Design, Construction and Testing of Multipoint Humidity, Temperature Data Logger

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Abstract

A low cost multipoint temperature, humidity data logger was built. It was designed using Max 6675 temperature sensors and DHT 11 Capacitive Humidity Sensors (CHS) and a thermistor. This CHS measures humidity in the air. Thus, the changes in the dielectric constant of CHS are nearly directly proportional to the relative humidity of the surrounding environment. Arduino Mega was the data processing element. The response time of both sensors were one minute interval. The trend of the temperature and the humidity flow pattern showed that they approached standard showing that the system actually senses changes in the surroundings effectively. The accuracy of these sensors were +0.5 and 1%.

Keywords: *multipoint; temperature; humidity; data logger; Arduino mega; sensor*

Introduction

Typically, data loggers are small, stand-alone, battery-powered devices that are equipped with a microprocessor, memory for data storage and sensors, [Daly and Flye, (2000); Obi et al, (2020)]. In this paper, we present a portable and rugged data acquisition module that is designed to monitor the performance of the constructed Native-Kankan padded evaporative space cooler. A system like this could be used in monitoring the humidity and temperature of certain systems which can help in determining the efficiency and otherwise of such components. Most low-cost humidity and temperature measuring devices are hand-held and cannot be logged whereas some other loggers are quite expensive.

Multipoint data logging is a method of automatic data capture (using digital technologies such as advanced microprocessors, solid state sensors and fully featured software, which maximize accuracy) in which values from a sensor are recorded and stored in a regular intervals, [Abrar and Patil, (2013); Ojike et al, (2016); Obi et al, (2020). Thus, this humidity and temperature logger is a portable measurement device that is capable of autonomously record humidity and temperature over time. These sensors are also physical phenomena that are stimuli into electronic signals, [Ojike et al, (2016); Obi et al, (2020)]. These electronic signals such as humidity and temperature in this work are then converted into digital data that can be retrieved, and used as the need arises. As there is no moving part to wear out and with powerful software compensation, data loggers can deliver greater accuracy over larger periods of time [Ojike et al, (2016); Sagarkumar et al, (2008); Obi et al, (2020)]. The objectives of this work are to develop a portable low-cost humidity and temperature logger using DHT 11 and Max 6675 sensors to determine the humidity and temperature flow pattern of indoor and outdoor space systems installed with constructed Native-Kankan padded evaporative space cooler. The need for this design arose as a result of the fact that most humidity and temperature loggers are beyond the reach of most researchers in developing countries due to the high cost of these systems and the difficulty in accessing fund prevalent in these regions.

System Description

The data logger prototype was developed based on a microcontroller, battery powered, and equipped with internal memory module for data Storage, Real Time Clock (RTC) and sensors, [Aneja and Singh, (2011); Agus et al, (2011); Obi et al, (2020)]. The system developed has a low power consumption, low cost and portable. Figure 1 shows the inside view of the complete Arduino setup box and also the complete Arduino setup box of the humidity and temperature data logger. Figure 2 shows the block diagram of the data logger.

(a) Inside view of complete Arduino setup box (b) Complete Arduino setup box

Fig. 1. The Humidity and Temperature Data Logger

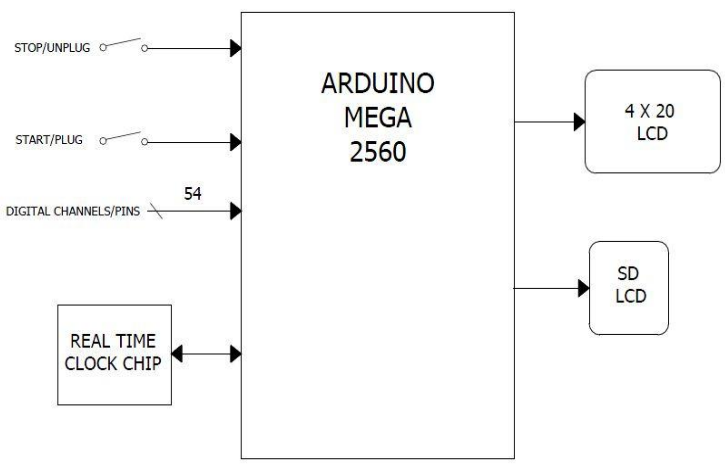


Fig. 2 The Block diagram of the data logger

Fig. 3 shows the data logger software flowchart. The logger starts and initializes, communicates, displays and memory card checked and displays memory card ok. Microcontroller unit (mCU) will detect the timer/tick every 1 second to check RTC timestamp, [Agus et al, (2011); Obi et al, (2020)]. For example, if the timestamp was set to 1 minute, then mCU will record humidity, ø and temperature, T every 1 minutes into memory.

