International Journal of Industrial and Manufacturing Systems Engineering
2016; 1(2): 34-44
http://www.sciencepublishinggroup.com/j/ijimse
doi: 10.11648/j.ijimse.20160102.12

Development of a Temperature Data Acquisition (TDAq) Device in Agroforest Environments

Bello R. S.[1, *], Nebo U. E.[1], Onilude M. A.[2]

[1]Department of Agriculture & Bio-environmental Engineering, Federal College of Agriculture, Ishiagu, Nigeria
[2]Department of Agricultural & Environmental Engineering, University of Ibadan, Ibadan, Nigeria

Email address:
segemi2002@gmail.com (Bello R. S.), ugochukwugeneral@yahoo.com (Nebo U. E.), ma.onilude@mail.ui.edu.ng (Onilude M. A.)
[*]Corresponding author

To cite this article:
Bello R. S., Nebo U. E., Onilude M. A. Development of a Temperature Data Acquisition (TDAq) Device in Agroforest Environments. *International Journal of Industrial and Manufacturing Systems Engineering.* Vol. 1, No. 2, 2016, pp. 34-44.
doi: 10.11648/j.ijimse.20160102.12

Received: September 7, 2016; **Accepted**: October 2, 2016; **Published**: October 26, 2016

Abstract: A data acquisition (DAQ) device had been developed and constructed for measuring temperature in agroforest production processes. The system configuration broken into building blocks performs different functions. A digital integrated circuits (LM35 temperature transducer), a AT89C51 microcontroller, MAX232 serial communication interface, DB-9 serial communication connector, ADC0804 analog digital converter, a 16-pin liquid crystal display (LCD) and 7805 voltage regulator were used in the design and implementation of the system. The software controlling the system adopted in the design is an embedded system structure encrypted in the microcontroller. The integration of the blocks circuit involved resulted in the complete functional temperature acquisition system. The performance test carried out under a simulated controlled environmental conditions satisfies the designed purpose.

Keywords: Data acquisition, Agroforest, Temperature, Microcontroller, Crystal display

1. Introduction

Data acquisition (DAQ) is a process of sampling signals that measures real or physical conditions (e.g. temperature, light intensity, fluid flow, gas pressure etc.), and converting the resulting samples into digital numeric values that can be manipulated by a computer. Usually, irrespective of the physical property to be measured, the physical state must be transformed by sensory devices into a form that can be sampled by a data acquisition system (i.e. an electronically based monitoring system) consisting of many components that are integrated to sense physical variables with the use of transducers; condition the electrical signal to make it readable by an analog-digital converter (ADC); convert the signal into a digital form acceptable by a computer, process the signal, analyze, store and display the acquired data with the help of a software.

1.1. Data Acquisition (DAQ) Systems

Several microcontroller-based data acquisition (DAQ) systems have been presented by different authors [1, 2, 3]. In the majority of the presented solutions, the developed DAQ devices are not general purpose DAQ's, but rather have been specially designed for specific DAQ applications such as temperature or humidity measurements. Many instruments and methods of measuring temperature have been known and used over the years. However, most of these instruments and methods only measures temperature in analog form and as such does not store the measured temperature data at the various time interval such measurements were taken, thereby making it a little bit difficult in data collection (measurement) and imputation for future purpose for obvious reasons; 1) The existing instruments available does not accept an intelligent computer program which can monitor, read and store the data collected automatically, and 2) Most of these instruments installations are time consuming if there is no existing primary device for measuring flows.

Considering that the conventional method of temperature data acquisition lacks the capabilities to store information, also it lacks the ability to display information. This project tends to handle those problems in which the traditional/conventional method cannot solve by making it possible for monitoring weather parameters using computer-based programmed device which has the intelligence of reading the environmental and room temperature at a given range, and also stores it in order to make it readable and accessible for further monitoring and checks of the poultry environmental weather conditions.

The application of this software in a computer device to convert the signal into digital form, by processing, analyzing, storing and displaying the acquired data in an agroforest thermal environment is presented in [4]. The objective of this project therefore is focused or aimed at the development and installation of a computer-based software for measurement and storage of physical quantity taken over a period of time.

1.2. Data Acquisition (DAQ) Systems for Physical Quantities

Nowadays, data acquisition systems for physical quantities are being designed to be highly efficient and highly inexpensive to do their required function. This is due the fact that microcontrollers and embedded processors now form the basis for such system designs [5].

Thus an embedded product uses a microprocessor or microcontroller to do one task only. The choice is usually left in the hands of the embedded system designer [5]. In trying to measure temperature using an embedded design approach, temperature sensors are to be used for thermal monitoring purposes and applications. A designer must evaluate the trade-off of the sensor, conditioning circuitry and sensor output in order to maximize the measurement accuracy while easing the interface to the microcontroller. In addition, the designer must consider system integration issues such as the location of the sensor, grounding, EMI/EMD protection and shielding in order to prove a robust temperature measurement.

The implementation of data acquisition systems in our everyday activities is generally for the analysis of logged data and the improvement of object measurement. The recent trends in digital systems; the rapid growth in the use of micro-computers to perform different digital control & measurement functions and its applications in agroforestry, has become a very important area of interest as digital systems are being widely used owing to their cheap cost, accurate and relative simplicity of implementation. The growing changes in environmental conditions due to global warming have resulted in changes in temperatures within our immediate working and breeding environments. inaccessibility in remote places like mountainous or hilly terrain which is far from human settlement, it is very difficult to obtain such data like temperature readings when large scale projects such as solar panel installation occurs. This project aims at developing a system capable of acquiring, reading, storing data and displaying them as output data which can be used in monitoring, analysis, and applications in agroforest process operations over a period of time. Thus, this project comes in handy as a meteorological device.

2. Temperature Acquisition Systems

2.1. History of Temperature Measurement

Temperature measurement has been an age long tradition spanning ancient times when people were physically aware of hot and cold and probably relate temperature by the size of the fire needed and how close to sit to be kept warm to primitive times when dogs were used instead of blankets to keep warm [6], and through the times of the ancient Greeks knowledge that air expands when heated and applied the principle mechanically, but they developed no means of measuring temperature or amount of heat needed and devised no measuring instruments until first attempt of standardized temperature measurement reported as early as 170AD by Claudius Galenus and in the early 1600's, when an Italian physicist named Santorio Santorio developed a crude thermometer-like device which he referred to as a "thermoscope" [7].

