Design, Simulation and Construction of a Digital Mobile Weather Monitoring Station

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ABSTRACT

Despite the importance of weather in aviation industry, agriculture practices and other sectors, the measurement of atmospheric parameters in real time monitoring has been sparsely discussed in the literature and the importance of digital mobile weather station has not been well stressed out. In this study, design and construction of a digital mobile weather station was carried out using Arduino Nano microcontroller ATMega385p. The circuit was simulated using Proteus v8.7. The constructed device was used to measure temperature, humidity and sunlight. The device readings were compared with standard measured values obtained from Nigerian Metrological Agency (NIMET) in the month of February and August. Result shows that the slope of the regression line (zero intercept) relating device measurement to standard readings from NIMET in the month of February for temperature was 1.01 (R^2 = 0.923) while that of humidity was 1.006 (R^2 = 0.987), and sunlight was 1.002 (R^2 = 0.999). Also, the slope of the regression line (zero intercept) relating device measurement to standard readings from NIMET in the month of August for temperature was 0.994 (R^2 = 0.985) while that of humidity was 1.002 (R^2 = 1), and sunlight was 0.998 (R^2 = 0.991). This implies that there is no significant difference between device measurement and standard readings from NIMET since both regression lines accounts for ≈ 98.23% of the variance. However, the device can be used to obtain data on weather parameters with great degree of accuracy for flight monitoring, surfing, plant growth and development, and marine technology.

Keywords: *atmospheric parameters; mobile weather station; metrology; microcontroller; regression analysis; Proteus8.7*

1. Introduction

Weather is the state or condition of the atmosphere at any given period of time (Ukhurebor et al., 2017; Ahrens, 2003). It directly or indirectly affects our day by day life, for example cloud bursts, storms, tornado, tsunami etc. (Sabharwal et al., 2014). Weather affects almost every field of man's activities, including agriculture, health, transportation and leisure time. According to Ukhurebor *et al.* (2017) one of the major influence on the lives of people is weather, as it has significantly shaped our cultures, habits, attitudes, behaviour and our environments in general. Weather has always been a universal concern with the present changes in the climate and global warming becoming an issue. It is mostly influenced by many factors including location latitude, elevation and proximity to water bodies (Chawla et al., 2015).

Weather monitoring has been very important to man due to the rapidly changing atmospheric conditions. A weather station is that facility on land or sea, which has the instruments and devices for observing and measuring atmospheric parameters to provide the information for weather forecasts (Sabharwal et al., 2014). The parameters for weather observations include temperature, atmospheric pressure, relative humidity, wind speed, light intensity, altitude, dew point, precipitation, wind direction, rainfall amounts etc. (Ukhurebor et al., 2017; Sabharwal et al., 2014). Weather monitoring holds great importance in agricultural production on crop growth, development, and yields, on the incidence of pests and diseases, on water needs, and on fertilizer requirements (Tabassum, & Hossain, 2018). According to Panigrahy *et al.* (2016) for more production, a farming system needs real-time monitoring and update of soil moisture, rain detection, and different data analysis. In the case of Nigeria, the aviation industry has suffered loss of lives and properties worth billions of naira due to bad weather monitoring information (Daily Post Nigeria, 2002). For example, the recent plane crash of the Nigerian Air Force jet which killed the Chief of the Army Staff, Lt Gen Attahiru Ibrahim, and 10 other officers on the 18th May, 2022 was due to bad weather (Sahara Reporters, 2021; The Cable, 2021). Also, the Nigerian Airforce F7-Ni fighter aircraft which crashed in Yola on 10th October, 2015 killing the pilot, was also attributed to bad weather and not enemy attack (Omonobi, 2015). Therefore, a good weather monitoring system is of great importance.

In view of the above, the objective of this study is to design, simulate and construct a digital mobile weather monitoring systems consisting of weather sensors to measure the meteorological variables and data logging facility in a cost effective manner. The combination of multiple sensors into one integrated weather station board has been made possible by the use of microcontrollers. The advantage is that programmable alerts are available in this monitoring systems which indicate out-of-range conditions. Data logging facility is available. In line with Sabharwal *et al.* (2014) the system can be linked to the PC or Laptop and the detailed information from a number of channels on a huge geographical area can display on a GUI application which can be used by the weather stations to make the forecasting.

2. Materials and Methods

2.1 Materials

The materials and their specification that were used for the design, simulation and construction of a digital mobile weather monitoring system include ATmega325 Arduino Nano microcontroller, DHT11 Temperature/Humidity Sensor, Liquid Crystal Display, Photo Resistor (Light Sensor), MQ5 Smoke Sensor, Soldering Iron, Digital and Analog type Multimeter, Toggle switch, Bread Board, Vero Board, Soldering Lead, White plastic casing, IN4007 Zener Diode, 18v DC Regulated to 5v, Serial Terminal, Connecting Wires, resistor, and capacitors.

2.2 Methods

The method for this study is in Four (4) parts which includes design, simulation, construction, and testing methods.

2.2.1 Design Method

The design of the digital mobile weather monitoring station was carried out according to the block diagram shown in Figure 1. The block diagram has six segments which are: The Power supply, Temperature & Humidity sensor using DHT11, the smoke sensor (MQ5), the Sunlight intensity (LDR_1) sensor, the microcontroller (ATMEGA 325) and the Liquid Crystal Display (LCD).

