Implementation of Arduino Board on Wind Turbine Instrumentation System Using LabVIEW

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Abstract: *High quality measuring equipment ensures a successful wind measurement. Inaccurate wind Measurements result in losses. Wind monitoring is essential in wind industry. As wind is intermittent in nature, continuous monitoring is needed for wind potential assessments prior to setting up a wind park when the wind park is in operation mode. In this project, development of a system to record and analyze parameters like wind speed, wind direction, pressure and temperature, humidity, lightning using LabVIEW is reported. Interfacing is done using Arduino board. Current and voltage from utility feeder are also monitored to measure power and power factor. The rotor blade is designed based on the site wind data, estimate the wind turbine generator chosen for the site, the annual energy production and levelised cost of production etc.*

Keywords: Wind Speed, Wind Direction, Temperature, Pressure, Lightning, Humidity, Labview

1. Introduction

A global standard of wind measurement and the most accurate measuring technology are required for assessing potential wind park sites and also for monitoring and maintaining existing wind parks. Prior to setting up a wind park, wind is monitored for wind resource assessment. Such measurements are usually done for a minimum period of one year, during which wind data is gathered at regular intervals.

The measured data is processed and then analyzed. A wind energy conversion system does not give energy at constant rate, so we need to calculate the minimum available energy at a site, the lull hours for construction of storage systems etc. Wind measurements are also done after setting up a wind farm when it is in operation. Measuring equipment must perform to ensure the quality of data essential for producing accurate wind site assessments.

An accurate wind resource assessment requires the comparison of new detailed wind data with long-term meteorological data to avoid uncertainties. Both are analyzed together to determine the wind power density of the site or to decide whether the site is suitable for installation of a wind park. In this project, wind speed is calculated with Mean and annualized mean wind speed, wind power density, wind shear, turbulence intensity, mean air temperature, mean air density, speed frequency distribution, wind rose, daily and hourly distribution are the required wind resource assessment report statistics.

Such estimations also indicate whether the project is profitable or not. Once a wind farm is in operation the developed system helps to analyze whether the generator is producing maximum output or not; also, continuous monitoring using this system helps to determine whether the system is healthy or not. Based on the wind availability and the output it also helps to understand whether a machine needs maintenance or not. Wind speed monitoring necessary for pitch regulation of the turbine beyond the rated wind speed.

In this project, PID is used to calculate the wind speed parameters like temperature, humidity etc. Further reduce the error.

1.1 Arduino

In this project, the Arduino board is proposed instead of DAQ (Data acquisition) to reduce the cost of the hard ware and the system is implemented on Arduino Duemilanove. Arduino board is mainly used for interfacing the hardware and PC. The Arduino Duemilanove ("2009") is a microcontroller board based on the ATmega168 or ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started."Duemilanove" means 2009 in Italian and is named after the year of its release. The Duemilanove is the latest in a series of USB Arduino boards.

Figure 1: Arduino Board

The paper has organized as follows: section 2 explains overview of the system. Section 3 explains Wind Speed Measurement and Wind Direction. LabVIEW Interface for Arduino is shown in section 4. Results and conclusion of the work is presented
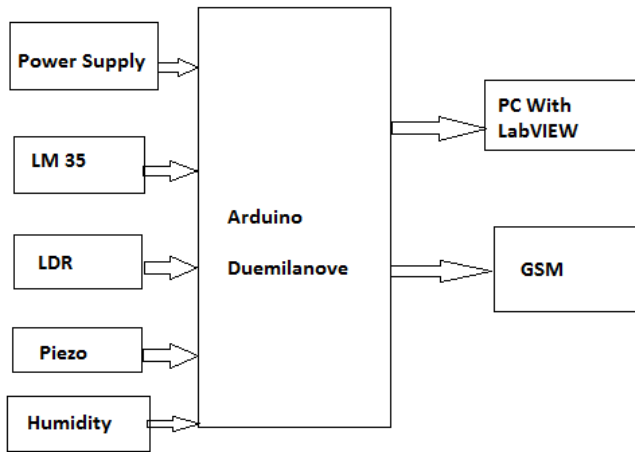
1.2 System Overview

Figure 2: System Over View

1.2.1 Temperature Sensor

Figure 3: LM35 Voltage Sensor

It has an output voltage that is proportional to the Celsius temperature. The scale factor is $.01V/^\circ c$. The LM35 does not require any external calibration or trimming and maintains an accuracy of $+/-0.4^\circ c$ at room temperature and $+/-0.8^\circ c$ over a range of $0^\circ c$ to $+100^\circ c$. Another important characteristic of the LM35DZ is that it draws only 60 micro amps from its supply and possesses a low self-heating capability. The sensor self-heating causes less than $0.1^\circ c$ temperature rise in still air.

$$tempC = \frac{0.5 * val * 100}{1024}$$

Where,

Val = is the value send to the computer by the serial port temp C= is the calculated temperature value (in Celsius), 5 is the reference we are using, 1024 is the resolution of the 10 bit internal ADC.