Several methods have been developed over decades for measuring temperature; most of these methods rely on measuring some physical properties of working materials that varies with temperature. To properly understand the basic concept of temperature acquisition system, an understanding of the history of temperature measurement is needed and its evolution over the years to become an embedded system application. In the early 1960's, among other scientific credits, In the early 1960's, among other scientific credits, Galileo Galilei reportedly invented another style of thermoscope, sometimes referred to as a "Galileo Thermometer" which operated on the principle of buoyancy [6]. Further development of temperature measurement using a fluid as the indicator and a calibrated scale to measure the fluids displacement in relation to temperature is credited to such scientists as Ole Christensen Roemer, who in 1701 reportedly made one of the first practical thermometers using red wine as the indicator; Daniel Gabriel Fahrenheit, who soon after, developed a more accurate scale and Andres Celsius, who developed a metric scale of temperature reading/measurement [8]. William Thompson (Lord Kelvin) and William Rankin were credited in the mid-1800's with having broadened the calibrated temperature measurement scale range to include "absolute zero", thus making it more useful for research purposes [6].

As technologies in the areas of physics, metallurgy and electronics progressed in the 1800's, so has temperature measurement technology and measurement instrumentation in general. Several scales of temperature measurement created in the 16^{th} and 17^{th} centuries and are still in use today include the Fahrenheit, Centigrade (also referred to as Celsius), Kelvin and Rankin scales. Each is based on a different scale and must be mathematically converted from one form to another in order to determine the equivalent value in another scale according to the following Equations.

Centigrade to Fahrenheit scale [9]:

$$\text{Degrees C} = \left(°\text{F} - 32\right) \times \frac{5}{9} \tag{1}$$

Celsius to Kelvin [9].

$$K = 273.15 + ℃ \tag{2}$$

2.2. Temperature Control Methods

The earliest methods of temperature measurement were mechanical in nature and used a fluid such as alcohol as the indicator and then applied a linear change in the fluids density in relation to its temperature [8]. The change in any linear dimension of the solid is called a linear expansion. A non-fluid method of measuring temperature that was developed much later uses a helically-wound bimetallic strip to operate a dial type indicator. A bimetallic strip consists of two thin layers of different metals that have different coefficients of expansion, such as brass and steel that have been bonded together [10]. The development of light emitting diodes (LEDs), liquid crystal display (LCDs) and large scale integration of electronics to a size and cost that are attractive has driven changes in the technology of temperature measurement for the past two decades [5] while digital measurement has replaced the former mechanical means of temperature measurement.

2.3. Conceptual Framework

The development of light emitting diodes (LEDs), liquid crystal displays (LCDs) and large scale integration of electronics to a size and cost that are attractive has driven changes in the technology of temperature measurement in recent years. Digital measurement has replaced the former mechanical means of temperature measurement. Digital temperature measuring devices have the advantages ranging from being more value. However, when determining the type of temperature measurement device most suitable for a specific application, accuracy, repeatability, reliability, durability, suitability and cost should be major considerations. With this understanding of the methodology of temperature measurement which was more mechanical in nature, it is pertinent to discuss modern temperature measurement and data acquisition.

2.4. Modern Methodology of Temperature Measurement

From previous sections, the evolutionary trends in data acquisition technology of any physical quantity has taken a quantum leap forward over the centuries. In measuring temperature, man has transited from an era of calibration to an era of industrial automation and monitoring [11]. Forty years ago in a college laboratory, a student tracking for the temperature rise in a crucible for sodium tungsten bronze would make use of a bridge, a look-up table, a pad of paper and a pencil. Today's college students are much more likely to use an automated process and analyze the data on a personal computer.

But the evolution of the automated-process of data acquisition of any physical quantity cannot be talked about without going backward to history. In the year 1963, IBM (International Business Machine) produced computers which were specialized for data acquisition. These include the IBM 7700 data acquisition system which was short lived and replaced with the IBM 1800 data acquisition and control system. However, these expensive systems were surpassed in 1974 by the general purpose S-100 computers and data acquisition cards. This gave birth to PC based data acquisition.

Temperature data logging is the most popular device for continuous monitoring of temperatures, data storing and protection for any system that will be utilized for process control [3]. Thus in designing a temperature acquisition system to be used for remote monitoring or process control in industrial environments, the advantages is low cost, fast system response, high reliability and long distance communication are usually critical factors to be considered [12. An industrial enterprise without proper monitoring and diagnosis strategy will probably suffer from various accidents some of which are even fatal to the operators themselves [2].

2.5. Temperature Measurement in Agroforest Environments

In agricultural systems such as greenhouses or farms, to analyze problems related to the indoor environment, direct measurements by suitable electronic instrumentation may be implemented [1]. Although, measurements of temperatures using multi-sensors system have long been used in agricultural farms in the study of indoor environments of farms they are however complex and are usually not interfaced with computer systems.

Several researches have showed that the influence of temperature, greatly affects the performance of broilers under indoor environmental conditions [13, 14, 15, 16, 17] According to [18], directives broiler facilities must be constructed and operated to provide the animals with a proper environment in terms of temperature, relative humidity and gases (ammonia and carbon dioxide) for efficient meat production.

According to [19], poultry meat production (especially broiler production) in many areas is affected yearly by massive bird mortality due to confluence of high temperature and humidity values which causes great economic losses and animal suffering, which is inconceivable in a modern society, that uses a high technological investment at these poultry farms and establishes regulations to ensure animal welfare. Intensive production normally takes place at mechanically ventilated farms with a high level of investment which allows a high density of animals and more thermal comfort in comparison with naturally ventilated farms. In this way, housing conditions is acknowledged to influence animal welfare more than animal density [20].

[21] utilized the concept of thermoelectricity in the design of multi-junction thermocouples embedded in asphalt bonded solar panel (thermogenerator) in electricity generation and its application in small scale agroforest based undertakings such as timber processing shed, agroforestry processes such as timber drying, processing shed thermal conditions, kiln, etc.

