DEVELOPMENT OF CLOUD-BASED STAND-ALONE WEATHER STATION: AN INNOVATIVE APPROACH FOR HIGHER CROP PRODUCTION

[1]Kuponiyi D. S & [2]Aiyelabowo O. P.

[1]Department of Electrical/Electronic Engineering, Gateway Polytechnic, Saapade, Ogun State
[2]Department of Electrical/Electronic Engineering, The Federal Polytechnic, Ilaro, Ogun State
dsniyi@hotmail.com; peter.aiyelabowo@federalpolyilaro.edu.ng

Abstract

Food production is germane to the development of any nation. The survival and improvement in crop production, which yields food availability, is dependent on weather conditions. Generating climate conditions data for forecast of crop production is required if bumper yield of crop is desired. Often times, in this era of climate change, food production has suffered a setback as weather conditions keeps varying. In this paper, a weather condition monitoring system is developed to give readings of temperature, humidity and wind speed. Various sensors were put together to collect readings of the mentioned parameters. The output of these sensors serves as input to a micro-controller which processes the information for storage. These stored data are then retrieved for forecasting of weather condition annually for crop production. The system was tested and measurement of the three weather parameters were collected.
Keywords: Weather, temperature, humidity, wind speed and microcontroller.

Introduction

Meteorology includes the study of day-to-day variations of weather conditions, the study of electrical, optical and other physical properties of the atmosphere and the study of the average and extreme weather conditions over long period of time (Balasubramanian, 2014). These climatic parameters are stored in a meteorological station. The observations from the meteorological station is used to give notice on weather conditions and also extends the service for the benefit of commerce, agriculture etc. This notice may include routine weather phenomena, warnings of impending floods and regular forecast of river stages. After collection and analysis, it publishes records of temperature, rainfall, wind and often weather element and develops applications of climatologist for agricultural, industrial and commercial uses.

The significance of a meteorological station lies on the degree of accuracy gotten from the information obtained. It is expected to perform the functions of collecting data for forecasting weather and assemble the same data over considerable periods of time in order to make climatic recommendation for that area (Reddy, Nukala Rohit, A.Naveen Kumar, 2018).

Most weather stations in use in Nigeria are imported and are not designed with the atmospheric condition of Nigeria. In this work a weather station is designed and implemented with the nation's atmospheric condition. Measurement of atmospheric parameters were taken and logged in the cloud for assessment.

Related Work

A number of methods of meteorological system development been reported in Literature. (Emran et al., 2020) constructed a microcontroller Based System for Determining Instanteous Wind Speed and Direction. The parameter measured are the atmospheric wind speed and wind direction. (Susmitha, 2014), designed and Implemented a Weather Monitoring and Controlling System. The system gathers the data about stickiness and temperature but can't sense the wind speed and humidity of the atmosphere.

Gahlot et al., (2015), designed a Zigbee based weather monitoring system. The system is short ranged and of less information speed.

Kalsi, (2008) developed a Satellite Based Weather Forecasting in Wireless Communications and Networking Conference. The design operates using network and wireless communication but has the weakness of tremendous initial cost, noise and interference.

Lambebo & Haghani, (2014), design a Wireless Sensor Network for Environmental Monitoring of Greenhouse gases but has the weakness of Specific substitution of sensor, lower speed, less secure because programmer can read information like username and password.

Methodology

The system is composed of six (6) stages as shown in Figure 1. These stages are;