1.2.2 LDR

Light-dependent resistor alternatively called an LDR, photo resistor, photoconductor, or photocell, is a variable resistor whose value decreases with increasing incident light intensity.

Figure 4: LDR Sensor

LDRs or Light Dependent Resistors are very useful especially in light/dark sensor circuits. Normally the resistance of an LDR is very high, sometimes as high as 1000 000 ohms, but when they are illuminated with light resistance drops dramatically.

1.2.3 Piezo Sensor

Piezo is derived from the Greek word piezein, "to squeeze." Piezoelectric materials produce a voltage when strained. Piezoresistive materials exhibit a change in resistance when subjected to pressure. When pressure (stress) is applied to a material it creates a strain or deformation in the material. In a piezoelectric material this strain creates an electrical potential difference, a voltage. The effect is reversible. When an electric potential is applied across two sides of a piezoelectric material, it strains. Both effects were discovered by Jacques and Pierre Curie in 1880-1.The piezoelectric effect is found in materials with a specific electrical crystalline structure. These are known as piezoelectric materials.
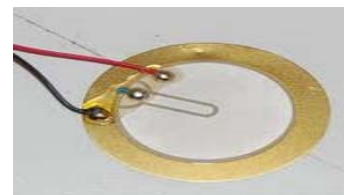

Figure 5: Piezoresistive Sensor

1.2.4 Humidity Sensor

Humidity sensor works on the principle of relative humidity and gives the output in the form of voltage. This analog voltage provides the information about the percentage relative humidity present in the environment.

A miniature sensor consisting of a RH sensitive material deposited on a ceramic substrate. The AC resistance (impedance) of the sensor decreases as relative humidity increases.

Figure 6: Humidity Sensor

1.2.5 GSM

The Global System for Mobile communication, usually called GSM, Telecommunications Standards Institute (ETSI) to describe protocols for second generation (2G) digital cellular networks used by mobile phones. The GSM standard

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was developed as a replacement for first generation (1G) analog cellular networks, and originally described a digital, circuit switched network optimized for full duplex voice telephony. This was expanded over time to include data communications, first by circuit switched transport, then packet data transport via GPRS (General Packet Radio Services) and EDGE (Enhanced Data rates for GSM Evolution or EGPRS). Further improvements were made when the 3GPP developed third generation (3G) UMTS standards followed by fourth generation (4G) LTE Advanced standards. "GSM" is a trademark owned by the GSM Association. GSM is a cellular network, which means that mobile phones connect to it by searching for cells in the immediate vicinity.

List of **AT** commands for SMS control

purpose	commands
Send SMS	AT+CMGS / AT+CMSS
Read SMS	AT+CMGR / AT + CMGL
Write SMS	AT + CMGW
Delete SMS	AT + CMGD

1.3 Wind Speed Measurement and Wind Direction

1.3.1 Wind Speed Measurement

An anemometer is used for wind speed measurement which is a critical parameter for the evaluation of a site's wind energy. A cup type anemometer is used for wind speed measurement, it uses MOC7811 Optocoupler IC.

Figure 7: Wind Speed and Direction

The measured wind speed is monitored, stored and analysed using labVIEW. The data is sampled for every second and the average over 10 min is displayed. The stranded deviation, maximum and minimum wind speed is obtained.

1.3.2 Wind Direction

This wind direction is measured with wind vanes. Assessing wind direction helps to avoid sheltering effects within the wind park. In the initial assessment wind direction is used to determine in which direction at a site wind potential is high. The turbines will be installed facing that direction.

The wind vane is made of potentiometer. The output voltage indicates the direction. By this lab view program the wind direction at any instant can be measured.

2. LabVIEW Interface for Arduino (LIFA)

LabVIEW programs are called as Virtual Instruments because the icons appearance and operation imitate actual Instruments like switches and meters.

2.1 Front panel

Front panel is the user interface of VI. It contains controls and indicators. Controls are like inputs that supply data to the block diagram and indicators are like outputs that display the data which will be generated by the block diagram.