2.6. Thermal Requirements Agroforestry

Agroforestry is a group of land use practices that involve all agricultural commodities produced in mixing trees and or shrubs with non woody crops and sometimes livestock for the purpose of crop diversification, improved profitability and improved environmental stewardship. Agroforestry has expanded scope of introduction of long term crops (trees and shrubs) into open agricultural landscapes, agricultural husbandry, a wide range of crops and livestock into existing woodlands and environment. Agroforest environment as such comprises of all flora and fauna found within the agricultural and forest enclaves. Typical of these are the animals, poultry, timbers (wood) and other creatures exiting within these habitats. Exposure of these elements to strong, direct sunlight or hot, humid conditions long enough to cause heat stress as indicated by prolonged panting or deformation may result in the death, property alteration and eventual loss to the farmer. Variations in housing requirements could affect birds and animal's ability to maintain their normal body temperature but under any management system ambient temperatures high enough to cause prolonged panting may occur, particularly when humidity is relatively high. To achieve this, a temperature acquisition system embedded with an intelligent computer which monitors the temperature conditions in poultry housing system.

Many instruments and methods of measuring temperature have been known and used over the years. However, most of these instruments and methods only measures temperature but does not automatically store the measured temperature values at the various time interval such measurements were taken, thereby making the whole process of measurement a little cumbersome and time consuming if there is no existing primary device for measuring such flow.

Incorporating a computer interface for temperature monitoring especially in agricultural farmstead buildings and machineries is also an innovation.

3. Materials and Method

3.1. Material Selection and Specifications

The materials used in the construction of this project are locally manufactured materials which were easily purchased from the local market. Table 1, show the different material descriptions, specification and quantity used.

Table 1. *List of material used in the project construction.*

S/N	Material description	Specification	Quantity
	Microcontroller	AT89C2501	1
	Resistors	1kΩ, 10kΩ, 43kΩ	3
	Transistors	BC337	2
	Reset button		1
	Capacitors	10μF, 150μF	2
	Voltage regulator	7805 IC	1
	Diode	1N4007	1
	Liquid crystal display (LCD)	2*16	1
	Vero board		1
	Thermoplastic casing		1
	Temperature transducer	LM35	1
	Serial communication interface	MAX232	2
	Serial communication connector	DB-9	2
	Analog digital converter	ADC0804	1

(Source: Author's field work, 2014)

3.2. Methodology

In engineering design and development, components/material selection must meet set standards in order to achieve the designed goal. To determine the appropriate approach to this work, considerations was given to the type of temperature measuring device most suitable for a specific application. Each system segment was developed and tested first before the final coupling.

3.2.1. System Configuration

The overall system design was formulated in a block diagram linking the different interfaces of the hardware sub-system as shown in Figure 1.

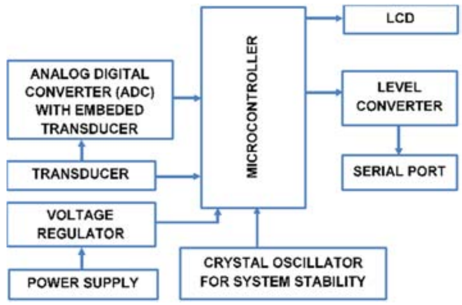

Figure 1. *Overall system flowchart showing different interfaces.*

3.2.2. System Design

The digital integrated circuits (ICs) used in the design and implementation of the system is LM35 temperature transducer, AT89C51 microcontroller, MAX232 serial communication interface, DB-9 serial communication connector, ADC0804 analog digital converter, a 16-pin liquid crystal display (LCD) and 7805 voltage regulator (Figure 1). An embedded system structure in which the software controlling the system is embedded in the microcontroller was adopted in the design (figure 1) which is further broken down into three basic parts: Hardware sub-system, software sub-system and power supply system.

The hardware sub-system: The design procedure adopted in the development of the microcontroller is the modular type (Figure 2) for ease system testing. Figure 2 shows the schematic of the different functional interfaces that make up the hardware sub-system i.e. the input interface, the control system and the output interface.

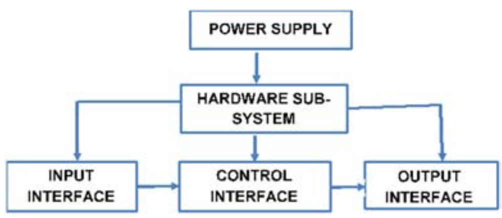

Figure 2. *Interfaces of the hardware sub-system.*

i. Input interface:

The input interface comprises of a transducer (temperature raising/reading device) and an analog digital converter (ADC).

(1) *Transducer*: The choice of the transducer was based on the characteristics of the available temperature sensors. Thus, the LM35 temperature sensor was selected for the design. The LM35 is a precision integrated circuit temperature sensor, whose output voltage is linearly proportional to the Celsius temperature. The transducer interfaced to the microcontroller via the ADC requires no external calibration since it is intrinsically calibrated and maintains accuracy of $\pm 0.4\,°C$ at room temperature, and $\pm$ 0.8 °C over a range of 0 to 100 °C. The sensor has a sensitivity of $10\,mV/°C$ and it operates over a range of $-55°C$ to $+150°C$. The voltage range is between $4V$ to $20V$, but a voltage of 5V was adopted for the design, while considering the requirement of the microcontroller. Figure 3 shows the different pin connections of the transducer.

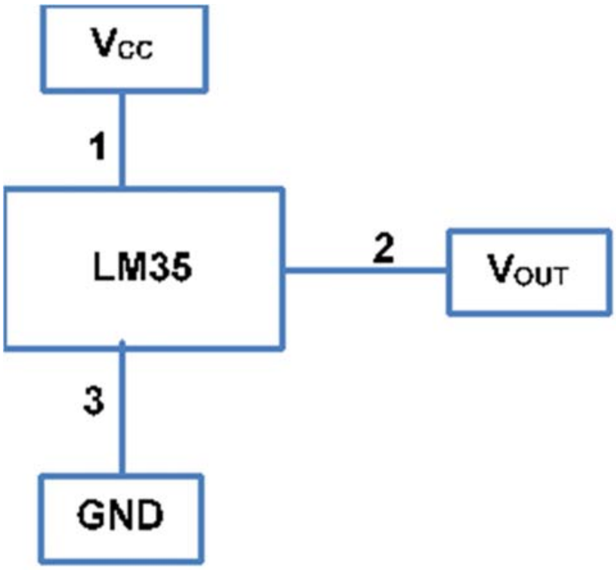

Figure 3. *LM35 temperature transducer showing its structural pin connections.*

In Figure 3, pin 1 represents the voltage from the voltage regulator, pins 2 and 3 indicates respectively the output voltage and ground (earth). Since the output voltage of the LM35 sensor can be measured, the actual temperature measured by the device can be estimated from Equation (3).

$$\text{Temperature (°C)} = V_{OUT} \times 100\,°C/V \quad (3)$$

Where, V_{OUT} is the output voltage of the LM35 temperature transducer.