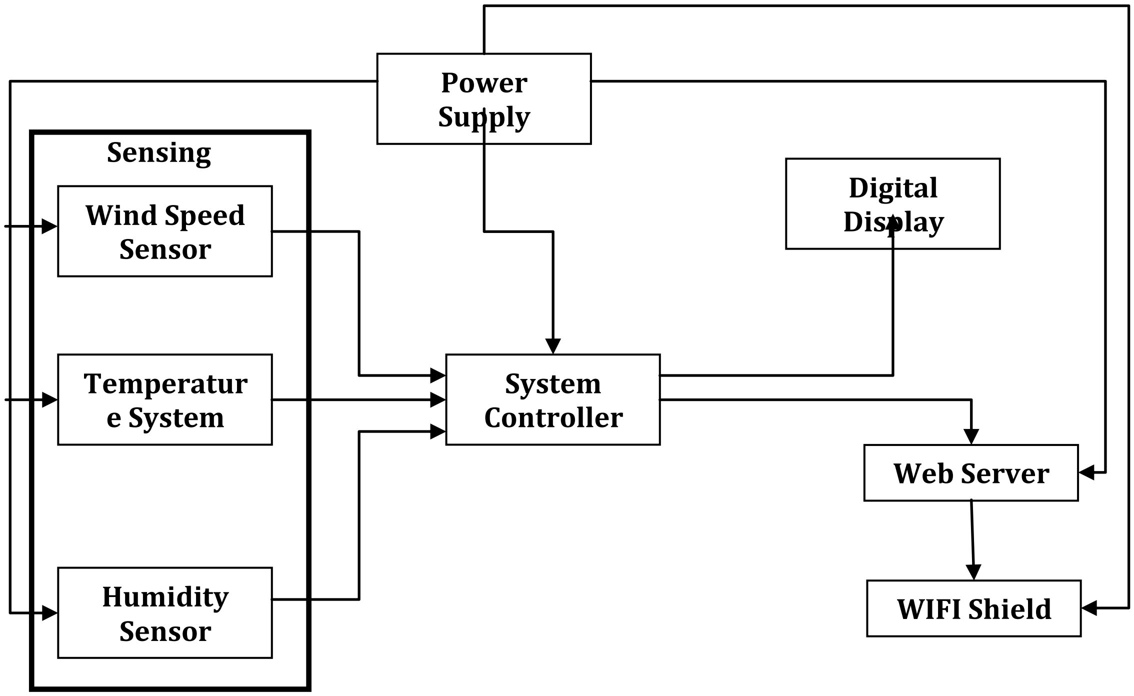


Figure 1: Cloud-based weather station block diagram

- Power Supply
- Controller
- Sensing
- WIFI Shield
- Web Server
- Digital Display

Power supply

This unit provides dc voltage to other stages in the system. Since the system is a stand-alone, it is powered via solar energy. The solar energy consists of solar panel, battery and a charging circuit. The solar panel collects sun radiation which via solar cells are transduced to dc voltage. Although the battery supply dc voltage requirement to the system, the solar panel, output after regulation, is used to charge the battery.

The required power for the entire system is 35.22 W.

Panel Sizing

Rated energy is 35.22 x 1.3 = 45.786

$$Derated\,energy = \frac{Rated\,energy}{3.4} = \frac{45.786}{3.4} = 13.47$$

$$No\ of\ panel\ required = \frac{Derated\ energy}{Power\ of\ solar\ panel} = \frac{13.47}{15} = 0.898 \simeq 1$$

Selected panel is 15 W monocrystalline PV module.

Battery sizing

Battery loss = 0.85, Battery depth discharge = 0,6, Nominal voltage = 12 V

$$Battery\ size = \frac{Required\ power \times 3}{\text{Battery loss} \times \text{Battery depth discharge} \times \text{Nominal voltage}} = \frac{35.22 \times 3}{0.85 \times 0.5 \times 12} = 17.26\,A$$

$$Battery\ size \simeq 20\,A$$

Chosen battery = 12 V-20 A

Charging Method

The constant voltage method was chosen for the charging circuit. It maintains constant voltage throughout the charging process, regardless of the state of the battery's charge. The charging is done at a constant voltage of 12 V. The solar power supply provides for all the units power requirement'

Controller

The controller unit is responsible for the coordination of all processes in the system. It is a microcontroller built around the PIC 16F877A microcontroller. The PIC 16F877A is a 44 pin microchip having five (5) I/O ports, fifteen (15) interrupts, eight (8) A/D input channels and a parallel slave port. The Microcontroller pin configuration is shown in Figure 2. The input ports are configured for the DHT11 and anemometer to feed it with temperature, humidity and wind speed. Through the A/D converter onboard it, the analog input is converted to digital, which is processed for its output port. The output ports are configured for the liquid crystal display (LCD) and the Wifi shield.

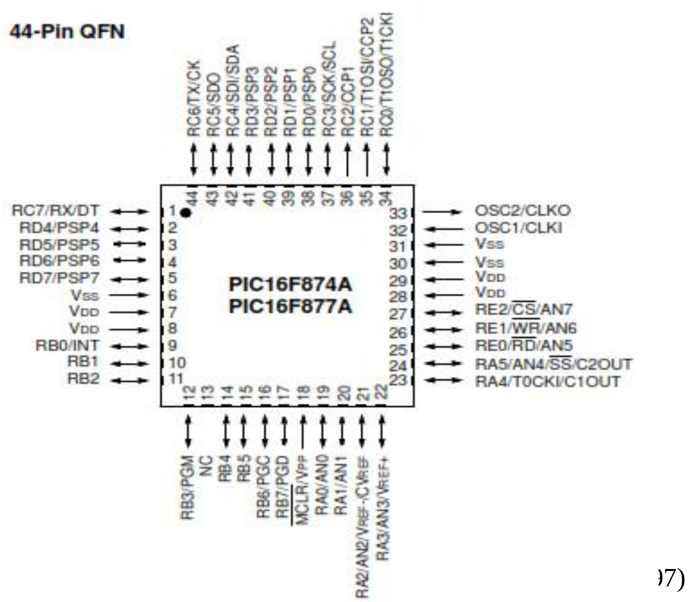


Figure 2: Microcontroller pin configuration

Wind Speed Sensor

This sensor is used for measuring the average and maximum wind speed (gust) during the sampling interval. The instrument used is an anemometer. An anemometer is a device used in measuring the speed of air spreads overflow in the atmosphere in wind tunnels and in other gas flow applications. The use of anemometer spreads over sectors such as meteorology to civil engineering.