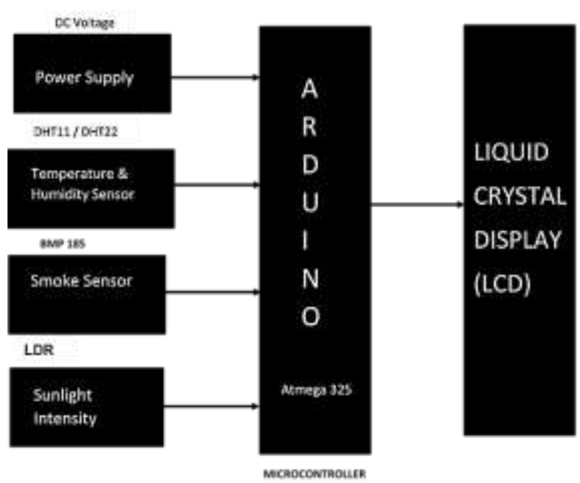


Fig. 1: Block Diagram of Digital Mobile Weather Station

2.2.1.1 Power Unit Design Method

The power unit uses a DC supply which has basically three major units: the battery, the filter and the regulator.

Battery: The voltage requirement was 5Vdc. However, the power supply is realized when two 9V dry cells batteries are connected in series, giving a total of 18Vdc which is then regulated to 5Vdc through a Zener diode (IN4007) by a regulator (LM 7805).
Filter: A filtering circuit guarantee the desired output voltage. To obtain the value of the input capacitance in the filter section the equation (1) is used:

$$C = I\frac{dt}{dv} \quad (1)$$

Where dt is the time between peak of the input wave, C is the filter capacitance, I is the peak output current, and dv is the rectified voltage.

Voltage Regulator: Voltage regulator is an electronic component designed to maintain a stable voltage supply. The regulator used in this work is LM 7805, which provides fixed regulated voltage from 18v to 5v.

$$V_T = V_1 + V_2 \quad (2)$$

Where V_T is the total voltage in series, V_1 is the voltage of the first 9V batter and V_2 is the voltage of the second 9V battery. Since the microcontroller voltage requirement is $5V$, we then need to carry out our design having that at the back of our mind.

Capacitor Design: If C_1 parallel to C_2, the equivalent capacitance is given as:

$$C_{eq} = C_1 + C_2 \quad (3)$$

$C_3 // C_2$ and C_3, using this relation

$$C = \frac{Q}{V} \quad (4)$$

were C = capacitance, Q = is charge on the conducting plate, and V = voltage

$$Q = \frac{C}{V} \quad (5)$$

Therefore,

$$C_1 = \frac{Q}{V} \quad (6)$$

$$C_2 = \frac{Q}{V} \quad (7)$$

For the design of resistor used in the solar sensor stage

$V = IR$ (Ohms law) (8)

Where $V =$ voltage develop, $R =$ Resistance to the conducting flow, I= current dissipated

R = V/I (9)

2.2.1.2 Temperature/ Humidity Sensor Design Method

DHT11 detects water vapour by measuring the electrical resistance between the two electrodes. The humidity sensing components is moisture holding substrate. With electrodes applied on the surface substrate ions are released between the electrodes. The change in resistance between the two electrodes is proportional to the relative humidity, DHT11 measure temperature with surface mounted NTC temperature sensor (Thermistor built into the unit).

2.2.1.3 Smoke and Sunlight Intensity Sensors Design Method

Basically, there are two types of smoke sensors: Photoelectric smoke sensors and the ionization smoke detector and light source. The moment smoke enters the chamber and crosses the part of the light beam, the smoke scatters the light beam. When it gets in touch with the sensor, it triggers the alarm and then send a signal to the microcontroller which then transmit it to the LCD (readable information). For the sunlight intensity, the **l**ight dependent resistor (LDR) is the sensors employed in this work. It uses the principle of photoconductivity in which light is absorbed by the material and the conductivity of the material reduces.

2.2.1.4 Microcontroller Unit Design Method

The Microcontroller is designed to execute specific operation in an embedded system. It does this by interpreting data it receives from its input and output peripherals using its central processor. The thermal sensors will be converted to digital signals and further processed by a microcontroller, which is acting as data logger. It then sends the information to the LCD into a readable form. All other components are interfaced with the microcontroller which controls and synchronizes the entire operations of the modules and handles data and command from external devices. However, the period T in which the microcontroller finishes its single instruction is given as follows:

$$T = \frac{1}{F}$$ 11

The features of the microcontroller are presented in Table 1 and the microcontroller Atmega328p pin mapping is also presented in Figure 2.

Table 1: Features of the microcontroller

S/N	Features	Specifications

1	Microcontroller	ATMega 325P
2	Operating Voltage	3.3V or 5V (depending on module)
3	I/P voltage	3.35 -12v (3.3 module) or 5-12v (5 module)
4	Digital I/P Pins	14 (of Which 6 provides PWM O/P
5	Analog input pins	6
6	DC current per I/P Pin	40 mA
7	Flash memory	32 KB (of which 0.5kb, used by boat loader)
8	SRAM	2kb
9	EEEPROM	1kb
10	Clock	8 MHz (3.3v) or 16 MHz (5v Module)
11	Analog input pins	6
12	DC current per $\frac{i}{p}$Pin	40MA

(Components101, 2018)