(2) *Analog digital converter (ADC):* The signal from the LM35 temperature transducer is analogue in nature, which must be converted in digital form for the microcontroller to understand its signal. To achieve this, the temperature transducer must be interfaced with an ADC. This ADC converts the analog input of the temperature transducer and sends the converted (digital) signal to the microcontroller interfaced with it. In the implementation of this project, the analog digital converter used is the ADC0804. It is a 20-pin ADC and its bits are given by the relationship:

$$\text{Step size resolution} = \frac{2\times V_{ref}}{2x} \quad (4)$$

Where x = number of bits of ADC

The choice of ADC used for this design was due to the fact that the ADC has 8-bit digital output which is compatible with the 8-bit microcontroller used for the design implementation. Also, it has fast conversion time and requires only $5V$ functioning.

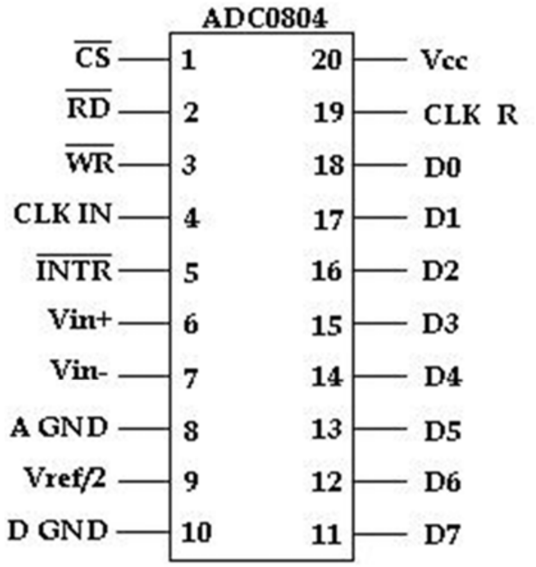

Figure 4. *ADC0804 pin layout [22].*

In the operation of the system, the clock frequency required by the ADC0804 is determined using Equation (5).

$$f = \frac{1}{1.1RC} \quad (5)$$

Where F is the clock frequency, R and C, are respectively the resistor required and capacitor required by the ADC0804, as stipulated by the manufacturers. The arrangement is shown in Figure 5.

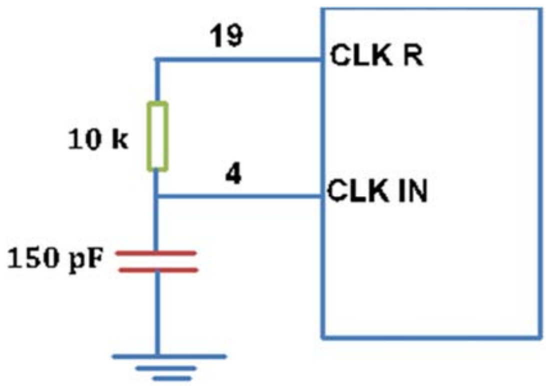

Figure 5. *ADC0804 clock frequency arrangement (Source: www.datasheetcatalog.com).*

Figure 6 shows the circuit diagram of the LM35 temperature transducer interfaced with the ADC0804 and the microcontroller unit as designed using Proteus Professional 7.

