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Wireless Wind Turbine Monitoring Using Arduino

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ABSTRACT: This project describes the design and implementation of a Wireless monitoring system for turbines using Arduino. Here we employ an Arduino based wireless system that measures and transmits the different electrical and mechanical parameters of the turbine. The parameters that are to be monitored are current, voltage, speed and vibration in the turbine. These parameters are sensed and given to the Arduino. Arduino transmits the parameters using suitable medium to a PC which enables remote monitoring.

This can be done using Arduino with RF wireless technology. Arduino is a open source platform, both in terms of Hardware and Software. RF is a new kind of low complexity, low power consumption, low data rate and low cost wireless network technology. Wireless sensor network receives the parameters that are measured in the wind turbine and transmit it to the RF receiver that is placed an the receiver's side.

Further all the obtained data and the control data are displayed on the PC which runs Labview which is an advanced measurement and automation software. Use of VI has innumerable advantages such as easy configuration, easy control, variety of data representation, ease of modification, low cost and a host of others.

I. INTRODUCTION

In this era of huge energy demands and shortage of the existing conventional energy sources, wind energy is one of the most established and cost-competitive renewable energy sources. Wind power, as an alternative to fossil fuels, is plentiful, renewable, widely distributed, produces no greenhouse gas emissions during operation and uses little land. [1]

Current scenario

In the Current Situation Microcontroller (using PIC) and Manual Process is employed. So, By using PIC Microcontroller it does not have withstand capacity, failed to produce fast switching operation and does not control various parameters. So, Monitoring with Fast Operation is needed for Wind Turbine.

Small wind turbine

A wind turbine is a device that converts kinetic energy from the wind into electrical power. A wind turbine used for charging batteries may be referred to as a wind charger.

The result of over a millennium of windmill development and modern engineering, today's wind turbines are manufactured in a wide range of vertical and horizontal axis types. The smallest turbines are used for applications such as battery charging for auxiliary power for boats or caravans or to power traffic warning signs. Slightly larger turbines can be used for making small contributions to a domestic power supply while selling unused power back to the utility supplier via the electrical grid. Arrays of large turbines, known as wind farms, are becoming an increasingly important source of renewable energy and are used by many countries as part of a strategy to reduce their reliance on fossil fuels.[2]

A small wind turbine is a wind turbine used for micro generation, as opposed to large commercial wind turbines, such as those found in wind farms, with greater individual power output.[3]

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These turbines may be as small as a fifty-Watt generator for boat, caravan, or miniature refrigeration unit.

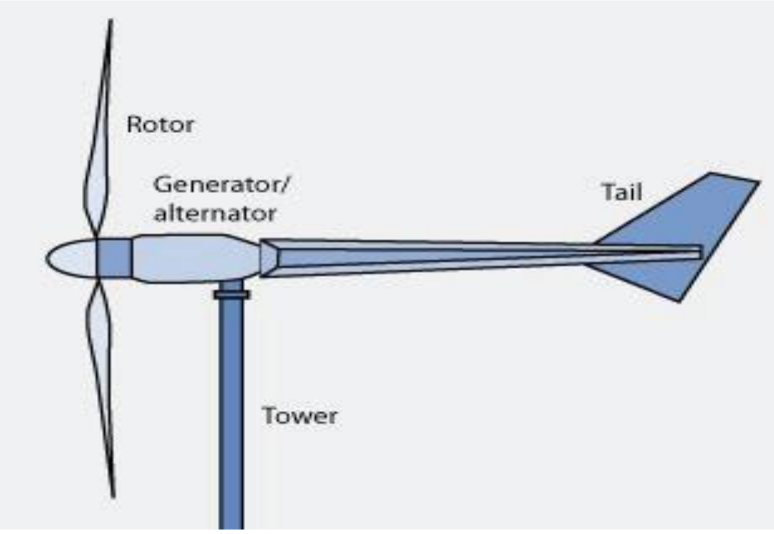

Fig 1.1.1 Basic Small Turbine Model

II. NEED FOR SMALL WIND TURBINE

Characteristics of a small wind turbine. For our Virtual Labs project, we need to monitor the operating parameters, most notably rotational speed, for our small wind turbine. This experiment will be hosted on our Virtual Labs site [2]. Students and researchers will be able to access the site and remotely measure and analysis the various electrical and mechanical parameters of the turbine.

In other applications, turbine designers, interested users and others may have the need to monitor the characteristics of their turbine for research and development purposes, for performance validation or for scientific and engineering curiosity. The system described here can be used to easily modify an existing turbine to accomplish this. Most low-cost, small wind turbines on the market today are designed for low cost, reliable, long-term operation and rarely have in-built monitoring capabilities to measure rotating speed, torque, or voltage and current output. One of the primary reasons for this is because small horizontal axis wind turbines need to yaw directly into the wind for maximum power output and normally employ a passive tail vane to accomplish this. To avoid tangling, twisting and ultimately breaking the power wires that take the turbine's electrical output to the ground, slip rings are incorporated between the turbine and the tower, to allow the turbine any possible yaw rotation, while still carrying the power to the ground. These slip rings normally have only two or three contacts, to take the dc or ac electrical output to the ground.[4]

