WEATHER VARIABLES MONITORING SYSTEM WITH A DEVELOPED GRAPHICAL USER INTERFACE USING INTERNET OF THING

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ABSTRACT
The pursuit for a weather monitoring system is critical for the measurement and observation of environmental parameters that are connected with human activities and habitation. In this study, a revolutionary weather monitoring system that uses a flexible graphical user interface (GUI) platform through a JAVA script software code is designed. The device is embedded with a ATMEGA 328P-PU microcontroller for the analysis of the signals from temperature, humidity, wind speed and rainfall rate sensor respectively. An analogue to digital converter initiates a signal conversion that enable GUI, to capture a reliable weather parameter at an interval of 10 minutes on a real time; through an ESP8266 Wi-Fi shield that creates a remote and host link between the sensors and the GUI. The developed system's performance was evaluated by comparing results with available weather monitoring instruments. The developed system compared favourably with an available weather monitoring instrument with mean average accuracy of 99.96%, 99.41%, 99.96% and 99.26% in temperature, humidity, wind speed and rainfall rate respectively.

Keywords: Sensor, ATMEGA 328P-PU, JAVA script, monitoring

1.0 INTRODUCTION
The need for an effective environmental monitoring system is of high importance because it provides the predictability of the climatic parameters that are associated with weather forecasting. Existing technology emphases on monitoring different parameters in a manner that sensors are strategically located some specified and random locations for data acquisition. There is a huge demand for a weather monitoring system in the electronic market based on its versatility and importance of the measured parameters like temperature, humidity, wind speed etc. The beauty of a data acquisition system is to have a retrievable platform where information could be fetched at any time when the need arises. A data acquisition comprises a transmitting unit where data is being transmitted and a host unit which receives the data sent from the transmitter. For proper data archiving, a computer system is most preferred. In a data acquisition system, data measurement is carried out by sensors which measures variables as physical quantities which are being converted to desirable form by the microcontroller. (Fridzon & Ermoshenko, 2009) and (Abistado, Arellano, & Maravillas, 2014) reported that the knowledge of climate change is essential for trade and agriculture, so that its effect could be well known and an appropriate action can be taken at a right time. Systems for monitoring parameters that results in events such as flash floods, tornadoes, floods and forest fires are very important to have (Azmil, Ya'acob, Tahar, & Sarnin, 2015).
(Susmitha & Sowmyabala, 2014) designed and implemented a weather monitoring and controlling system that uses pairs of sensors (temperature, Gas, and humidity) to monitor the weather variables which is sent to LPC1768 microcontroller (ARM9). The data from the sensors are collected by the microcontroller, processed

and transmit to LABVIEW using the serial communication network which keeps the data in excel page. The GSM module in the system makes the result to be accessible through short message service (SMS). The system uses a compact circuitry built around LPC1768 (ARM9) microcontroller programs developed in embedded C using the IDE Keiluvision4. The works of (Đorđević & Danković, 2019) and (Rahut, Afreen, & Kamini, 2018) focused on the use of internet of things (IoT) to develop smart weather monitoring and real time alert system. Multiple sensors were used to send data to web page and the data sensor data are plotted as graphical statistics. The data uploaded to the web page can easily be accessible from anywhere in the world. Similar efforts were reported in (Morón, Diaz, Ferrández, & Saiz, 2018), (Alkali, et al., 2019) and (Vijayalakshimi & Lakshmi, 2016). In (Morón, Diaz, Ferrández, & Saiz, 2018), a weather station based on an Arduino platform was developed to collect and store ambient temperature, relative humidity, barometric pressure, wind speed and air quality data. Comparing the obtained data to those obtained using a validation station containing commercial sensors. The results show how the use of low-cost Arduino sensors allows one to obtain similar results to those collected from more professional meteorological stations with insignificant scatter between both technologies. The work of (Vijayalakshimi & Lakshmi, 2016) developed a system that fetches weather conditions continuously using various sensors interfaced with Raspberry pi to measure various weather parameters like temperature, humidity, pressure, gas concentration, light intensity etc. The system displays it on liquid crystal display (LCD) for local monitoring, transfers to web pages created for remote monitoring and stores in a database for further analysis.

In the work being reported, a microcontroller-based weather monitoring device using an internet of thing (IoT)is developed. The device is a multi-caded system that is incorporated with a low pass filter that initiates an active sensor to efficiently monitor the remote environmental factors using GMS module technology. This study will alleviate the herculean task of retrieving data from the archive of the Meteorological Agency, and ease of monitoring and analysis the weather parameters. This work is aimed at developing a weather station, with a graphical user interface, that measures key climatic parameters (temperature, humidity, rainfall, and wind speed) using real time data processing. This work has produced a serviceable and repairable weather variable monitoring system using a flexible and adjustable graphical user interface (GUI) through a real-time Wi-Fi communication.

