Design and construction of a low-cost weather station

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***Abstract*— This work is focused on the design and construction of a low cost weather station which makes weather related data available for different purposes such as agriculture, aviation weather forecasting, etc. Conventional weather stations are larger in size and incur a huge cost in terms of installment, which is a limiting factor for developing countries. Although low cost miniature systems are also available but they are of poor precision. The goal of the project is to introduce an economical system that ensures flexibility, portability, scalability and user friendly operations. The design is made up of an outdoor module which measures four weather elements (temperature, atmospheric pressure, relative humidity and wind speed) through their respective sensors. The system utilizes solar energy which makes it a stand-alone system. Measured data through the developed system can be uploaded to the web server and sent to the user through web page or through text messages. This module transmits the sampled data wirelessly through radio frequency (RF) to an indoor module which receives the data and automatically logs the data to a database. A VISUAL BASIC C based graphical user interface (GUI) was also incorporated to view the logged data and perform some setup operations on the system.**

***Index Terms*— GUI, humidity, microcontroller, sensors, software development, temperature, Weather station.**

I. INTRODUCTION:

Weather and Climate changes is a common phenomenon around the world. However, in many developing countries, changes in the weather and climate conditions is a major concern, and this is because the people who are affected by these change, usually have little or no resources as well as opportunities to manage, measure, adapt, or share these changes.

Monitoring the weather condition of a place in combination with the collection of information about the temporal dynamics of these weather changes is very important to human life today. Some of its importance and uses are seen in several areas like agriculture, aviation, forecasting, health, and the engineering field. The device allows for keeping track of different climate's behavior including temperature, humidity, atmospheric pressure, light-intensity rainfall, wind speed, and wind direction.

But there cannot be a study of the weather condition of a place, nor its prediction without the knowledge of the prevailing conditions of the atmosphere [1]. For this reason, man has always devised means of measuring different elements of the weather.

By scientist Jackson's definition, a weather station is an observation post where meteorological conditions are observed and recorded [2]. It is a data acquisition system that begins with sensing of variables (i.e. elements of the weather being monitored), signal conditioning and processing, storage, and finally analysis of the recorded data [2]. The weather conditions over a considerably vast area vary widely, hence the need to localize weather stations to a small region. Modern weather stations are built around relatively high-power digital processors that continually pool the sensors that serve as their link to the analog world. The primary benefit of a weather station is that it keeps the users abreast of the prevailing conditions of the atmosphere. The recorded (logged) data could also be analyzed by specialized meteorological software to predict the weather [2]. Weather stations also provide data archives over a long time [3]. Such archives could be used by academia or research institutions.

In a weather station, all its parameters (wind speed, humidity, temperature, etc.) are necessary to maintain the balance in its operation, both in the agricultural field as well as in industrial processes. Furthermore, weather affects a wide range of man's activities, and modern weather monitoring systems and networks are designed to make the measurements necessary to track these movements cost-effectively. For instance, Temperature and Humidity are indicates for both indoor and outdoor locations. Programmable alarms are also available in the monitoring system which indicates out-of-range conditions.

But before now, weather monitoring systems are generally based on mechanical, electromechanical instruments which suffer from the shortcomings like poor rigidity, the need for human intervention, associated parallax errors, and durability.

Hence, the motivation for this work is centered on the prevailing shortage of weather-related data in Nigeria. The proof of this fact could be seen in poor weather forecasting in the country, poor response to weather-related natural disasters, and unnecessary disruption of flights and flood disasters that destroy lives and properties. This is a result of the unavailability of a network of weather stations dedicated to national weather service and partly due to the high cost of imported weather stations. In addition, operating and managing imported weather stations requires much technical expertise, making their use difficult for private users like small-scale agriculturists, schools, and industrialists.

Hence, the weather station design presented in this work was realized by using moderately inexpensive and common off-the-shelf components to reduce the size, space, and cost of running a weather station. This would make weather-related data readily available to small-scale farmers, institutions, and others that may need it without huge financial implications. The simplicity of operation was also factored into the design and as such a very high technical know-how is not necessary to operate the system.

Based on these, the device was constructed to collect, store and accurately display metrological data. Also, the device aids the study of meteorological phenomena, make access to flexible service and installation options and ensure usability in Climatology and other global warming purposes.

II. LITERATURE REVIEW:

The study of weather is as old as man as he has always tried to figure out the causes of different weather conditions he finds himself in and possibly predicts and measure what the weather would be like in a short term.

Measurement basically tells us about the property of something, even though it might not tell us how heavy an object is, how hot, or how long it is. A measurement gives a number to that property. Measurements are always made using an instrument of some kind, and the result of a measurement is normally in two parts: a number and a unit of measurement; e.g. 2 cm. Units of measurement are standardized. The International System of Units (SI) is used worldwide so that measurements can be consistent everywhere.

Measurements are only ever estimated. Every measurement is subject to some uncertainty. The uncertainty of a measurement expresses how good the estimate is.

This work reviews reported studies on different weather parameter, sensor fabrication technologies, principles of materials, applications, and sensing mechanisms.