Adding additional slip rings to carry data signals would require a complete redesign of the turbine and is not feasible for most applications. In the case of large scale turbines, with electronic, motorized yaw control, the possibility of twisting data and power wires is eliminated and the instrumentation is done within the turbine hub itself, with cables used to route the power and data down to the ground. In our work, we have implemented a novel system that measures and wirelessly transmits the monitored data across the turbine's yaw pivot. This allows a small, pre-built horizontal axis wind turbine to have the same monitoring capabilities as the much larger turbines.[5]

III. PRIOR WORK AND BENEFITS OF OUR SYSTEM

There are numerous systems for monitoring wind energy systems. A large number of these are for structural heath monitoring of large wind turbine towers and blades. Many of these utilize wireless sensor networks. There are also a number of systems that are utilized for diagnostic monitoring of wind turbines. These systems typically have monitoring of rpm as part of their diagnostic capability. However, both structural health monitoring and the diagnostic

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monitoring system are frequently designed for use with large scale wind energy. While these are certainly important, they are not directly relevant to our need for monitoring the rpm and power of our small wind turbine.[6-7]

There are also innumerable smart meter monitoring systems available in the market and in the literature. These can be used with smaller power output systems such as small wind turbines. The system described here, on the other hand, is specifically suited to small wind turbines that employ slip rings for power transfer, by using a wireless transmission and reception. It is able to provide details of both power production and rpm. It has the most advantages for horizontal axis wind turbines, which are most prevalent on the market, but will also work for vertical axis turbines as well. The system described here can also be helpful in monitoring requirements for smart grid integration. Design Of Our System In our experiments we have used a small 300W turbine with a permanent magnet generator and a two wire output. A two contact slip ring is built-in to take the power out. As mentioned before, a wired instrumentation approach is not possible since the hub needs to rotate 360 degrees to align to the wind. As it is a passive system, it may rotate repeatedly in the same direction,which would eventually break the wires. Therefore, we have overcome this problem by using a wireless approach.

IV. DESIGN

Smaller scale turbines for residential scale use are available. They are usually approximately 7 to 25 feet (2.1–7.6 m) in diameter and produce electricity at a rate of 300 to 10,000 watts at their tested wind speed. Some units have been designed to be very lightweight in their construction, e.g. 16 kilograms (35 lb), allowing sensitivity to minor wind movements and a rapid response to wind gusts typically found in urban settings and easy mounting much like a television antenna. It is claimed, and a few are certified, as being inaudible even a few feet (about a metre) under the turbine.

The majority of small wind turbines are traditional horizontal axis wind turbines, but vertical axis wind turbines are a growing type of wind turbine in the small-wind market. Makers of vertical axis wind turbines such as WePower, Urban Green Energy, Helix Wind, and Windspire Energy, have reported increasing sales over the previous years.[8] The generators for small wind turbines usually are three-phase alternating current generators and the trend is to use the induction type. They are options for direct current output for battery charging and power inverters to convert the power back to AC but at constant frequency for grid connectivity. Some models utilize single-phase generators.[9] Dynamic braking regulates the speed by dumping excess energy, so that the turbine continues to produce electricity even in high winds. The dynamic braking resistor may be installed inside the building to provide heat (during high winds when more heat is lost by the building, while more heat is also produced by the braking resistor). The location makes low voltage (around 12 volt) distribution practical.[10] Small units often have direct drive generators, direct current output, lifetime bearings and use a vane to point into the wind. Larger, more costly turbines generally have geared power trains, alternating current output and are actively pointed into the wind. Direct drive generators are also used on some large wind turbines.

V. TECHNICAL ANAYSIS OF SMALL WIND TURBINE

Turbines with a diameter of less than 15m and a power output below 50kW are classified as small. However, most small wind turbines have a diameter of around 7m or less and a power output ranging between 1kW and 10kW. For very small installations, such as a remote household, wind turbines can have a diameter smaller than 2m and an output of kW or less. Medium size wind turbines have a rotor diameter of 15-30m, and a maximum output of 50-250kW.
The majority of small-scale wind turbines are built on freestanding poles or towers. However, building mounted turbines are another option. Such turbines are directly installed on a building, usually on the rooftop. Both vertical and horizontal axis turbines can be building-mounted, but they might be subject to more turbulence. Most small wind turbines have a permanent magnet generator and do not require a gearbox. This type of generator produces alternating current (AC), which must be rectified to direct current (DC) by means of a simple bridge rectifier. Similar to solar photovoltaic (PV) systems, the DC-voltage allows the use of these turbines for battery charging. For in-battery charging systems, a charge controller is added to prevent the battery from overcharging. In grid-connected systems, an inverter is used to control the SMWT and for supplying electricity to grid voltage and grid frequency. A dump load is required to protect the inverter from overvoltage and to prevent the turbine from over speeding.

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Wind Turbine is basically connected with an protection Box and wind inverter with a generally we used to customize the inverter and with a protection box an usually used to systemizes and prevent the wind turbine from wind inverter also an generator.

