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Development of a Microcontroller Based Heat Index Meter

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ABSTRACT: The research focuses on the development of a heat index meter using microcontroller technology. A DHT22 thermo-hygrometer sensor was employed to measure ambient temp and relative humidity simultaneously. The analogue values of these parameters were fed into Arduino Uno Microcontroller which is the heart of the developed meter. The microcontroller has been programmed to compute the heat index using an embedded equation. The microcontroller is interfaced with a 16 by 2 Liquid Crystal Display (LCD) to display the measured temperature, relative humidity as well as the computed heat index. The developed instrument performed satisfactorily during testing and evaluation. It is therefore recommended for measurement and monitoring of heat index.

Keyword: DHT; Thermo-hygrometer; LCD; Microcontroller; Heat Index

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INTRODUCTION

Atmospheric weather condition plays a vital role in determining the comfort level of both plants and animals in any environment. The knowledge of life sciences has revealed that various types of living things require different atmospheric weather conditions for their survival. Even man-made devices such as electronic gadgets, drugs, chemicals, and reagents also have their recommended storage and operating weather conditions. Among all the atmospheric parameters, temperature and humidity are the most important parameters that determine the habitability and the chances of survival of living things in a particular environment (Pipoly *et al.,* 2013).

Temperature is a fundamental quantity that expresses the level of hotness or coldness of matter (Lawal *et al.,* 2016). It is a measure of the average translational kinetic energy of a system. Temperature is an ever-changing parameter because of the exposition to a huge array of stimuli from their environment (Vathana and Janarthanan, 2017). Humidity refers to the moisture content in the atmosphere. It is commonly expressed as the percentage of water vapor required to saturate the air at a particular temperature. This percentage is known as relative humidity. Accurate knowledge of the variability of temperature and humidity is of great relevance in the study of agriculture, ecosystem, climate change, weather forecast, radio wave propagation etc.

Several studies have revealed that temperature variation is largely influenced by humidity hence, it is important to factor the humidity of an environment when determining the temperature. The temperature value which is a function of humidity is called apparent temperature or heat index. The heat index is what the temperature feels like to the human body when relative humidity is combined with the air temperature (US Department of Commerce, 2005).

METHODOLOGY

Hardware Selection and Configuration

The developed heat index meter is made up of three major sub-circuits which are; the input unit, the processing unit, and the output unit. The input unit consists of temperature and humidity sensors for sensing the respective physical quantities. The device employed is a two-in-one Digital Humidity and Temperature (DHT) sensor popularly known as DHT22 or Am2302. It is a basic low-cost electronic transducer that uses integrated capacitance and thermistor to measure the surrounding air and spits out a digital through one of its terminals. It consists of 4 terminals labeled as VCC (1), Data (2), NC (3) and Ground (4) as shown in Figure 1. The operating voltage for proper operation ranges from 3 to 5 V while the maximum operating current is 2.5 mA. It has the ability to measure temperature between 0 and 50^o C with an accuracy and resolution of ± 2^o C and 0.01^o C respectively. The humidity range is 20 – 80% with an accuracy of and resolution of ± 5% and 0.1%. Further details about DHT22 are contained in the electronic datasheet for DHT sensors (Alldatasheet, 2003).

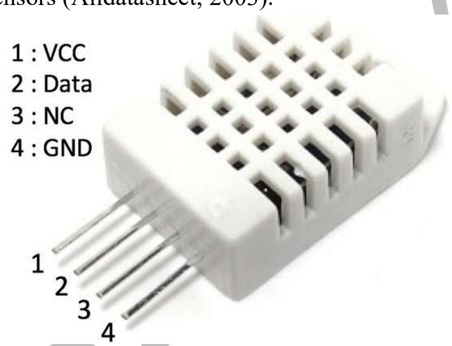

Figure 1: Image of DHT22 and the PIN Configuration

The data pin (pin 2) of the sensor is connected to pin 8 of the Arduino Uno board while pin 1 and 4 were connected to the +5V and 0 V (ground) of the DC voltage source powering the entire circuit.

