DESIGN AND CONSTRUCTION OF A DIGITAL ANEMOMETER

BY

OKUBADEJO, OLUMIDE JOHN

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DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING,

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NIGERIA.

NOVEMBER, 2011.

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A PROJECT SUBMITTED TO THE

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING,

FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA

NIGERIA.

IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF THE AWARD OF BACHELOR OF ENGINEERING (B. ENG) DEGREE IN ELECTRICAL AND AND COMPUTER ENGINEERING

NOVEMBER, 2011.

DECLARATION

I Okubadejo, Olumide John declare that the work in the project report entitled Design and Construction of a Digital Anemometer has been performed by me under the supervision of Professor Oria Usifo. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

OKUBADEJO OLUMIDE JOHN ____________ 13th NOV 2011

Name of student ____________ Signature and date

CERTIFICATION

This is to certify that the project report entitled DESIGN AND CONSTRUCTION OF A DIGITAL ANEMOMETER meets the requirement for the award of Bachelor of Engineering degree (B. Eng) in Electrical and Computer Engineering, Federal University of Technology, Minna.

for ____________________ 18/11/11 ____________________

Project Supervisor | Date

Name and Signature

PROF. ORIA USIFO

ENGR A. G. RAJI ____________________ (March 15, 2012) ____________________

Head of Department | Date

Name and Signature

Engr Dr. G. F. Igbalo ____________________

External Examiner | Date 6/3/2012

Name and Signature

DEDICATION

With gratitude to God, this project is dedicated to my parents Mr and Mrs Okubadejo and my entire family for their encouragement and love.

ACKNOWLEDGEMENT

I

I give special thanks to my parents Mr. and Mrs. Okubadejo, for their never ending support, love, guidance and prayers and also to my dearest siblings for their love and support.

Special thanks and my unreserved appreciation go to my very good friends, who know themselves for their care and friendly advice which has made me the better person I am today.

My appreciation also goes to my HOD Engr. Raji, my supervisor Professor Oria Usifo, all lecturers and laboratory attendants in Electrical and Computer Engineering and also my colleagues.

May God continue to bless me, my family, friends and well wishers, all 500Level students and most importantly Electrical and Computer Engineering.

ABSTRACT

A digital wind meter is a device with the capability of measuring wind speeds digitally with no mechanical device attached. It is part of a comprehensive system of wind parameter measurement as it measures a very important parameter associated with wind speeds. This device in this context does not stop at the measurement of wind speed alone but provides an adequate system with which the measured wind speed can be viewed and analyzed all over the world. It achieves this by incorporating a server system that feeds wind speeds to different locations around the world. This systemized calculation and observation of wind speed provides a relief to wind turbine designers, aircraft agencies and metrological agencies as they can observe the speed of wind adequately.

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CHAPTER ONE

1.1 INTRODUCTION

Wind power is the generation of wind energy by the use of wind turbines, mills e.t.c. wind power generation is an important part of electricity generation because from it, it is possible to generate high amounts of electrical energy. In generating this energy, it is wind speed that is used to drive the turbine to generate electricity. It is therefore a necessity, to be able to measure accurately the speed of wind.

Measurement and instrumentation has been solidly rooted in the basis for electrical and electronics engineering and with advancement in this technology over the years, it has become a major part of electronics design. The human nature is such that men want to know what is going on around them. The question how much?

Everything parameter has a unit and a method of measuring it. This inventive innovation has helped in the generation of tools and devices that serve to measure these parameters. Experiments over the years have served to generate more and more devices to measure more and more parameters and that is the scenario that brought about the invention of the wind meter.

The Wind meter serves as one of the answers of measurement and instrumentation to the generic question of how much?

1.2 WHAT IS A WIND METER?

A wind meter is used for measuring the speed or pressure of wind. Information gathered by a wind meter can be used to determine how quickly a storm will arrive in a given area or whether dangerous wind conditions may cause risk for aircraft or damage to property.

1.3 TYPES OF WIND METERS

1. **Velocity wind meter**

   The simplest wind meter is the cup wind meter that uses the speed at which metal cups mounted on horizontal arms spin in the wind to calculate its speed. Laser Doppler and sonic wind meters uses sophisticated technology to measure wind speed to a more precise degree.

2. **Pressure wind meter**

   The earliest type of pressure wind meter was the plate wind meter which measures the pressure with which the wind pushes a suspended metal plate. A tube wind meter is a later development and is now supplemented by specialized electronic sensors that use the effects of wind upon a liquid-filled tube to measure wind pressure.

1.4 AIM AND OBJECTIVE

The basic aim of this project is to design and construct a wind meter, which is used at solving the problem of having non-digitized wind meters at wind stations and subsidiaries. The present state of the power industry delves into the use of wind to supply electrical power and to drive mechanical equipment and it is with this need that wind meters that are mobile come for effective usage.

The objectives of this project are as follows;

a. Provide a wind meter that is less bulky
b. Provide a wind meter that can quickly detect small changes in wind speed
c. Provide a wind meter that is abstracted from machines and other devices
d. Provide a mechanism where the values of a wind meter can be viewed all over the world

1.5 SCOPE AND LIMIITATION

In wind turbines and airports, wind meters are fitted as immobile devices. It would be important to note that some of the wind meters are fitted to the body of other turbine machines or radar devices but wind speed is something that changes over a little scope of time so it is necessary to be abreast at all times of any new development in wind speed. This project provides us with a handy, easy to use, digital wind meter. The extra sensitivity of the sensors allows small changes in wind speed to be detected quickly.

However, certain limitation surface as certain aspects of wind sensing would not be considered. These include;

1. Wind pressure
2. Wind direction

Other limitations include;

1. Inadequate financing

2. Inadequate time for the design

1.6 SIGNIFICANCE OF STUDY

In a country like ours where power supply is inadequate, any means possible to achieve a higher generation of power is a welcome development. It is by this that wind turbines come in. a major part of a wind turbine is the driving of the turbine blades by wind. This is only achieved with the wind having sufficient speed. It is therefore a revelation to the fact that wind speed is a necessary tool for power generation.

By the constructivism entailed in this research, an efficient mode of wind speed detection serves as a foundational tool for effective power generation.

The use of wind meters is not limited to power generation but can be seen in great usage by meteorological agencies and airports

1.7 RESERCH METHODOLOGY

According to Eddiefloyd (2003), research provides the basis for constructing new theories as well as an opportunity for testing existing theories, while theories inspire and guide practical research. In any situation where a standard meaningful research is to be conducted, then the data must be collected for the purpose of presentation and analysis. Collection of data is very important as any mistake or biasness done during data collection would automatically affect the analysis, which would lead to wrong conclusions and thus research would be rendered invalid.

The research methodology used in this project is the experimentation method. Experimentation method defined in a narrower sense is "The systematic experimentation with data and existing theories to form new theories and new products in a way that permit some degree of analytic interpretation"

CHAPTER TWO

2.0 ANEMOMETRY

Anemometry comes from the Greek term *anemos* for wind. It means measuring the speed of wind. Traditionally anemometers have been important tools for meteorology. They have also been instrumental in measuring the speed of airflow in wind tunnels or in other gas- flow applications.

The most widely known type of anemometer is the rotating anemometer. This device is mounted on an axis to rotate freely in the wind, indicating the wind's direction. The current from a photo-diode, whose light is blocked periodically by the rotating axis, can be used to measure the rotation speed. Then, the rotation speed and the rotation circumference can be multiplied to calculate the wind speed. However, when measuring a weak airflow with the rotating anemometer, there must be enough wind to overcome friction and accelerate the moving parts. Also it is not easy to measure the speed of gusts using revolving anemometers. Commercially available rotating anemometers claim performance with 0.4-60m/s-measurement range and 0.3 ~ 0.5 m/s accuracy

2.1 REVIEW OF SOME RELATED LITERATURE

The first wind meter was created in 1450 by Italian Renaissance architect, scientist and inventor Leon Battista Alberti. Since that time, many inventors have built off of Alberti's principles, creating new innovations such as Thomas Romney Robinson's hemispherical cup wind meter in 1846 and Andreas Pflitsch's sonic wind meter in 1994.

2.1.1 ALBERTI'S ANEMOMETER IN 1450

These are the earliest anemometers and are simply a flat plate suspended from the top so that the wind deflects the plate. In 1450, the Italian art architect Leon Battista Alberti invented the first mechanical anemometer

2.1.2 ROBERT HOOK'S ANEMOMETER IN 1664

In 1664 the plate anemometer was re-invented by Robert Hooke (who is often mistakenly considered the inventor of the first anemometer). Later versions of this form consisted of a flat plate, either square or circular, which is kept normal to the wind by a wind vane. The pressure of the wind on its face is balanced by a spring. The compression of the spring determines the actual force which the wind is exerting on the plate, and this is either read off on a suitable gauge, or on a recorder. Instruments of this kind do not respond to light winds, are inaccurate for high wind readings, and are slow at responding to variable winds. Plate anemometers have been used to trigger high wind alarms on bridges.