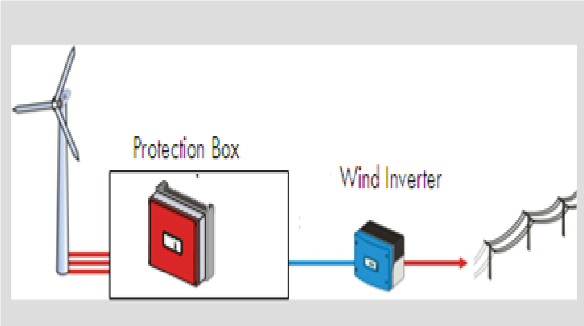

Fig 1.1.2 Small Wind Turbine Technical Analysis

1.2.1 FOR WIND TURBINE MODEL

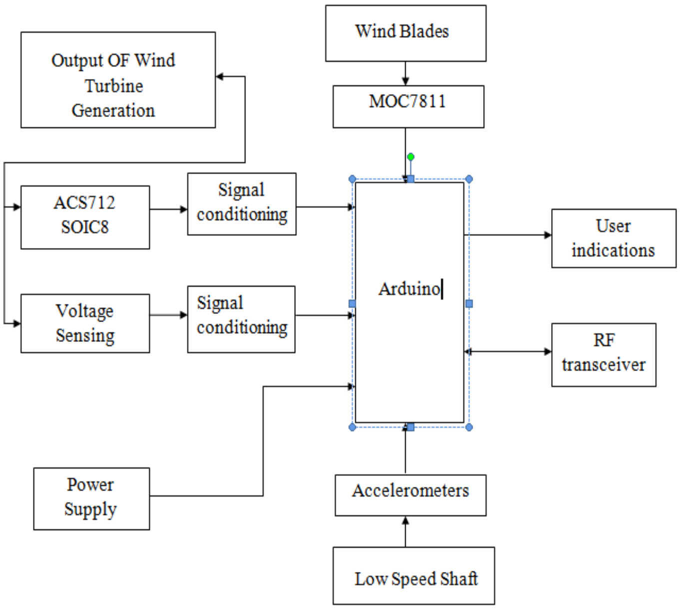

Fig 1.2.1 Block Diagram of Wind Turbine Model

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1.2.2 CONTROL ROOM MODEL

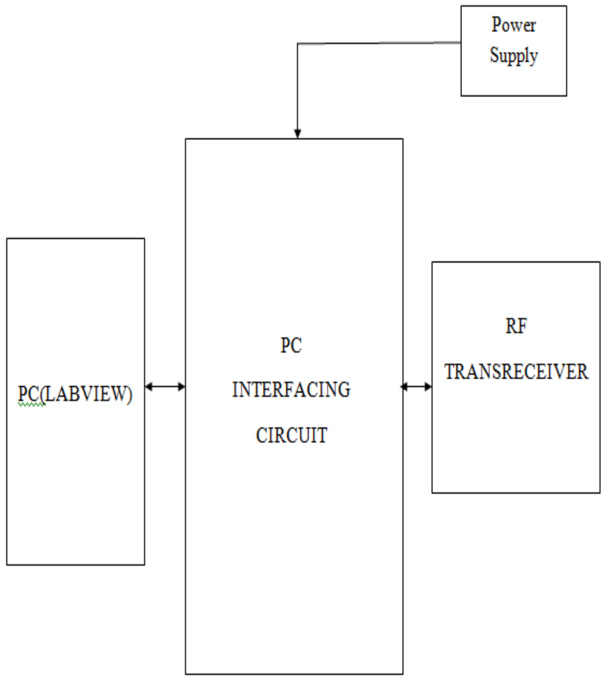

Fig 1.2.2 Block Diagram of Control Room Model

Steps followed in designing the system

Three general steps can be followed to appropriately select the system,

Identify Sensing variables important to Monitoring.
It is very important to correctly identify the parameters that are going to be sense by the controller interface, and how they are to be Sense.The set of variables typically used in Small Wind Turbine shown below,

Table 1.4.1 Important of Various Sensor

SI.NO	SENSOR	IMPORTANCE
1	Speed Sensor	Enhanced MOC7811 sensor is used to identify the speed of the blades connect to shaft in wind turbine
2	Vibration Sensor	3-axis Accelerometer is used to sense the low speed shaft vibration caused by the high speed or mechanical damage.
3	Current Sensor	This Sensor is used to sense the wind turbine output generation current.
4	Voltage Sensor	.This Sensor is used to sense the wind turbine output generation Voltage

An electronic sensor for measuring a variable must readily available, accurate, and reliable and low in cost.If a sensor

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is not available,the variable cannot be in corporate into the control system,even if it is very important. Many times variables that cannot be directly or continuously measured can be controlled in a limited way by the system. For example, sensing level sin system solutions for Small Wind Turbine Monitoring are difficult to sensing continuously.

An important element in considering a Monitoring system is the control strategy that is to be followed. The simplest strategy is to use threshold sensors that directly affect actuation of devices. .For example, the temperature outside the atmosphere affect the sensor, this can actually causes a false detect.

The Current Sensor and Voltage Sensor also affected by rain and snow. This system should be provided with strong acrylic material to with stand all the natural scenario.
More complex control strategies are those based not only on the current values of the controlled variables, but also on the previous history of the system, including the rates at which the system variables are changing. strong acrylic material to with stand all the natural scenario.

VI. IDENTIFYING THE HARDWARE AND SOFTWARE

It is very important that control system functions are specified before deciding what software and hardware system to purchase. The model chosen must have the ability to Expand the number of measured variables(input subsystem) and controlled devices (output subsystem) so that Sensing and changing needs of the production operation can be satisfied in the future. Provide a flexible and easy to use interface. It must ensure high precision measurement and must have the ability resist noise .so that Sensing and changing needs of the production operation can be satisfied in the future.