2.1 Humidity Basics and Measurement Parameters:

Humidity is defined as the amount of water vapour in an atmosphere of air or other gases. Humidity parameters are stated in diverse ways and the corresponding units are based on the measurement technique used. The most commonly used terms are ―Relative Humidity (RH), ―Parts Per Million (PPM) by weight or by volume, and ―Dew/Frost Point (D/F PT), in which the two latter are subclasses of ―Absolute Humidity (AB).

Absolute Humidity (vapour density) is defined as a ratio of the mass of water vapour in the air to the volume of air, with the unit of grams per cubic meter or grains per cubic foot (1 grain = 1/7000 pound lb) and expressed as:

$$AB = M_v/v \quad (1)$$

where AB is the absolute humidity (g/m3 or grains/ft3), mw is the mass of water vapour (gram or grain) and v is the volume of air (m3 or ft3). Relative Humidity (abbreviated as RH) is defined as the ratio of the amount of moisture content of air to the maximum (saturated) moisture level that the air can hold at the same given temperature and pressure of the gas. It is expressed as:

$$RH\% = (P_v/P_s)\times 100 \quad (2)$$

2.2 Classification and Applications of Humidity Sensors:

Humidity sensing studies have evolved rapidly, so that humidity sensors regardless of their mode of fabrication have been widely employed in industrial and household applications, such as instrumentation equipment or for human comfort issues. Due to the different operating conditions of humidity sensors in different areas of application ranging from indoor to open-air uses, various types of humidity sensing instruments have been developed based on different work principles and diverse hygroscopic sensing materials [4] and [5]. Among the different humidity evaluation terms and units available, absolute and relative humidity are the two most prevalent ones. However, in reviewing the humidity sensors that play significant roles in the design and operation of a weather station, a wide range of humidity sensors comes into play.

2.2.1 Optical Humidity Sensors:

Fiber-optic humidity sensors are based on the colorimetric interaction of materials immobilized on the surface of the fiber core or its cladding in the humidity-sensing section. The sensing mechanism relies on a humidity-induced refractive index change in the materials, which causes the transmitted optical intensity through the sensing section to vary as a function of the relative humidity. To explain this function better, [6] in their research work, presented an optical-fiber humidity sensing system based on the colorimetric interaction of cobalt chloride with water molecules.

Fig. 1. Optical humidity Sensor

2.2.2 Gravimetric Humidity Sensors:

Surface acoustic wave (SAW) devices have been widely used in humidity measurement applications. [7] Presented a SAW sensor with the ability to measure vapor (humidity) with greater sensitivity than bulk wave sensors. In addition, [8] through his research proposed a cantilever-type resonator utilizing a stratified structure with a piezoelectric polymer layer (polyvinyl-difluorene, PVDF), showing the usability of gravimetric humidity sensors.

2.2.3 Capacitive Humidity Sensors:

Approximately 75% of the humidity sensors on the market today operate on the capacitive technique [9]. Capacitive humidity sensors offer different advantages, like high output signals and very low power consumption. Using these sensors, the ambient relative humidity level is measured by detecting moisture-induced changes in the dielectric constant of a hygroscopic layer. Typically, capacitive humidity sensors function based on the two interdigitated electrodes (IDE) composed in them, covered by a dielectric layer, which is sensitive to humidity changes.

2.2.4 Piezo resistive Humidity Sensors:

Piezo resistive materials have found widespread application in human-made sensors. In fact, transduction from air humidity through the mechanical domain is a mature sensing technique. Typically, piezoresistive humidity sensors utilize a suspended structure coated with a water-absorbent layer and polymer-based films that have 2–6% water absorption, which results in a volume expansion ratio of approximately 5.5×10−5/%RH.(106). Piezo resistors are used to detect the bending of this structure prompted by humidity changes.

2.3 Temperature Measurement System:

Temperature which is a comparative measure of thermal state can be measured by several scales and units that exist for measuring temperature. The most common among these units are Celsius (denoted by ºC), Fahrenheit (denoted by ºF), and Kelvin (denoted by K). It is a very critical and widely measured variable and encompasses a wide variety of needs and applications. To fulfill this wide array of needs, a large number of sensors and devices have been developed. Temperature measurement can be done through different methods.

2.3.1 Temperature Sensing Techniques:

There are a variety of techniques employed for sensing temperature which utilize diverse physical phenomena like thermoelectricity, thermal expansion, fluorescence, etc. The selection of any of these techniques depends upon specific requirements or constraints. For example, a sensor may be required to establish direct contact with the environment in which the temperature is being measured, or on contrary, it may not be desirable at all for the sensor to have any contact with the environment.

2.3.2 Contact Temperature Sensors:

Contact temperature sensors measure their temperature. One deduces the temperature of the object with which the sensor is in contact, by assuming or knowing that the two are in thermal equilibrium (i.e, there is no heat flow between them). Temperatures of surfaces are especially complicated to measure by contact means and very difficult if the surface is moving. Hence, it is cautious to be very careful when using such sensors on new applications.

2.3.3 Thermocouples:

Thermocouples are pairs of dissimilar metal wires joined at least at one end, which generates a net thermoelectric voltage between the open pair according to the size of the temperature difference between the ends, the relative Seebeck coefficient of the wire pair and the uniformity of the wire-pair. Among the easiest temperature sensors to use, thermocouples stand out and are widely used in science and industry [10].