2.1.3 JAMES LIND'S TUBE ANEMOMETER IN 1775

James Lind's anemometer of 1775 consisted simply of a glass U tube containing liquid, a manometer, with one end bent in a horizontal direction to face the wind and the other vertical end remains parallel to the wind flow. Though the Lind was not the first it was the most practical and best known anemometer of this type. If the wind blows into the mouth of a tube it causes an increase of pressure on one side of the manometer. The wind over the open end of a vertical tube causes little change in pressure on the other side of the manometer. The resulting liquid change in the U tube is an indication of the wind speed. Small departures from the true direction of the wind causes large variations in the magnitude.

2.1.4 DR JOHN THOMAS ROBINSON'S CUP ANEMOMETER IN 1846

A simple type of anemometer is the cup anemometer, invented (1846) by Dr. John Thomas Romney Robinson, of Armagh Observatory. It consisted of four hemispherical cups each mounted on one end of four horizontal arms, which in turn were mounted at equal angles to each other on a vertical shaft. The air flow past the cups in any horizontal direction turned the cups in a manner that was proportional to the wind speed. Therefore, counting the turns of the cups over a set time period produced the average wind speed for a wide range of speeds. On an anemometer with four cups it is easy to see that since the cups are arranged symmetrically on the end of the arms, the wind always has the hollow of one cup presented to it and is blowing on the back of the cup on the opposite end of the cross.

When Robinson first designed his anemometer, he asserted that the cups moved one-third of the speed of the wind, unaffected by the cup size or arm length. This was apparently confirmed by some early independent experiments, but it was incorrect. Instead, the ratio of the speed of the wind and that of the cups, the anemometer factor, depends on the dimensions of the cups and arms, and may have a value between two and a little over three. Every experiment involving an anemometer had to be repeated.

2.1.5 WILLIAM HENRY DINES PRESSURE TUBE ANEMOMETER IN 1892

The highly successful metal pressure tube anemometer of William Henry Dines in 1892 utilized the same pressure difference between the open mouth of a straight tube facing the wind and a ring of small holes in a vertical tube which is closed at the upper end. Both are mounted at the same height. The pressure differences on which the action depends are very small, and special means are required to register them. The recorder consists of a float in a sealed chamber partially filled with water. The pipe from the straight tube is connected to the top of the sealed chamber and the pipe from the small tubes is directed into the bottom inside the float. Since the pressure difference determines the vertical position of the float this is a measure of the wind speed.

The great advantage of the tube anemometer lies in the fact that the exposed part can be mounted on a high pole, and requires no oiling or attention for years; and the registering part can be placed in any convenient position. Two connecting tubes are required. It might appear at first sight as though one connection would serve, but the differences in pressure on which these instruments depend are so minute, that the pressure of the air in the room where the recording part is placed has to be considered. Thus if the instrument depends on the pressure or suction effect alone, and this pressure or suction is measured against the air pressure in an ordinary room, in which the doors and windows are carefully closed and a newspaper is then burnt up the chimney, an effect may be produced equal to a wind of 10 mi/h (16 km/h); and the opening of a window in rough weather, or the opening of a door, may entirely alter the registration.

While the Dines anemometer had an error of only 1% at 10 mph (16 km/h) it did not respond very well to low winds due to the poor response of the flat plate vane required to turn the head into the wind. In 1918 an aerodynamic vane with eight times the torque of the flat plate overcame this problem.

2.1.6 THE THREE CUP ANEMOMETER

The three cup anemometer developed by the Canadian John Patterson in 1926 and subsequent cup improvements by Brevoort & Joiner of the USA in 1935 led to a cup wheel design which was linear and had an error of less than 3% up to 60 mph (97 km/h). Patterson found that each cup produced maximum torque when it was at 45 degrees to the wind flow. The three cup anemometer also had a more constant torque and responded more quickly to gusts than the four cup anemometer.

2.1.7 MODIFICATION OF THE THREE CUP ANEMOMETER

The three cup anemometer was further modified by the Australian Derek Weston in 1991 to measure both wind direction and wind speed. Weston added a tag to one cup, which causes the cup wheel speed to increase and decrease as the tag moves alternately with and against the wind. Wind direction is calculated from these cyclical changes in cup wheel speed, while wind speed is as usual determined from the average cup wheel speed.

Three cup anemometers are currently used as the industry standard for wind resource assessment studies.

2.1.8 WIND MILL ANEMOMETERS

The other forms of mechanical velocity anemometer may be described as belonging to the windmill type or propeller anemometer. In the Robinson anemometer the axis of rotation is vertical, but with this subdivision the axis of rotation must be parallel to the direction of the wind and therefore horizontal. Furthermore, since the wind varies in direction and the axis has to follow its changes, a wind vane or some other contrivance to fulfill the same purpose must be employed. An *aero vane* combines a propeller and a tail on the same axis to obtain accurate and precise wind speed and direction measurements from the same instrument. In cases where the direction of the air motion is always the same, as in the ventilating shafts of mines and buildings for instance, wind vanes, known as air meters are employed, and give most satisfactory results.

2.1.9 HOT WIRE ANEMOMETERS

Hot wire anemometers use a very fine wire (on the order of several micrometers) electrically heated up to some temperature above the ambient. Air flowing past the wire has a cooling effect on the wire. As the electrical resistance of most metals is dependent upon the temperature of the metal (tungsten is a popular choice for hot-wires), a relationship can be obtained between the resistance of the wire and the flow speed.[2]

Several ways of implementing this exist, and hot-wire devices can be further classified as CCA (Constant-Current Anemometer), CVA (Constant-Voltage Anemometer) and CTA (Constant-Temperature Anemometer). The voltage output from these anemometers is

The laser is emitted (1) through the front lens (6) of the anemometer and is backscattered off the air molecules (7). The backscattered radiation (dots) re-enter the device and are reflected and directed into a detector (12).

Laser Doppler anemometers use a beam of light from a laser that is divided into two beams, with one propagated out of the anemometer. Particulates (or deliberately introduced seed material) flowing along with air molecules near where the beam exits reflect, or backscatter, the light back into a detector, where it is measured relative to the original laser beam. When the particles are in great motion, they produce a Doppler shift for measuring wind speed in the laser light, which is used to calculate the speed of the particles, and therefore the air around the anemometer.

2.1.11 SONIC ANEMOMETERS

Sonic anemometers, first developed in the 1970s, use ultrasonic sound waves to measure wind velocity. They measure wind speed based on the time of flight of sonic pulses between pairs of transducers. Measurements from pairs of transducers can be combined to yield a measurement of velocity in 1-, 2-, or 3-dimensional flow. The spatial resolution is given by the path length between transducers, which is typically 10 to 20 cm. Sonic anemometers can take measurements with very fine temporal resolution, 20 Hz or better, which makes them well suited for turbulence measurements. The lack of moving parts makes them appropriate for long term use in exposed automated weather stations and weather buoys where the accuracy and reliability of traditional cup-and-vane anemometers is adversely affected by salty air or large amounts of dust. Their main disadvantage is the distortion of the flow itself by the structure supporting the transducers, which requires a correction based upon wind tunnel measurements to minimize the effect. An international standard for this process, ISO 16622 *Meteorology—Sonic anemometers/thermometers—Acceptance test methods for mean wind measurements* is in general circulation. Another disadvantage is lower accuracy due to precipitation, where rain drops may vary the speed of sound.

Since the speed of sound varies with temperature, and is virtually stable with pressure change, sonic anemometers are also used as thermometers.

Two-dimensional (wind speed and wind direction) sonic anemometers are used in applications such as weather stations, ship navigation, wind turbines, aviation and weather buoys.

2.1.12 PING-PONG BALL ANEMOMETERS

A common anemometer for basic use is constructed from a ping-pong ball attached to a string. When the wind blows horizontally, it presses on and moves the ball; because ping-pong balls are very lightweight, they move easily in light winds. Measuring the angle between the string-ball apparatus and the line normal to the ground gives an estimate of the wind speed.

This type of anemometer is mostly used for middle-school level instruction which most students make themselves

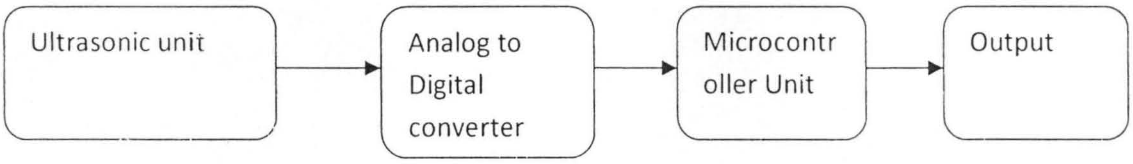
2.2 EFFECT OF DENSITY ON MEASUREMENT

In the tube anemometer the pressure is measured, although the scale is usually graduated as a velocity scale. In cases where the density of the air is significantly different from the calibration value (as on a high mountain, or with an exceptionally low barometer) an allowance must be made. Approximately 1½% should be added to the velocity recorded by a tube anemometer for each 1000 ft (5% for each kilometer) above sea-level.