Hardware must always follow the selection of software, with the hardware required being supported by the software selected.In addition to function all capabilities, the selection of the control hardware equipment (successes and failures),and cost.

VII. PROBLEM DEFINITION

Vaild Wind Power Problems->There are many claimed, but unjustified, problems with wind power; much of this page deals with these claims. This section lists some of the real problems and will redirect the reader elsewhere (mainly on this page) for details. The problems can be placed into several catagories.

Noise Problem->Turbines can, under some circumstances be heard at distances at least as great as 2.5km. While the sound is not loud, some people find it annoying, and at smaller distances (perhaps 1km or less) it may stop some people from sleeping and lead on to anxiety and stress in some people; this, in turn, can lead to health problems.

Power Availability and transmission Problem->The wind does not blow all the time. When the wind is not blowing wind turbines do not generate power. At times of peak electricity demand winds tend to be lighter than average.When any type of generation is not in the same place as consumption there is the need to transmit the power from one place to another. This requires very expensive high capacity, high voltage, transmission lines. For example, South Australia has much more wind power per capita than other states; if wind generation is high and consumption is low in SA then the power must be sent interstate.

Environment problem->There are a number of environmental concerns that are perfectly valid. Wind turbines do kill some birds and there are problems involved with the necessary distruction of remnant native vegetation and possible erosion problems connected with the building of roads and hardstands. It seems that wind turbines kill a worrying number of bats, but there is a lack of research on this; birds are pretty and visible, bats are rarely seen and are not 'cute and cuddly'.

At least some wind turbines (and much other modern machinery) use magnets based on a group of elements called rare earths; the mining of rare earth minerals in third world countries has been carried out with little concern for environmental damage. Much of the world's rare earths come from China, see the Guardian Weekly for a description of some of the environmental damage there.

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VIII. PROPOSED SYSTEM FOR SMALL WIND MONITORING:

The proposed system is an embedded system which will closely monitor the instruction through small wind turbine. This system power with Ardunio, which make more power efficient and more reliable to use. This system uses microchip wireless digital chips to communicate to other devices, this communication network now as RF transreceiver. This is smart system to transmit its frequency about 100meters, many devices can be used to make a network, and it does not need any hub for communication. The system will collude its self and form a network with them. This system has four sensors they are, Speed Sensor for monitoring speed, the current sensor sense the current in output of the wind turbine generation. The Voltage Sensor use to sense the voltage in output of wind turbine generation. The Vibration sensor use to detect the vibrations made gearbox and low speed shaft. These sensors are connected to their individual processor. The Labview in the control room shows the monitoring and history of the network. The sensors are connected to processor and then monitor.

Manual monitoring system vs arduino based monitoring system

Table 2.5 Difference between two systems

It required more people to implement the monitoring system.	It required less than two people for installing the system.
Backup can be done in papers.	backup can be done by software which is ever lasting
Monitoring do not possible in rain and snowfall.	It is possible to monitor in any condition
There liability of the system is relatively low	There liability of the system is relatively high
High maintenance and need of skilled technical labour.	Low maintenance and need of technical labour only.
Malfunctions in local devices,all local and tele-data will be lost and hence the whole system collapses	No malfunctions occur in the system.

Modes of operation

Tarang can be interfaced with a micro controller or a PC using serial port with the help of appropriate level conversio

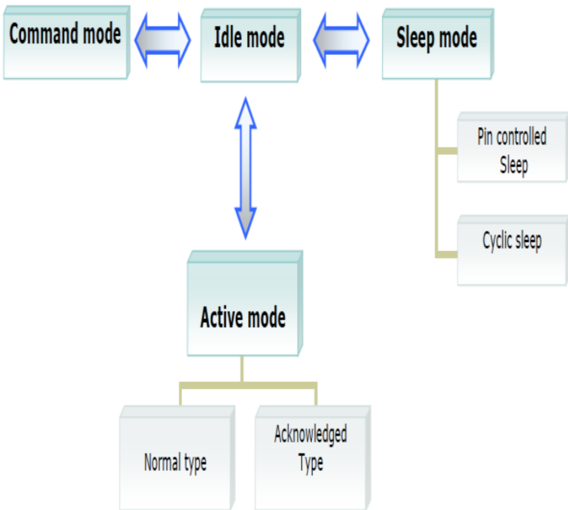

Fig 3.19 Modes Of Operation

ARDUINO:

Arduino is a single-board microcontroller, intended to make the application of interactive objects or environments more accessible. The hardware consists of an open-source hardware board designed around an 8bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. Pre-programmed into the on-board microcontroller chip is a boot loader that allows uploading programs into the microcontroller memory without needing a chip (device) programmer.

