Development of NCAM Temperature and Humidity Sensor

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Abstract: ***In the present day, the necessity to monitor environmental factors in all industries is necessary in research institutes and even for domestic uses. The analogue data measurement for monitoring of temperature and humidity requires manual effort to note readings which are very tedious and time consuming and may lead to inaccurate measurements due to human errors. The manual systems fail to provide and store precise values of parameters with high accuracy and have drawback of storage/memory. Therefore, it is important to develop an automated temperature and humidity sensor with materials acquired locally capable enough to monitor all the environmental parameters with utmost possible accuracy that is cost-effective as well as portable too. The measuring device obtains temperature and humidity data by using DHT11 sensor. The hardware used for the project includes Arduino Nano, Liquid Crystal Display (LCD) and DHT11 sensor using the Arduino IDE software. C programming language was used and the libraries of each component were installed in the Arduino IDE. A program code in the Arduino IDE (sketchbook) was created to enable the DHT11 sensor, LCD and Arduino work. The DHT11 was initialized at 5 V. The readings were recorded when the values displayed on the LCD for human interface after communicating with the Arduino. The device was evaluated at NCAM greenhouse for different time intervals for five days. The results showed that the cost-effective portable device is able to detect and record temperature and humidity effectively***

Keywords: Arduino IDE, Temperature, Humidity, Sensor, C programming, DHT11

1. Introduction

Over many decades the demand for temperature and humidity sensors has shown that temperature and humidity are the principal process variable of serious concern to many industries such as agricultural, petroleum, pharmaceutical, food processing, etc. The continuous monitoring of temperature and humidity are major criteria in all of the above-mentioned industries [1]. The controlled environment forms a foremost criterion in all of the above industries. Any kind of deviation in the environmental conditions or the pre-set parameters can cost heavy financial losses due to alterations in productivity in the pharmaceutical and agricultural industries.A precise monitoring of humidity and temperature is required in biomedical industry due to the screening of drugs and use of various cell culture methods. While providing life support in healthcare sectors the environment-controlled conditions is required.The variations in environment i.e., temperature and humidity of patients could be life threatening. Also, in the agricultural industry such as NCAM, monitoring of temperature and humidity of processing machine is very essential to avoid deterioration such as fish kiln for smoking fish and in greenhouse to increase crop productivity. The analogue data measurement requires manual effort to note readings which is very tedious and time consuming. It further fails to provide and store precise values of parameters with high accuracy. Presently, most of the digital measuring instrument in Nigeria are imported, therefore, it is important to develop a locally made temperature and humidity sensor which can be utilized to monitor agricultural produce environment with high level of accuracy that is efficient, cheaper, affordable and easily expandable.

2. Literature Review

Several research works have been carried out in various institutions across the world to provide a better managed, efficient and cost-effective way for simultaneous measurement of temperature and humidity. Temperature and humidity are very important parameters of the environment used for many industrial purposes such as food, medicine, papermaking, textile, meteorological, semiconductor, services etc. Currently, optical fibre sensors have received extensive recognition in sensing and measurement areas due to their many advantages over their conventional electronic counterparts[1].

[2] it wasreported that the monitoring of environmental variables such as temperature, pressure and humidity have a long history of development and the variables have shownsignificant impact on the productivity of plant growth, the quality of food industry and the efficiency of many temperature and humidity sensitive equipment. Thisreliable measurement and monitoring device is very essential in this era of competitive technology.

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2.1 Temperature Sensors

Temperature sensors possess an important role in industries such as agricultural, petrochemical, medical, automotive, aerospace,defence, consumer, electronics, etc. Temperature monitoring and control in such industries is critical for proper functionality, for example maintaining a specific temperature is essential for equipment used to fabricate medical drugs or in a greenhouse to monitor the yield of the crop planted. There are many different types of temperature sensors available and all have different characteristics depending upon their actual application. A temperature sensor consists of two basic physical types namely: -

- Contact Temperature Sensor: These types of temperature sensors are required to be in physical contact with the object being sensed and use conduction to monitor changes in temperature. The most commonly used are thermistor, resistive temperature detectors and thermocouple.
- Non-Contact Temperature Sensor: These types of temperature sensors use convection and radiation tomonitor changes in temperature and do not have to be in direct contact with the object being sensed.Example of this type is the optical pyrometer.

2.1.1 Types of Temperature Sensors

a) Thermistor

A thermistor is a special type of resistor which changes its physical resistance when exposed to changes in temperature. Thermistors can either have a Negative Temperature Coefficient of resistance (NTC), that is their resistance value decreases with an increase in temperature, or have a Positive Temperature Coefficient (PTC), in which their resistance value increases with an increase in temperature.