The processing unit is the heart of the heat index meter. It receives the measured temperature and humidity and computes heat index in degrees Celsius using equation (1) (US Department of Commerce, 2005).

$$HI = C_1 + C_2X + C_3R + C_4TR + C_5X^2 + C_6R^2 + C_7X^2R + C_8XR^2 + C_9X^2R^2 \qquad (1)$$

$C_1 - C_9$ are constants given as:

$C_1 = -42.379$
$C_2 = -2.049015$
$C_3 = -10.143331$
$C_4 = -0.224755$
$C_5 = -6.83783 \times 10^{-3}$
$C_6 = -5.481717 \times 10^{-2}$
$C_7 = -1.22874 \times 10^{-3}$
$C_8 = 8.5282 \times 10^{-4}$
$C_9 = 1.99 \times 10^{-6}$

X is the temperature factor given as $X\frac{T-32}{9}$

T is the temperature in degrees Celsius

R is the relative Humidity in %

The processing unit deployed in this project is the Arduino Uno R3 board which is made of Microcontroller IC {Atmega328P) and its peripherals. It has 6 analogue input pins and 14 digital Input/Output (I/O Ports) pins as shown in figure 2. Some of these pins are multifunctional hence they can be used for other purposes. It has a clock speed of 16 MHz, EEPROM of 1 Kb and flash memory of up 32 Kb which makes it ideal for the developed instrument. The full technical specifications of the Arduino Uno board and Atmega328P IC are available at Arduino website (Arduino, 2014).

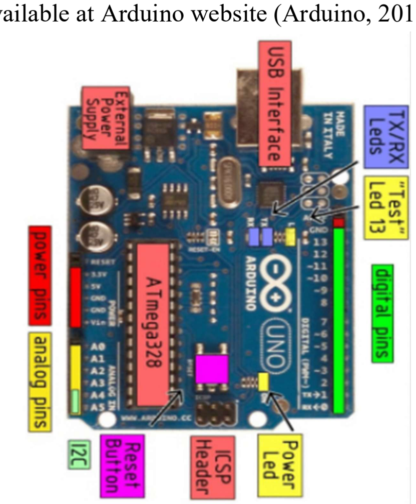

Figure 2: Image of Arduino Uno Board (Aniedu *et al.*, 2016)

The pin 4 and 5 of the analog input ports of the Arduino were made to function as serial data (SDA) and serial clock (SCL) pins respectively. These pins were interfaced with the corresponding SDA and SCL. The temperature T(°C), Relative Humidity H(%) and Heat Index are sent to the output unit via the SDA and SCL pins shown in the circuit diagram presented in Figure 4.

The output unit is the final stage which presents the measured and calculated parameters. It is made of 16 by 2 Liquid Crystal Display (LCD) panel connected to the Arduino Uno board via i2C adapter. Figure 3 shows the block diagram of a typical 16 by 2 LCD Panel. It is a digital display board capable of displaying 32 alphanumeric characters on two lines at a time. Each line can accommodate 16 characters hence the name 16x2 LCD screen. The i2C adapter reduces the bulk of wires and eliminate construction of backlight contrast potentiometer when interfacing parallel port LCD with Arduino board. The Reset (RS, Read/Write (RW) and Enable (E) pins of the LCD were connected to pins 4, 5 and 6 of the i2C adapter respectively. The data pins D4 – D7 shown in Figure 3 were connected to pins 9 – 12 of the i2C adapter as depicted in Figures 4 and 5.

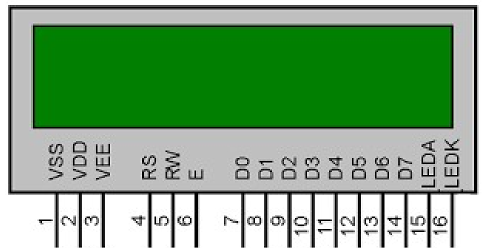

Figure 3: Block diagram of 16 x 2 LCD

Software Implementation and Simulation

The entire circuit was designed and simulated on proteus 8 professional electronic simulator software. Algorithm and flow chart for the operation of the hardware were prepared in accordance to its requirements. The program code was written and compiled using Arduino compiler software. The Hex file was generated and uploaded to the Microcontroller IC COM Port after satisfactory simulation on the proteus software.