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Arduino boards can be purchased pre-assembled or as do-it-yourself kits. Hardware design information is available for those who would like to assemble an Arduino by hand. It was estimated in mid-2011 that over 300,000 official Arduinos had been commercially produced.In This Paper we have used arduino

IX. CIRCUIT SCHEMATIC OF THE SYSTEM

TRANSMITTER:

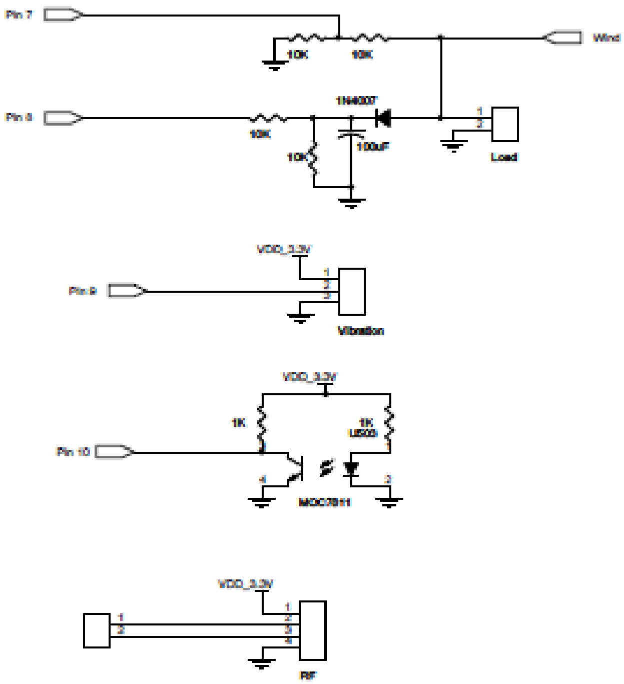

Fig 3.29 Circuit Diagram of Transmission

Receiver

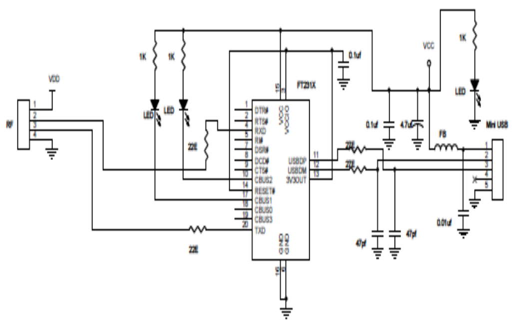

Fig 3.30 Circuit Diagram of Receiver

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Eagle

A schematic or a circuit diagram is only a technical representation of a circuit design. However for actually constructing a circuit design into a physical board a PCB (Printed Circuit Board) is needed. A PCB is the base on which the different components are placed and soldered. The PCB contains copper traces or tracks that establish connection between the components placed on the board. The following picture shows a just a PCB and a PC with components placed and soldered in it.

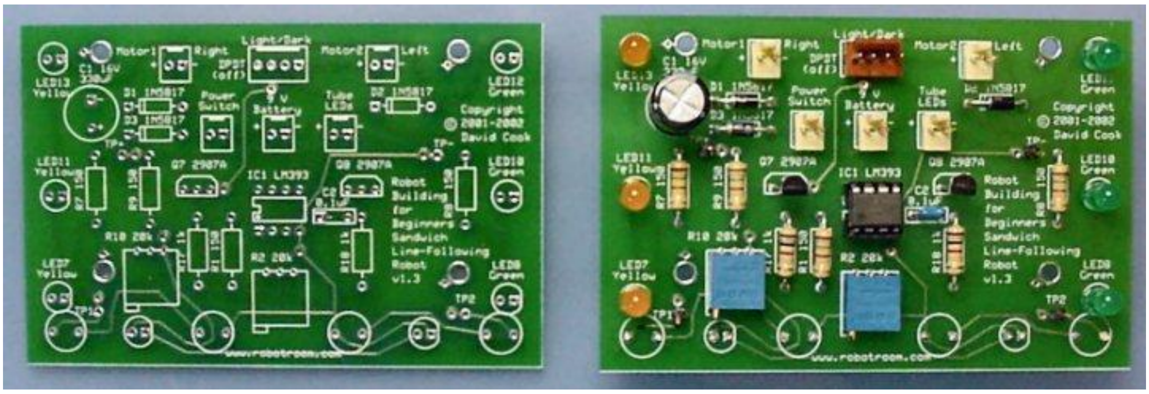

Fig 3.31 PCB SCHEMATIC

Before a PCB can be physically fabricated it has to be designed to decide where all the components will be placed and arranged and how the PCB traces will connect the different components. This process is called PCB design.

There are different software available that can be used for PCB design. EAGLE (**E**asily **A**pplicable **G**raphical **L**ayout **E**ditor) is one such software created by the company called CADSOFT. EAGLE is a easy to use yet very capable software for PCB design. Hence it is the ideal choice for small to medium projects including student projects.

The following steps show the creation of a simple PCB design, beginning with the next step which is to start EAGLE

2. Start a new PCB design by selecting board from the File>>New menu.
3. Start adding components to the design using the add button.