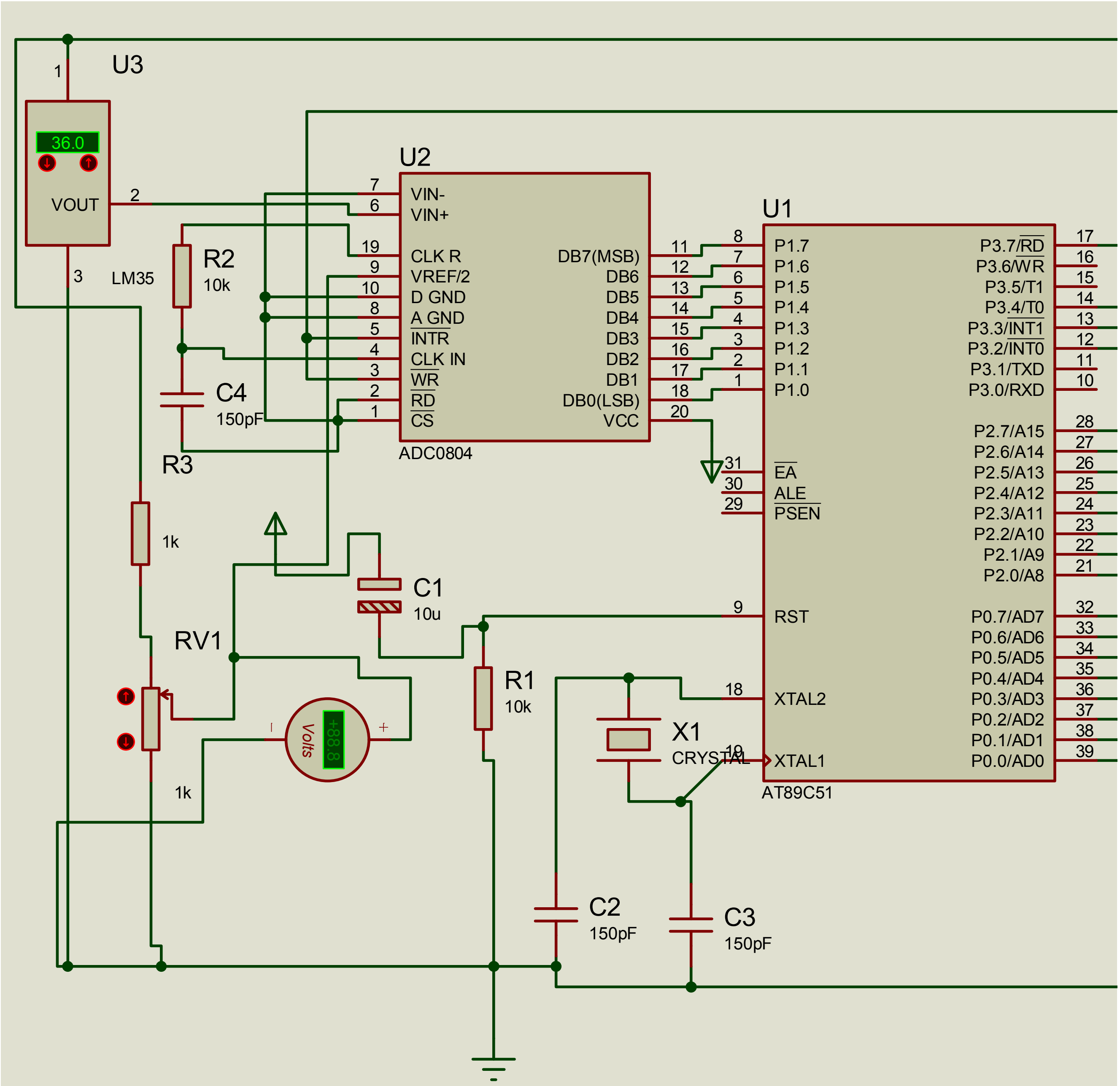

Figure 6. *LM35 interfaced to ADC and microcontroller as designed using Proteus Professional 7.*

ii. Control System (microcontroller):

A microcontroller integrates a number of components of a microprocessor system (i.e. CPU core (microprocessor), memory (RAM and ROM) and parallel digital 1/0) onto a single microchip. The microcontroller is the brain of the system. It supports multi-level programming i.e. its memory can be mapped into various sections. Usually, each sub-routine of flow chart of a system is assigned to a particular section of the memory of the microcontroller, with one central programming calling each sub-routine when necessary. Also, microcontrollers are cheap and support serial data communication because it supports a set of back rates which are compatible with most computers.

The selected microcontroller used in the implementation of the design is the AT89C51 built on the 8051 microprocessor architecture. AT89C51 is an 8-bit microcontroller and has 4KB of flash programmable and erasable read only memory (PEROM) and 128 bytes of RAM. It can be erased and program to a maximum of 1000 times. It is a low-voltage and high-performance integrated circuit (IC) which provides a highly-flexible and cost-effective solution to many embedded control applications. It has low power consumption, serial communication capability, fast response time and has 40 pins input/output ports.

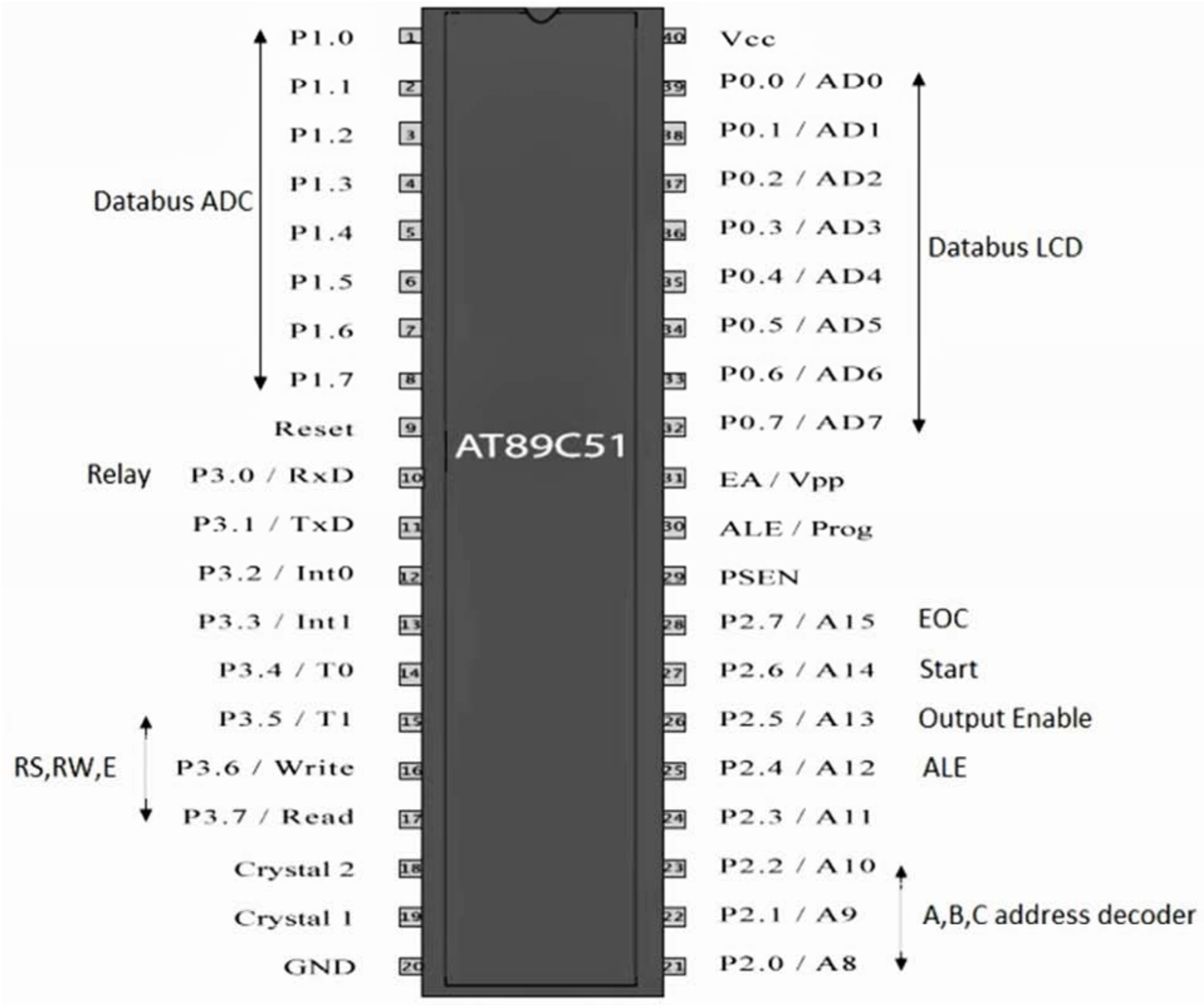

Figure 7. *Port (pin) configuration layout of the AT89C51microcontroller [22].*

iii. Output interface:

The output interface comprise of the liquid crystal display (LCD) and serial communication interface.

