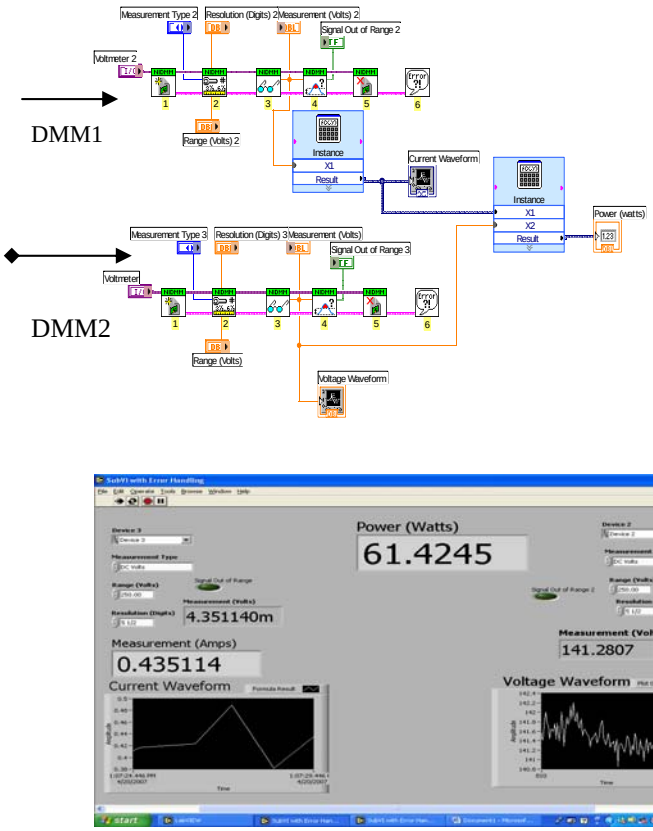

Figure 5. Labiew virtual instrument based design and the resulting front panel

A sample result of the data collected in two consecutive days, one rather cloudy and the next sunny is shown in Fig. 6

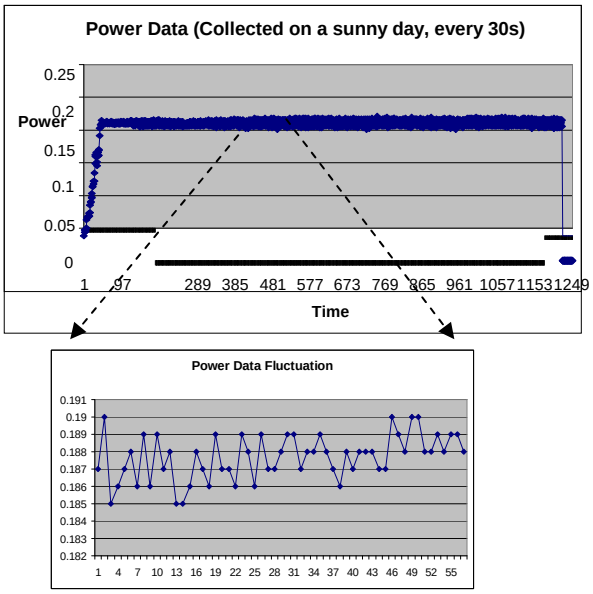

Figure 6. Power data sampled every 30s on a sunny (not windy) day

3 WEATHER MONITORING SYSTEM

The weather station contains a complete wireless Vantage Pro2 weather monitoring system as shown in **Fig. 7.**

Figure 7. Vantage Pro2 Weather Station (Photo, courtesy of Davis Instruments Inc.)

The Vantage Pro2, from Davis Instruments [6] comprises precision weather instrument, including:

An Integrated Sensor Suite with a:

- A Rain collector;
- A Temperature Sensor;
- A Humidity Sensor;
- An Anemometer; and
- A Solar panel

A Wireless Console/Receiver; and

A Mounting hardware

The complete weather station shown in **Fig. 8** is configured and installed next to the renewable power station. The weather data can be accessed wirelessly from a distance of 1000ft.

Figure 8. Complete weather station and sample data collection

The console must first be setup with pertinent information pertinent to the project site, such as:

- Time & Date
- Latitude (N 38 ° 56')
- Longitude, W 77 (from www.geocoder.us)
- Time zone (EDT)
- Daylight savings settingsDaylight savings settings
- Elevation 282/86 (ft/m)
- Beginning of rain season
- Serial Baud Tate (19200)

The weather data is first transmitted wirelessly to the console by a transmitter located at the project site. The collected weather data is then stored in the data logging computer located in the project lab through a 19200 Baud serial port access. The data will then be accessed from Labview and be made available for remote access with the online monitoring system outlined in section 4.

4 ONLINE (WEB-BASED) MONITORING AND PUBLISHING OF POWER DATA

The on line monitoring of the power data is accomplished with the Web access features of the LabView software package from National Instruments.

The procedure is as follows:

<u>On the server computer</u>:

Loading VI's as depicted in **Fig. 5** and other collected weather data as in **Fig. 8** to memory; and
Configure the server computer by :

- Setting access limitation of the server by authorized IP addresses of client computers
- Setting a time limit for a client to access the server
- Providing browser access capability by making the VI's visible
- Enabling the server

<u>The client computer placed at the project site will have the following features</u> :

- No need to load Labview application software
- A "runtime engine" (29 Mb) file provided by National instruments has to be loaded
- The IP address of the client computer should be listed in the browser access list of the server computer
- The VI on the server computer can then be accessed using the web UR of the server computer
- The power monitoring program can then be run from the client computer.

5 STUDENT PARTICIPATION

The entire project was undertaken by engineering students in the school of engineering and applied sciences (SEAS) at UDC. The interdisciplinary nature of the project provided a great team work opportunity to the students. **Fig. 9** shows a few of the students who participated in this project.

Figure 9. Student participation
(The left photograph students are standing next to the solar array. In the right photograph, Abyu is erecting the pole which carries the weather data collector unit)

6 IMPLEMENTATION OF THE MONITORING SCHEME IN RURAL ETHIOPIA

The power and weather monitoring scheme is scheduled to be implemented at a solar/wind hybrid power station in rural Ethiopia. In fact, on July 24, 2008 a renewable energy power source comprising a 10-panel PV array and a wind generator was inaugurated in Farsi Senkele district, near the town of Ambo, 110 km from the capital Addis Ababa. The power source as depicted in Fig. 10 is used for water pumping with a DC submursible pump. The water is pumped into a 10,000 liter reservoir shown in **Fig. 11** and dispensed to the local community of 2,000 people.

Figure 10. Solar/wind, hybrid power station in Farsi Senkele (Ethiopia)

Figure 11. Water reservoir (10,000 liter) in Farsi Senkele

7 CONCLUSION

The remote access to power evaluation and weather data collection can be very useful for monitoring power stations located in hard to access areas. It is a perfect tool for studies of the correlation between the local weather conditions and power generated by solar and wind energy sources It is particularly useful in monitoring research projects put in place in developing countries and monitored from academic institutions located in the US or Europe. The proposed monitoring system is expected to very helpful in gathering data from the renewable energy hybrid station recently inaugurated in Ethiopia.

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