Prototype Development and Calibration

The two most important parts of the system are the sensing elements i.e. DHT 11 humidity sensors and Max 6675 temperature sensors and the data processing elements. The data processing element used in this work is Arduino, a microcontroller. A microcontroller is a small computer on a single integrated circuit containing a processor, memory, and programmable input/output peripherals, [Arduino cc; Obi et al, (2020)]. The Arduino mega is a microcontroller board based on the ATmega 2560 [datasheet]. It has 54 digital input/output pins (of which 15 can be used as Pulse-width modulation, PWM Output). A 16MHz crystal oscillator, a Universal Serial Bus (USB) connection, a power jack, an In-Circuit Serial Programming (ICSP) header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. It is programmed with the Arduino software. Fig. 4 shows the electronic circuit diagram of the humidity and temperature data logger.

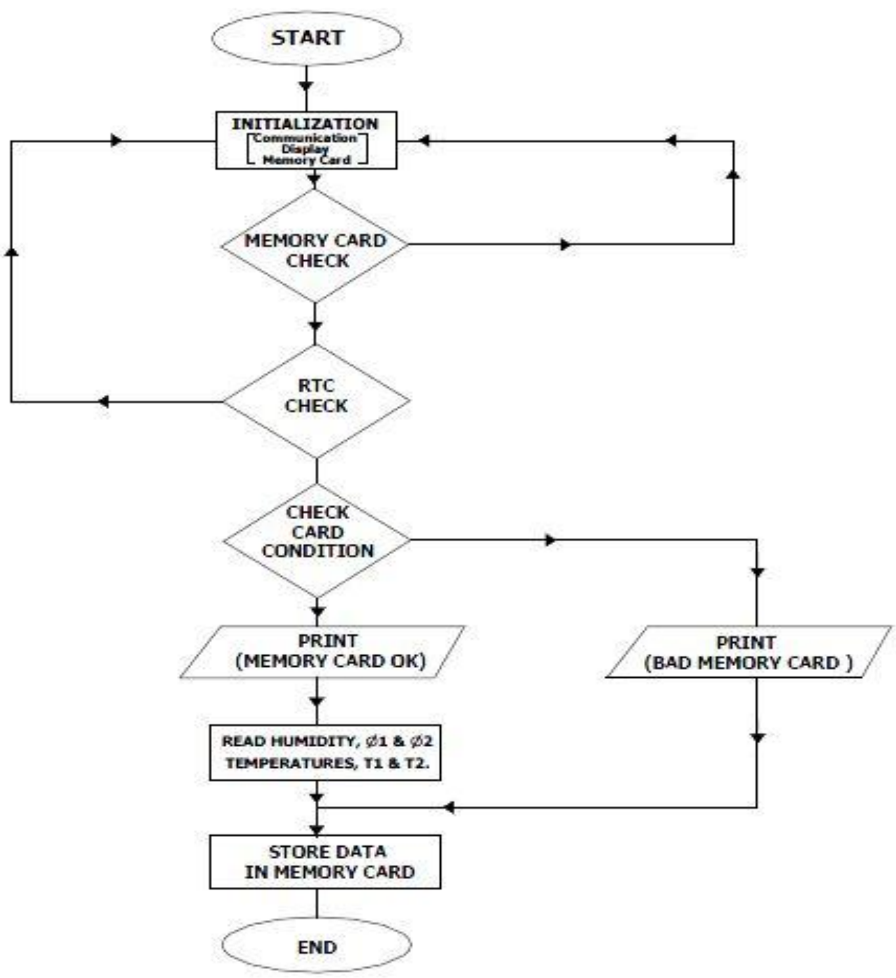


Fig. 3 data logger software flowchart

4 Experimental Setup and Testing

The Experimental setup incorporated the following resources: (1) the built data logger containing the Arduino Mega board, digital temperature humidity DHT 11- humidity sensors, MAX6675 plugs cum sensors, Two LCD Screens, Vero board, Jumper wires; (2) Type K thermocouples. The built data logger has a port for memory card used for data storage. The DHT 11-humidity sensor has inbuilt capacitive humidity sensor and a thermistor to measure the surrounding air hence producing a digital signal. Two LCD screens were used to visualize the displayed information of temperature and humidity fluctuations in the cooler test rig, [Inyako et al, (2018)]. The Jumper wires were used to connect Arduino components to the Vero and Mega boards. The Arduino Mega microcontroller used has in it stored written codes that programmed the inputs/outputs of the Arduino system to ensure measurements. These codes were written via the open-source integrated development environment IDE software application downloadable for windows. The microcontroller is powered using a USB cable connected to a computer, [Inyako et al, (2018)].