2.0 SYSTEM ARCHITECTURE

The core of the system is a microcontroller, ATMEGA 328P-PU that receives analogue signal from the sensors, processes it and transmit it in the computer system via an ESP8266 Wi-Fi wireless transfer protocol. The number of sensors to be used is dependent on the number of weather variables to be monitored. In this work, the weather variables of interest are temperature, humidity, wind speed and rainfall rate respectively. Figure 1 shows the block diagram of the proposed system.

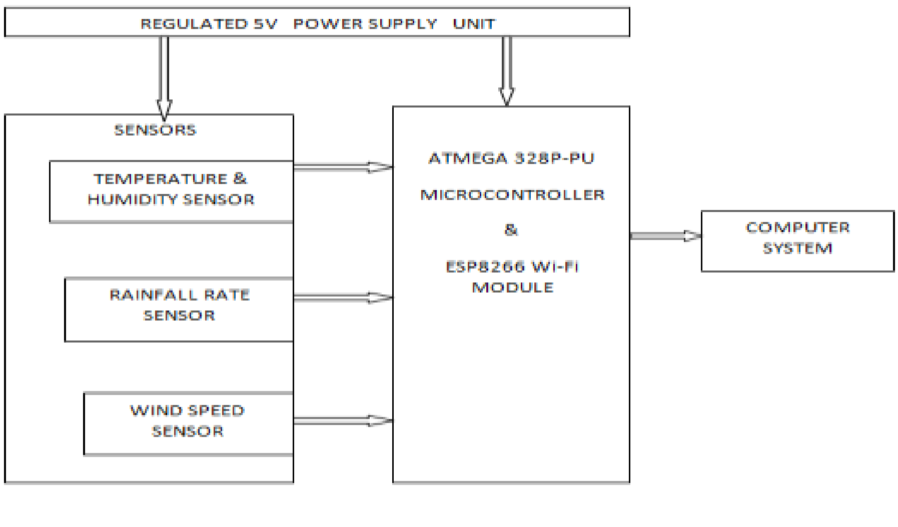

Figure 1: Block diagram of the weather station with different sensors connection to the microcontroller and wi-fi Module.

The designed system consists of two sections: the hardware and the software units. The hardware unit comprises of power supply unit, sensing stage and microcontroller unit which performs signal modification/signal conversion, signal transfer and signal/data visualisation. The software unit interfacing that ensures visualisation and storage was implemented through a developed graphical user interface (GUI) with JAVA script. The flow chart of the software interfacing of the system is given in figure 2.

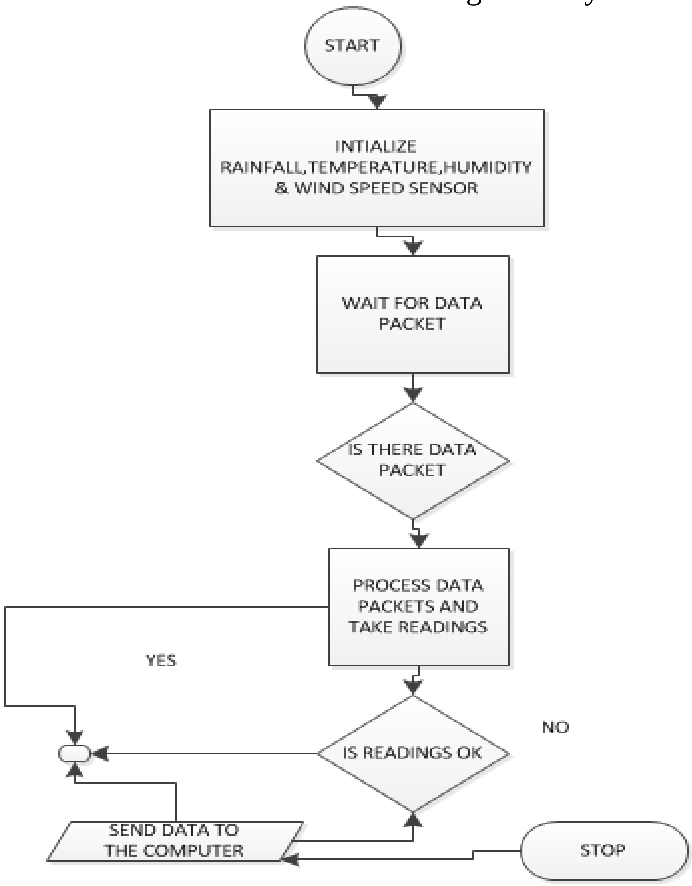

Figure 2: Flowchart of the developed system

2.1.1 Power Supply Unit

The data collected in the system is in real time, hence there is need for constant and reliable power supply to the system. The choice of solar power system is considered. A 30-watt solar panel is selected to continuously charge a 12V, 20Ah deep cycle battery whose output is regulated to give a desired 5V in which the system operates. A 7805 regulator IC was used to give a 5V regulated output to power the microcontroller since it will not require a voltage that exceeds 5V. Figure 3 illustrates the block diagram for the implementation of the power supply.