2.4 BRIEF DESCRIPTION OF THE ANEMOMETER DESIGN

The anemometer being designed in the project is the ultrasonic digital anemometer. This anemometer comes true as an industry standard.

It is a one dimensional anemometer (measures only wind speed) that computes the value of wind speed through a microcontroller and displays on an LCD. It follows a three pronged process which is adequately outlined below;



The advantage of this method of measuring wind speed is that it enables us to be able to rectify any inconsistency and also enables this through a more digitized processing format

2.5 DESIGN GOALS

The anemometer design has the following incorporated into it as its goals:

1. **ROBUSTNESS AND STABILITY;** Robustness is the ability of the system to handle abnormal situations. It also refers to a system that can perform well under a variety of normal and abnormal situations. The anemometer is design in an experimentally efficient format that incorporates this into it.
2. **SIMPLICITY:** This project is designed to be simple as possible. In other words, the project must offer its functionality effectively and efficiently with a minimum utilization overhead.
3. **FLEXIBILITY:** flexibility is the ease with which a component can be modified for use in application for use in applications or environment other than those for which it is specially designed (IEEE definition for flexibility). The project is designed to be flexible in the sense that, other students can improve on it, thereby increasing its functionality.

2.6 HISTORICAL BACKGROUND OF JAVA

Java was developed at Sun Microsystems by a team led by James Gosling. It was designed in 1991 for use in embedded consumer electronic appliances. In 1995, renamed Java, it was redesigned for developing Internet applications.[4]

Java has become a very popular software development platform that developers struggle to adopt. Java's rapid rise and wide acceptance can be traced to its design characteristics, particularly its promise that you can write a program once and run it anywhere, i.e. across operating systems and processor architecture.

It advantages include scalability, reusable codes, platform independence, shorter codes and it is safe as it avoids CPU corruption.

2.6 TECHNICAL TERMS ASSOCIATED WITH JAVA LANGUAGE

In discussing Java, it is important to clearly define or distinguish between the various java related terms.

Java programming language: The Java programming language is the language in which Java applications, applets, servlets, and components are written.

Java Virtual Machine (JVM): When a Java program is compiled, it is converted to byte codes that are the portable machine language of a CPU architecture known as the *Java Virtual Machine* (also called the Java VM or JVM). The JVM can be implemented directly in hardware, but it is usually implemented in the form of a software program that interprets and executes byte codes. [5]

Java Platform: The Java platform is distinct from both the Java language and Java VM. The Java platform is the predefined set of Java classes that exist on every Java installation; these classes are available for use by all Java programs. The Java platform is also sometimes referred to as the Java runtime environment or the core Java APIs (application programming interfaces). The Java platform can be extended with optional packages (formerly called standard·extensions).

Java API: The application program interface (API) contains predefined classes and interfaces for developing Java programs. The Java language specification is stable, but the API is still expanding. [4]. These APIs exist in some Java installations but are not guaranteed to exist in all installations. [5]

Java Development Kit (JDK): JDK consists of a set of separate programs for developing and testing Java programs, each of which is invoked from a command line.

Besides JDK, there are more than a dozen Java development tools on the market today [4]. Three major development tools are:

- JBuilder by Borland
- NetBeans Open Source by Sun
- Eclipse Open Source by IBM

CHAPTER THREE

DESIGN AND METHODOLOGY

3.1 BASIC PRINCIPLE OF ANEMOMETER DESIGN

The main fact acoustic digital anemometry takes advantage of is that sound propagation speed is directly affected by the motion of its propagation medium. For sound waves traveling in air, any airflow affects the propagation speed.

Noting this fact, suppose there are two nodes 1 and 2 and there is also airflow from node 1 to node 2 along the line connecting these two nodes. If the sound of speed is measured from node 1 to node 2 (See figure 3.1.1) the result will be

V12 = Vsound_still + Vairflow E 3.1.1

where V12 is the speed of sound with 1 as the transmitter and 2 as the receiver,

Vsound_still is the speed of sound in still air and Vairflow is the airflow speed along the line from node 1to node 2.

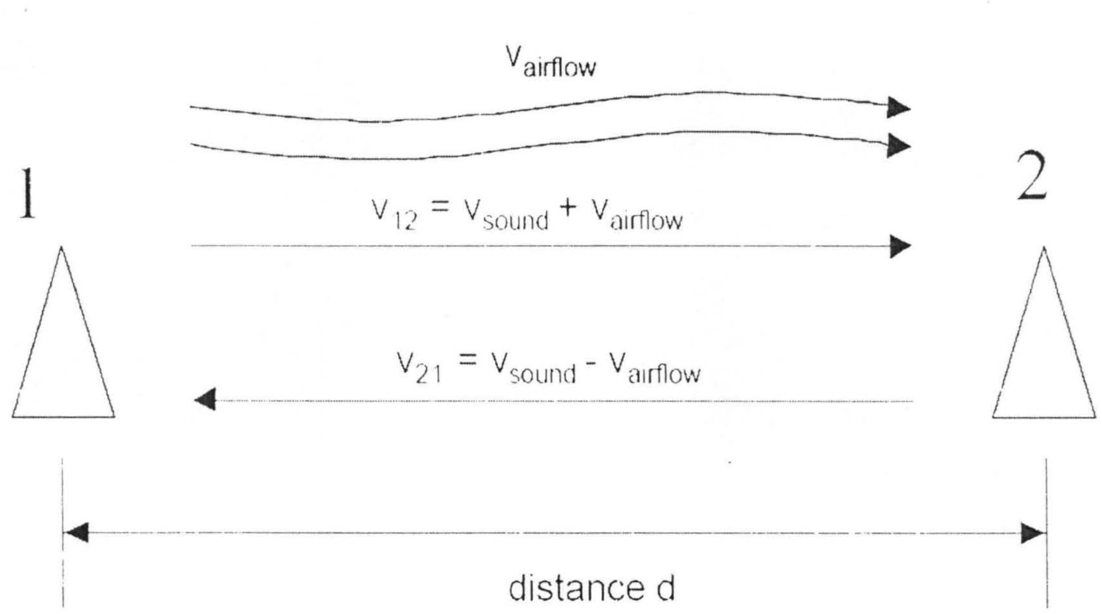


Figure 3.1.1 Basic Principle of Airflow Measurement

Next, if an acoustic signal is transmitted in the opposite direction, i.e., 2 is the transmitter and 1 is the receiver, the sound speed will be measured as:

V_{21} = Vsound_still - Vairflow E $_{3.1.2}$

where the variables V_{21}, Vsound_still, and Vairflow are defined similarly to those in E $_{3.1.1}$

If V_{12} and V_{21} are measured for these two cases, Vairflow can be obtained using

Vairflow= $(V_{12}-V_{21})/2$. E $_{3.1.3}$

The directionality of the flow can be easily determined by noting that airflow has the same direction as the transmission that yields a higher acoustic speed. It should, however, be kept in mind that by taking the difference of two speeds the result would be only the component of airflow along the line connecting nodes 1 and 2 (see figure 3.1.1)

As already discussed, speed of sound is a strong function of the properties of the propagation media, i.e. temperature, type, state, etc. This dependence can significantly affect the Vsound_still component. But in the difference of V12 and V21 Vsound_still term drops out and this strong dependence on ambient conditions is not a main concern.

3.2 OBTAINING THE VELOCITY

Since airflow can be measured if one knows the acoustic speed in both directions, the question becomes "How can one measure this acoustic speed?" To this end, some fundamental properties of sound waves should be utilized.

In the case of a single frequency sinusoidal signal, the transmitted signal has a phase shift at the receiving end (See figure 3.2.1). The amount of the phase shift due to the distance traveled can be determined using the fact that the received signal is a delayed version of the transmitted. Hence the received signal *r (t)* is written as:

$r(t) = sin[2pf(t - td) + r_0] = sin[2pf t - 2pf td + r_0] = sin[2pf t - j + r_0]$

Where, t_d is the delay, f is the frequency and r_0 is the initial phase of the sinusoid. Noting that the time delay is simply

$t_d = d/v$

where, d is the distance traveled, v is the speed of sound, the phase shift $2pf\ td$ can be expressed as a function of distance and velocity,

$j = 2pftd = 2pf\ d/v$

where j is defined as the phase shift from the initial phase.

It is clearly seen from the phase shift relation that for a given distance, if the phase shift j can be measured, the velocity can be obtained.

However, there are two important points that need serious consideration. First, the phase measurement is going to give the total phase (r_0-j), while the actual phase shift of interest is 'j'. The second problem is that, the measured phase is (r_0-j) (mod2p), as opposed to (r_0-j) itself.

The phase measurement is equal to the actual phase value only if the actual phase is in the interval [0, 2p), which is only true for small values of d.

To solve the first problem, two sinusoidal signals with different frequencies (f1and f2) but the same initial phase can be used. Taking the difference of the measured phases, the initial phase $r0$ can vanish from the rest of the equations.

