Integration of Sensors on the UNH Wind Turbine

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Abstract

Though wind energy is seen as a main source for renewable energy, implementation of wind turbines is not as prevalent as other forms of renewable energy, such as solar panels. Research is underway to understand small-scale wind turbines that may be suitable for residential installations. The Mechanical Engineering department has a small wind turbine for students to conduct research on. The turbine is currently mounted on the roof of the Tagliatela College of Engineering building. The purpose of this 2014 SURF project was to integrate sensors on the turbine enabling data to be collected. It is important to collect data, such as wind speed, atmospheric pressure, air temperature, etc, to facilitate an understanding of the performance of the wind turbine. Data is collected using various sensors such as, a weather station, which has barometric sensors, temperature sensors, and wind sensors. Another type of sensor implemented was a current sensor, which is used to measure the current being produced by the turbine, once a load was expressed on the turbine. The data being collected will be analyzed through data acquisition software, in particular with the use of LabView™.

Introduction

A common renewable source of energy is wind energy. A wind turbine is a common way to harness wind energy and convert it into electrical energy. The wind turbine is made up of a nacelle, blades, tower, and base; these parts are labeled in Figure 1. Inside the nacelle there is a generator that has an input shaft connected to the blades. As wind travels over the blades the generator is transforming wind energy into mechanical energy.

There are two common types of wind turbines, the Vertical Axis Wind Turbine (VAWT) and the Horizontal Axis Wind Turbine (HAWT).

In a HAWT the rotation axis is horizontal to the ground. The turbine being used for this study is a small scale HAWT. The turbine is made by Sunforce® and is rated for 600W. The blades measure in length 22.5 inches each.

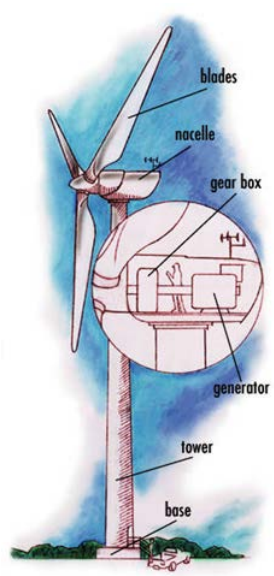

Figure 1: Sketch depicting the various parts of a Horizontal Axis Wind Turbine [4].

Sensors Integrated

The first task was to integrate sensors that will provide RPM, voltage and current data. A weather station with a PC interface is being used to gather data on wind speed, wind direction, humidity, barometric pressure, and the amount of rain over a period time.

Figure 2: Depicts the weather station and the display

We are also using current sensors to measure the current being supplied by the turbine. A similar setup had been implemented for a solar panel data collection setup; the circuitry was replicated for the turbine station.

The last device being used to gather data is a Data Acquisition Card (DAQ Card) connected to the PC. This collects the data for frequency, voltage and current sensor outputs. The integration of the DAQ Card via LabView™ is critical to collect data. With the data collected we will be able to better understand small wind turbines under different environmental conditions. These sensors are important in that, they will allow us monitor the turbine and draw different analysis based on performance. This will generate a set of baseline data. If any changes are made on the turbine we can see how those changes impact the turbines performance by comparing the values to the baseline data.

In order to measure the RPM of the turbine we need to measure and record the frequency using a DAQ Card. The DAQ Card measurements can be analyzed through a program called LabView™.

The peak voltage has to be less than +/- 10 volts in order to be wired to the DAQ Card. Since, the turbine output measurement needed to be high impedance, we connected 6 resistors in series then wired the two leads of the resistors between two phase outputs of the 3 phase AC turbine. At that point the DAQ Card could be connected to one of the 6 resistors dropping the voltage to 1/6th of the actual voltage coming out of the turbine. This idea is based of Kirchhoff's Voltage Law. In order to test this, the peak and RMS voltages were measured before adding any resistors and then measured again using a new resistor circuit. Measurements were taken by using a digital multi meter (DMM).

Results

Figure 3 shows the series of resistors used to scale the peak voltage down. The two leads of the oscilloscope are attached across one of the resistors such that we could analyze its wavelength. Figure 3 displays the scaled down peak voltage across two of the three legs. The potential difference (Peak Voltage) between those two legs was in between +/- 10 volts.

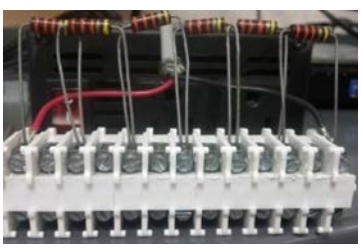

Figure 3: Depicts the series of resistors used to drop the peak voltage

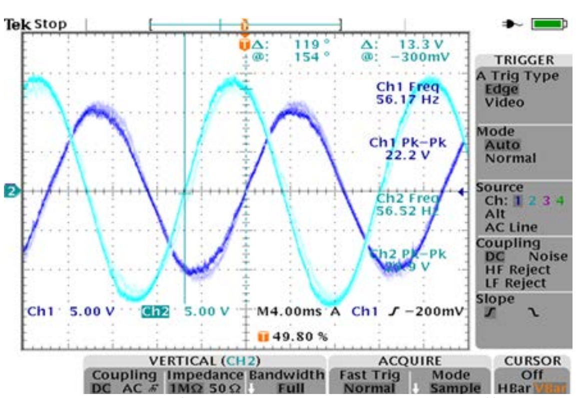

Figure 4: Screen shot of oscilloscope depicting a phase difference at full voltage.