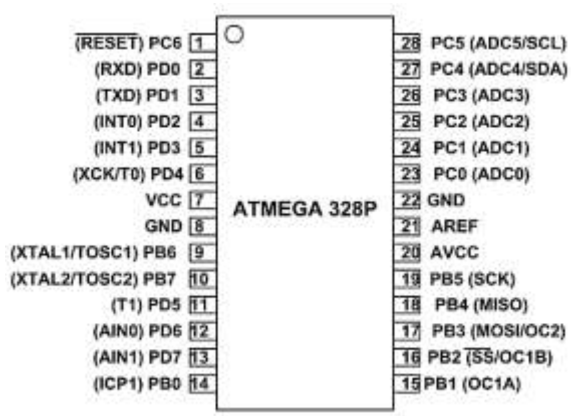


Fig. 2: ATMega 328P pinout (Components101, 2018)

2.2.1.5 Liquid Crystal Display

The LCD displays in a visual form the data being transmitted into a readable manner. The pin out connection of the LCD versus the Arduino Nano are given as follows:

i. D6 of the LCD is connected to pin 2 of the Arduino.
ii. D4 to pin5, pin1 (Vss) is connected to the variable resistor.
iii. VEE is meant to vary the potentiometer.
iv. D11 to pin 5 of the Arduino, and the RW (pin5) to the ground.
v. Pin13 to pin3 and pin14 to pin2.
vi. R5 to ground.
vii. R15 of the LCD will produce 5V, passing through a resistor of 330 ohm.
viii. Ao of Arduino Nano is connected to Ao of the MQR (smoke sensor).
ix. A1 to the LDR.
x. Pin11 of the Arduino Nano is connected to the data pin of the DHT11.

xi. While the Vcc of the DHT11 will produced 5V.

2.2.2 Simulation Method

The simulation of the device was carried out using Proteus v8.7 software. It was done to ascertain the successful realisation of the circuit. The simulation process includes the software implementation, flow chart, and the algorithm.

2.2.2.1 Software Implementation Method

The software used for this project is Proteus version 8.7, which is a software programme using C++ Machine language. This is chosen because it made the Microcontroller easy to debug, test, maintain, and frees the programmer from the details of multi-byte math and paging and generally improves code readability. It also maintains ability using C++Development (King, 2009).

2.2.2.2 Flow Chart

The flow chart for the simulation of the digital mobile weather station is presented in Figure 3.

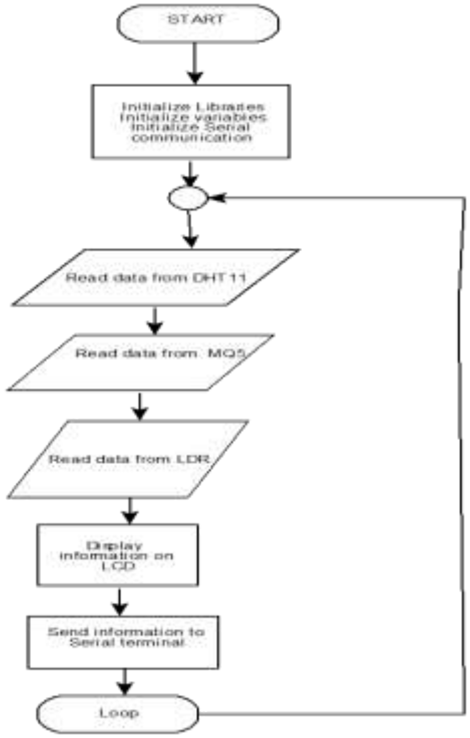


Fig. 3: Flow Chart of Digital Mobile Weather Station

2.2.2.3 System Algorithm

The algorithm for the study is as follows.

1. Realization of voltage requirement which is 5v from the regulated voltage, using a simple circuit connection.

2. Initialization of libraries, variables and serial communications.

3. Reading of data from DHT11 (Temperature and Humidity), MQ5 (Smoke sensor) and LDR (Light or solar sensor).
4. Send the information to the serial terminal.

2.2.3 Construction Method

Basically, the construction of this project was done in three parts including layout of the design, component assembly/ placement, and soldering methods. The layout was done according to circuit specifications following the block diagram. The components were first assembled on a breadboard to see its workability after which they were transferred to the Vero board for permanent soldering. However, too much Lead was avoided to prevent clumsiness, bridging of the component and short circuiting.

2.2.4 Testing Method

2.2.4.1 Continuity Test Method

The entire component in the device where properly tested to ascertain their proper working condition. To ensure that no components are being heated and to ensure that there is no loading effect, a stage-by-stage test was carried out to check the continuity of each stage using the digital multimeter.

2.2.4.2. Validity Test Method

Measurements were carried out with the device to measure temperature, humidity, smoke, and sunlight intensity for every 30 minutes interval from 6:00 am to 6:00 pm in wet and dry season for the months of February and August respectively. The results of the device measured values were compared to standard measured values from Nigerian Metrological Agency (NIMET) using a simple regression analysis.

3. Results

3.1 Design Analysis

3.1.1. Power Unit

From Equation 1 we obtained the equivalent voltage as:

$$Veq = V_1 + V_2$$

$$Veq = 9V + 9V = 18V$$

Since the voltage requirement of the microcontroller is 5v dc, the regulator then regulates it to 5v dc.

C_1 is parallel to C_2 therefore, the equivalent capacity of a parallel combination of capacitor in the group.

$$C_{eq} = C_1 + C_2 + C_3$$

C_3 is also parallel to C_1 and C_2.