2.3.4 Resistance Temperature Detectors (RTDs):

Resistance Temperature Detectors (RTDs) are wire wound and thin film devices that measure temperature because of the physical principle of the positive temperature coefficient of electrical resistance of metals. The way RTDs work is such that, the hotter they become, the higher the value of their electrical resistance and vice versa, [11]. RTDs are popular and appear nearly linear over a wide range of temperatures, and some are small enough to have response times of a fraction of a second.

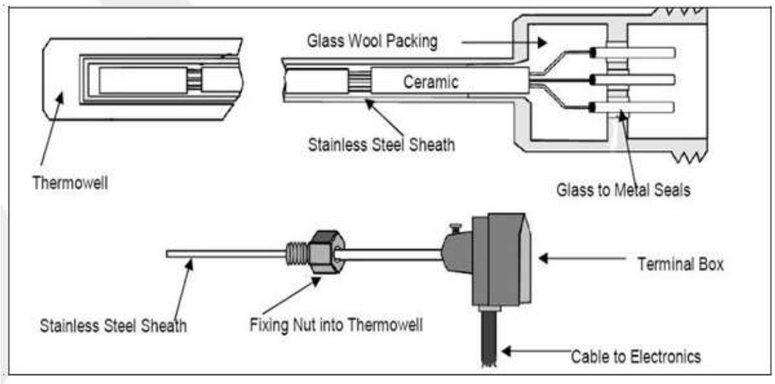

Fig. 2. Resistance Temperature Detectors

2.3.5 Thermistors:

Thermistors are special solid temperature sensors that behave like temperature-sensitive electrical resistors [12]. Largely, these are of two types. First the NTC-negative temperature coefficient thermistors and secondly, the PTC-positive temperature coefficient thermistors. NTC is used mostly in temperature sensing, [13], while PTC is used mostly in electric current control [14].

2.4 Pressure Sensors:

Pressure is commonly defined as the force per unit area applied in a direction perpendicular to the surface of an object. The formula is written as: $P = F/A$

Fig. 3. Pressure Sensor

Where P is the pressure, F is the normal force, and A is the area of the surface of contact. When two objects are contacted, they exert force on each other. A sensor is a device that measures a physical quantity and converts it into a signal, easy to read by an observer or instrument. There are various types of sensors: thermal sensors, pressure sensors, mechanical sensors, electromagnetic sensors, and others. Pressure is detected by mechanical elements such as plates, shells, and tubes that are designed and constructed to deflect on application of pressure.

2.4.1 Load Cell:

A load cell is a type of pressure sensor, which is commonly used in the industrial weighing product to measure force such as goods and vehicles. The gripper of a robotic hand that picks up an object can be equipped with load cells to provide compression force feedback to the control system which both prevents the object to be released too early or being damaged at its release.

2.4.2 Tactile Pressure Sensor:

The tactile pressure sensor measures various parameters of an object through physical touch between the sensor and an object [16]. The measured parameters are, namely, pressure, temperature, normal and shear forces, vibrations, slip, and torques.

2.5 Anemometer:
An anemometer is a device for measuring wind speed and is a common weather station instrument. The term is derived from the Greek word anemos, which means "wind". The first known description of an anemometer was given by Leon Battista Alberti around 1450. As regards it being a weather station tool, there are several types of anemometers.

2.5.1 Cup anemometers:
Cup anemometer is a simple type of anemometer, invented in 1846 by Dr. John Thomas Romney Robinson, of Armagh Observatory. It consisted of four hemispherical cups, with each mounted on one end of four horizontal arms. These also were mounted at equal angles to each other on a vertical shaft. The airflow past the cups in any horizontal direction turned the cups in a manner that was proportional to the wind speed.

2.5.2 Windmill anemometers:
The windmill anemometer is a mechanical velocity anemometer that belongs to the windmill type or propeller anemometer. In the operation of this 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.

2.5.3 Sonic anemometers:
Sonic anemometers were first developed in the 1970s, and engaged ultrasonic sound waves to measure wind velocity. They measure wind speed based on the time of flight of sonic pulses between pairs of transducers. So that the measurements from pairs of transducers can be combined to yield a measurement of velocity in 1-, 2-, or 3-dimensional flow.

2.6 Stevenson Screen:
Aside from the effect of urbanization, the uncertainty of temperature measurements is affected by different factors. For example, temperature sensor accuracy, sensor time constant, suitability of the sensor to the screen, and the enclosure used to house the sensor [17]. To measure atmospheric temperature accurately the temperature sensor must be shielded from both direct and indirect sources of radiation. Stevenson screen plays a major impact on the temperature measured by the weather station and hence, should always be kept clean.

III. METHODOLOGY:
In this section, the tests conducted, the instrument, procedural setup, processes and other relevant design factors adopted in the conceptualization and manufacture of the device are discussed. For design simplicity and efficiency, the choice of hardware was based on two categories of requirements namely System requirements (Main requirements) and Component requirements. These requirements were anchored on the system and component constraints such as:

1. Energy efficiency
2. Cost
3. Small form factor
4. Autonomy
5. Self-sustainability
6. Operating temperature

3.1 Design Approach:
The design approach centers the device operation on a digital system. As shown in Fig.4, the system plays the role of receiving information from the sensors, sorting, and processing the information before sending the results to the computer interface through the USB and serial port. Thus the system is the hub of information processing, sorting and the link between the component part of the device.