$Dj12 = (r_0-j1) - (r_0-j2) = (j2-j1) = 2pf1\ d/v - 2pf2\ d/v = 2p(f1-f2)\ d/v,$

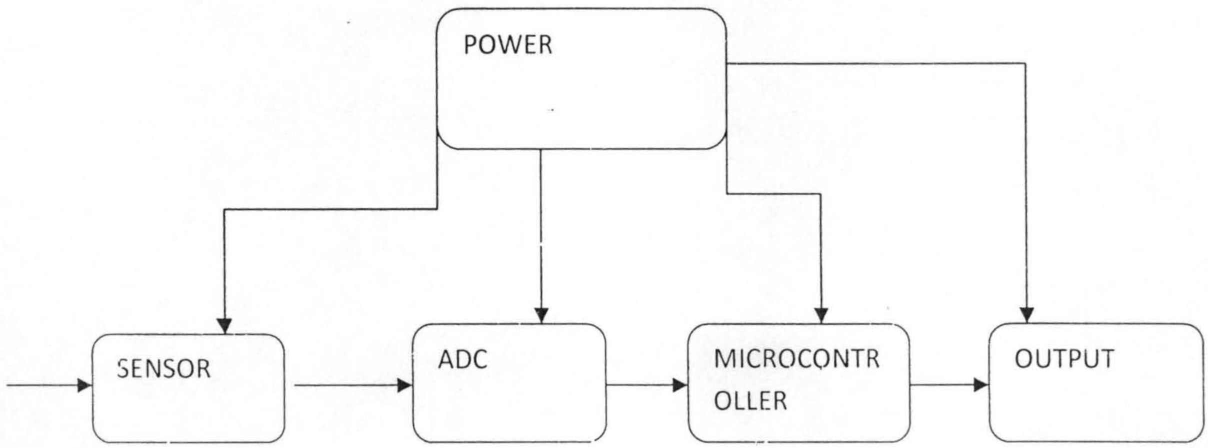
Where, $Dj12$ is defined to be the difference of the measured phases. Then the acoustic propagation speed can be expressed as a function of the measured phase difference

$v = 2p(f1-f2)\ d/Dj12$

Also, it can be observed that the phase difference increases proportional to *(f1-f2) d/v*, which is slower than the increase in the first case, which is proportional to f1d/v.

3.3 ANEMOMETER SUBSECTIONS

For the anemometer to function to expectation and properly, several sections come together in harmony to form the basic building blocks for this design. The design is based upon the principle of acoustic sounds which encapsulates theories such as sampling and quantization of the output signals and a microcontroller to control the inflow and the outflow of information and signals. This design presents a deviation from the normal anemometer which is based upon the principle of heat.



The varied subsections act in synergy towards creating a system that effectively measures the velocity of wind. This is the block diagram that simulates the most basic design of this system

3.3.1 POWER SUBSECTION

The power section of the design is very important because most of the components require electrical power to perform their functions effectively. The power subsection is going to accommodate many other sections because they all dependent on this section as it gives them the accurate framework for them to perform their tasks. The power subsection therefore was designed with much care and consideration. It is therefore imperative, to account for a number of parameters before jumping into the design of the system.

3.3.1.1 FACTORS CONSIDERED IN POWER SYSTEM DESIGN

Flexibility

The flexibility of the system is paramount in our minds as the design structure we aim to achieve should be as portable as possible so it is imperative that the power system should be flexible enough to power the whole system yet still attaining a minimalist size.

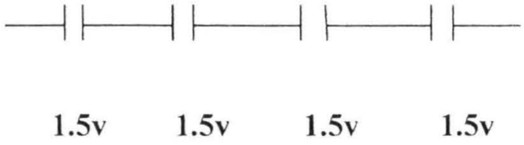
Portability

The portability of the system is also paramount as this helps us to attain our overall design aim of portability. With this in mind, the design is made in such a way that it gives no room for rectification. This system can only be achieved using the battery system and approach

3.3.1.2 ANALYSIS OF POWER SUBSECTION

In order to attain all the aims listed for the power subsection, the system was powered using DC power supply of 6V obtained from the use of four alkaline batteries connected in series. Each of the alkaline battery cells has a voltage rating of 1.5V giving us a cumulative voltage from our calculations of 6V.

Total voltage rating= $1.5v+1.5v+1.5v+1.5v=6v$



3.3.2 ANALOG TO DIGITAL CONVERTER SUBSECTION

The voltage output of the wind sensor is needed in corresponding digital format for control and display uses. The Analogue to Digital converter does the leading task.

The converter requires the circuit below with respect to its manufacturer's datasheet. Pin 6 of the integrated circuit is connected to pin 3 of the temperature sensor. Pins 11,12,13,14,15,16,17 and 18 serve as 8-bit output of the device. Pins 4 and 19 are connected to a RC circuit for internal clocking or timing.

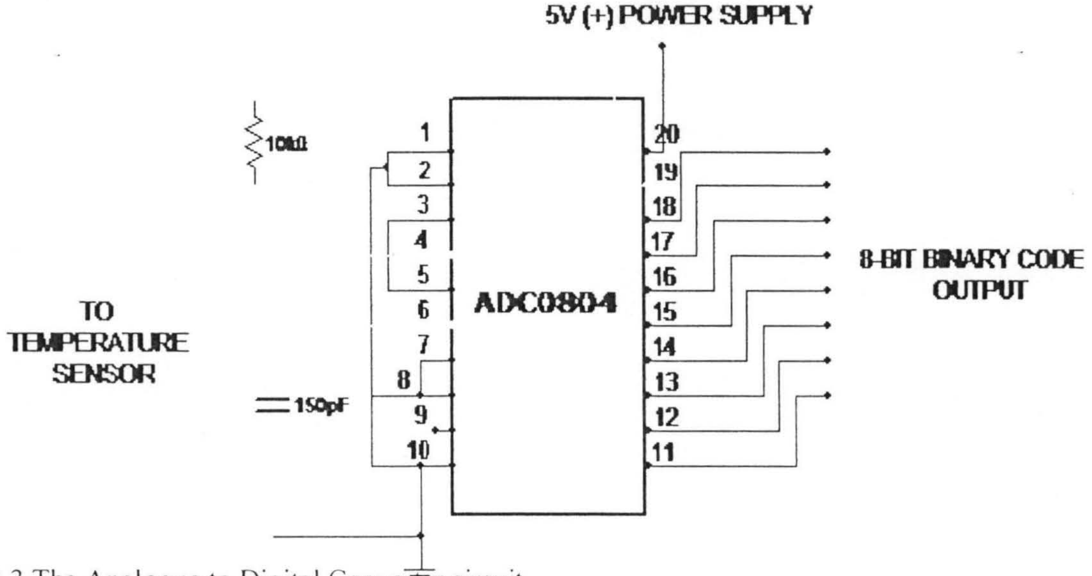


Fig 3.3 The Analogue to Digital Converter circuit

The RC circuit consists of a 10KΩ and a 150pF resistor and capacitor respectively.

The internal clocking of process in the ADC is given as:

$$f = \frac{1}{RC}$$

$$f = \frac{1}{10 \times 10^{3} \times 150 \times 10^{-12}}$$

$$f = 666.7KHz$$

$$T = \frac{1}{f} = \frac{1}{666.7KHz} = 1.5\mu s$$

$$T = 1.5\mu s$$

The result above shows that the Analogue to Digital Converter operates at a very high speed in the conversion of analogue signal to digital form.

The ADC is set to a resolution of 10mV/bit, which signifies that its output code is incremented by a digit one for every 10mV.This process allows for direct conversion of the analogue output from the temperature sensor into digital. This is because the two devices are in tune to one and the same resolution.

3.4.1 Control Oscillator

The control oscillator consists of two operational frequency outputs from pins 1 and 2.The first signal serves the output calibrating unit, while the other is used for manual fan speed regulation or switching.