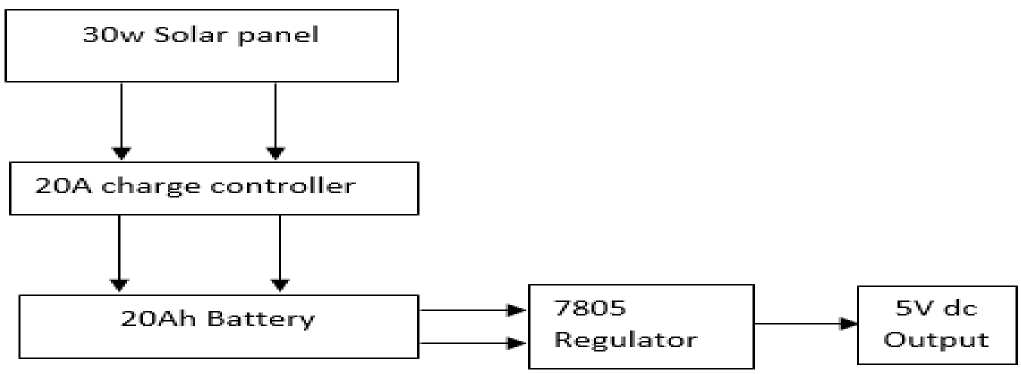

Figure 3: Block diagram of regulated 5V power supply unit using IC 7805

2.1.2 Microcontroller Section

This section employed ATMEGA 328P-PU which is a 28-pin integrated circuit microcontroller. ATMEGA 328P-PU features an inbuilt 32K bytes of programmable flash with enabled write capability platform, coupled with EEPROM memory of 1KB and SRM of 2KB memory space. Digital operations could be performed with available 14 digital pins and 8 ADC pins. A 16 MHz crystal oscillator in the pins 9 and 10 of the microcontroller allows the supply of square wave that drives the microcontroller into active performance (Hassan, Huzaifa, Sodunke, & Odiete, 2019).The microcontroller works based on conditional statements embedded in it through a desired programming language (Sodunke, et al., 2020)

Figure 4 (a) : A 28-pin ATMEGA 328P-PU micro-controller

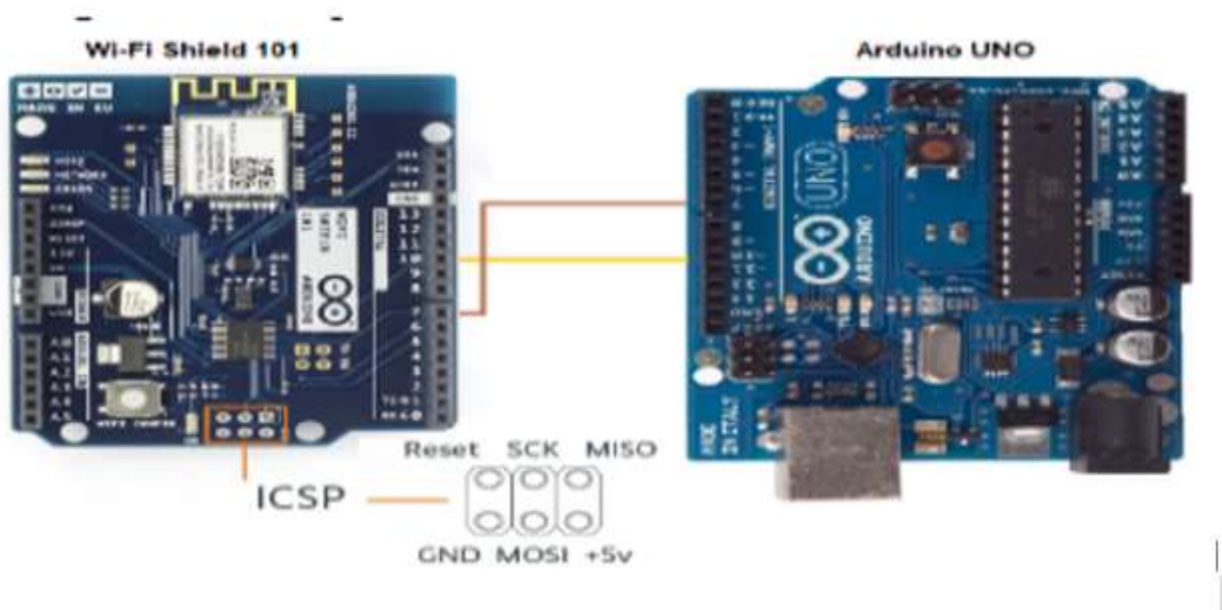

Figure 4 (b): A set-up connection between ATMEGA-328P and Wi-Fi communication module

2.1.3 Digital Temperature and Humidity Sensor (DHT 111)

DHT 111 is a digital type of temperature and humidity sensor that uses a capacitive humidity sensor and a thermistor to measure the surrounding air. It is in a composite form and produces a signal output of temperature and humidity in digitalized form. The architecture of DHT 111 sensor qualifies it for usage in a long-term application. The sensor comprises of a NTC temperature measurement and resistive sense of wet components. The choice of a DHT 111 temperature and humidity sensor in this work is because of its fast response, precise calibration and real-time digitally producing output. Figure 6 shows the data timing diagram of a DHT 111 sensor. The data timing platform has revealed the rate at which the microcontroller (user, host) sends signals to the microcontroller and release instructions that converts low power mode to high-speed mode. This would then make the DHT 111 to send a signal in a 40-bit mode and enhances signal transfer.