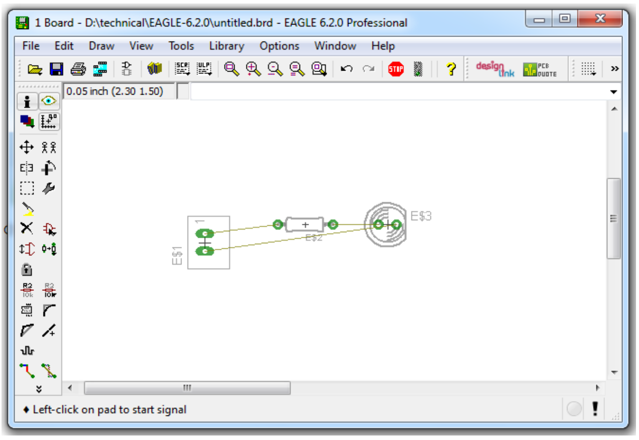

Fig 3.34 STEP 4 In EAGLE

4. Connect the components using the Signal command, to establish the connection between them.

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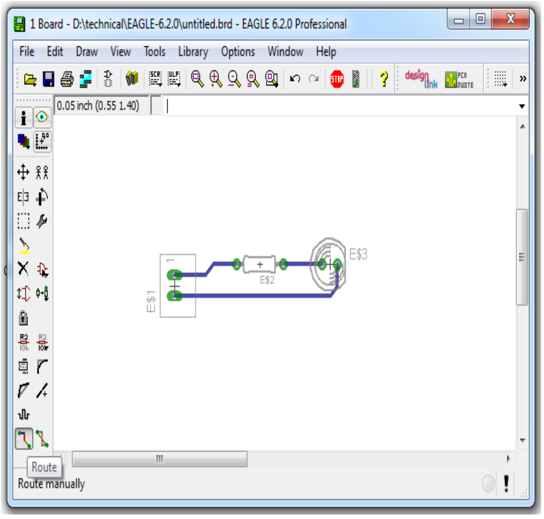

Fig 3.35 Step 5 in Eagele

5. Draw the copper trace using **Route** command for small boards and use auto router for complicated designs.

ORCAD

OrCAD is an EDA (electronic design automation) software that combines different tools for various stages of a electronic circuit design. OrCAD has a tools for schematic design, PCB design and also simulation tools when the simulation models are available.

One of the tools in OrCAD is called Capture. OrCAD Capture is used for schematic design or circuit design. Capture is like most CAD based design software where the different components are provided as a library. The user can select different components needed for a design from the library and can add them to the circuit. Once all the necessary components are added they can be interconnected using wires in the software. The following pictures show this procedure step by step.

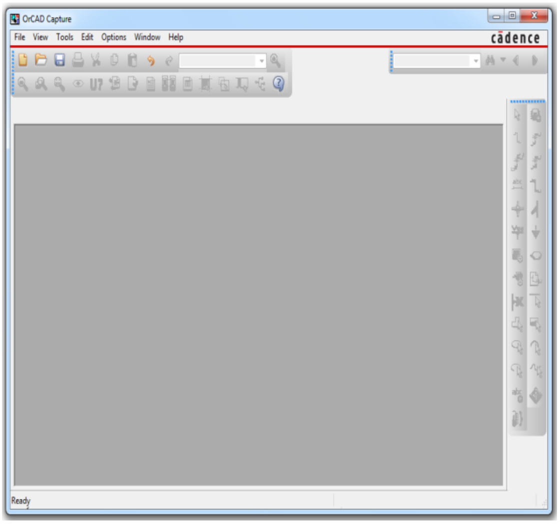

Fig 3.36 ORCAD STEP 1

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Open OrCAD Capture

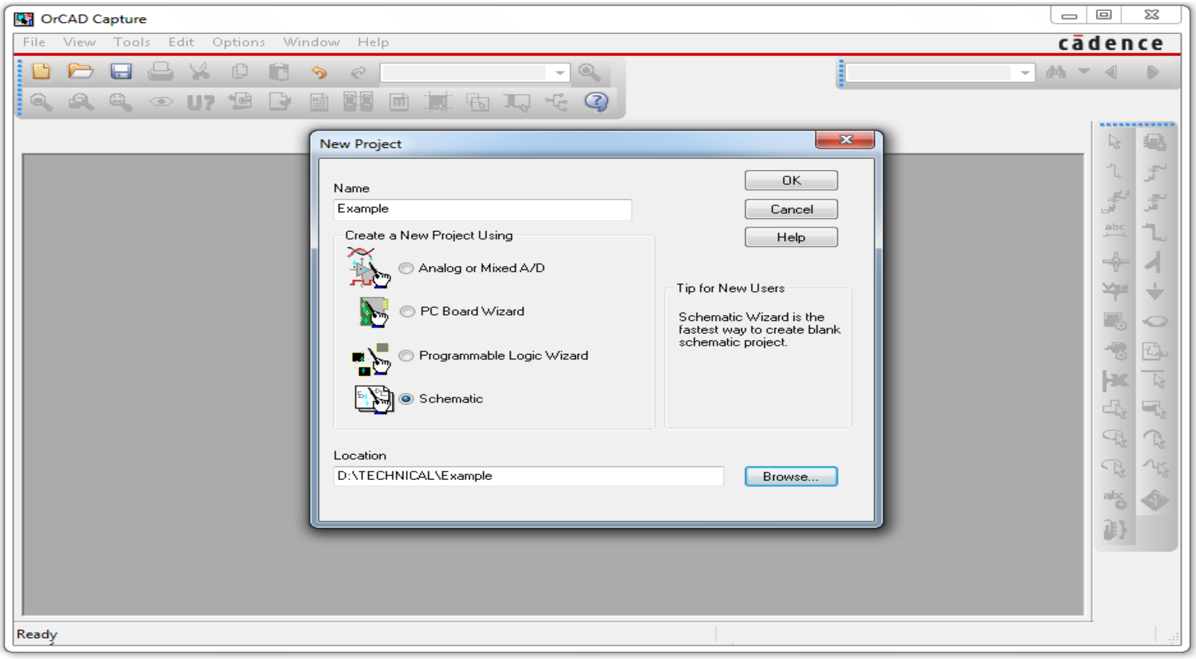

Fig 3.37 ORCAD STEP 2

1. Create a new project and select Schematic from the project type options, as show above.
2. Select components from the library as shown above