Figure 2.1: A NTC Thermistor

b) Resistive Temperature Detectors (RTD)

An RTD, also known as a resistance thermometer, measures temperature by correlating the resistance of the RTD element with temperature. An RTD element consists of a film or, for greater accuracy, a wire wrapped around a ceramic or glass core. The most accurate RTDs are made using platinum but lower cost RTDs can be made from nickel or copper.RTDs are used to measure temperatures from -196° to 482° C (-320° to 900° F).

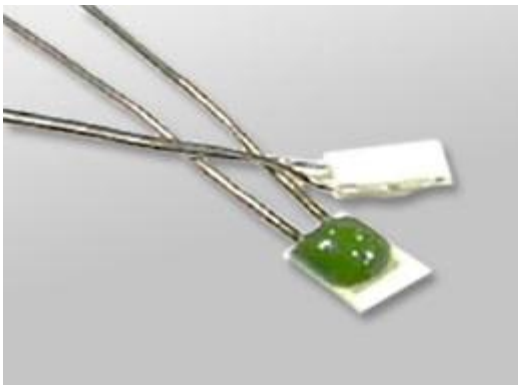

Figure 2.2: A Resistive Temperature Detectors

c) Thermocouple

Thermocouples are thermoelectric sensors that basically consists of two junctions of dissimilar metals that are welded or crimped together. One junction is kept at a constant temperature called the reference (Cold) junction, while the other the measuring (Hot) junction. When the two junctions are at different temperatures, a voltage is developed across the junction which is used to measure the sensed temperature.

Figure 2.3: K Type Thermocouple

d) Pyrometer

A pyrometer is used to measure the temperature of an object from a distance without making contact. The method used for making these non-contacting temperature measurements is known as radiationpyrometer. Non-contact temperature sensors use the concept of infrared radiant energy to measure the temperature of objects from a distance. After determining the wavelength of the energy being emitted by an object, the sensor can use integrated equations that take into account the body's material and surface qualities to determine its temperature [3]. Pyrometers are most useful for measuring the temperature of objects that are at high temperature, moving, surrounded by an electromagnetic field, or in a controlled environment. They are commonly used for race car tires, pottery kilns, steel mills, steam traps, and semiconductors. Figure 2.4 shows a pyrometer.

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Figure 2.4: Pyrometer

2.2 Humidity Sensors

Humidity sensors or hygrometers, are used to measure humidity levels in the atmosphere by monitoring the moisture and air temperature, and reporting the relative humidity (RH) in the air. Relative humidity is the ratio of moisture in the air to the highest amount of moisture at a particular air temperature. All types of sensors monitor the changes in the atmosphere in a fixed time in order to calculate the humidity in the air.

2.2.1 Types of Humidity Sensors

a) Capacitive

A capacitive humidity sensor measures the relative humidity by placing a thin strip of metal oxide between two electrodes. The electrical capacity of the metal oxide changes with the atmosphere's relative humidity. Capacitive sensors are robust against effects such as condensation and temporary high temperatures but they are subject to contamination, drift and aging effects, but are suitable for many applications.

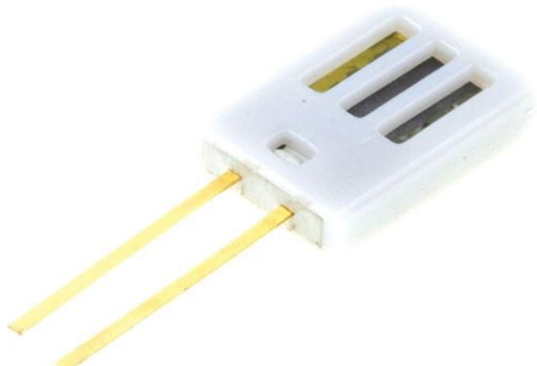

Figure 2.4: Capacitive Humidity Sensor

b) Resistive

Resistive humidity sensors utilize ions in salts to measure the electrical impedance of atoms. As humidity changes, so does the resistance of the electrodes on either side of the salt medium. Resistive sensors are less sensitive than capacitive sensors. The accuracy and robustness against condensation vary depending on the chosen resistive material.

Figure 2.5: Resistive Humidity Sensor

c) Thermal

Two thermal sensors conduct electricity based upon the humidity of the surrounding air. One sensor is encased in dry nitrogen or dry air (sealed) while the other measures ambient air (vented). The difference between the two measures the humidity. These sensors measure absolute humidity rather than relative humidity.