Now to determine the value of C_3(10nf), we use equation 6 as follows:

$$C = {}^{Q}/_{V}$$

$$Q = C\,x\,V = 50,000 = 50\,NC/m^2$$

$$Q = C\,x\,V$$

$$C_3 = {}^{Q}/_{V} = \frac{50\,Nc/M^2}{5} = \frac{50{,}000{,}000}{5} = 10\,nf$$

$$C_2 = \frac{Q}{V}$$

$$But\ Q = CV = 1{,}000{,}000{,}000\ x\ 5 = 5\ x\ 10\ nc/m^2$$

$$C_2 = \frac{Q}{V} = \frac{5x10^{-9}}{5} = 1000\mu f$$

$$C_1 = \frac{Q}{V}$$

Since $Q = C\,x\,V = 100x10^{-9}NC/m^2$

$$C_1 = \frac{Q}{V} = \frac{500\ x\ 10^{-9}}{5} = 100nf$$

3.1.2 Solar Sensor Stage

The limiting resistor connected in series with the LDR can be calculated using equation 8 and 9 as follows:

$$I = \frac{V}{R} = \frac{5}{10,000} = 0.0005 = 0.5mA$$

Now the value of R is obtained as:

$$V = IR$$
$$R = \frac{v}{i} = \frac{5}{0.5mA} = \frac{5}{0.5000} = 10,000\Omega = 10k$$

3.2 Simulation Result

Simulation was done using Proteus 8.7 according to the circuit design. The result of the simulation is clearly shown as output from the Proteus software in Figures 4, and 5. The firmware for the Portable Weather Station is developed in Arduino programming language and the hardware is simulated in Proteus ISIS 8.7 environment.

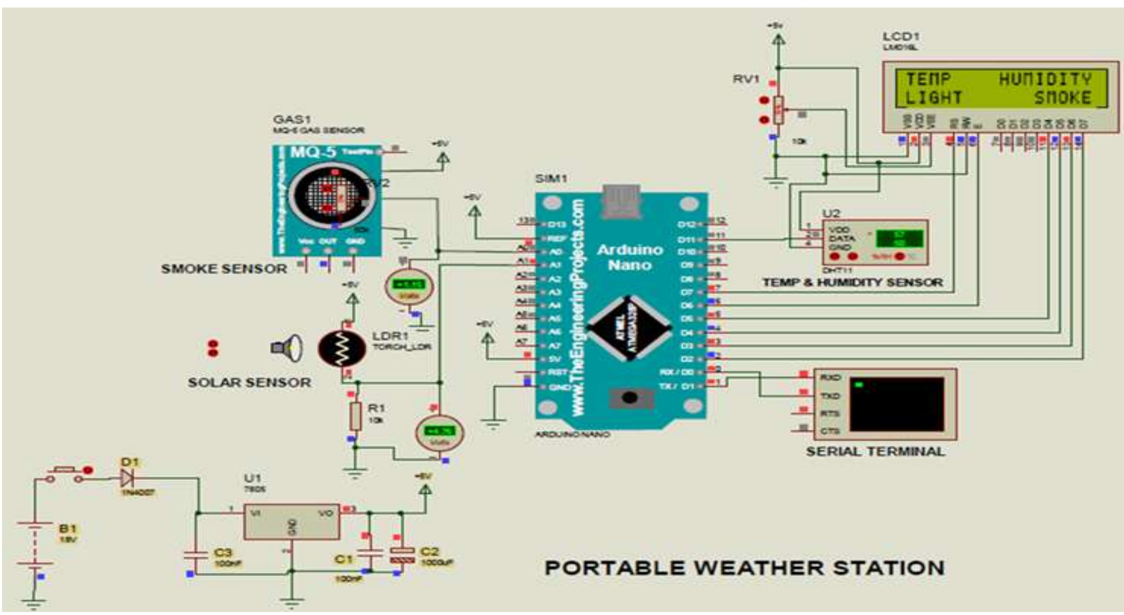


Fig. 4: Simulated result of system initialized showing weather parameters to be measured