Using the early stated formula in chapter 2, related to 4060B frequency outputs, the leading two frequencies can be calculated as follows:

$R_{TC} = 33K\Omega$

$C_{TC} = 0.001\mu F$

$R_S = 100K\Omega$

$$f_m = \frac{1}{2.3R_{TC}C_{TC}}:$$

$$f_m = \frac{1}{2.3\times33\times10^3\times0.001\times10^{-6}} = 13175.2Hz$$

$$f_m \approx 13.2KHz$$

Output frequency from pin 1 whose O value is 12, of the 4060B integrated circuit is given below:

$$f_{O12} = \frac{f_m}{2^{12}}$$

$$f_{O12} = \frac{13200}{2^{12}} = 3.2Hz$$

$$f_{O12} = 3.2Hz$$

$$T_{O12} = \frac{1}{f_{O12}} = \frac{1}{3.2} = 0.31s$$

$$T_{O12} = 0.31s$$

Output frequency from pin 3 whose Q value is 13, of the 4060B integrated circuit is given below:

$$f_{O13} = \frac{f_m}{2^{13}}$$

$$f_{O13} = \frac{13200}{2^{13}} = 1.6\,Hz$$

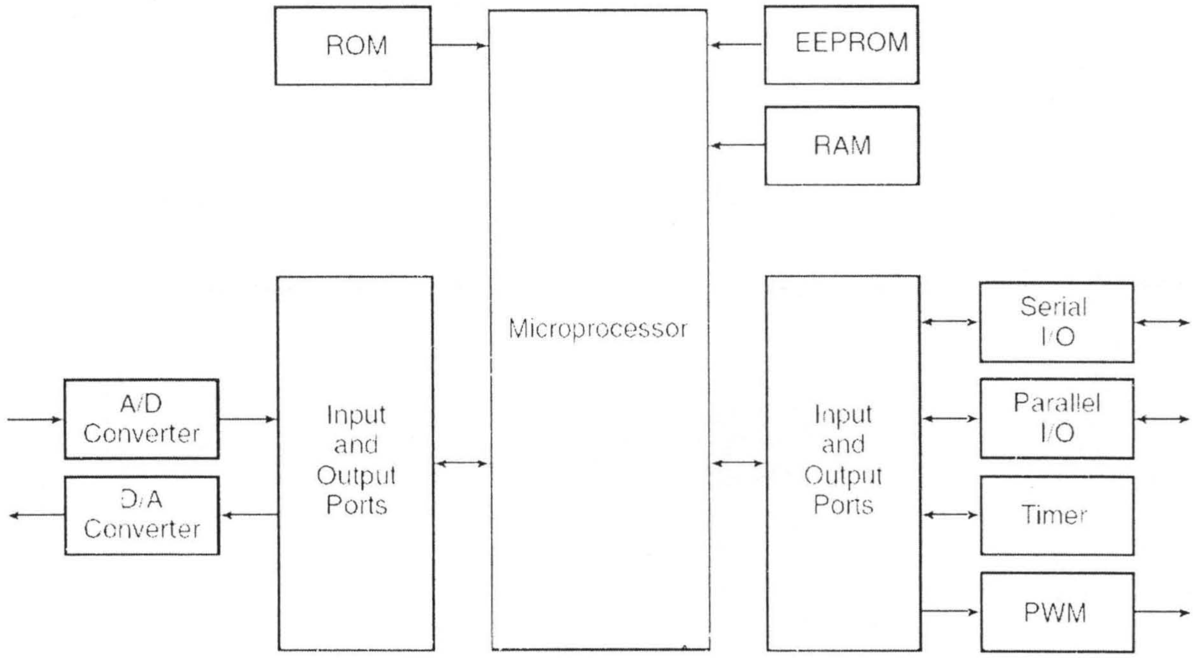
$$f_{O13} = 1.6\,Hz$$

$$T_{O13} = \frac{1}{f_{O13}} = \frac{1}{1.6} = 0.625\,s$$

$$T_{O13} = 0.625\,s$$

3.3.3 MICROCONTROLLER SUBSECTION

The microcontroller subsection is subsequently used to the process the ouput from the analogue to digital converter. The digital output from the ports of the analogue to digital converter is fed into the digital input port of the microcontroller. The microcontroller used is the PIC 16F628 which is characterized by its 18 ports consisting of power, ground, input ports, output ports, clock input and serial inputs



3.3.4 OUTPUT SUBSECTION

The output subsection was designed to accommodate to different sections within it. The job of the first subsection is to display the output (Wind velocity) on the screen and the job of the second section is to send the current wind speed via a computer to a server thereby updating it of the current wind speed in the location of the anemometer.

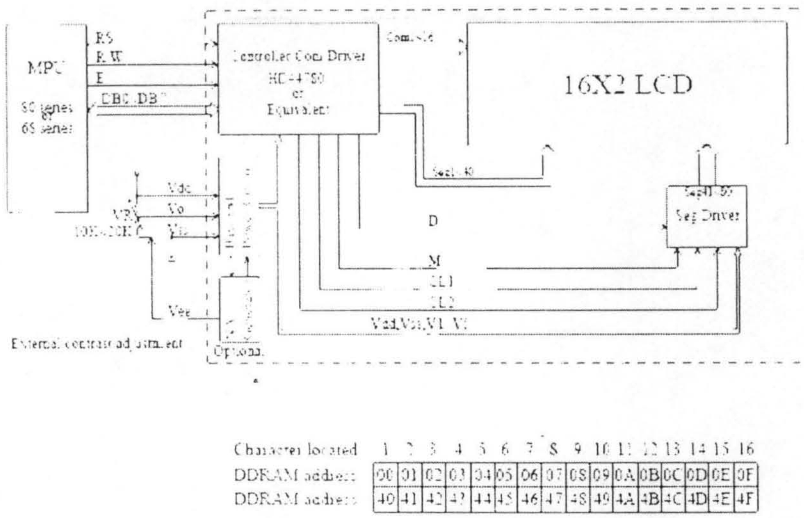
3.3.4.1 LIQUID CRYSTAL DISPLAY (LCD)

It was imperative at the time of design to use a liquid Crystal Display (LCD). The output subsection consists of a 16 by 2 (16 columns and 2 rows) connected directly to the output port of the microcontroller.

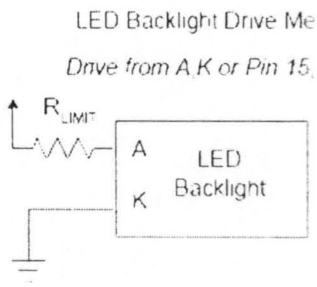
The LCD has 14 pins each of which is performing a designated task towards the working of the output subsection. Below is a table of the pins and their designated tasks'

PIN	**TASK**
1	GROUND
2	POWER
3.	CURRENT LIMITING
4	SET/RESET
5	READ/WRITE
6	ENABLE
7	DATA PIN 0
8	DATA PIN 1
9	DATA PIN 2
10	DATA PIN 3
11	DATA PIN 4
12	DATA PIN 5
13	DATA PIN 6
14	DATA PIN 7

The output subsection is powered with a voltage level of 5V connected to Pin 2 which serves as the voltage input pin.



PIN NO	SYMBOL
1	Vss
2	Vdd
3	Vo
4	RS
5	R/W
6	E
7	DB0
8	DB1
9	DB2
10	DB3
11	DB4
12	DB5
13	DB6
14	DB7
15	A/Vee
16	K



3.3.4.2 COMPUTER OUTPUT

To accommodate this facility in this design, the system must be configured in such a way that transmission and reception of data is not only permissible but possible. Data can be transmitted in bytes and as such whatever data is necessary for the transmission of data must be converted to this format implicitly. To achieve the rxtx.dll library which is written in native visual basic was integrated with the javacomm.jar file to create a perfect combination of reception and transmission. The rxtx.dll is an open source library that funds the transfer of data of data from hardware to software and vice versa. This file would be loaded and accurately implemented to function at runtime.

3.4 INTEGRATING THE HARDWARE DESIGN

The design integration is a major component as it is what gives rise to anemometer itself. The integration starts from the power subsystem as it is worthy to know that all the systems need power to function adequately. From this point, we can bring the sensor system into play.

The sensor acts as input for the control system and it therefore necessary for it to be put in place effectively before the control system can work adequately and effectively. This proves to be the best practice in integrating the design.

The control subsection comes in next. With all other systems in place, it is for it to function and finally gives an output to the display unit. The control unit also performs filtering and other activities to make sure that the input signal is correct for processing.

3.5 BASIC DESCRIPTION OF THE SOFTWARE PROCEDURE

The software design is done so as to be able to receive incoming data from the anemometer and load to a local or an international server that provides information about the wind speeds in different locations at the same time. This facility aids the possibility of billions of people knowing the wind speed of a particular location at the same time. The software encompasses related algorithms that are implemented in such a way as to achieve the overall aim of the system.