In figure 4, channel 1 represents the outside of the first resistor in a six resistor divider between the black and red wire connections in figure 3, which are the phase outputs. Channel 2 represents the outside of the sixth resistor in a six resistor divider between the black and red connections in figure 3, which are the phase outputs.

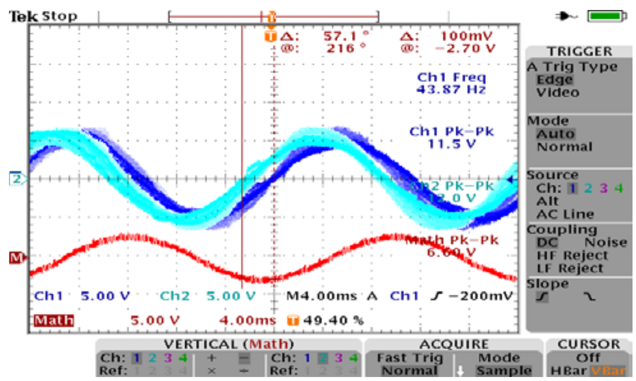

Figure 5: Depicts the rpm difference between two legs. This is shown at 1/6th the voltage

In figure 5, channel 1 represents the one side of the third resistor in a six resistor divider between the black and red wire connections in figure 3, which are the phase outputs. Channel 2 represents the other side of the third resistor in a six resistor divider between the black and red connections in figure 3, which are the phase outputs. Using the function Math (Differential) we determined the voltage at peak to be +/- 3.30Vpk @ 43.87Hz representing 1/6 of the 14.00Vrms @ 43.87Hz between the black and red phase outputs.

In figure 6, channel 1 represents the Outside of the first resistor in a six resistor divider between the black and red wire connections in figure 3, which are the phase outputs. Channel 2 represents the outside of the sixth resistor in a six resistor divider between the black and red phase outputs.

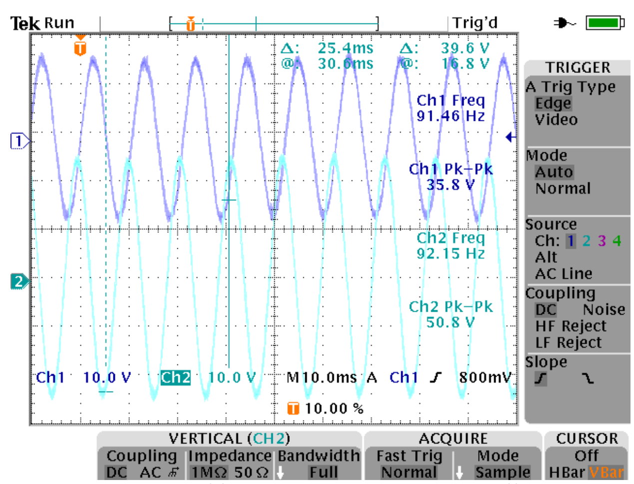

Figure 6: An example of full voltage Turbine Outputs at different RPM

Conclusions and Future Work

The integration of sensors on the wind turbine is necessary in order to analyze the turbine's performance. Through the use of the weather station data and current/voltage/frequency measurements from the DAQ Card, we will be able to better understand the conditions when the turbine performs best.

In order to baseline for eventual DAQ measurements, we used an oscilloscope and DMM to measure frequency, peak voltages and RMS voltages. Now that peak differential voltages are under 10 volts, we can wire a DAQ Card to the system. These DAQ measurements will allow for the creation of a LabView™ PC interface. We can now have one interface to display the weather station data as well as the turbine RPM and voltage output along with the readouts from the current sensors.

The goal of wind turbines is to produce electricity used to power electronics and other devices. Different devices will draw or require different *amounts* of electricity – this is called load. The *size* of the load will impact the performance and behavior of the turbine. As such, a rheostat will be used to test the turbine at different loads. A rheostat is a device which has a variable resistance and will simulate varying loads on the system. This testing setup is underway and will be continued into the Fall semester.

At the conclusion of summer, a work station had been set up in Buckman 116 Lab. Much work remains but we shall soon be able to collect and analyze wind turbine data.

Figure 7: Depicts the Wind Turbine Work station

References

1. Sarma, Mulukutla S. (2001). Introduction to Electrical Engineering. Oxford University Press.
2. http://windeis.anl.gov/guide/basics/
3. http://www.teachergeek.org/wind_turbine_types.pdf
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Biography

I am currently a sophomore undergraduate student, double majoring in System and Mechanical Engineering. I have always been interested in engineering, taking after my father who we sought electrical engineering guidance from for this project. SURF 2014 was my first experience in carrying out research and it solidified my desire to focus on hands-on application of engineering. One area of engineering I am looking to work in is aerospace; the complexity of the systems involved presents ample opportunity to contribute and innovate.