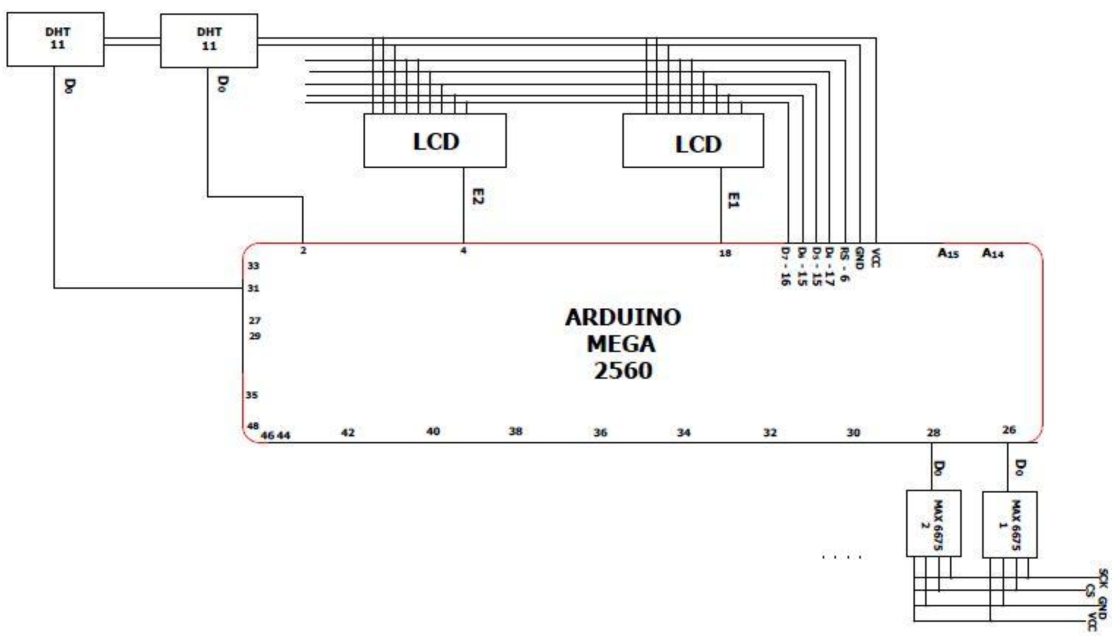
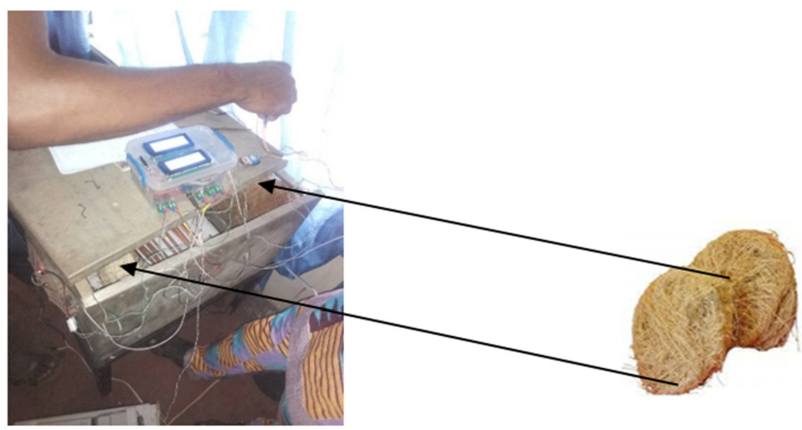


Fig. 4: The Electronic Circuit Diagram of the Data Logger

Two type K thermocouples and two humidity sensors were procured and placed at specific points on the evaporative cooler. The points were labelled as indoor space/cooler exit air temperature-T_1, out-door ambient/cooler inlet Temperature of the room-T_2, ambient humidity-$\emptyset_1$, humidity of the cooled air released into the room-$\emptyset_2$. Picture preview of the experimental setup and Arduino components are presented in figures 5 and 6.

(a) (b) (c)

Fig. 5. (a) Arduino Mega board, (b) MAX6675 plug assembly, (c) MAX6675 plug /Type-K Thermocouple, Source: (sparkfun.com).



(a) (b)

Fig. 6. (a) Cooling Test Rig-Arduino Set up, (b) Native-Kankan fibre sponge used as wet and dry filter pads.