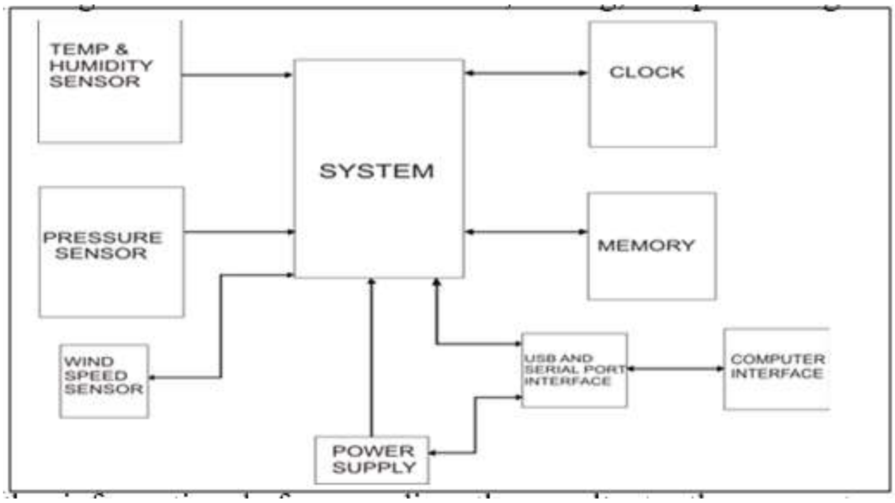

Fig. 4. The Block diagram

In line with the objectives of designing the device with economy, portability and ease of use, a microcontroller unit comes into near perfection and is used to design the system.

Specific features of the microprocessor that makes its incorporation useful in achieving the objectives of designing a weather station that is flexible, easy to operate, and has the capacity to store and display metrological data on a visual display monitor are:

1. It is completely digital and can perform arithmetic operations.
2. It can store data.
3. Microprocessors can convert the signals from sensors into digital information that can be used for analysis.

A Microchip PIC18F2550 8-bit RISC microcontroller makes up the microcontroller unit (MCU) used in the design. It is a common, commercial and handful microcontroller that has features corresponding to the systems and component requirements stated in section 3.0.

Besides being a control unit comprised of basic embedded elements and handling digital signal processing (DSP) or arithmetic, storing and input/output (I/O) (Wang, 2011), other relevant components features of the Microchip PIC18F2550 8-bit RISC microcontroller are:

A Microprocessor (CPU or MPU) – The CPU is the core of the MCU. It handles all arithmetic functions needed to be performed. In addition, it uses buses to communicate with the memory components, communication systems, I/O ports and registers. Due to this features it is the most power consuming component on the MCU.

Registers – The CPU uses registers to store temporary information (in bytes) that it is using at any given time.

Memory Components – The MCU can have a various type of volatile and non-volatile memory components like RAM, ROM, EPROM and EEPROMs. They are used to store permanent or temporary data and program instructions.

Serial Communication Connections – The most common ways to communicate with other peripherals connected to the MCU is to use serial communication that uses a communication standard like RS-232, SPI (Serial Peripheral Interface), I2C (Inter-Integrated Circuit) or UART (Universal Asynchronous Receiver Transmitter). UART is currently the most used communication standard.

Thus, the microcontroller plays a key role in the readout as it acts as the brain for all the control, conditioning and communication hub for all the sub-circuits connected to it.

3.2 Design Description:

In the hardware development stage, electrical connections between the system, and sensors are designed and tested based on the component specifications of voltage, and amperage. To supply power to the modules, an external power supply circuit was assembled, which also serves as an extension board between the components. The system comprised of circuits and subassemblies such as:

1. The DHT11 circuit which was connected to the one wire port.
2. The RTC (real time clock) conditioning circuit which was connected to an I2C port.
3. The Pressure conditioning circuit connected to the ADC port.
4. The Wind Pulse control circuit connected to the pulse counter of the microcontroller.
5. The serial communication connected to the UART module of the microcontroller.
6. The Universal Serial Bus (USB) communication connected to the USB module of the microcontroller.

3.3 Components, Circuits and Sub-Assemblies:

The major components, circuitry and sub-assemblies are discussed in this section.

3.3.1 The Microcontroller:

PIC18F2550 is a microcontroller based on the Reduced Instruction Set Computing (RISC) architecture which executes about 38 sets of instructions in a single-clock cycle. To achieve throughputs close to 1 MIPS per MHz, the PIC18F2550 8-bit RISC microcontroller allows the optimization of power consumption against processing speed.

The main features of PIC18F2550 8-bit RISC microcontroller adopted in the implementation of the design are: The Analog to Digital Converter (ADC), the Timer/Counter for generating PWM signals USB (universal Serial Bus) and the Serial Communication port (USART). For programming the device, we will use the In-System Programming (ISP) configuration connected to a PIC Programmer.

3.3.2 The Sensor Circuit:

The schematic in Fig. 5 shows the connection of the sensors to the microcontroller ports. It also shows the external EEPROM and Real Time Clock circuits connected by an I2C bus, a keyboard, an RS-232 bonding circuit and output power amplifier which complete the list of important connected devices. Even in Fig 5, the microcontroller is shown to sit in the middle of the design signaling its relevance and in the operation of the weather station device.