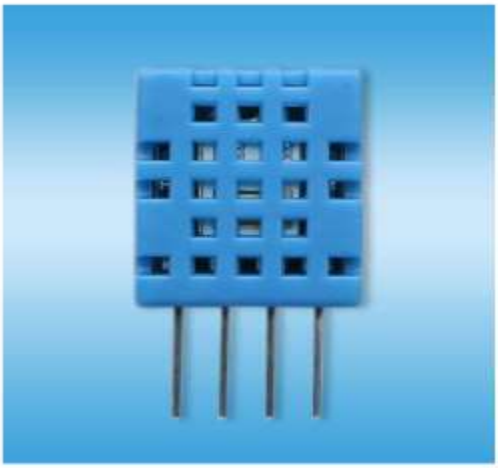

Figure 5: Depicts the Temperature and Humidity Sensor (DHT 111)

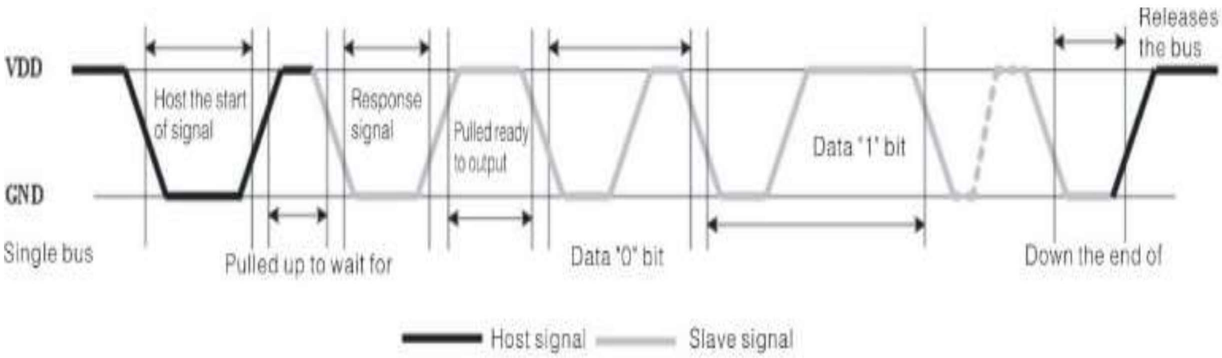

Figure 6: Illustrates the data timing of DHT 111

2.1.4 Wind Speed Sensor

Measurement of wind speed is carried out through an anemometer as shown in figure 7. The anemometer is designed to work outside and perform measurement of with speed with ease. The sensor could be powered by 7-24V DC. The output voltage of 0.4V and 20V gives 0 m/s and 32.4 m/s wind speed respectively. Weatherproof available connector and rugged nature of the sensor makes it valuable for this study.

Figure 7: A wind speed sensor with its wired connector

2.1.5 Rainfall Rate Measuring Sensor

The rainfall sensor as shown in figure 8, has an opening/aperture that allows water in, there is a switch inside which opens through activation by rainfall. The principle at which the switch is activated based on magnet attached to the tip of the rainfall rate sensor. This sensor is utilized based on its low cost and high reliability.

Figure 8: A rainfall sensor

The designed weather station consists of rainfall, wind speed and temperature and humidity sensors. The designed circuit for the system is as shown in Figure 9. The system operates by collecting rainfall, wind speed, temperature and humidity parameters via their respective sensors. All these sensors are being linked directly to the digital pins of the ATMEGA 328P-PU microcontroller. The microcontroller receives the signal in an analogue form from the sensors and converts it to digital form using the analogue digital converter (ADC) of the microcontroller does. The modified signal is being sent to the USB cable. A USB-USB cable allows signal transfer from the designed circuit to the computer system in order to earn graphical visualization of signals through the developed Graphical User Interface (GUI).