(1) *Liquid crystal display interface:* The output interface shows the interfacing of the Liquid Crystal Display (LCD) to the micro-controller. The LCD requires 5V for its functionality. It is used to interact with the outside world. The LCD used in this project is a 2*16 display i.e. 16 character line and 2 row. It has three control lines as well as eight input/output lines. The three control lines are referred to as EN, RS and RW while the eight input/output lines are referred to as data bus where EN line is called "enable" used to alert the LCD that data is being sent to it, RS line is the "register select" line (When RS is low (0), the data is to be treated as a command (such as clear screen, position cursor). When RS is high (1), the data being sent is text data which should be displayed on the screen), RW is the "write select" line (When RS is low (0), the information on the data bus is being written to the LCD. When RW is high (1), the program is effectively querying the LCD) and the data bus which consists of 8 lines which are referred to as DB0 to DB7. The pin description of the LCD is given in Table 2.

Table 2. *Pins description of LCD.*

No	Symbol	Function
1	VSS	Ground (0V)
2	VDD	Supply voltage logic (+5V or 3.3V)
3	VO	Contrast adjustment
4	RS	Register select
5	RW	Write select
6	EN	Enable signal
7	DB0	Data bus
8	DB1	Data bus
9	DB2	Data bus
10	DB3	Data bus
11	DB4	Data bus
12	DB5	Data bus
13	DB6	Data bus
14	DB7	Data bus
15	LED_A	Led power supply +(5V)
16	LED_K	Led power supply (0V)

Source: [22]

(2) *Serial communication interface:* In the serial communication interface, a level converter integrated circuit (IC) was used to interface with the

microcontroller. The TXD and RXD pin of the microcontroller, which are also port 3 pins, are used specifically for transferring and receiving data serially. These pins are compatible and require a line driver such as the MAX232 chip. Figure 8 shows the schematic diagram to illustrate a basic understanding of the serial communication interface used. The details of components used for the serial communication interface are not included in this article.

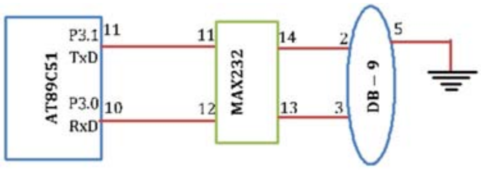

Figure 8. *Serial communication interface connection.*

iv. Power supply:

All components in the system work with 5V voltage supply. This is achieved by the use of a 9V lithium battery which is connected to a 7805 voltage regulator to which regulates the voltage to 5V require by the system. The positive output terminal from the 7805 regulator gives the V_{CC} while the negative terminal represents the ground (GND). The total current measured at the regulator output is 6mA. The schematic diagram, Figure 9, show the power supply system components.

Figure 9. *Schematic of the power supply system.*

(1) *The voltage regulator:* The 7805 voltage regulator regulates the voltages from the 9V lithium battery to 5V which is required by the ICs used in the system microcontroller.
(2) *Reset and crystal oscillator:* The reset pin (Figure 10) is an input pin and it is actively high. Upon applying a high pulse to this pin, the microcontroller will reset and terminate all activities. This is often referred to as a power on reset. In order for the reset input to be effective, it must have a minimum duration of 2 machine cycles.

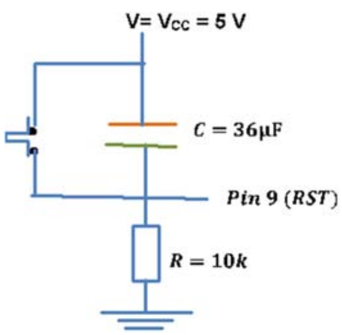

Figure 10. *Schematic of the reset input pin.*

The crystal oscillator on the other hand, is an electronic circuit that uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency. This frequency is commonly used to keep track of time to provide a stable clock signal for digital integrated circuits. Thus, the crystal oscillator determines the frequency of operation of the system while the 33µF capacitor makes for system stability during operation (Figure 11).

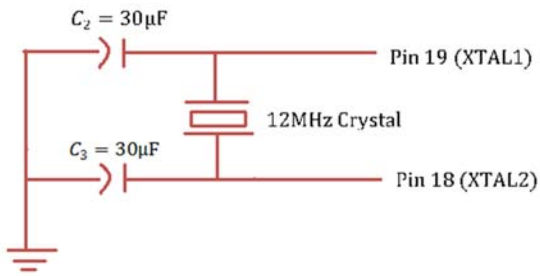

Figure 11. *Schematic of the oscillator circuit.*

It should be noted that the 33µF capacitor is recommended by the manufacturer of the microcontroller. From the datasheet, C_2, C_3 ranges between 30µF $\pm$ 10µF for the crystal [22]. The crystal frequency as recommended by the manufacturers for number of pulses in one second is12 MHz (Figure 12).

3.3. Project Embodiment

The project embodiment shows the image of the embodied temperature acquisition system. The function displayed on the LCD of the system is the recorded temperature of the immediate environment where the system is installed (Figure 12).

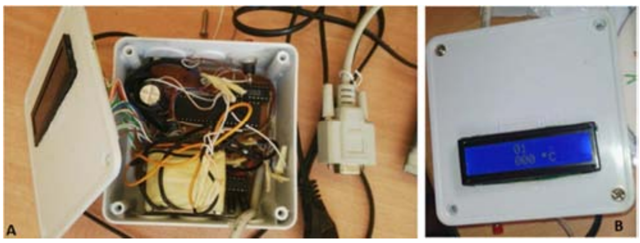

Figure 12. *Experimental device showing building blocks (A) and the screen display (B).*

4. Results and Discussions

4.1. Results

The design of the temperature acquisition system was broken into building blocks. Each block performs a certain function different from the other blocks. However, the integration of the circuit of all the blocks involved resulted in the complete functional temperature acquisition system. The integration of the circuitry of the blocks was done and also the testing of the entire project design to ensure that it satisfies the aim for which it is designed.