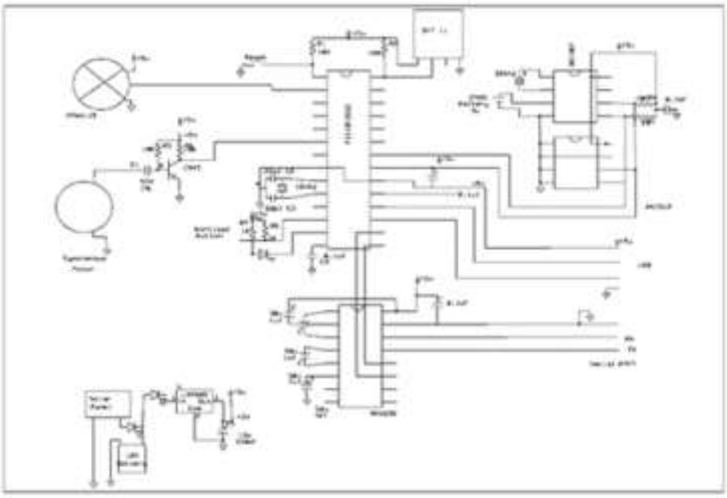

Fig. 5. The circuit diagram

The power system comprised of a 12V battery and a solar panel/module that charges the battery via the diode D1. Power was supplied to the system through the diode D2. While the 12 Volts was regulated to 5 Volts by the 7805 voltage regulator (as required by the microcontroller sensors), the diode protects the circuit from reverse battery polarity. The DHT11 require 5V and its digital output is connected to the controller pin28 (port B7). The pressure sensor was also connected to the analog input of the controller and operated on 5 Volts.

The wind speed was read by a synchronous DC motor with output proportional to the rotating speed. The microcontroller timer counter was fed with the pulse amplified output from the motor. The RTC and the external memory were connected to the I2C bus and connected to the controller Port B0 and port B1 respectively.

The 32KHZ crystal set the RTC oscillators' frequency while the 3V cimos battery kept the system clock running (if there is no system power). The R5232 level shifter link the microcontroller serial port with the external peripheral, while the USB is directly connected to the microcontroller USB PIN 17 and 18 and the capacitor C4 connected to the PIN14.

Resistor R1 raised the reset PIN high, while the reset buttons linked the reset PIN to the ground. Crystal oscillator CRX1 12MHZ provides the clock frequency for the system via the clock circuitry C2 and C3. R8 and boot loader switch provide the boot loader circuit that enables the serial program mode at the microcontroller. The rest of the operations are done by the system firmware.

3.4 System Design:

Unlike in the past when flowcharts were used to simulate and design algorithms before actual programming was done, Object Oriented Programming (OOP) software such as Visual Basics® and Delphi® were found to be the best use case for the development of the software which runs the device. This decision was arrived at because flowchart is difficult to use since it provides no organizational insight except for small systems.

3.5 The Programming Language used and its Architecture:

Delphi, an objected oriented programming language (OOP) and integrated development environment (IDE) was used in the development of the program. Although Microsoft Visual Basic is no doubt the most popular object–based development tool for Windows programming, Delphi® was considered as an alternative choice to avoid the large time and effort that could be invested in applying another language in cases of fixes and future upgrades. Also, while Visual Basic implements a number of essential object-oriented programming (OOP) tools, it lacks pointers and formal OOP language extensions. Visual Basic relies on a run-time interpreter that is found in Microsoft Office. In terms of actual used of the program developed, Visual Basic programs generally are not as fast as programs created with Delphi's optimizing compiler. Delphi is similar to Object Pascal; which even non-Pascal programmers will find easy to pick up by knowing object-programming principles. Unlike Visual Basic, Delphi can compile an entire application into a single executable file. This file may be rather large, but it eliminates the need to distribute a number of run-time files with the application such as "VBRUN.dll".

3.6 Output Files:

Besides showing the information processed by the device on the screen for weather assessment, the need for the information to be available in the future for analysis and other use makes it important for the device to be able to store this information in output files.

When the compilation is successful, the microC PRO for PIC generates output files in a project folder (folder which contains the project file .mcppi).

Table 1 Assembly View Shows a Summary Of The Output Files From The Software

Format	Description	File Type
Intel HEX	Intel style hex records. Use this file to program MCU	.hex
Binary	mikro Compiled Library. Binary distribution of application that can be included in other projects.	. mcl
List File	Overview of MCU memory allotment: instruction addresses, registers, routines and labels.	.lst
Assembler File	Human readable assembly with symbolic names, extracted from the List File.	.asm

3.7 The Graphic User Interface (GUI) Software Development:

As discussed in section 3.5, OOP was used for the development of the interface. The structured system design technique for software design was employed. This ensured that there was a bridge between the system requirements and implementation of the software developed.

Two versions of the GUI software (Visual Basics® and Delphi®) were developed and used to represent the collected and processed data. At some point, MATLAB was used to analyze the data collected and also to simulate weather conditions that were not obtainable during the season of the test so as to check the functionality of the device in such situations.