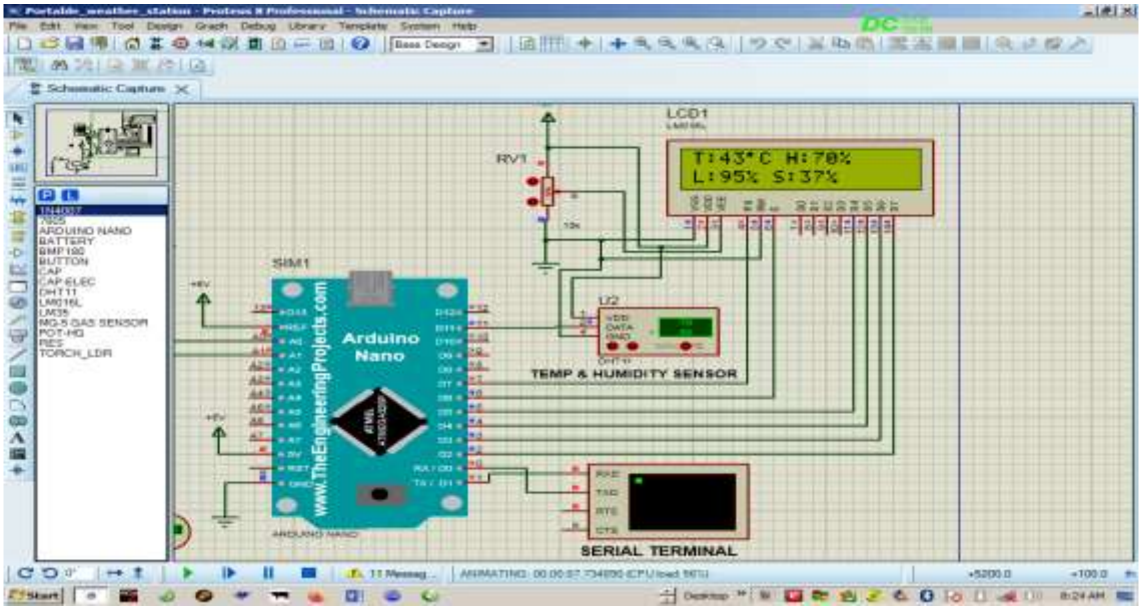


Fig. 5: Simulation results with all measured weather parameters

Figure 4 shows the simulation result of system initialized showing weather parameters to be measured including temperature, humidity, light, and smoke. Figure 5 shows the simulation results after varying the smoke sensor to 50% and varying the light source close to the LDR, with the DHT11 Sensor set to temperature 50°C and Humidity 72%.

3.3 Circuit construction and Casing

The construction was carried out first on a bread board to ensure that the circuit is working as required, then transferred to the Vero board for permanent soldering. The top view of the constructed device in the casing with permanent soldering on Vero board is shown in Figure 6. The casing used was a white coloured plastic material, having the dimension 15cm length x 15cm width for mechanical protection. It is provided with 2no. of 0.5cm diameter hole for the light intensity and smoke concentration, 2no. of 2cm x 1cm windows for the temperature/humidity and USB port. 4no. of 0.25cm diameter hole within 0.5cm diameter groove edges of its top side for screw lock, 1no. of 0.5cm diameter hole for the power switch tighten by 1.5cm diameter nut and 1no. of 7cm x 2.3cm hole for LCD. Figure 7 shows the isometric diagram of the casing, while the complete packaged device in a casing is shown in Figure 8.

Fig. 6: Top view constructed device on Vero board

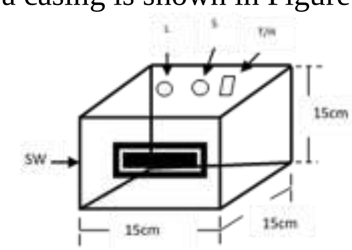


Fig. 7: Isometric diagram of the casing

Fig. 8: Complete packaged device in casing

3.4 Circuit Testing Analysis Result

3.4.1 Continuity Test

The entire components in the device were properly tested to ascertain their proper working condition using a digital multimeter. Confirmation of its work was done after the components were soldered on the Vero board and oscillation of the circuit was checked using oscilloscope. Since the voltage requirement of the microcontroller was 5Vdc the proper checking/ testing was done to see whether the output power from the regulator is exactly 5Vdc.

3.4.2 Validation Test Results

Performance evaluation test was carried out to validate the functionality of the constructed device. The device was tested for temperature, humidity and sunlight intensity and the results were recorded against the standard measurements done by Nigeria meteorological Agency (NIMET). Measurements were carried out at 30 minutes interval from 6.00am to 6.00pm for both wet and dry season. Measurement of temperature was carried out on 3rd February, 2019 for dry season and 18th August, 2019 for wet season. Measurement of humidity was carried out on 5th February, 2019 for dry season and 9th August, 2019 for wet season. Measurement of sunlight intensity was carried out on 10th February, 2019 for dry season and 15th August, 2019 for wet season. The results are presented in Tables 2, 3 and 4 respectively.

Table 2: Result of Temperature for the month of February 3rd and August 18th, 2019

Time	February Reading		August Reading	
	Device Reading °C	**NIMET Reading °C**	**Device Reading °C**	**NIMET Reading °C**
6:00	31.2	31.3	20.3	20.2
6:30	31.5	31.4	20.4	20.3
7:00	31.6	31.5	21.7	21.6
7:30	32.3	32.5	22.3	22.4
8:00	33.5	33.6	23.6	23.5
8:30	34.3	34.5	24.4	23.4
9:00	34.7	34.9	25.5	25.3
9:30	35.8	36.7	26.3	26.2
10:00	37.4	37.9	27.2	27.1
10:30	37.2	37.1	27.0	27.1

11:00	36.8	34.7	28.3	28.2
11:30	35.6	35.4	28.2	28.1
12:00	34.1	35.7	29.6	29.5
12:30	36.5	36.6	29.4	29.3
1:00	37.3	37.5	29.4	29.8
1:30	38.9	38.7	30.3	30.2
2:00	39.2	39.4	31.2	31.5
2:30	39.7	40.3	31.7	31.6
3:00	39.5	39.6	31.4	31.3
3:30	38.4	39.3	30.5	30.4
4:00	37.7	38.8	29.6	29.5
4:30	36.8	37.8	28.7	28.5
5:00	35.8	36.9	27.6	27.5
5:30	34.7	35.8	26.4	26.3
6:00	33.6	34.8	27.2	25.4
Mean	35.76	36.11	27.13	26.97