5 Results and Discussion

Results obtained from a cooling load test period for 30 minutes are presented in figures 7-9. In Fig. 7, the temperature profile of the indoor space/cooler exit air temperature –T_1 and the out-door ambient/cooler inlet temperature of the test room-T_2 is plotted against time. The consistent drop in their temperatures clearly shows the evaporation rate and hence, decrease in the space/cooler exit air temperature –T1. The measured data presented in table 1, shows the temperature of the indoor space of the test room $T_{2,}$ dropped from 27℃ to 24.5℃ while the temperature of the cooler inner chambers $T_{1,}$ dropped from 26.25℃ to 24℃. The decrease in the cooler air temperature resulted to the temperature regulation of the indoor test room space over time, (Inyako et al, 2018). In Figure 8, the variations of exit temperature from the cooler test rig showed little or no effects on the humidity levels and the careful study of figure 9 revealed that as the out-door temperature reduces or increases the humidity levels changes insignificantly, Inyako et al, 2018. However, at low temperatures and where the increase in temperatures are insignificant, the temperature profile and humidity profile are almost the same. This is in agreement with literature, (Daly and Flye, 2000)

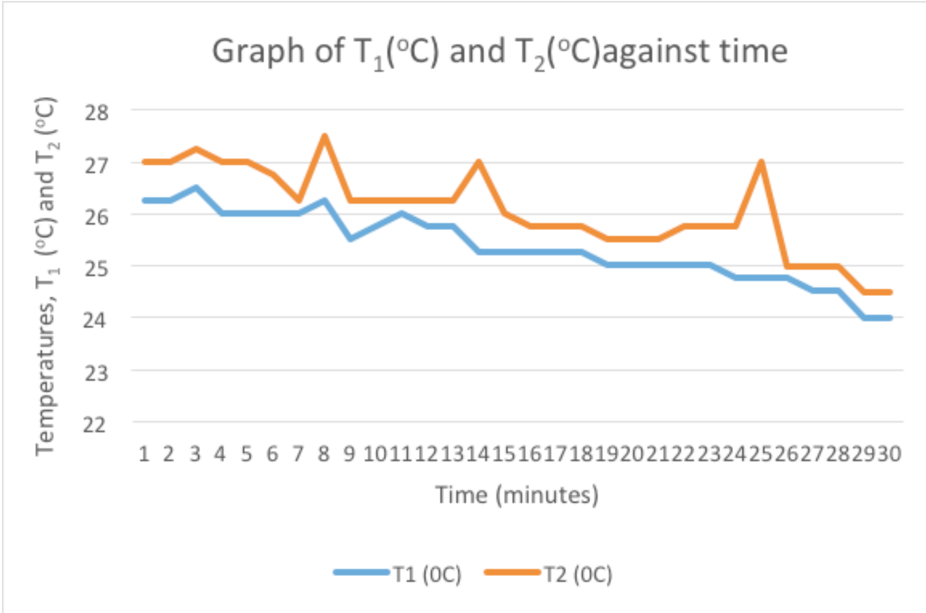


Fig. 7: T_1 (°C) and T_2 (°C) against time.