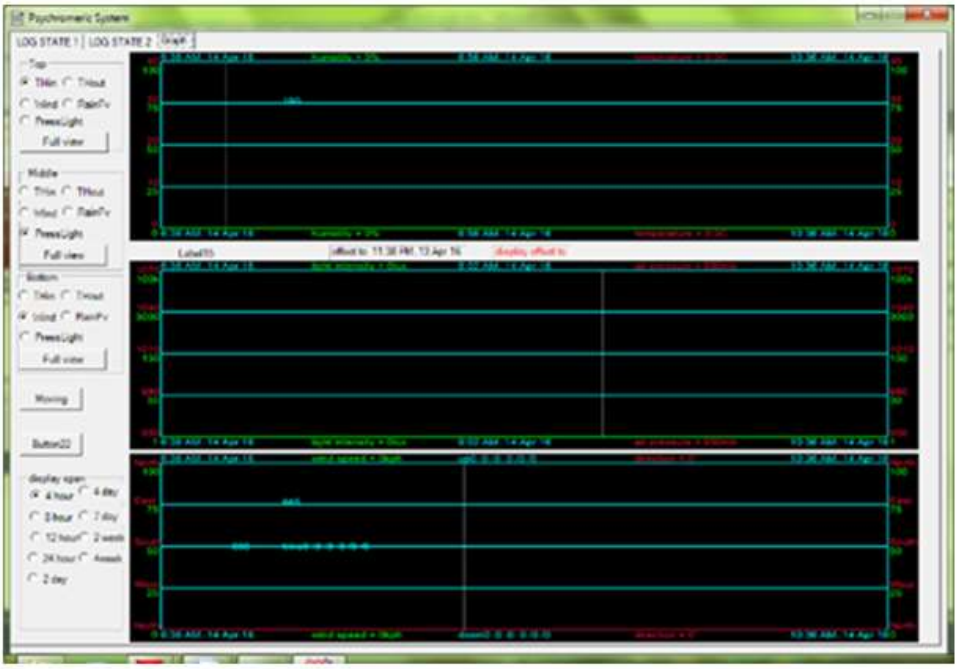

Fig. 6. Application Development Interface using Delphi®

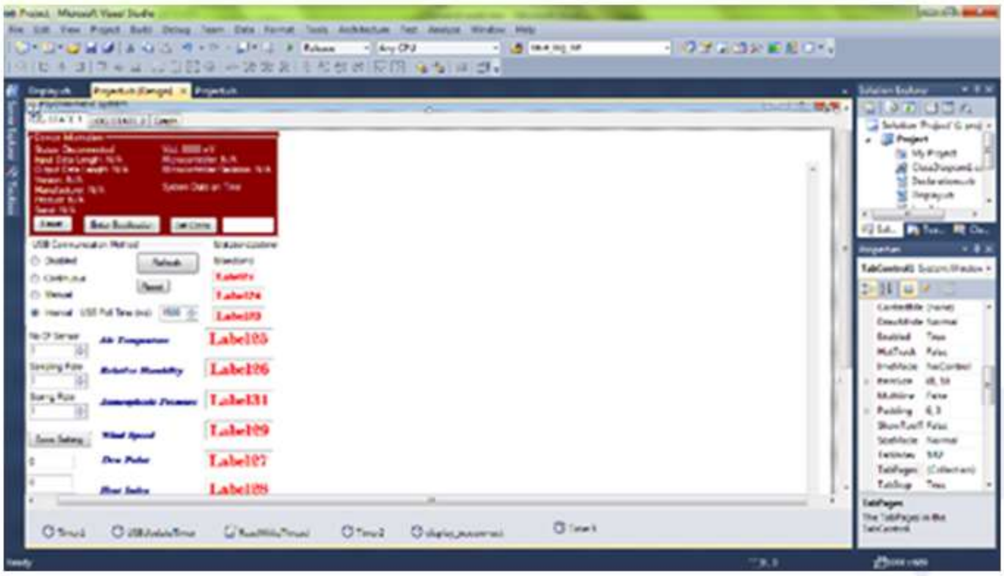

Fig. 7. Application Development Interface using Visual Basics®

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3.8 Procedure for Data Collection:

As stated in section 1.0 of the project, designing a system capable of collecting, and examining the psychometric and thermodynamic properties of the weather for discuss and other potential applications makes it imperative for the right procedure to be used, so as to obtain the relevant data from the atmosphere, store the data and display them via the GUI developed. A simple understanding of how the sensors used work will show how the main goal of this project was to design and realize a System capable of recording the Psychrometry data of an environment within the tropical climatic condition. The system was designed to be moveable such that it will be convenient for capturing data at various locations for a specific duration of time.

3.9 Method of Data Analysis:

The experimental methodology in this study is non-rigorous. However, where necessary, assumptions were made to put the data collected into perspective and valuable for computation. Simulation an integral part of engineering experimental design which uses a particular set of artificial conditions in order to study or experiment a phenomenon. A system or a property that could exist in reality was also used to test known weather conditions which were not obtainable in the season when the test was run. To measure the thermodynamic changes, a graph of the relative humidity (%RH) and the room temperature (°C) were plotted against the time (Hr). Also, a plot of the saturation vapor against the temperature was used to study the psychometric properties of the environment.

IV. RESULTS:

From previous data studies, it was noted that, while the temperature and relative humidity are mutually highly dependent variables, the absolute humidity varies with the temperature only minimally and this uncoupling is very convenient for the psychrometric properties of a location. The absolute humidity is also pressure dependent, but as the pressure changes influence, the location environment does the same as the climatic condition.