The following algorithms were implemented and inter connected so as to achieve the overall aim

1. Byte input algorithm
2. Byte processing Algorithm
3. Server update algorithm

4. Server download algorithm

3.5.1 BYTE INPUT ALGORITHM

This performs the task of continuously scanning the ports for inputs from the locally connected anemometer. This algorithm is implemented as an event triggering process that triggers an event when a certain condition is perceived and the condition in this respect is the availability of byte from the ports. The algorithm is implemented thus;

i. Load all necessary startup files
ii. Attempt connection to the server
iii. While information is not available at the ports, continue scanning the ports
iv. If information is available, trigger the byte processing algorithm

This serves as the basic process that is implemented by the byte input algorithm

3.5.2 BYTE PROCESSING ALGORITHM

The byte processing algorithm is called upon whenever there is information available from the ports by the locally connected wind speed meter. This algorithm aims to serve as a conditioning unit that conditions the input provides to data types that can be used by the system. The basic procedure implemented by this system is outlined below;

i. Receive information in bytes
ii. Perform an implicit conversion of data to the double data format
iii. Strip the data of excess decimal places
iv. Display it on the software display board
v. Call the server update method

3.5.3 SERVER UPDATE ALGORITHM

The server update algorithm updates all locally connected servers and remotely connected server of the wind speed data obtained at the location in which it is placed. This algorithm ensures that all connected servers are not starved of the necessary data they need from that local station. The algorithm to facilitate the achieving of this aim is outlined below;

i. Receive formatted data
ii. Retrieve the address of all servers
iii. Send information to the servers and wait for feed back
iv. If feedback is available, it declares server as responding else it declares it as non responsive

3.5.4 SERVER DOWNLOAD ALGORITHM

The local base station does not only update the server with information about the wind speed in its environment, it also needs to be able to furnish itself with information about wind speeds from other locations. It does this via the server download algorithm. It enables the local software to download the different wind speed form different server locations. The implementation of the algorithm goes thus;

i. Locate responsive servers
ii. Establish connection
iii. If connection could not be established, indicate a network problem
iv. Else download data and display it

3.6 CHOICE OF PROGRAMMING LANGUAGE

The language used for the development of this software is java. Java is a general purpose concurrent, class based, object oriented language that is specifically designed to have as few implementation dependencies as possible. It is intended to let application developers "write once, run anywhere". The reason for my choice of java as a programming language is because it is robust, secure and portable. It allows the programmer to create controls and then write code for each control so that it could be executed at the press of a command button

3.7 ABOUT JAVA

Java is an object oriented language introduced in 1995 by sun Microsystems. The fundamental structural component of a java program is a class. All data and methods are associated with some class. There is no global data or function as in C++. Classes can be members of packages; packages and class membership help determine scope and visibility of data and methods.

It advantages include scalability, reusable codes, platform independence, shorter codes and its safe as it avoids CPU corruption.

Java applications are typically compiled to byte code (class file) that can run on the java virtual machine regardless of the computer architecture.

3.8 SYSTEM REQUIREMENT

The hardware requirement for the software to work perfectly is;

1. At least a pentuim 2- class processor with a speed of 450Mhz
2. Random Access memory size of 512MB and above
3. Hard disk storage capacity of 1GB and above

4. Uninterruptable power Supply

The software requirements include;

1. Java development Kit (JDK)
2. Java runtime environment
3. Netbeans 6.5 and above
4. Suitable antivirus

3.9 SOFTWARE AND HARDWARE MAINTENANCE

Software should not be abandoned as soon as it becomes operational because it has to be monitored to ensure that it meets the user the management requirements and to see it is can accommodate any feasible additional changes. It is a well known fact that system depreciates over time. If such cases occur, the system designer or attendant could be called upon to perform any of the following tasks;

- Preventive maintenance: changes to change the existing system so as to reduce the risk of failure while operating
- Corrective maintenance: Correcting the problems that arise while using the system
- Perfective maintenance: Enhancements or modifications to improve the safety, reliability, efficiency or cost-effectiveness of operation.
- Adaptive maintenance: Adaptations to address requirements that arise due to changes in the environment.

CHAPTER FOUR

CONSTRUCTION, TESTING AND DISCUSSION OF RESULTS

4.1 CIRCUIT CONSTRUCTION

This part of the project involved practical exercise of converting the circuit diagram on the paper into a real working hardware. The first part entailed verifying the workability of some parts and components of the involved circuit on the bread board. It was a temporary circuit connection.

The main construction was done on a Vero board. The involved electronic components were carefully connected together under the guide of the circuit diagram. The breaking down of the complete circuit during the design analysis, in the early chapter, was of great importance in the construction. Each unit circuit was executed one after the other. After which all the units were joined together as a single working construction.

The power supply unit was quite delicate during the construction- it was made with great care. After the complete construction, the power unit was properly checked for short circuit and unwanted bridges.

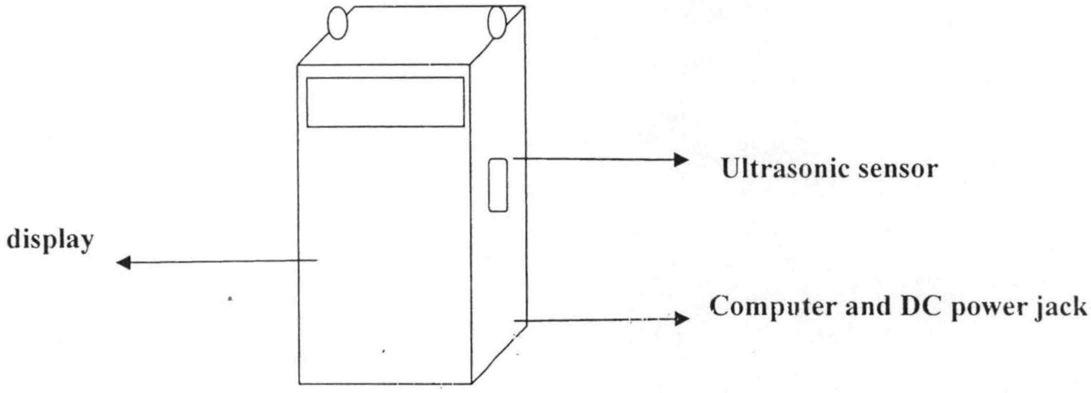
The circuit's construction involves the following materials and tools:-

- Soldering iron
- Soldering lead
- Jumper wires
- Integrated circuit sockets
- Cutting knife
- Razor blade
- Pliers

- Pair of Scissor
- Digital multi-meter

4.1.1 Casing Construction

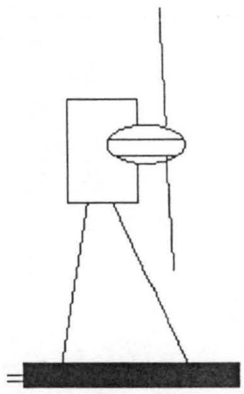
The casing of the project was made with cheap plastic material. The choice of the material allowed holes and openings, for external parts of the circuit, to be easily made on the casing. Below is a diagrammatic representation of the casing used.

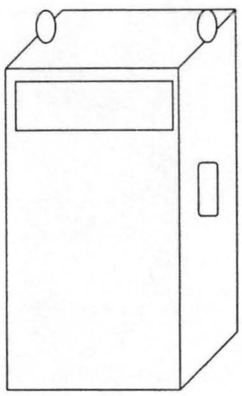


4.2 TESTING

The testing of the device was carried out by connecting a regulated fan to the socket and gradually increasing the applied voltage to the fan. The wind speed meter was placed directly across it so as to facilitate the correct measurement of the wind speed.

Once the setup was complete, it was time to begin testing of the device. It was discovered, that as the voltage to the fan increased, the wind speed generated by the fan increased.and also the measured wind speed also increased. The setup is diagrammatically represented below;

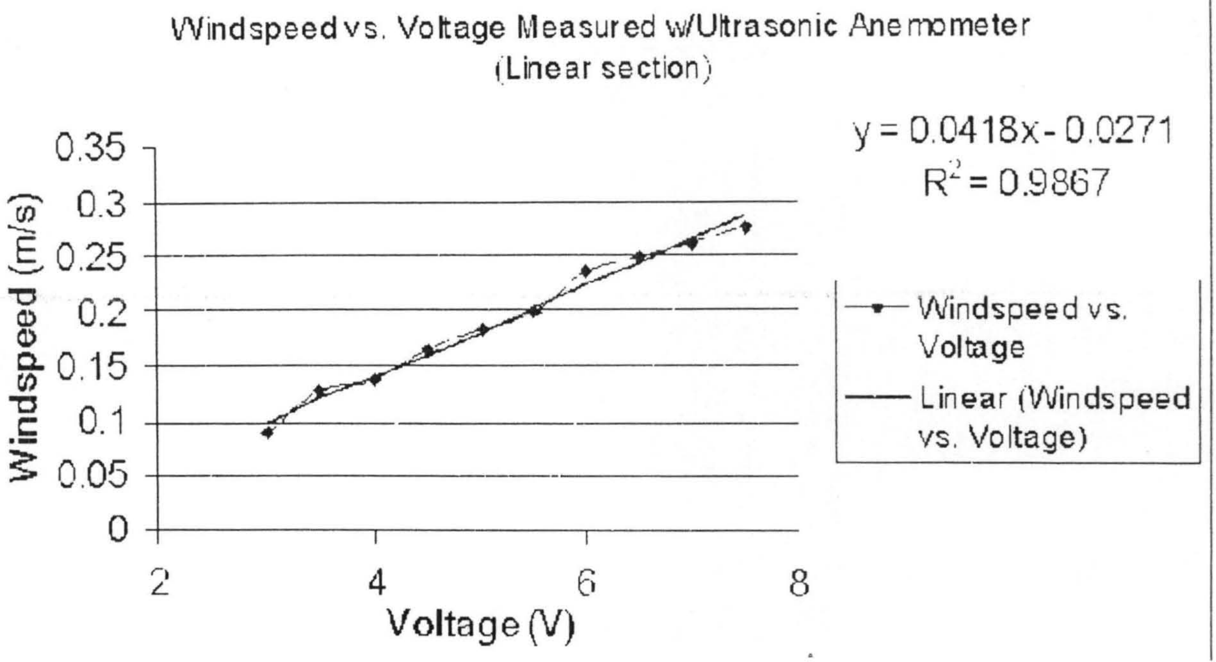




4.3 DISCUSSION OF RESULT

The results obtained were in coherence with the applied principle in the development of the ultrasonic wind speed meter. The readings obtained showed a linear relationship between the airflow in the fan and the anemometer readings.