Figure 2.6: Thermal Humidity Sensor

3. Materials and Methods

3.1 Materials

3.1.1. Arduino Nano V3

The Arduino Nano is a small and microcontroller board based on the ATmega328 (Arduino Nano 3.0) or ATmega168 (Arduino Nano 2.x). It can be used for a wide range of applications such as control system, robotics, instrumentation, automation etc.It has the following specifications.

Figure 3.1: Arduino Nano V3

3.1.2 DHT11 Sensor

The DHT11 sensor comprise of 3 parts namely a capacitive humidity sensor, a thermistor and a chip that performs analog to digital conversion and outputs a digital signal with the temperature and humidity. The digital signal can be read using any microcontroller. The DHT11 element is strictly calibrated in the laboratory that is extremely accurate on humidity calibration [4]. The calibration coefficients are stored as programs in the One-Time Programmable (OTP) memory, which are used by the sensor's internal signal detecting process [5]. The specifications of the sensor are: -

- Ultra-low cost
- 3 to 5V power and I/O

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- 2.5mA max current use during conversion (while requesting data)
- Good for 20-90% humidity readings with 5% accuracy
- Good for 0-50° C temperature readings ±2° C accuracy
- No more than 1 Hz sampling rate (once every second)
- Body size 1 5.5mm x 1 2mm x 5.5mm
- 4 pins with 0.1 " spacing

Figure 3.2: DHT11 Sensor

3.1.3 16x2 Liquid Crystal Display (LCD)

LCD (Liquid Crystal Display) is used in all the electronics projects to display the status of the process. A 16x2 alphanumeric LCD is most widely used module of LCD nowadays. There are several other types of LCD available in the market also. The LCD are low cost, easily programmable, displays large number of characters and compatible with almost all microprocessor and microcontroller. 16x2 LCD has two horizontal line comprising a space of 16 displaying character. It has two inbuilt registers namely command and data register.

Figure 3.3: 16x2 LCD

3.1.4 Battery

A 9V battery was used to power the device.

Figure 3.4: 9V Hi - Watt Battery

3.2 Methods

3.2.1 Development of the Device

The method adopted in the development of this device was done using DHT11 which stands for Digital Humidity and Temperature sensor. The Arduino Nano microcontroller development board is connected with the DHT11 sensor. For acquiring the signal from the sensor, a program code in Arduino IDE sketch book was created to enable the DHT11 sensor, liquid crystal display and Arduino works. The data observed or measured by the sensor is display on a Liquid Crystal Display (LCD) for human interface [6]. The sensor was initialized by supplying +5 V. The principle of operation of this device explains the function of each component and their outputs. The flow chart, wiring DHT11 sensor and LCD display to Arduino Nano and circuit diagram of the device is shown in Figure 3.5, 3.6 and 3.7 below.