Table 3: Result of Humidity for February 5th and August 9th, 2019

Time	**February Reading**		**August Reading**	
	Device Reading %	**NIMET Reading %**	**Device Reading %**	**NIMET Reading %**
6:00	34.2	34.1	91.1	91.2
6:30	33.1	33.0	90.5	90.7
7:00	32.3	32.4	89.1	89.2
7:30	30.1	30.0	79.0	79.1
8:00	30.2	30.1	68.1	68.2
8:30	29.1	29.2	67.1	67.2
9:00	28.0	28.1	65.1	65.3
9:30	27.2	27.1	63.1	63.2
10:00	26.1	26.2	60.1	60.2
10:30	25.3	25.2	59.0	59.2
11:00	24.1	24.2	57.0	57.1
11:30	23.3	23.1	55.1	55.2
12:00	22.1	22.2	54.0	54.1
12:30	21.4	21.5	42.1	42.2
1:00	21.1	21.2	40.1	40.2
1:30	21.2	21.3	39.1	39.2
2:00	22.0	22.1	38.1	38.2
2:30	25.2	25.3	37.2	37.1
3:00	26.0	26.1	38.0	38.1
3:30	28.1	28.2	43.1	43.2

4:00	29.2	29.3	50.1	50.2
4:30	29.1	29.0	51.3	51.1
5:00	30.0	31.1	52.3	52.4
5:30	31.1	33.2	59.0	59.1
6:00	33.2	33.1	60.1	60.2
Mean	27.31	27.45	57.95	58.04

Table 4: Result of Sunlight Intensity for February 10th and August 15th, 2019

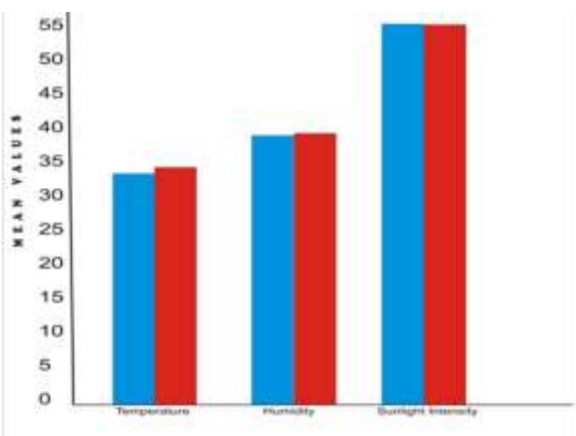
Time	**February Reading**		**August Reading**	
	Device Reading %	**NIMET Reading %**	**Device Reading %**	**NIMET Reading %**
6:00	55.0	54.1	35.0	35.1
6:30	56.1	56.2	36.1	36.2
7:00	57.2	57.3	37.0	37.1
7:30	58.0	58.2	38.0	38.1
8:00	59.1	59.4	40.0	40.1
8:30	60.1	60.3	41.1	41.2
9:00	62.1	62.2	42.1	42.1
9:30	64.0	64.3	44.2	42.1
10:00	66.1	66.2	46.0	46.1
10:30	66.9	67.8	47.2	47.1
11:00	69.2	69.4	47.1	47.2
11:30	70.1	70.3	49.0	49.1
12:00	72.0	72.2	50.1	50.2
12:30	73.0	73.2	52.0	52.1
1:00	74.1	74.2	53.2	53.1
1:30	76.0	76.1	54.1	54.2
2:00	76.1	76.2	54.0	54.1
2:30	75.3	75.2	53.4	53.2
3:00	75.0	75.1	53.0	53.1
3:30	73.1	73.2	50.1	50.2
4:00	71.0	71.2	45.1	45.2
4:30	70.3	70.1	44.3	44.2
5:00	68.1	68.2	43.2	43.1
5:30	55.4	55.2	42.5	42.3
6:00	52.5	52.3	41.4	41.2
Mean	66.23	66.32	45.57	45.51

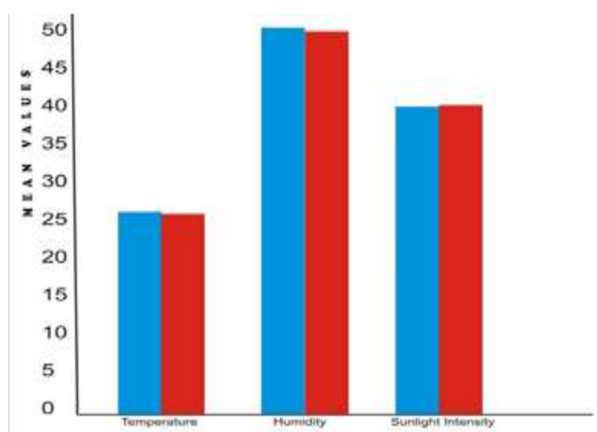
From Table 2, the variation of temperature can be seen as a function of time of the day and season with the device readings similar to that of standard NIMET readings. The lowest value of temperature occurred at about 6:00am for both seasons, dry (device = 31.2˚C, NIMET = 31.3˚C) and wet (device = 20.3˚C, NIMET = 20.2˚C), while the highest temperature value occurred at 2:30pm also for both seasons, dry (device = 39.7˚C, NIMET = 40.3˚C) and wet (device = 31.7˚C, NIMET = 31.6˚C) respectively. The average temperature values were device = 35.76˚C, NIMET = 36.11˚C for the dry season and device = 27.13˚C, NIMET = 26.97˚C for the wet season.