4.1 Discussion of Results:

A graph is plotted for the selected channel and all the data stored into the hard disk of the PC in comma separated value (.csv) format. The data stored can always be used for future analysis and also the wave form can be reconstructed when necessary.

For temperature and humidity, one representative curve for 12 hours of real time continuous observation is obtained and presented in Fig. 8, RH1 and RH2 are the observed temperature and humidity, and RH3 is taken from the psychometric system measurement. RH4 is observed by the designed system. All the four graph shows the similar nature of variations in humidity. The commercial digital hygrometers show a difference of 9% RH as seen from RH1 and RH2. The slight fluctuation in psychometric observation in RH3 may be due to fluctuation in air flow and resolution of the thermometers' reading. The variation between RH1 and RH4 is less than ± 2%. Where 5% is considerable in general, for RH measurement. Thus, the designed system gives better result.

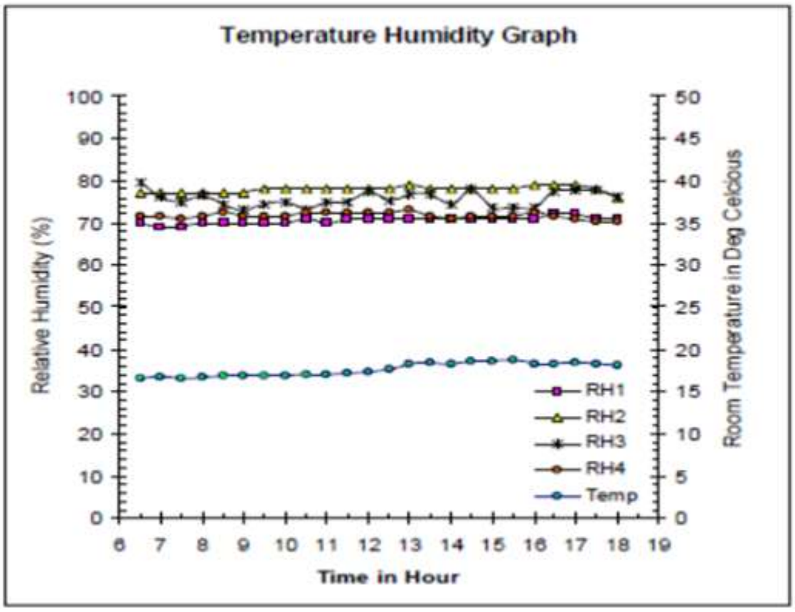

Fig. 8. Reconstructed waveform of the Temperature and Humidity

4.2 Simulation Graphs:

According to the simulated results, a rise in the temperature leads to a sharp rise in the saturation vapor pressure. This indicates that as more vapor escapes from the forces of molecular attraction in the liquid state into the gaseous state, the temperature also increases.

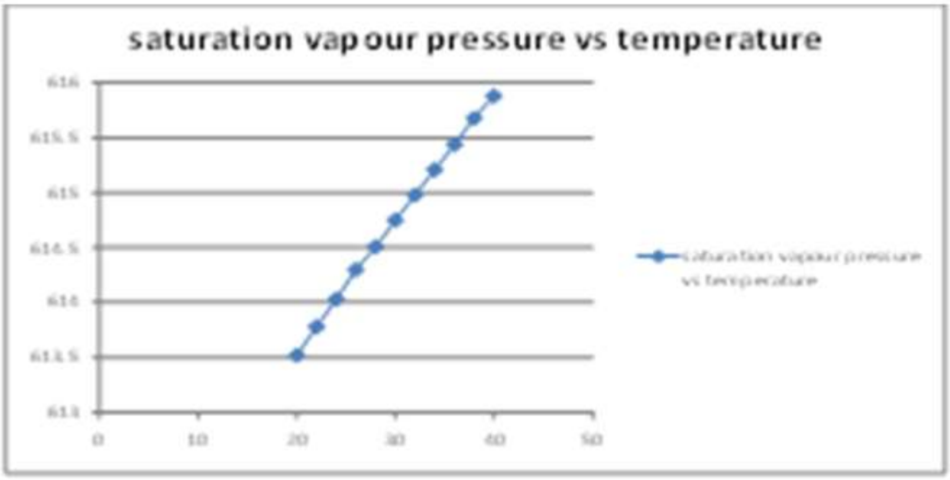

Fig. 9. (a): Graph of Ps (Pa) against t (°C).