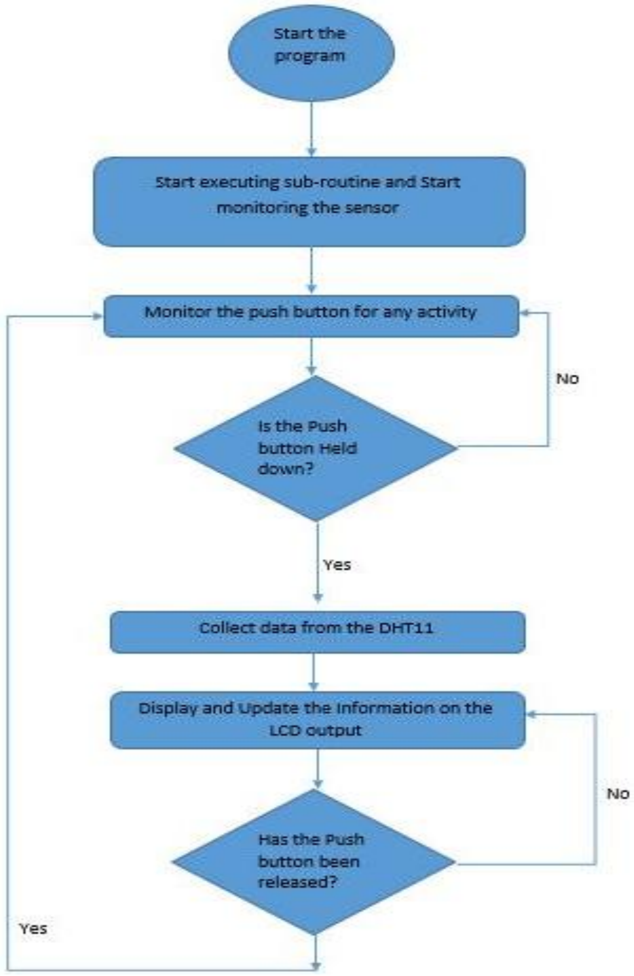

Figure 3.5: Flow chart of the device

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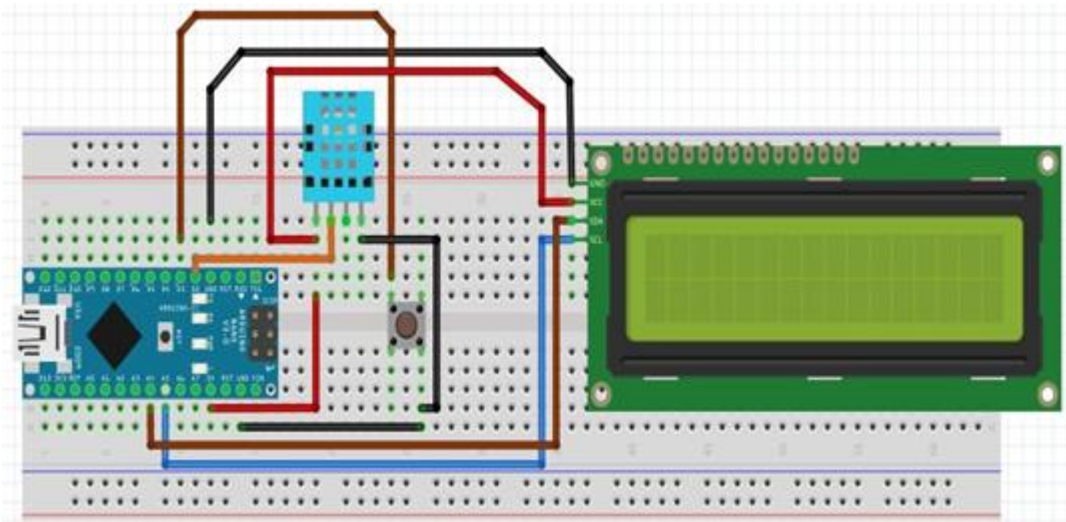

Figure 3.6: Wiring DHT11 Sensor and LCD display to Arduino Nano (3.0)

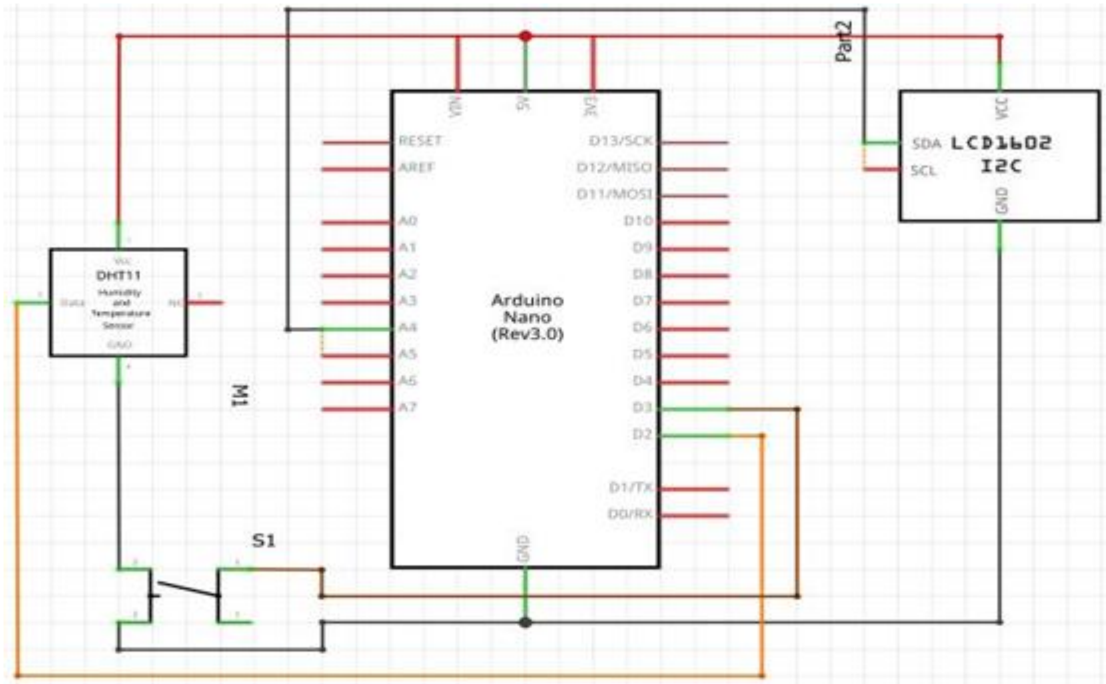

Figure 3.7: Circuit diagram for DHT11

4. Results and Discussion

The test was carried out to evaluate the performance of the hardware and software of the device at NCAM greenhouse and it was compared with the imported humidity and temperature sensor (TEMLOG). The tests were carried out at different stages during the development of the device in order to determine the efficiency and accuracy of each segment of the device. These include the circuit for the temperature and humidity device and the results when tested. The readings obtained were recorded and graphs was plotted to give a perfect view of the humidity and temperature for the specified location.