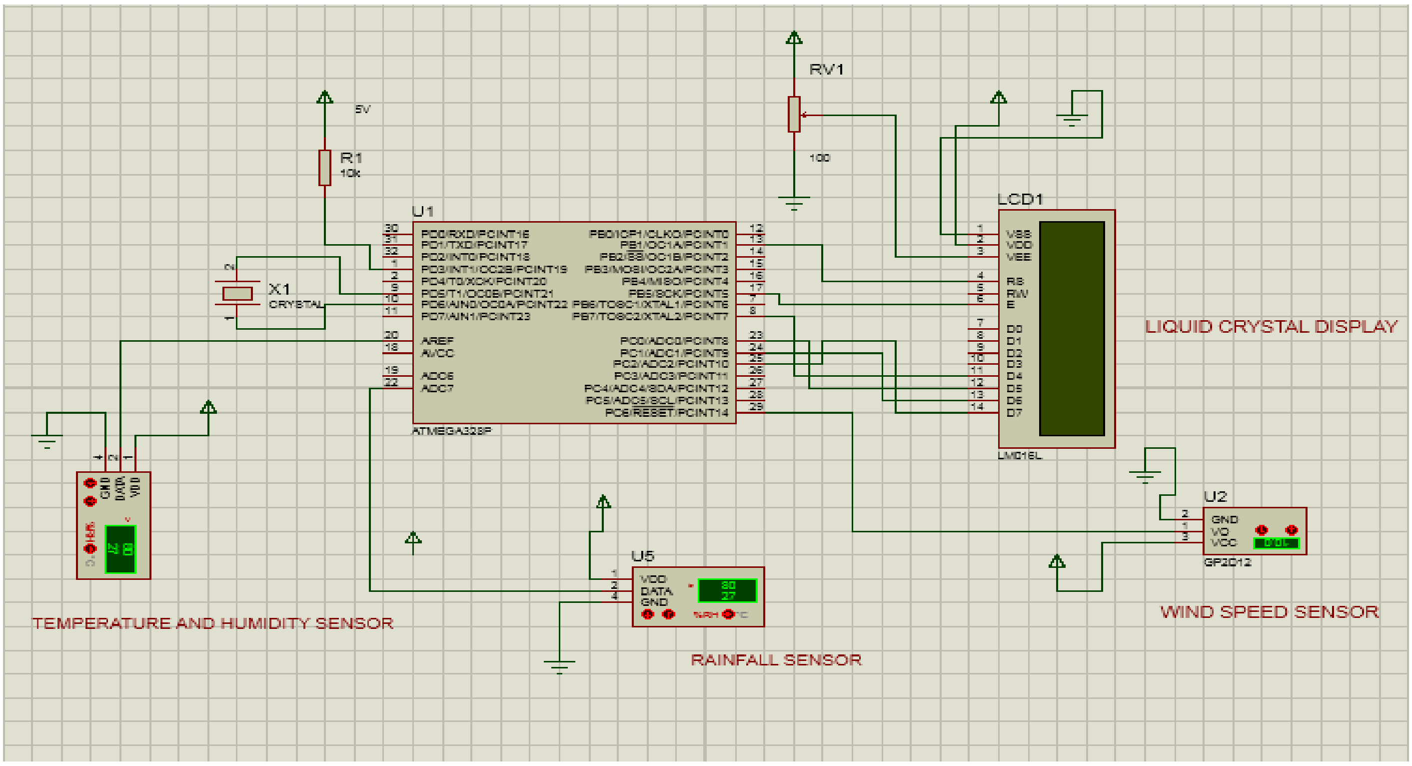

Figure 9: shows the circuit diagram of the sensors using ATMEGA 328 Microcontroller

3.0 TESTING, RESULTS AND DISCUSSION

Before implementation, the four sensors involved in the designed were tested to ascertain the compatibility of their outputs with the microcontroller. The operating voltages of the humidity, temperature, windspeed and rainfall rate 5V and 12V respectively. Each of the sensors has a two-input wire coupled with a single signal output cable. Electronically, a microcontroller can only admit input that ranges from 0 – 5V into the programmable input pins. So, it is required that each output voltage that will be fed into the microcontroller has to be investigated before it is introduced into the input pins otherwise it might get the microcontroller ablaze based on their voltage and temperature sensitivity. Upon implementation, the snapshot of the collected data in graphical and excel format is shown in figures 10 and 11 respectively.