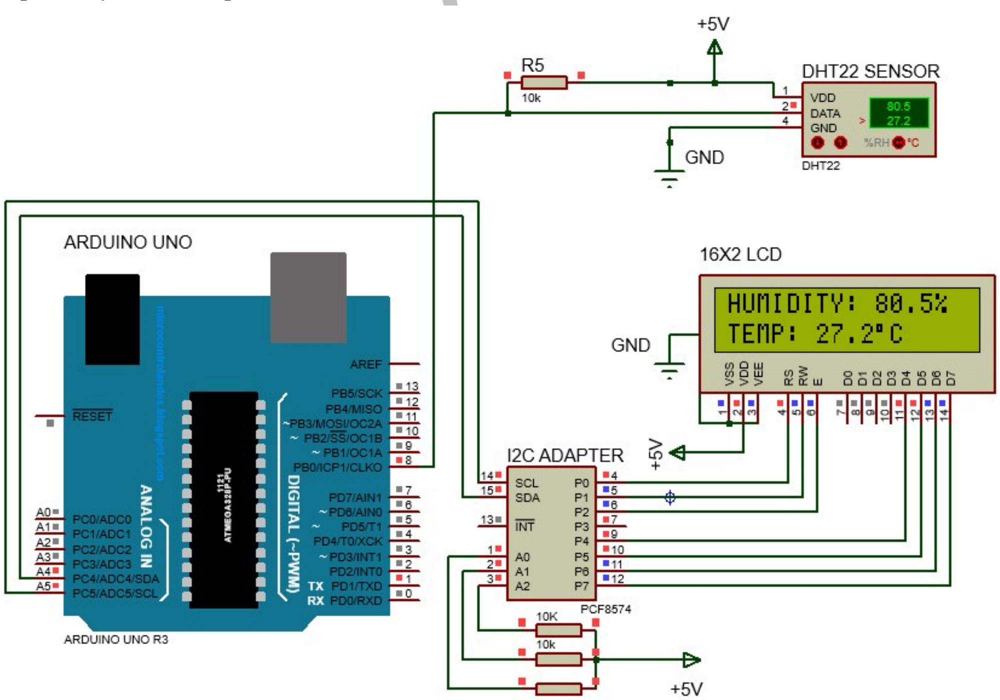

Figure 4: Circuit diagram of the developed heat index meter showing temperature and humidity

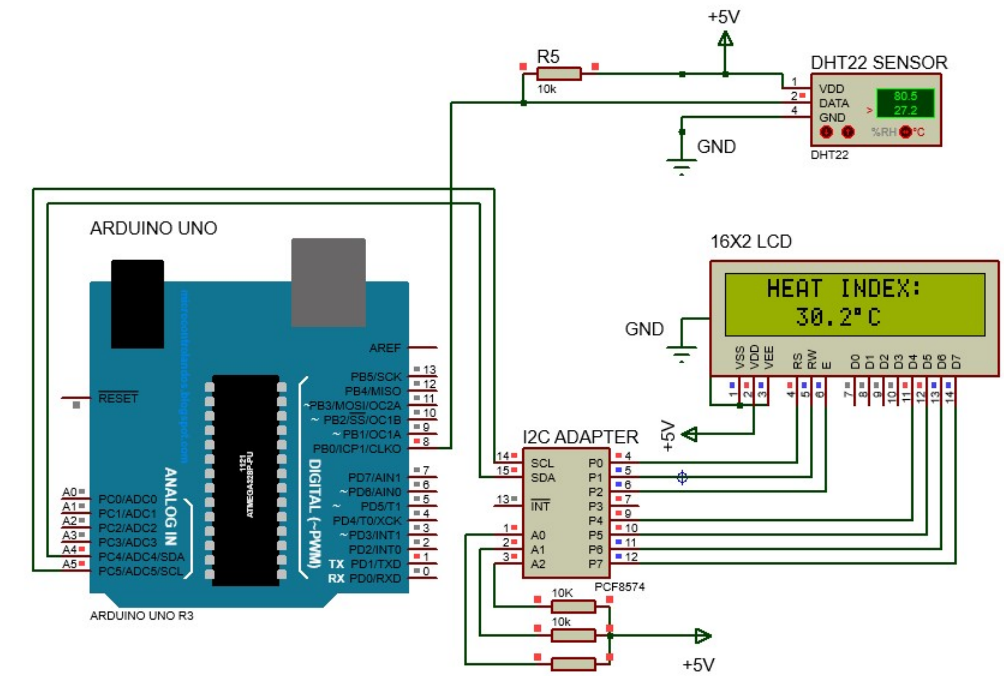

Figure 5: Circuit diagram of the developed heat index meter showing heat index

TEST, RESULTS AND DISCUSSION

The components were assembled and connected as illustrated in Figure 5. The hex file of developed code was initially uploaded onto the virtual Arduino IC in the proteus simulation software. The simulation was successful and satisfactory hence, the code was uploaded to the hardware and tested. Figure 6 is an image of the developed meter during testing and evaluation.