2.2 Block diagram

The code of the program is present on the block diagram (Fig. 8) and it resembles a flowchart. It defines the functionality of the VI. Block diagram objects include terminals, functions, constants, wires etc.

The NI LabVIEW toolkit helps us easily to interface LabVIEW software with Arduino microcontroller. With this toolkit and LabVIEW, you can control or acquire data from the Arduino microcontroller. Once the information is in LabVIEW, analyze it using the hundreds of built-in LabVIEW libraries, develop algorithms to control the Arduino hardware, and present your findings on a polished User Interface (UI).

A sketch for the Arduino microcontroller acts as an I/O engine that interfaces with LabVIEW VI's through a serial connection. This helps you quickly move information from Arduino pins to LabVIEW without adjusting the communication, synchronization, or even a single line of C code.

Using the common Open, Read/Write, Close convention in LabVIEW, you can access the digital, analog, pulse widthmodulated, I2C, and SPI signals of the Arduino microcontroller.

Top 5 reasons LabVIEW makes us more productive when using Arduino:

1. Interact with your system through a graphical user interface.
2. Streamline your design process with intuitive graphical programming.
3. Improve your debugging experience with interactive tools.
4. Leverage built in resources/functions for implementing simple to complex tasks.
5. Open API (Application Programming Interface) allows for complete customization

a) Setup
1. With Arduino board ready, make sure you have LabVIEW 2012 or newer version installed.
2. Install NI-VISA Drivers.
3. Install the Arduino IDE and drivers for Windows.
4. Install the LIFA (LabVIEW Interface for Arduino).
5. Upload the sketch 'LIFA_Base.pde' to the Arduino and we are done with the setup.
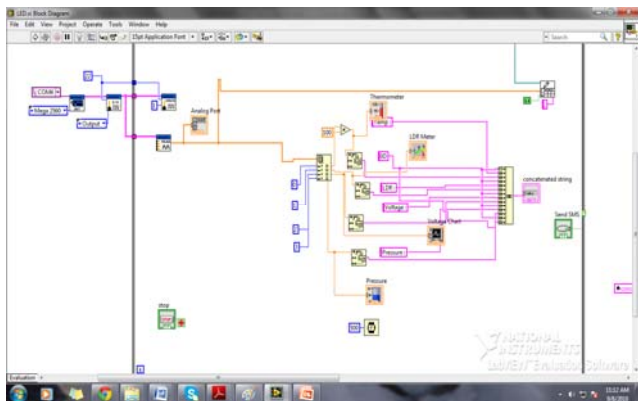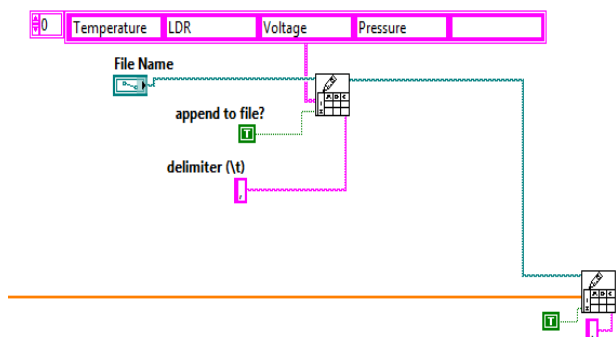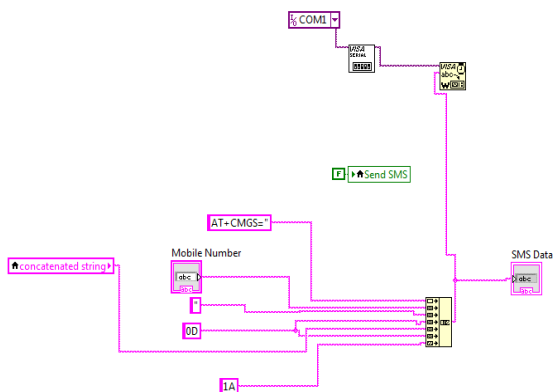
b) LabVIEW Block Diagram
c) For Reading Sensors Data

Figure 8: Block diagram of Wind Turbine

d) Storage of Data in Excel File

e) For Sending SMS of Sensors Data

3. Results

A monitoring system for wind farm using LabVIEW is developed. The parameters like wind speed, wind direction, temperature and pressure, humidity, lightning are continuously monitored and displayed. These measured are storied in data base and then used for wind resource assessment for estimating the site potential. The values of current, temperature, pressure, humidity, lightning, and wind speed obtained through LabVIEW are compared with actual values.
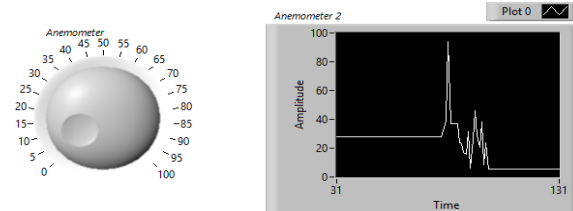

Figure 9: Wind Speed

An anemometer is used to measure the wind speed and it is monitored, stored and analyzed using LabVIEW. The data is sampled is for every second and the average over 10 minutes is displayed.