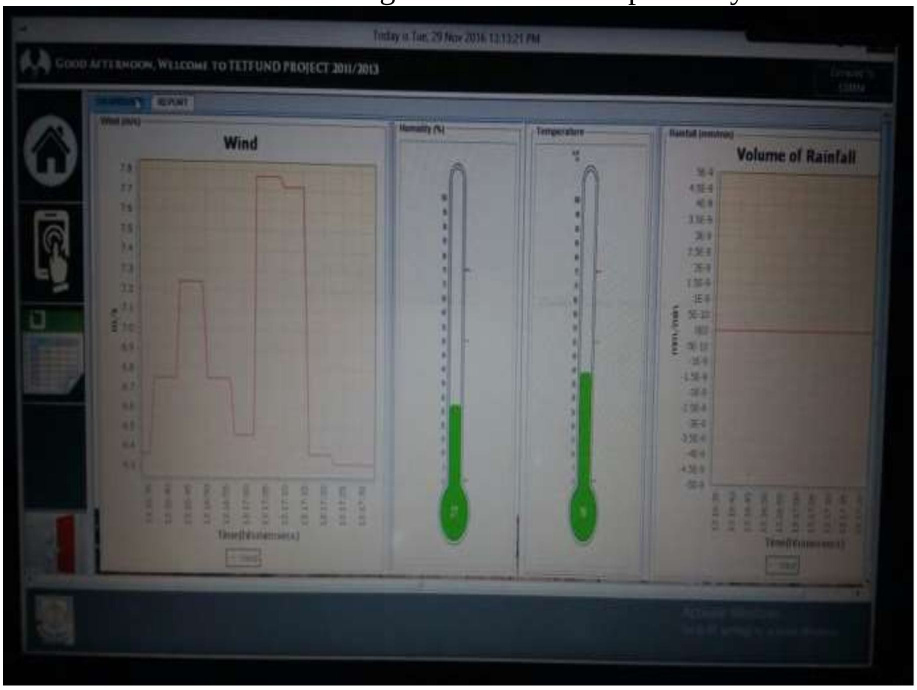

Figure 10: A snapshot of collected data in graphical form

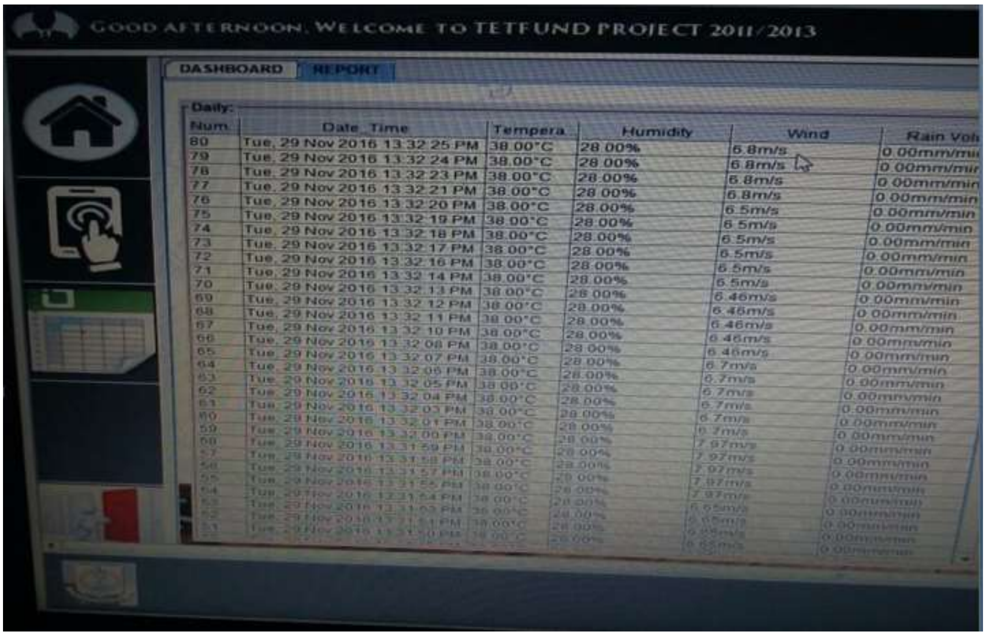

Figure 11: A snapshot of collected in excel format

For performance evaluation purpose, the measurement of constructing an instrument (weather station) was compared with that of available rain rate meter, anemometer, infrared thermometer and humidity meter for the weather condition of the campus of Moshood Abiola Polytechnic, Ojeere, Abeokuta Ogun State Nigeria. For the temperature, humidity and wind speed, the measurement was done in a day at an interval of 30 minutes from 11:30 am to 4:30pm. The rain fall rate was delayed till a later day when there was rainfall. 10 samples were also taken in at interval of 10minutes from 11:00am to 12:40 pm. The results of the comparison are presented in tables 1 to 4.

Table 1: Temperature performance evaluation result

Time (24hrs)	Infrared Thermometer (℃)	Measured Value (℃)	Difference
1200	34	33.92	- 0.08
1230	34	33.95	- 0.05
1300	34	34.01	+ 0.01
1330	34	33.97	- 0.03
1400	34	33.95	- 0.05
1430	34	34.08	+ 0.08
1500	34	34.03	+ 0.03
1530	34	34.01	+ 0.01
1600	34	34.02	+ 0.02
1630	34	34.00	0.00