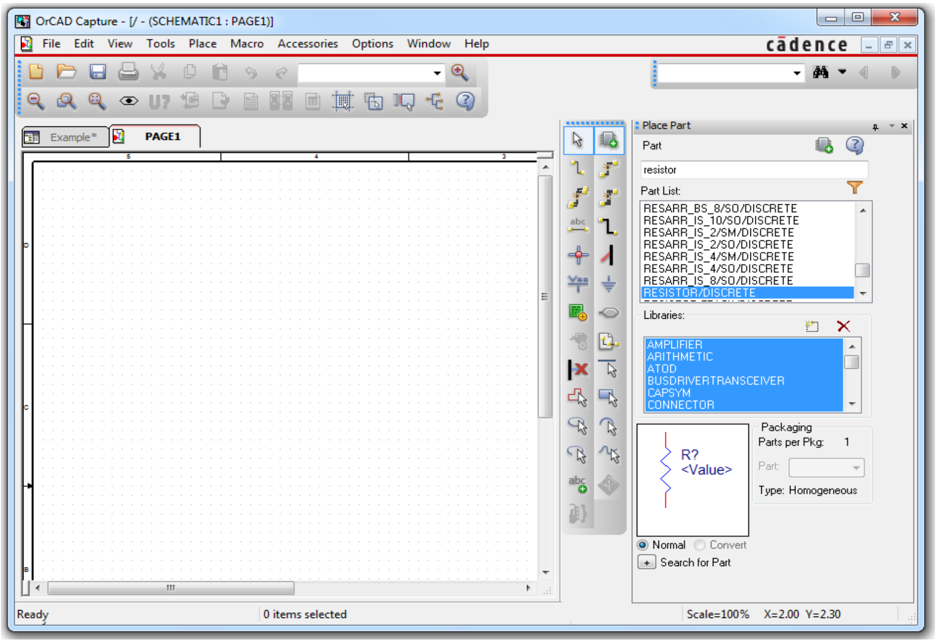

Fig 3.38 ORCAD STEP 3

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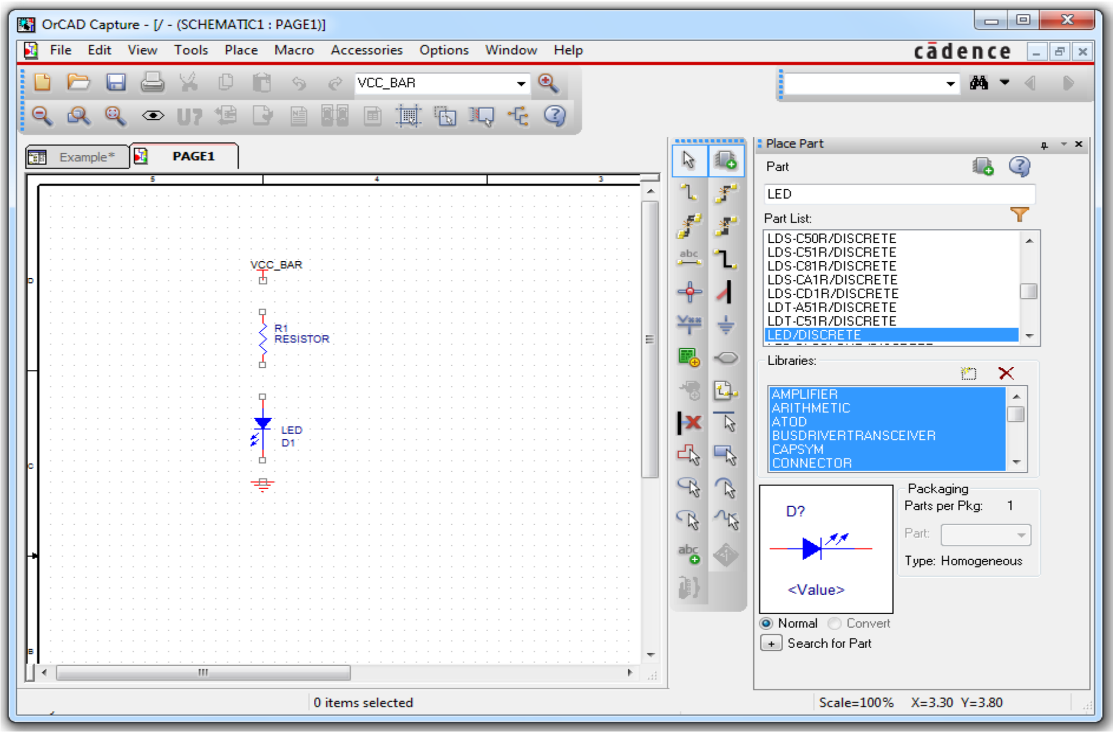