The circuit of the temperature and humidity device consists of liquid crystal display, DHT11 and Arduino Nano. The device was tested at NCAM greenhouse for five days and data obtained for the humidity and temperature are presented in Fig 4.1 – 4.5. It was observed during the testing of the device that the temperature and humidity measurements readouts of the imported humidity and temperature sensor (TEMLOGS) compared to the DHT11 gave an error margin of 3.70% and 9.54 % for temperature and humidity measurements respectively.

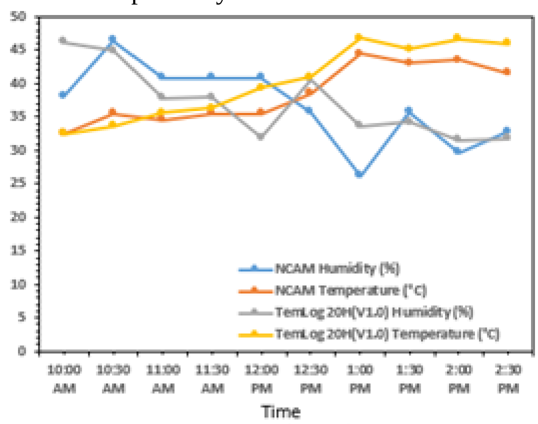

Fig 4.1: Temperature and Humidity comparison as at 13th August 2020

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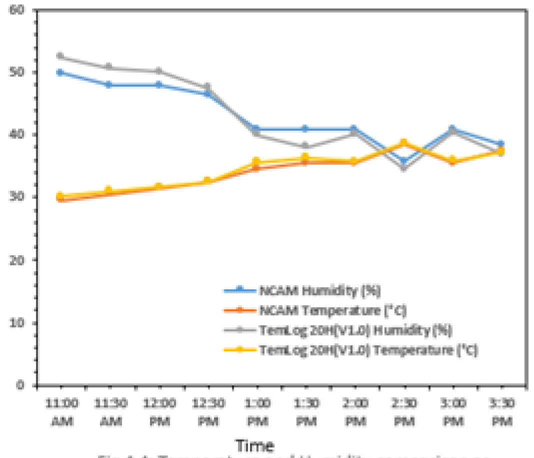

Fig 4.4: Temperature and Humidity comparison as at 18th August 2020

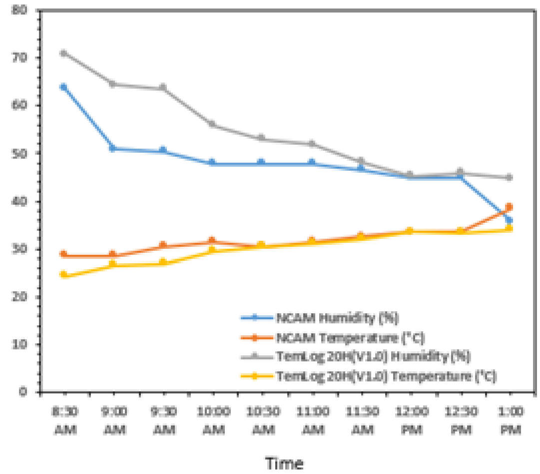

Fig 4.5: Temperature and Humidity comparison as at 19th August, 2020

5. Conclusion

The development of the temperature and humidity monitoring system was successfully developed using locally acquired materials that is reliable and cheap. These materials include: Arduino Nano, DHT11 and Liquid Crystal Display. The sensor transmits temperature and humidity wirelessly to the Arduino which then displays them on the Liquid Crystal Display. It will provide a convenient method for effective monitoring of temperature and humidity in real time. This system is compact to an extent and cost effective when compared to prices of instruments used to measure the environmental factors as these. From the measurements of humidity and temperature, it is clear that there is closeness in obtained data between the designed instrument and already available standard instruments (TEMLOG). The device is suitable for all kinds of short distance conditions of wireless data acquisition and transmission.

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