From Table 3, the variation of humidity was also seen as a function of time of the day and season with the device readings similar to that of standard NIMET readings. The lowest value of humidity occurred at about 1:00pm for dry season (device = 21.1%, NIMET = 21.2%) and about 2:30pm for wet season (device = 37.2%, NIMET = 37.1%), while the highest humidity value occurred at about 6:0am for both seasons, dry (device = 34.2%, NIMET = 34.1%) and wet (device = 91.1%, NIMET = 91.2%) respectively. The average humidity values were device = 27.31%, NIMET = 27.45% for the dry season and device = 57.95%, NIMET = 58.04% for the wet season.

From Table 4, the variation of sunlight intensity was also seen as a function of time of the day and season with the device readings similar to that of standard NIMET readings. The lowest value of sunlight intensity occurred at about 6:00pm for dry season (device = 52.5%, NIMET = 52.3%) and about 6:00am for wet season (device = 35.0%, NIMET = 35.1%), while the highest sunlight intensity value occurred at about 2:00pm for dry seasons (device = 76.1%, NIMET = 76.2%) and about 1:30pm for wet season (device = 54.1%, NIMET = 54.2%). The average sunlight intensity values were device = 66.23%, NIMET = 66.32% for the dry season and device = 45.57%, NIMET = 45.51% for the wet season.

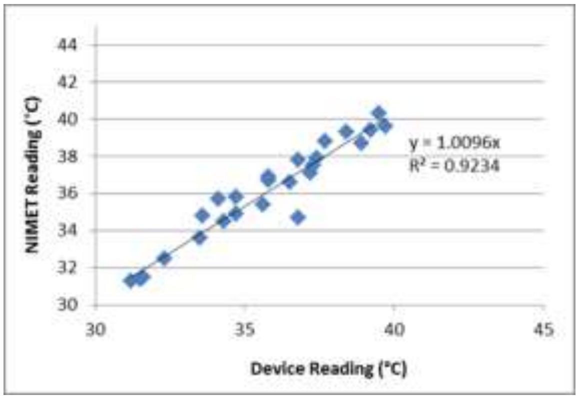
The minor variations observed between the constructed device readings as against the standard NIMET readings could be due to some errors in measurement898, like parallax error. Also, energy source from the battery could have been running out. However, the graph of the mean variation of the parameters; temperature, humidity, and sunlight intensity for the dry and wet seasons are presented in Figures 9. Further analysis carried out using regression analysis to show the variation of the device measured values to that of the standard NIMET values for temperature, humidity and sunshine in both dry and wet seasons are presented in Figures 10 and 11.



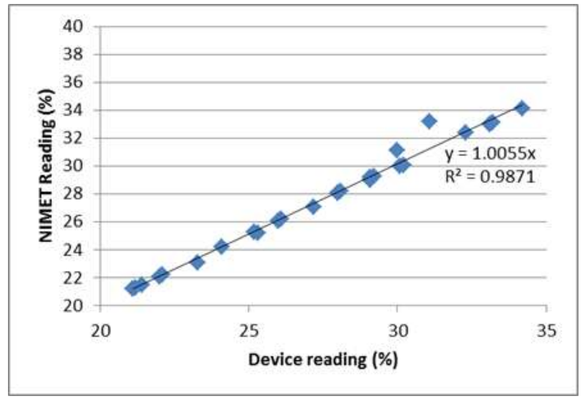


a) February b) August

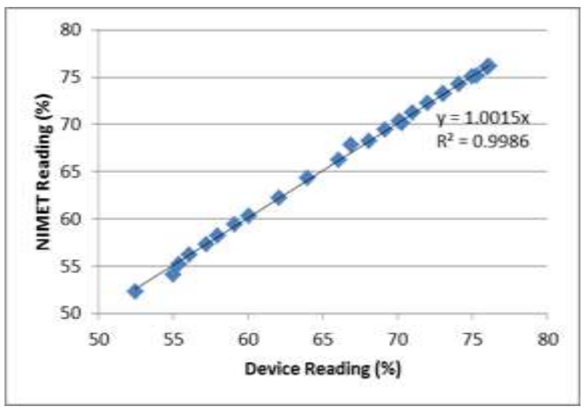
Fig. 9: Mean variation of temperature, humidity and sunshine



a) Temperature (on 3rd)

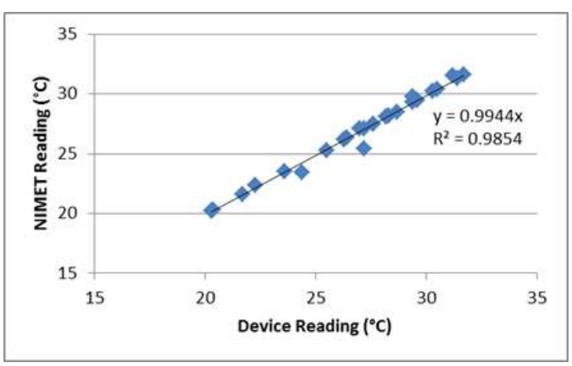


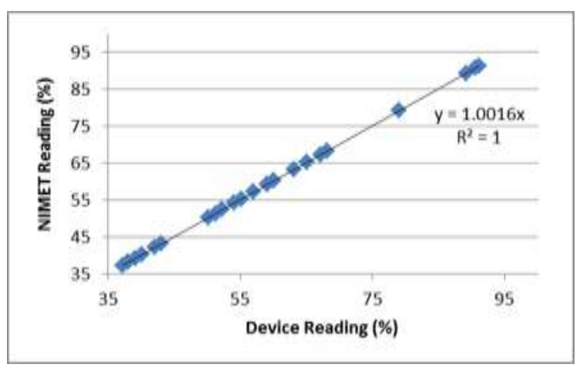
b) Humidity (on 5th)