Fig 3.39 ORCAD STEP 4

3. Place the needed components in the schematic page one by one.

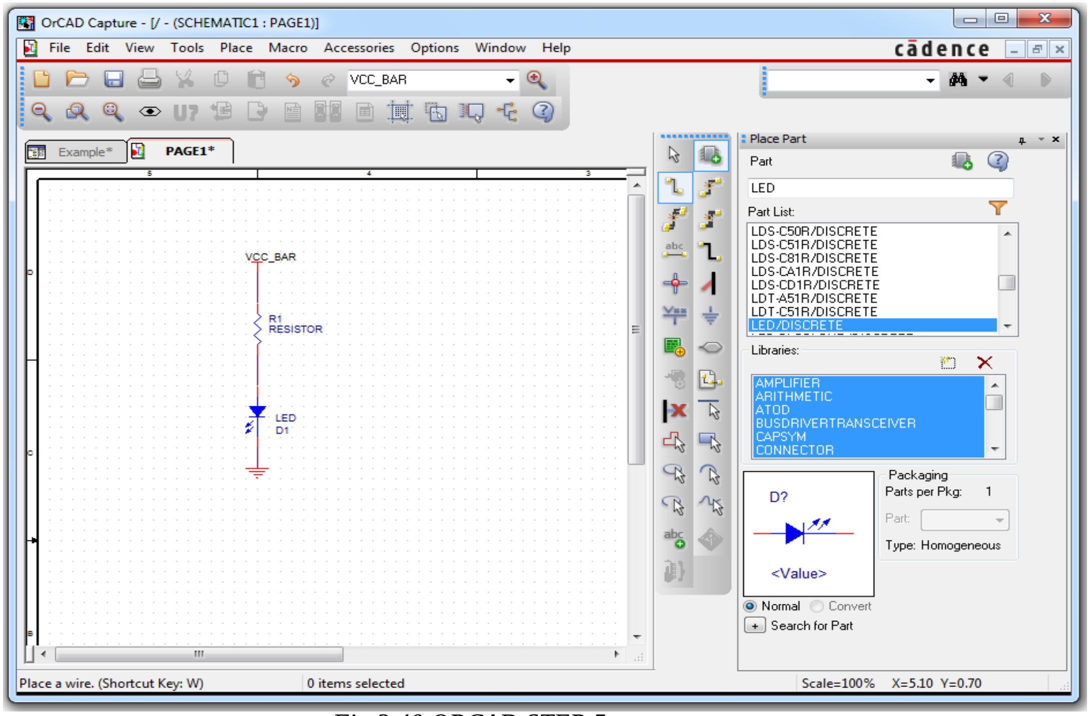

Fig 3.40 ORCAD STEP 5

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5.Connect the components using the wire tool.
The above few steps show how a simple schematic can be designed using OrCAD capture. Using a similar process circuit of any complexity can be drawn. Also if a certain IC or device is not present in the library users can also add new components to the library.

X. SIMULATION OUTPUT

Normal Condition

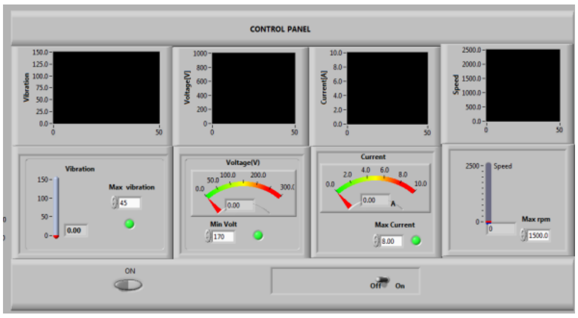

Fig 3.42At Normal Condition

3.44.3 Abnormal Condition

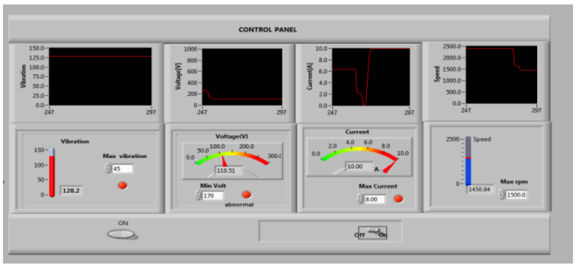

Fig 3.43At Normal Condition

XI. CONCLUSION

A step-by-step approach in designing the microcontroller based system for WIND Turbine Monitoring of the four essential parameters to Monitor Speed,Current,Voltage,Vibration has been followed. The results obtained from the measurement have shown that the system performance is quite reliable and accurate.
The system has successfully overcome quite a few shortcomings of the existing systems by reducing the power consumption, maintenance and complexity ,at the same time providing a flexible and precise form of securing the wind monitoring.
The continuously decreasing costs of hardware and software, the wider acceptance of electronic system in Major areas, will result in reliable monitor the systems that will addresss ever all aspects of quality and quantity of production. Further improvements will be made as less expensive and more reliable sensors are developed for use in Wind Mill production.

Although the enhancements mentioned in the previous chapter may seem far in the future, the required technology and components are available, many such systems have been independently developed, or are atleast test data prototype level. Also, integration no fall these technologies is not a daunting task and can be successfully carried out.It will possible to Monitor the Multiple wind turbines with sensor interconnected.

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