With an increase in voltage applied to the fan, an increased wind speed was measured across the ultrasonic wind speed meter which is in line with the theory of this project. Provided below is graphical representation of the graph plotted.



4.4 SOFTWARE INSTALLATION AND DESCRIPTION

4.4.1 Software Installation Requirement

The software requires the java platform to successfully run on a computer system. This Java platform is also referred to as the Java Run-time Environment (JRE). It could either be installed on the system on which the java program is intended to run or must have been embedded in the system's operating system.

4.4.2 Software Description

The calculator software was designed to be interactive and easy to use; able to accept inputs such as building details, constants, areas etc in textfields, convert the inputs into usable data types and then use them to carry out the required calculation. The results of the calculations are displayed either in a table in separate window or in a portion of the window where the data were entered.

The screen display of the software modules are shown in the figures below:

Fig 4.1 Before connection is Established

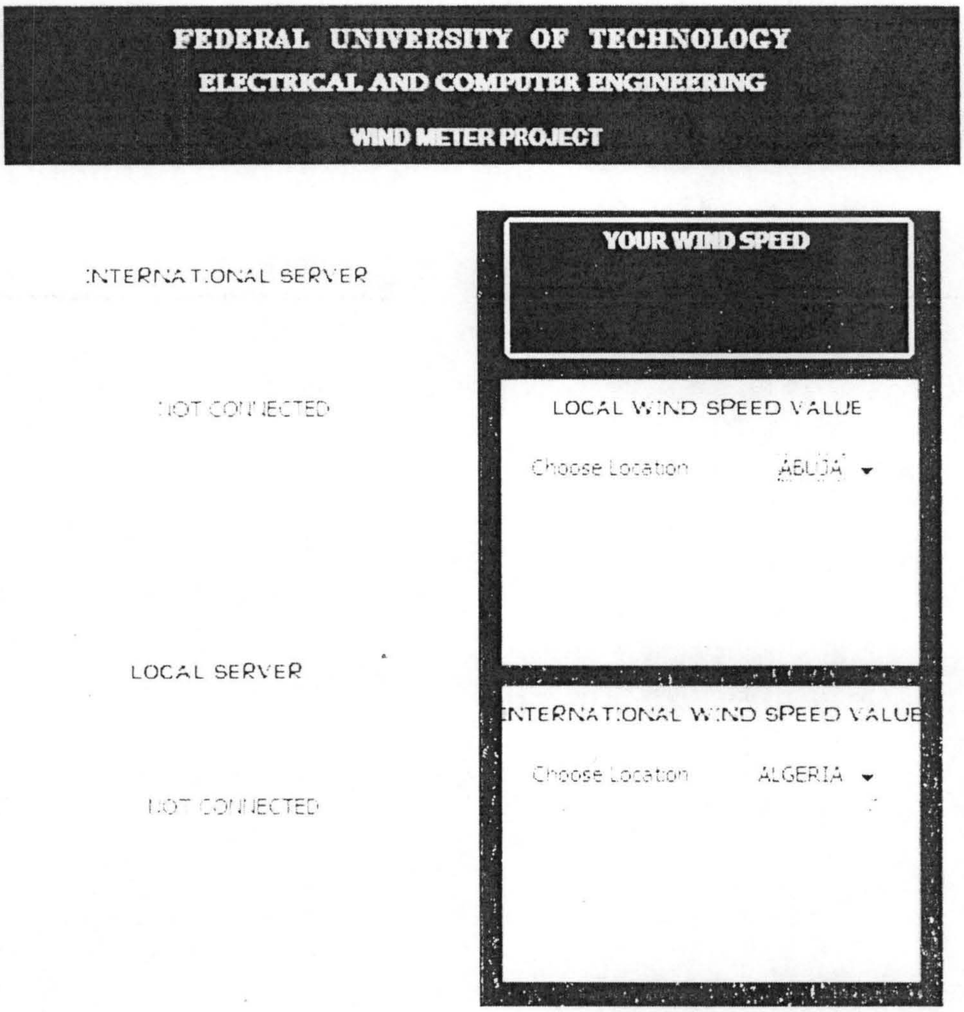
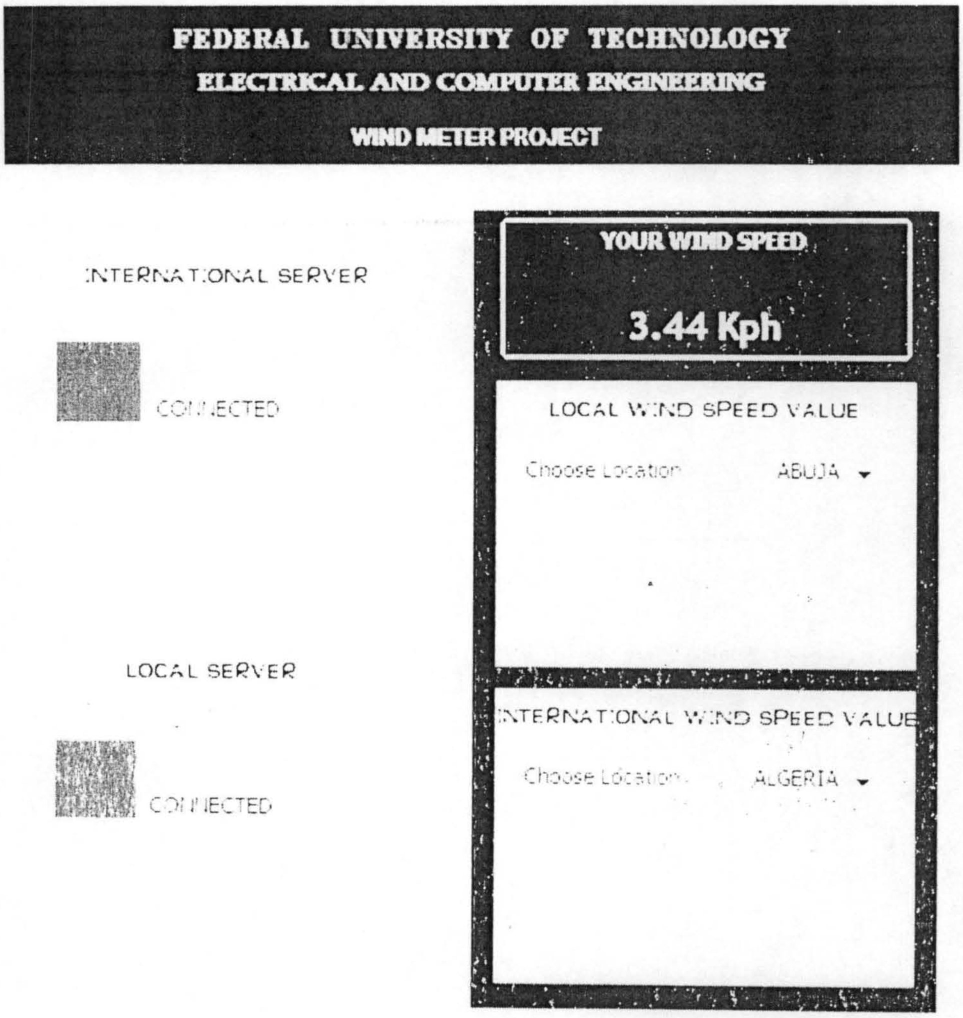

FEDERAL UNIVERSITY OF TECHNOLOGY
ELECTRICAL AND COMPUTER ENGINEERING
WIND METER PROJECT
INTERNATIONAL SERVER
NOT CONNECTED
LOCAL SERVER
NOT CONNECTED
YOUR WIND SPEED
LOCAL WIND SPEED VALUE
Choose Location
ABUJA
INTERNATIONAL WIND SPEED VALUE
Choose Location
ALGERIA

Fig 4.2 After Connection is Established



4.4 SERVER INSTALLATION

The server used was the apache tomcat server which served as the link between the World Wide Web and other smaller systems. To test it, a sample website was constructed.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The project has demonstrated the usefulness of integrated circuits in the design and development of electronic related products. This project shows that wind can be measured without any moving part. This has successfully demonstrated that there can be a deviation from the normal three cup anemometer to one that is totally electronics based.

5.2 RECOMMENDATIONS

1) The project can be expanded by making it to support greater wind speeds.
2) An expansion can be made to support calculating wind direction alongside the speed
3) More compact and advance integrated circuits could replace the ones in use for better performance.
4) Greater switching speeds could be used instead of three for better wind calculation.
5) Greater processing capabilities and computer wind speed logging.