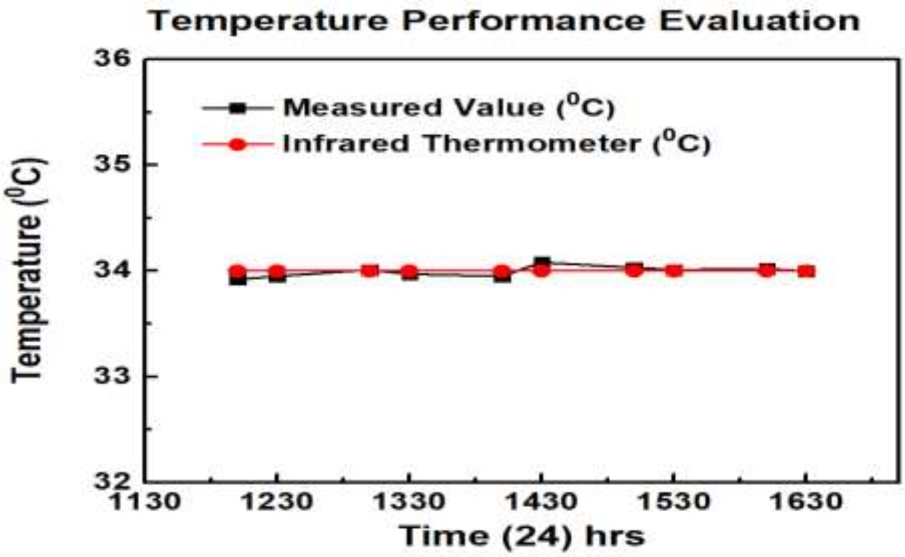

Figure 12: shows the infrared thermometer and the measured value plotted against time.

Table 2: Humidity Performance Evaluation result

Time (24hrs)	Hygrometer (%)	Measured Value (%)	Difference
1200	64.00	63.92	- 0.08
1230	64.00	63.82	- 0.18
1300	64.00	64.00	0.00
1330	64.10	64.00	+ 0.10
1400	64.03	64.00	+ 0.03
1430	64.30	64.20	+ 0.10
1500	64.30	64.30	0.00
1530	66.00	65.80	+ 0.20
1600	66.00	65.75	+ 0.25
1630	66.00	65.83	+ 0.17

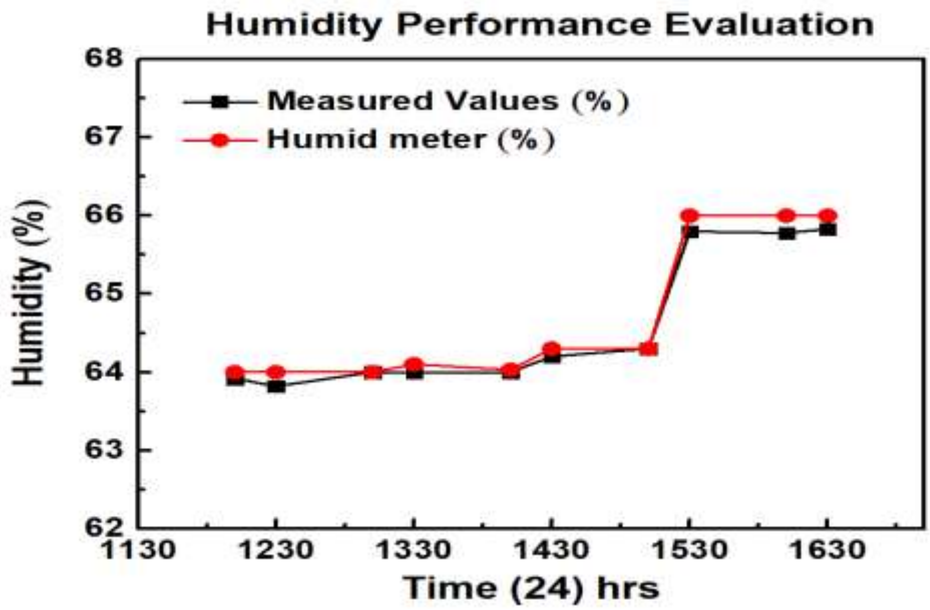

Figure 13: shows the hygrometer and measured valued plotted against time.

Table 3: Wind speed Performance Evaluation result

Time (24hrs)	Anemometer (m/s)	Measured (m/s)	Difference
1200	0.32	0.30	+ 0.02
1230	0.61	0.60	+ 0.01
1300	0.66	0.66	0.00
1330	0.73	0.74	- 0.01
1400	3.20	3.20	0.00
1430	4.20	4.10	+ 0.10
1500	4.30	4.40	- 0.10
1530	4.80	4.80	0.00
1600	5.10	5.00	+ 0.10
1630	5.51	5.50	+ 0.01