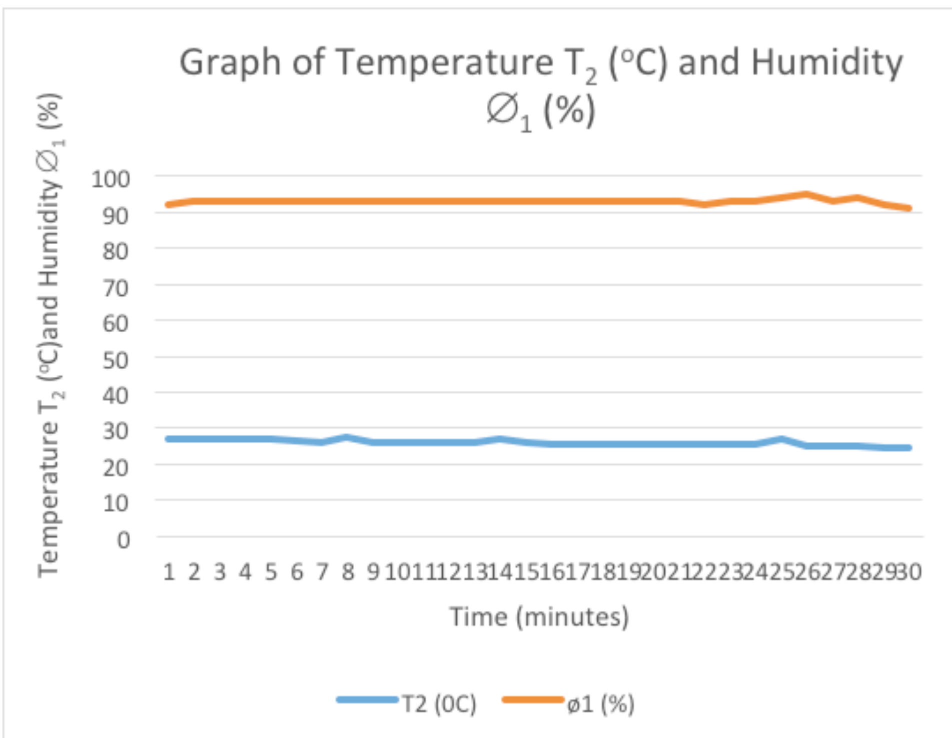


Fig. 8: T_1 (°C) and $\emptyset_2$ (%) against time.

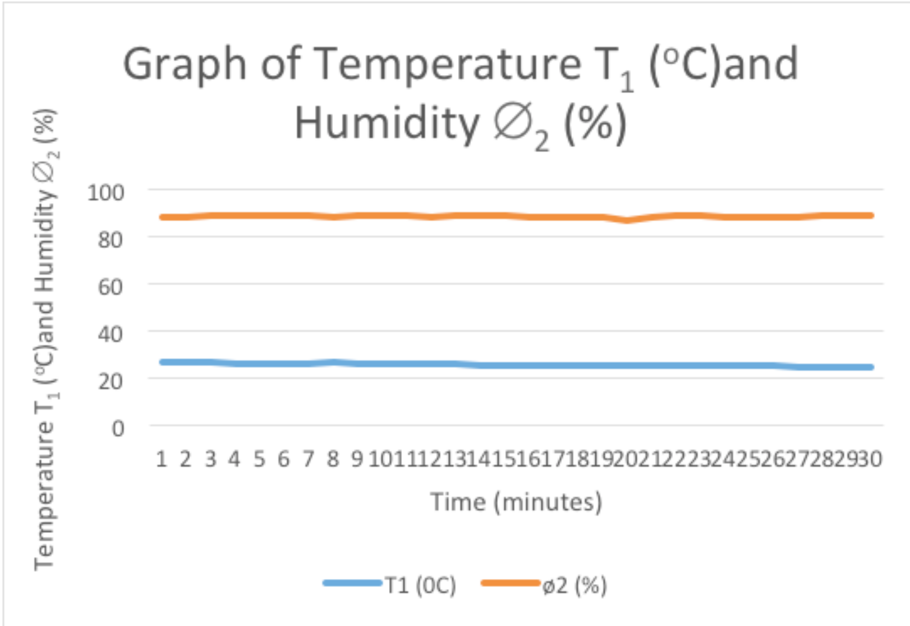


Fig. 9: T_2 (℃) and $\emptyset_1$ (%) against time.

Table 1. Measured Values

Time(min)	T_1 (℃)	T_2 (℃)	$\emptyset_1$ (%)	$\emptyset_2$ (%)
1	26.25	27	92	88
2	26.25	27	93	88
3	26.5	27.25	93	89
4	26	27	93	89
5	26	27	93	89
6	26	26.75	93	89
7	26	26.25	93	89
8	26.25	27.5	93	88
9	25.5	26.25	93	89
10	25.75	26.25	93	89
11	26	26.25	93	89
12	25.75	26.25	93	88
13	25.75	26.25	93	89
14	25.25	27	93	89
15	25.25	26	93	89
16	25.25	25.75	93	88

17	25.25	25.75	93	88
18	25.25	25.75	93	88
19	25	25.5	93	88
20	25	25.5	93	87
21	25	25.5	93	88
22	25	25.75	92	89
23	25	25.75	93	89
24	24.75	25.75	93	88
25	24.75	27	94	88
26	24.75	25	95	88
27	24.5	25	93	88
28	24.5	25	94	89
29	24	24.5	92	89
30	24	24.5	91	89

Source: Inyako et al, 2018

6. Conclusion

The design of a microcontroller-based portable humidity and temperature data logger has been described. Results showed that the Native-Kankan fibre-dry filter pad used reduced the humidity level of cooled air entering the indoor test room space by 2%, Inyako et al, 2018. This humidity and temperature data logger is effective and also an inexpensive tool for monitoring and measuring system performance like the Native-Kankan padded evaporative space cooler. The performance of an air quality of an indoor space room systems were obtained.

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