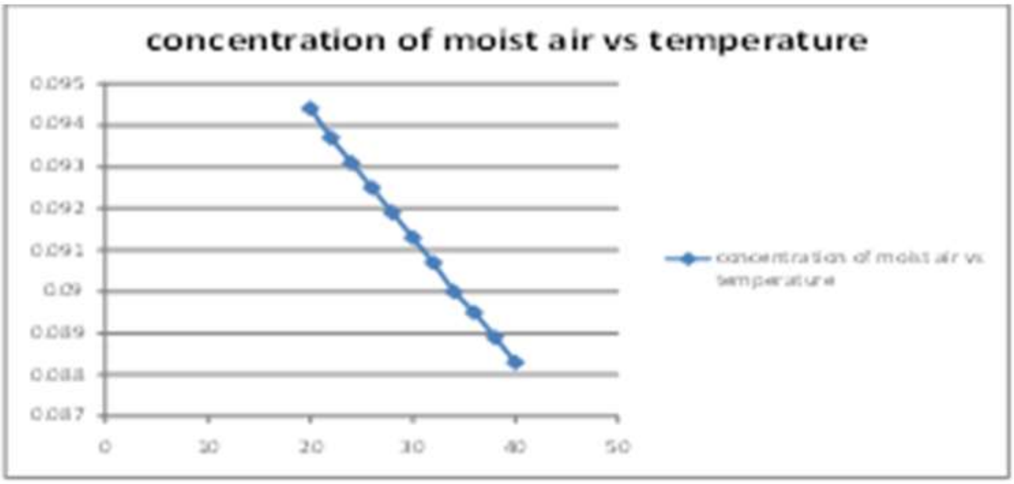

Fig. 9. (b): Graph of Cm (kgmol/m^3) against t (°C).

V. Conclusion:

In a time of complex systems and ever rising cost of gadgets, a simple, flexible and minimalistic design of a low cost weather station based on the reliable working mechanism of a simple microcontroller connected to a pressure sensor, a wind speed sensor and a temperature/humidity sensor, a clock and a memory unit powered by a 12 Volts battery is an absolute game changer. Coupled with its interactive user interface, and the ability for the information recorded, processed and stored to be made available visually, in digital form and at a time when it is needed makes the device useful in many meteorological applications.

References:

[1] R.F. Yates, “The Weather for a Hobby: A Guide to the Construction and Use of Weather Instruments Intended for Amateurs,” Dodd, Mead & Co, New York, NY, USA, 1947.
[2] R.M. Jackson, “Weather station,” Electronics Now, vol. 64, no. 10, pp. 31-38, 1993.
[3] Guo, X.; and Song, Y., “Design of automatic weather station based on GSM module,” Proc. Int. Conf. on Computer, Mechatronics, Control and Electronic Engineering (CMCE), Changchun, China, August, Vol. 5, pp. 80-2, Aug. 2010.
[4] S. Pokhrel, B. Jeyaraj K. S. Nagaraja, “Humidity-sensing properties of ZnCr2O4–ZnO composites,” Material Letters, pp. 22(23), 3543–3548, 2003.
[5] Q. Wang, Y.Z. Pan, S.S. Huang, S.T. Ren, P. Li, and J.J. Li, “Resistive and Capacitive Response of Nitrogen-Doped TiO2 Nanotubes Film Humidity Sensor,” Nanotechnology 22, 025501, 2011.
[6] A. Kharaz, and B. E. Jones, “A distributed optical-fibre sensing system for multi-point humidity measurement,” Sensors and Actuators A: Physical, vol. 47, no. 1-3, pp. 491-493, Mar.-Apr. 1995.
[7] H. Wohltjen, “Mechanism of operation and design considerations for surface acoustic wave device vapour sensors” Sensors and Actuators, vol. 5, no. 4, pp. 307-325, Jul. 1984.
[8] A. Glück, W. Halder, G. Lindner, H. Müller, and P. Weindler, “PVDF-excited resonance sensors for gas flow and humidity measurements,” Sensor and Actuators B: Chemical, vol.19, no. 1-3, pp. 554-557, Apr. 1994.
[9] Z. M. Rittersma, “Recent achievements in miniaturised humidity sensors—a review of transduction techniques,” Sensors and Actuators A: Physical, vol. 96, no. 2-3, pp. 196-210, Feb. 2002.
[10] L. Michalski, K. Eckersdorf, J. McGhee, “Temperature measurement,” J. Wiley (Chichester, West Sussex, England and New York) 1991.
[11] N.S. Boltovets, V.V. Kholevchuk, R.V. Konakova, V.F. Mitin, E.F. Venger, “Ge-film resistance and Sibased diode temperature microsensors for cryogenic applications,” Sensors and Actuators A: Physical, (92), pp. 191-196, 2001.
[12] M. Kimura, and K. Toshima,, “Thermistor-like pn junction temperature-sensor with variable sensitivity and its combination with a micro-air-bridge heater,” Sensors and Actuators A: Physical, (108), pp. 239-243., 2003.
[13] C. Saul, and J. Zemel, “Diode-based microfabricated hot-plate sensor,” Sensors and Actuators A: Physical, (65), pp. 128-135, 1998.
[14] R. Kersjes, and W. Mokwa, “Fast liquid flow sensor with thermal isolation by oxide-filled trenches,” Sensors and Actuators A: Physical, (47), pp. 373-389, 1995.
[15] S. Wu, H. Zhou, S. Yang, R. Wu, and Y. Chen “Development of a new temperature and humidity sensitive integrated sensor,” Research and Progress of Solid State Electronics, 18, pp. 349-53, 1998.
[16] M. H. Lee and H. R. Nicholls, “Review Article; Tactile sensing for mechatronics—a state of the art survey,” Mechatronics, 9(1), p. 1–31, 1999.
[17] S.J. Richardson, and F.V. Brock “Passive Solar Radiation Shields: Energy Budget - Optimizing Shield Design,” Symposium on Meteorological Observations and Instrumentation American Meteorological Society, Charlotte, NC, 1995.