The developed instrument was tested under different weather conditions to ensure optimum performance. Due to the unavailability of hygrometer and heat index meter, only the temperature measured by the developed meter $T_{DI}(^oC)$ were compared with the corresponding values obtained from standard instrument $T_{SI}(^oC)$. Table 1 presents typical results obtained from a standard thermometer and the developed instrument when their sensors were exposed to the atmosphere, heat from an electric heater, and coldness from a refrigerator.

Statistical analysis shows that the instrument performed excellently with an average percentage of about 4% and a correlation coefficient of 0.99. The sensor responds swiftly to changes in temperature and relative humidity. Hence, the instrument can be adopted in the monitoring and observation of these meteorological parameters.

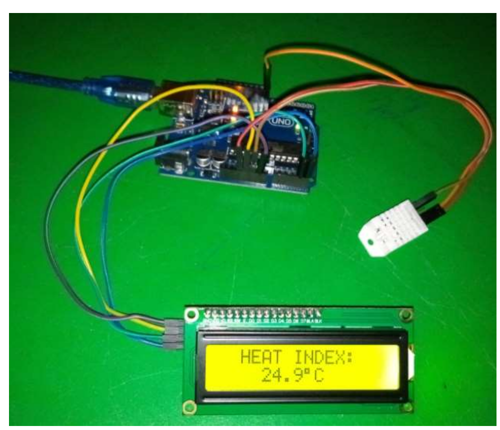

Figure 6: Testing and evaluation of the developed heat index meter

Table 1: Results of measurement taken by standard thermometer and the developed meter

T_{SI}(°C)	T_{DI}(°C)	RH%	Hi (°C)
19.8	20	98.2	15.8
20.9	21	97.4	17.3
21.7	22	96.1	19.1
23.3	23	94.9	21.1
23.8	24	93.6	23.3
24.8	25	92.5	25.6
25.9	26	91.4	28.1
27.3	27	90.2	30.8
28.4	28	90.1	33.8
28.8	29	89.7	37.0
29.7	30	85.7	39.4
30.8	31	80	40.9
31.9	32	75.3	42.4
33.3	33	74.2	45.3
34.1	34	78.5	51.3
34.7	35	74.8	53.2
34.8	36	72.7	55.9
37.3	37	69.3	57.7
38.2	38	66.8	60.0
38.8	39	64.6	62.4
39.9	40	62.4	64.7

CONCLUSION

A portable and cost-effective heat index meter has been designed and implemented using microcontroller technology. The instrument is capable of reading and displaying temperature and relative humidity between 0 – 50° C and 20 – 80 % respectively. The developed instrument was compared with a standard instrument and it has a correlation coefficient of 0.95. Computation of heat index is the major feature of the instrument, hence it can be deployed to determine the environmental comfortability of plants and animal at any instant. It has a degree of accuracy and reliability; hence it could be recommended for scientific, industrial and other purposes.

REFERENCES

Alldatasheet (2003): Electronic Component Data Sheet, http://www.alldatasheet.com/view.jsp?Searchword=DHT22

Aniedu A. N., Ufoaroh S. U., Okechukwu G. N. and Oranugo C. O (2016): Real Time Data Acquisition and Logging Using GSM Technology. Advances in Multidisciplinary and Scientific Research. Vol. 2 No. 2, Issue 1

Arduino (2014): Arduino and Genuino Products, Getting started with Arduino and Genuino Uno, https://www.arduino.cc/en/pmwiki.php?n=Main/arduinoBoardUno

Lawal B. Y., Dada J. B., Ahmed-Ade F. (2016): Construction of Automatic Temperature Controller for Monitoring Heating and Cooling Systems. Journal of Sustainable Technology. Vol 7. No. 1, ISSN: 2251-0680, Pp 1-5.

Pipoly I., Bokony V., Seress G., Szabo K. and Liker A. (2013): Effect of Extreme Weather on Reproductive Success in a Temperate-Breeding Songbird. PLoS ONE 8(11): e80033. https://doi.org/10.1371/journal.pone.0080033

US Department of Commerce (2005): National Weather Service, Oceanic and Atmospheric Administration https://www.weather.gov/ama/heatindex

US Department of Commerce (2005): National Weather Service, Oceanic and Atmospheric Administration https://www.weather.gov/media/epz/wxcalc/heatIndex.pdf

Vathana A. K., Janarthanan B. (2017): Design and Working of Datalogger Using Microcontroller AT89C51, International Journal of Latest Research in Engineering and Technology (IJLRET) ISSN: 2454-5031, Volume 03 - Issue 04, pp. 42-47.