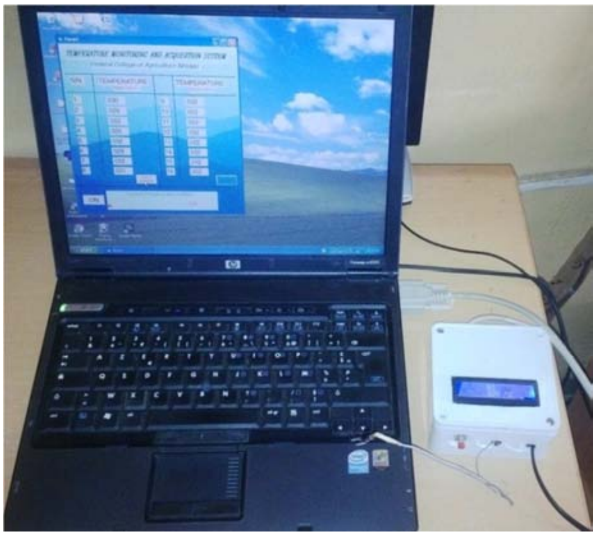

Figure 13. *Experimental setup of the device.*

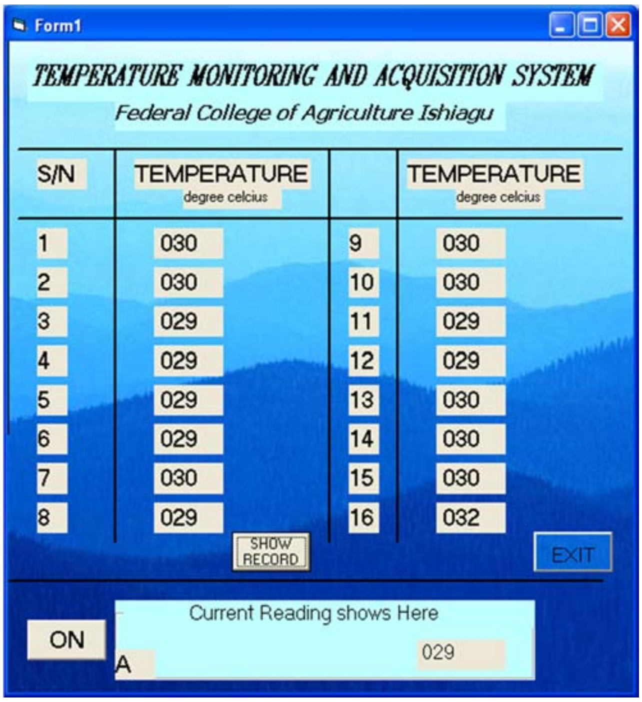

Figure 14. *Result of temperature monitored on computer screen.*

The test was carried out by entering the required specified temperature of the proposed environment and then left for ten minute after which the recorded temperature was uploaded into the personal computer via the serial communication port (Figure 14).

4.2. Discussions

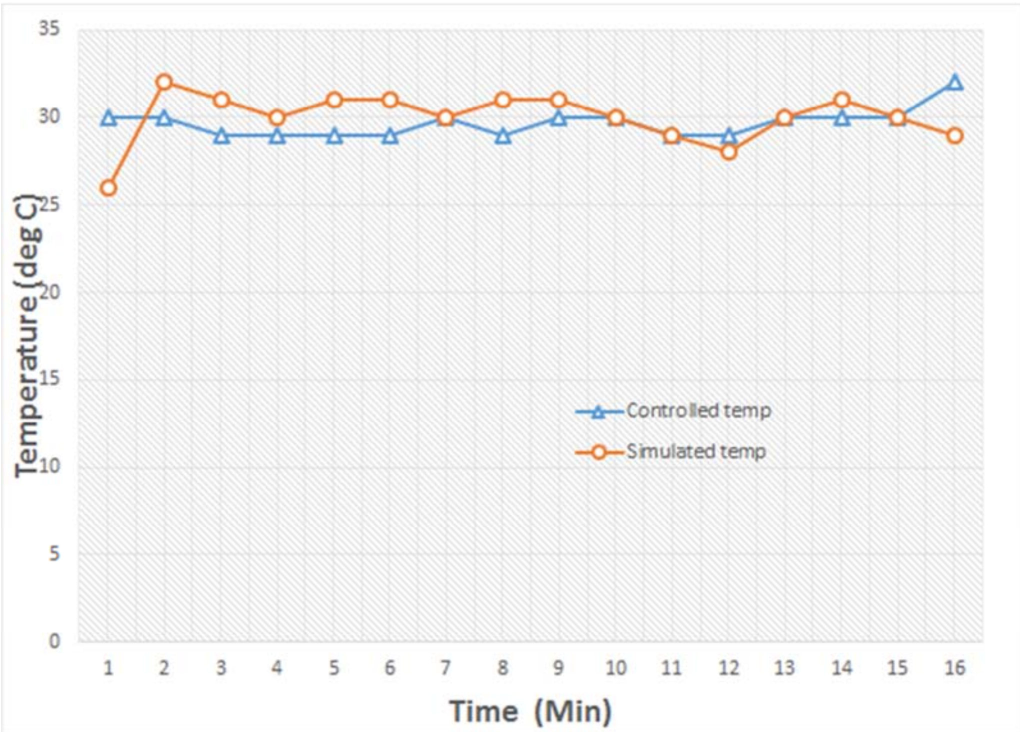

Figure 15. *Recorded temperature readings from the temperature acquisition system.*

The digital display of the temperature acquisition system measured every minute is plotted in a chart as shown (figure 15). These measured temperature value is not sequential since its value changes depending on the condition of the body at a given time. At intervals of 1-2 minutes, the instrument gave the same temperature reading (26 ℃) showing that the temperature is constant for these periods. However, at 3 minute, the temperature value increased to 31 ℃ but subsequently dropped back to 26 ℃ . The temperature readings changes continually depending on the temperature of body being measured until NA (not available is displayed). Thus, the system measure the direct instantaneous change in temperature. Comparing the simulated and measured temperature trends, a more realistic temperature profile was monitored by the instrument. The instrument sensitivity to environmental changes is very making it easier to detect slight variations in weather changes

5. Conclusion

Data plays an important role in almost all facets of human endeavour especially in agroforestry. Monitoring temperature within agroforest systems for efficiency optimization of process parameter, has been achieved by this device. It is one thing to collect data, yet it is another thing to retrieve it for analysis purpose. This data acquisition device is helpful in understanding and analyzing the phenomena being monitored. The operating conditions of agroforest systems which requires time-based monitoring can be conveniently monitored by this device.