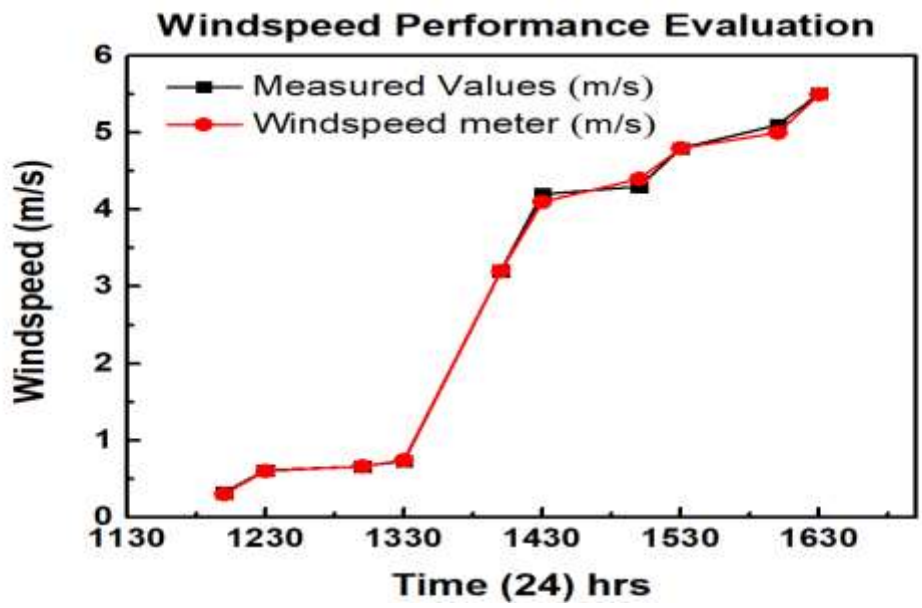

Figure 14: shows the anemometer and the measured value plotted against time.

Table 5: Rainfall Performance Evaluation result

Time (24hrs)	Raingauge (mm/hr)	Measured (mm/hr)	Difference
1110	3.01	3.00	+ 0.01
1120	3.02	3.00	+ 0.02
1130	4.01	4.00	+ 0.01
1140	6.10	6.00	+ 0.10
1150	7.10	7.00	+ 0.10
1200	7.20	7.00	+ 0.20
1210	7.00	7.00	0.00
1220	7.00	7.00	0.00
1230	8.00	8.00	0.00
1240	9.20	9.00	+ 0.20

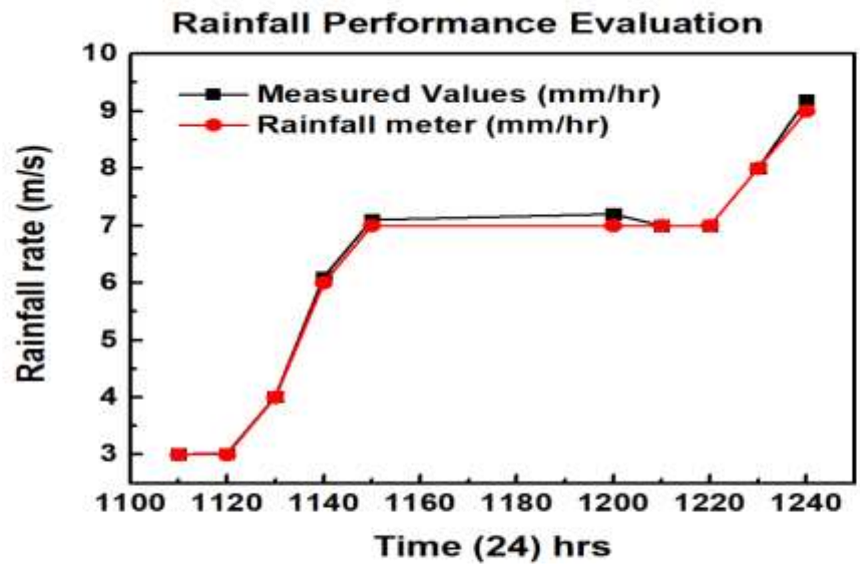

Figure 15: shows the rain gauge and measured value plotted against time.

The data presented in tables 1 to 4 were analyzed for mean average accuracy. A mean average accuracy of 99.96%, 99.41%, 99.96% and 99.26% were respectively obtained for temperature, humidity, wind speed and rainfall rate during experimental measurements. This high percentage of correlation between measurement obtained using developed system and an existing system indicates good performance of the system.

Figure 16: A snapshot of the weather station mounted on a pole.

4.0 CONCLUSION

A weather parameter monitoring system with a GUI has been successfully designed and developed using a low cost rainfall, wind speed, temperature and humidity sensors. The sensors are being handshake to an ATMEGA 328P-PU microcontroller while the ESP8266 Wi-Fi module facilitates the communication link between the collected data and the GUI environment on the computer system created for data archiving. The developed microcontroller program written in C language was embedded into a microcontroller to give readings of rainfall, wind speed, temperature and humidity in an interval of every 10 minutes which is also a method of data collection in most Meteorological Agency Stations. With this system, easy access to database of information at any time when the need arises is guaranteed. The beauty of this designed system is that it is rugged, serviceable and repairable compared to imported weather stations that are highly customized and must be returned back to the manufacturer when it develops fault or fails. The system compares favourably with existing system with correlation percentages of 99.96%, 99.41%, 99.96% and 99.26% in temperature, humidity, wind speed and rainfall rate respectively.

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