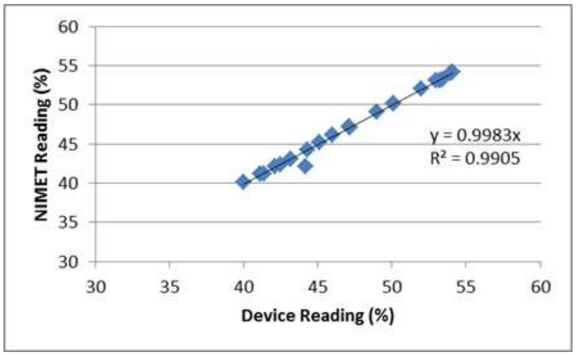
c) Sunlight Intensity (on 10th)

Fig. 10: NIMET versus Device readings for February, 2019





a) Temperature (on 18th) b) Humidity (on 9th)



c) Sunlight Intensity (on 15th)

Fig. 11: NIMET versus Device readings for August, 2019

4.5 Discussion

The constructed digital mobile weather monitoring station was used to measure temperature, humidity, sunlight intensity and smoke in the months of February to represent the dry season weather and August which represent raining season weather. Comparisons were made between the device measured values and some selected standard atmospheric condition values obtained from NIMET for the year 2019. However, findings have revealed significant information with good agreement. For February (dry season), the slope of the regression line (zero intercept) relating measured to calculated values for temperature was 1.01 (R^2 = 0.923) indicating, on average a perfect agreement between the measured and calculated value with data points closely fitted to the regression line and accounting for ≈ 92.3% of the variance. Similarly, the slope of the regression line (zero intercept) relating measured to calculated value for humidity was 1.006 (R^2 = 0.987) indicating, on average a perfect agreement between the measured and calculated value also with data points closely fitted to the regression line and accounting for ≈ 98.7% of the variance. Also, the slope of the regression line (zero intercept) relating measured to calculated value for Sunlight was 1.002 (R^2 = 0.999) indicating, on average a perfect agreement between the measured and calculated value again with data points closely fitted to the regression line and accounting for ≈ 99.9% of the variance. This means that there is no significant difference in the measured and calculated values in all cases. This research is similar with the work done Ukhurebor *et al.* (2017) who designed a cost effective weather monitoring device using an Arduino Mega 2560 microcontroller and some contemporary suitable sensors with a real time data logger and LCD, also similar to Tabassum and Hossain (2018) who designed and developed a weather Monitoring and Control System for a Smart Agro Farm using the Raspberry pi. Weather parameters like temperature, humidity, soil moisture content and rain detection were used in real time weather monitoring situations. Though, the difference with mine is that I compared my own readings with the standard values obtained from Nigeria meteorological

Agency (NIMET) in a regression analysis to further validate the effectiveness of the constructed device. This was not done in their work.

For August (rainy season), the slope of the regression line (zero intercept) relating measured to calculated values for temperature was 0.994 (R^2 = 0.985) indicating, on average a perfect agreement between the measured and calculated value with data points closely fitted to the regression line and accounting for ≈ 98.5% of the variance. Similarly, the slope of the regression line (zero intercept) relating measured to calculated value for humidity was 1.002 (R^2 = 1) indicating, on average a perfect agreement between the measured and calculated value also with data points closely fitted to the regression line and accounting for ≈ 100% of the variance. Also, the slope of the regression line (zero intercept) relating measured to calculated value for Sunlight was 0.998 (R^2 = 0.991) indicating, on average a perfect agreement between the measured and calculated value again with data points closely fitted to the regression line and accounting for ≈ 99.1% of the variance. This also means that there is no significant difference in the measured and calculated values in all cases.

For February measurement, the temperature variation equation in this study is $y = 1.0096x$, while for the humidity is $y = 1.0055x$, and for the sunlight is $y = 1.0015x$ respectively. For August measurement, the temperature variation equation in this study is $y = 0.9944x$, while for the humidity is $y = 1.0016x$, and for the sunlight is $y = 0.9983x$ respectively. A linear relationship between the measured and calculated values with closely fitted points validates the constructed digital mobile weather station with high accuracy as such can be a very useful and important device for use in the aviation industry for study of weather conditions for flight, in agriculture for field study of periodic plant growth and development, and for marine technology and surfing.

5.2 Conclusion

Weather monitoring plays an important role in human life, so the collection of information about the temporal dynamics of weather changes is very paramount (Susmitha & Sowmyabala, 2014; Ukhurebor et al., 2017). Measurement of atmospheric parameters in real time monitoring condition can be of great importance in averting many weather associated hazards (Tabassum & Hossain, 2018; Panigrahy et al., 2016). This research demonstrates the design, simulation and construction of an inexpensive digital mobile weather monitoring device that ensures flexibility, portability, scalability, and user friendly operations. The device is capable of providing data of some weather variables including temperature, humidity, fog/mist, and sunlight intensity. The measurement results from this constructed device were in good conformity with those data obtained from standard measurements from Nigeria Metrological Agency. The constructed digital mobile weather monitoring devices could be a solution to averting many weather associated hazards in Nigeria as it is cheap, affordable and reliable with high level of accuracy. It is also user friendly, and can be used to obtain data on weather parameters with great degree of accuracy for flight monitoring, surfing/leisure, plant growth and development, and marine technology.

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