Bill of Engineering Measurement and Evaluation (BEME)

The bill of engineering measurement and evaluation (BEME), Table 3 show all items used in the construction, the quantity, the unit cost as well as the overall cost of executing the project.

Table 3. *Bill of Engineering Measurement and Evaluation.*

S/N	Item	Quantity	Unit cost (₦)	Cost (₦)
1	Temperature sensor LM35	1	1,200.00	1,200.00
2	ADC 0804	1	1,000.00	1,000.00
3	Micro controller, AT89C51	1	1,900.00	1,900.00
4	16 × 2 liquid crystal display	1	1,600.00	1,600.00
5	MAX 232	1	1,100.00	1,100.00
6	DB -9 Connector	1	1,200.00	1,200.00
7	Resistors	11	50.00	550.00
8	Variable Resistor	1	60.00	60.00
9	Capacitors	8	50.00	400.00
10	Crystal oscillator	1	700.00	700.00
11	IC socket	4	50.00	200.00
12	Regulator, 7805	1	250.00	250.00
13	Programming	1	25,000.00	25,000.00
14	Connector wire	3	200.00	600.00
15	Soldering lead	1	400.00	400.00
16	Switches	5	80.00	400.00
17	Casing	1	4,000.00	4,000.00
19	PCB board	1	2,300.00	2,300.00
Total				42,860.00

References

[1] Bustamante, E., Guijarro, E., García-Diego, F. J., Balasch, S., Torres, A. G., (2012): Multi-Sensor System for Iso-temporal Measurements to Assess Indoor Climatic Conditions in Poultry Farms. Journal of Sensors 2012, 12, pp. 5752–5774.

[2] Rao, B. K. N., (1996): Handbook of Condition monitoring, Edevier Advanced technology, UK.

[3] Rejvi K, M., Rafiqul I, M., Jahiru, I., Madudur, R., and Alamgir, M. K., (2011): Design and Implementation of a Novel Multi channel temperature Data Logger with thermal protection". Canadian journal on Electrical and Electronic Engineering, Vol. 2, No. 2 February 2011.

[4] Bello R. S., Onilude M. A., Nebo U. E., 2014. Computer-Based Algorithm for Temperature Data Acquisition in Agroforestry. Unpublished Diplomate thesis, Dept of Agricultual & Bio-Environmental Engineering, Federal College of Agriculture, Ishiagu Nigeria.

[5] Mazidi, M. A, and Mazidi, J. G, (2000): The 8051 micro controller and embedded systems using Assembly and C", Prentice-Hall Inc, India, 2000.

[6] David, A. K., (2004): A brief history of temperature measurement", Towerly publishers.

[7] Hill, W, and Horowitz, P., (2002): The art of Electronics", Cambridge University Press, UK.

[8] Jim, L., (2004) "Temperature measurement circuits for embedded Applications", Microchip Technology INC.

[9] Ababio, O. Y., (2004): "New School Chemistry", Africana First Publishers.

[10] Okeke, P. N and Anyakoha, M. W., (2001): Senior Secondary School Physics", Macmillan, Lagos.

[11] Valvano, J. W., (2000): Embeded Micro-computer systems; Real work interfacing", Brooks Cole.

[12] Wang, S, Z., and Wang, X. W., (2010): A multi- channel temperature acquisition system based on ARM and CAN bus; International Conference on Computer, Mechatronics, Control and Electronic Engineering (CCMCE) 2010.

[13] Lott, B. D., Simmons, J. D., and May, J. D., (1998): Air Velocity and High Temperature Effects on Broiler Performance. Journal of Poultry Sci. 1998, 77, pp. 391–393.

[14] Lott, B. D., Simmons, J. D., and May, J. D., (2000): The effect of air velocity on broiler performance and feed and water consumption. Journal of Poultry Sci. 2000, 79, pp. 1396–1400.

[15] Yanagi, T., Xin, H., and Gates, R. S., (2002): A research Facility for Studying Poultry Responses to Heat Stress and its Relief. Appl. Eng. Agric. 2002, 18, pp. 255–260.

[16] Simmons, J. D., Lott, B. D., Miles, D. M., (2003): The effects of high-air velocity on broiler performance. Journal of Poultry Sci. 2003, 82, pp. 232–234.

[17] Yavah, S., Straschnow, A., Luger, D., Shinder, D., Tanny, J., Cohen, S., (2004): Ventilation, Sensible Heat Loss, Broiler Energy and Water Balance under Harsh Environmental Conditions. Journal of Poultry Sci. 2004, 83, pp. 253–258.

[18] European Union (EU) (2007): Laying Down Minimum Rules for the Protection of Chickens Kept for Meat Production; EU Council Directive 2007/43/EC; European Union: Brussels, Belgium, 2007.

[19] Eliseo, B., Fernando, J., García, D., Salvador, C., Fernando, E., Pedro, B., Antonio, H., and Antonio, G. T., (2013): Exploring Ventilation Efficiency in Poultry Buildings: The Validation of Computational Fluid Dynamics (CFD) in a Cross-Mechanically Ventilated Broiler Farm. Open Access Journal of Energies, 6, pp. 2605-2623. doi: 10.3390/en6052605. www.mdpi.com/journal/energies.

[20] Dawkins, M. S., Donnelly, C. A., and Jones, T. A., (2004): Chicken Welfare is influenced more by Housing Conditions than Stocking Density. Nature 2004, 427, pp. 342–344.

[21] Bello, R. S., Odey S. O., Eke K. A., Mohammed A. S., Balogun R. B., Okelola O. and Adegbulugbe T. A. (2012). *Application of Asphalt bonded Solar Thermogenerator in small Scale Agroforestry Based Industry*: in Elisha B. Babatunde (Ed), 2012. Solar radiation. *INTECH Open Access* Pub., Croatia ISBN: 978-953-51-0384-4. URL: http://www.intechopen.com/books/solar-radiation Pp 459-484.

[22] *www.datasheetcatalog.com*