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Citriniti, J. H. and George, W.K., 1994, "Experimental Investigationinto the Dynamics of the Axisymmetric Jet Mixing Layer," *Inter. Symp. Turbulenc e, Heat and Mass Transfer,* Lisbon, Portugal,August 9-12.

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APPENDIX 1

MICROCONTROLLER CODE

```
unsigned int vel1;

unsigned int vel2;

float velocity;

float velo;

char lm;


unsigned int ref=1024;

// Lcd pinout settings

sbit LCD_RS at RB4_bit;

sbit LCD_EN at RB5_bit;

sbit LCD_D7 at RB3_bit;

sbit LCD_D6 at RB2_bit;

sbit LCD_D5 at RB1_bit;

sbit LCD_D4 at RB0_bit;


// Pin direction

sbit LCD_RS_Direction at TRISB4_bit;

sbit LCD_EN_Direction at TRISB5_bit;

sbit LCD_D7_Direction at TRISB3_bit;

sbit LCD_D6_Direction at TRISB2_bit;

sbit LCD_D5_Direction at TRISB1_bit;
```

```
sbit LCD_D4_Direction at TRISB0_bit;

void main() {

 TRISA  = 0xFF;          // PORTA is input
 TRISC  = 0;            // PORTC is output
 TRISB  = 0;            // PORTB is output
 ADC_Init();
 Lcd_Init();
 Lcd_Cmd(_LCD_TURN_ON);
 Lcd_Cmd(_LCD_CLEAR);
 Lcd_Cmd(_LCD_CURSOR_OFF);
 Lcd_Out(1,2,"WELCOME");
 Delay_1sec();
 Lcd_Cmd(_LCD_CLEAR);
 Lcd_Out(1, 1, "PROJECT BY");
 Lcd_Out(2,1, "2006/24124EE");
 Delay_1sec();
 Lcd_Cmd(_LCD_CLEAR);
 for(;;){
 PORTC=1;
 Lcd_Out(1,2,"WIND METER");
 Lcd_Out(2,2,"Reading...");
```

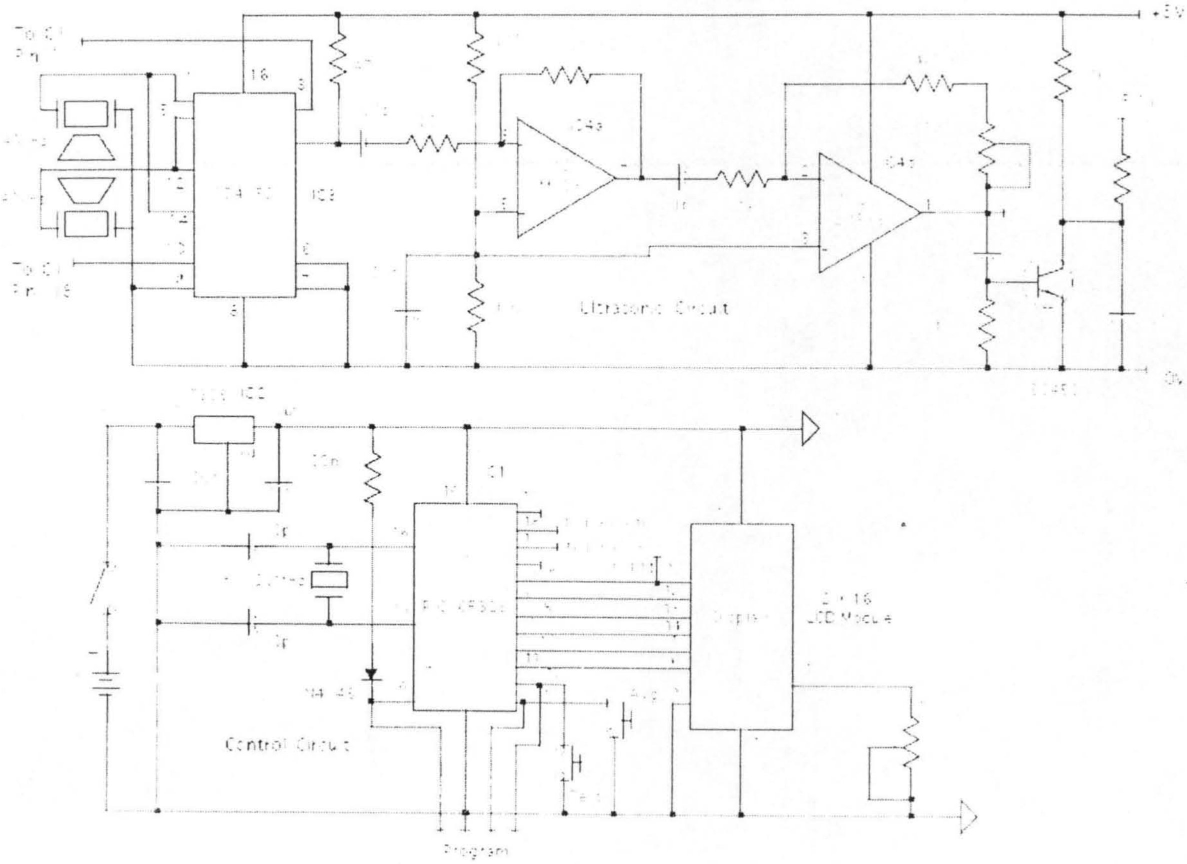
```
vel1=ADC_Read(1)-ref;
vel2=ADC_Read(2)-ref;
Delay_1sec();
PORTC=0;
if(vel1>vel2)
{
velocity=((vel1/vel2)*344)-344;
velo=velocity*3600;
    Lcd_Cmd(_LCD_CLEAR);
WordToStr(velo, lm);
 Lcd_Out(1,2,"WIND METER");
Lcd_Out(2,4,lm);
Lcd_Out_CP("metres/h");
 velo=velocity*3600/1000;
 Lcd_Cmd(_LCD_CLEAR);
 WordToStr(velo, lm);
  Lcd_Out(1,2,"WIND METER");
 Lcd_Out(2,6,lm);
 Lcd_Out_CP("kph");
 velo=velocity*3600*5/8;
 Lcd_Cmd(_LCD_CLEAR);
 WordToStr(velo, lm);
  Lcd_Out(1,2,"WIND METER");
```

```
Lcd_Out(2,6,lm);
Lcd_Out_CP("mph"); //calculate speeds
}
else{
     velocity=((vel1/vel2)*344)-344;
    velo=velocity*3600;
     Lcd_Cmd(_LCD_CLEAR);
WordToStr(velo, lm);
 Lcd_Out(1,2,"WIND METER");
Lcd_Out(2,4,lm);
Lcd_Out_CP("metres/h");
Delay_1sec();
 velo=velocity*3600/1000;
 Lcd_Cmd(_LCD_CLEAR);
 WordToStr(velo, lm);
  Lcd_Out(1,2,"WIND METER");
Lcd_Out(2,6,lm);
Lcd_Out_CP("kph");
 Delay_1sec();
 velo=velocity*3600*5/8;
 Lcd_Cmd(_LCD_CLEAR);
 WordToStr(velo, lm);
  Lcd_Out(1,2,"WIND METER");
```

```
Lcd_Out(2,6,lm);
Lcd_Out_CP("mph");
 Delay_1sec(); //calculate speeds
}
}
}
```

APPENDIX II

CIRCUIT DIAGRAM



APPENDIX III

SOFTWARE DEVELOPMENT CODE

```
package windmeter;


import java.io.IOException;

import java io.InputStream;


/**

 *

 * @author Olumide

 */

public  class SerialReader implements Runnable{

   InputStream in;

   @Override

public void run(){


}

   public SerialReader(InputStream in){

      this.in=in;

      byte[] buffer=new byte[1024];

      int len=-1;


      try{
```

```
        while((len=this.in.read(buffer))>-1){
          //int bou=in.read();
         // Double dou=(Double)buffer;
          System.out.println(new String(buffer, 0, len));
        }
      }
      catch(IOException a){
        a.printStackTrace();
      }
    }
}
package windmeter;



import gnu.io.CommPort;

import gnu.io.CommPortIdentifier;

import gnu.io.SerialPort;

import java.io.InputStream;



/**

 *
```

```
* @author Olumide

*/

public class communication {

public communication(){

   super();

}

void connect(String Portname) throws Exception{


   CommPortIdentifier portident=CommPortIdentifier.getPortIdentifier(Portname);

   if (portident.isCurrentlyOwned()){

      System.out.println("the Port is in use");

   }

else {

      CommPort port=portident.open(this.getClass().getName(), 2000);

      if (port instanceof SerialPort){

         SerialPort Sport=(SerialPort)port;

         Sport.setSerialPortParams(57600,                  SerialPort.DATABITS_8,
SerialPort.STOPBITS_1, SerialPort.PARITY_NONE);
```

```java
            InputStream in=Sport.getInputStream();

              Thread thread = new Thread(new SerialReader(in));

              thread.start();

        }

else {

            System.out.println("Only Serial Ports Are used");

}

}

}

}
```