Figure 10: Wind Direction

The wind direction is measured with wind vane using LabVIEW. The wind vane is made of potentiometer .The output voltage indicates the direction.
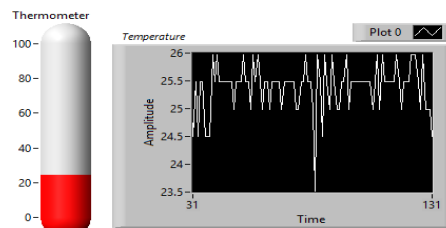
Temperature & Pressure
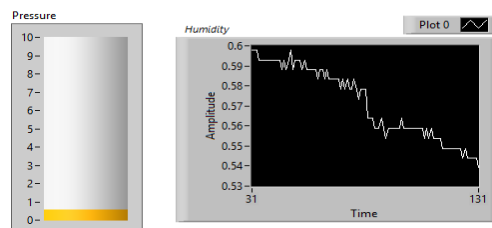

Figure 11(a)

Figure 11(b)

Temperature is measured using LM35 sensor in fig.11 (a).

LM35 has an output voltage that is proportional to the Celsius temperature. As there is no need to subtract a large constant voltage from its output to obtain centigrade scaling.

Pressure is taken by piezo sensor in fig.11 (b). The output of piezo sensor is proportional to the applied electric potential across two sides of a piezo electric material.
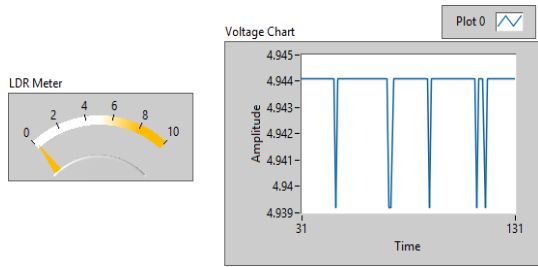
Figure 12: LDR

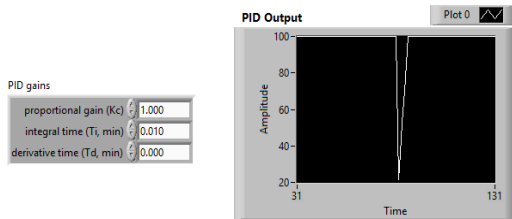LDR is a photo resistor whose value decrees with increasing incident light intensity.

Figure 13: PID Output

By using PID controller we can reduce the error to get an accurate output and provides fast response.
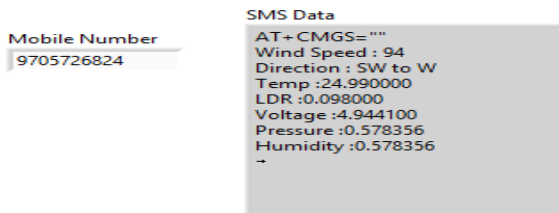

Figure 14: GSM Module Output

By using GSM module we can easily send the data when any abnormal conditions are occurred then GSM module will send the data to the corresponding station.

f) Excel sheet

Temperat	LDR	Voltage	Pressure				wind speed	wind direction
0.289	1.656	3.053	0	0.255	0.407		100	north
Temperat	LDR	Voltage	Pressure					
0.294	1.661	3.053	2.729	2.318	2.097		102	north
Temperat	LDR	Voltage	Pressure					
0	0	0	0.348	0.661	0.794		103.3	north
Temperat	LDR	Voltage	Pressure					
0	0	0	0.348	0.598	0.701		362	south
Temperat	LDR	Voltage	Pressure					
0	0	0	0.343	0.578	0.666		105.3	north

The collected data is stored in excel sheet to compare with previous data.

4. Conclusion

A cost effective means of employing powerful programming tool for various applications using prototyping board Arduino is developed. The potential of this method will be extended for various other engineering applications in the near future.

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Author Profile

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