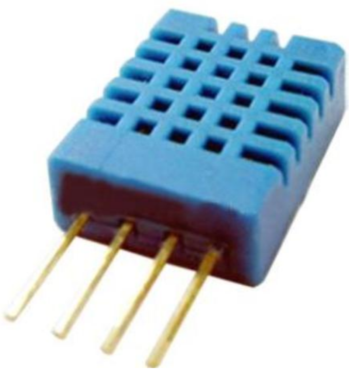
The cup anemometer is implemented in this design. It is selected for its affordability, linear normal speed range response and ability to operate efficiently under extreme weather conditions. 3-cup anemometer was selected. In this anemometer, the revolving cups drives an electric generator. The output of the generator operates an electric meter that is calibrated in speed. The 3-cup anemometer used is as shown in Plate 1.

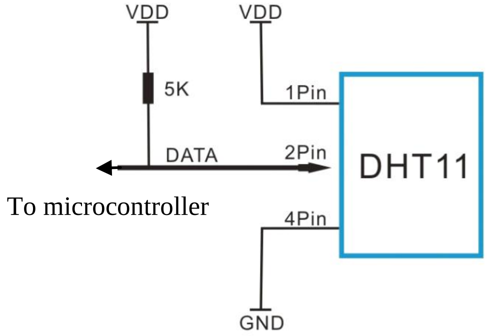
Plate 1: Anemometer

Temperature and Humidity sensor

Temperature is the measure of the degree of hotness or coldness while humidity is the measure of water content in air. The device implemented for the sensing of these parameters is the DHT11 sensor. It incorporates temperature and humidity sensor features with calibrated digital signal output. It comprises of a resistive-type humidity measurement component and an NTC temperature component and connects to an 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost effectiveness.

The component is four (4) pin single row pin packaged. Its specification is as highlighted in Table 1.





The pi shown in Figures 3 and 4, Uk, (2010).

Figure 3: DTH11

Figure 4: DTH11 pin configuration

Table 1: DTH11 Specifications

Parameters	Conditions	Minimum	Typical	Maximum
Humidity				
Resolution		1%RH	1%RH	1%RH
			8 Bit	
Repeatability			±1%RH	
Accuracy	25℃		±4%RH	
	0-50℃			±5%RH
Interchangeability	Fully Interchangeable			
Measurement Range	0℃	30%RH		90%RH
	25℃	20%RH		90%RH
	50℃	20%RH		80%RH
Response Time (Seconds)	1/e(63%)25℃, 1m/s Air	6 S	10 S	15 S
Hysteresis			±1%RH	
Long-Term Stability	Typical		±1%RH/year	
Temperature				
Resolution		1℃	1℃	1℃
		8 Bit	8 Bit	8 Bit
Repeatability			±1℃	
Accuracy		±1℃		±2℃
Measurement Range		0℃		50℃
Response Time (Seconds)	1/e(63%)	6 S		30 S

Uk, (2010)

Microcontroller-Web server Interface

Since the content of the microcontroller is to be uploaded into the cloud, there is need for an interface, a device that will via Wifi transfer the data to the web server. This interface is called the Wifi shield, it connects the microcontroller to the internet using the Wifi library and to read and write and SD card using the SD library.

The Wifi implemented in this design is a Wifi shield V2.0. It has eight digital pins (D0 – D7) which can be used for transmission or reception. It has an on-board antenna which helps it to cover a wide range and transmit stronger signals. Various control parameters required to drive the Wifi shield are as shown in Table 2.

Table 2: Wifi shield V2.0 Specifications

Parameter	Value
Operating voltage	3.3~5.5 V
Compatible board directly	Arduino Uno/Seeeduino
Current	25~400mA
Transmit power	0-10 dBm
Frequency	2402~2480 MHz
Channel	0~13
Network rate	1-11 Mbps for 802.11b/6-54Mbps for 802.11g
Dimension	60X56X19 mm
Net Weight	24±1 g
Secure WiFi authentication	WEP-128, WPA-PSK (TKIP), WPA2-PSK (AES)

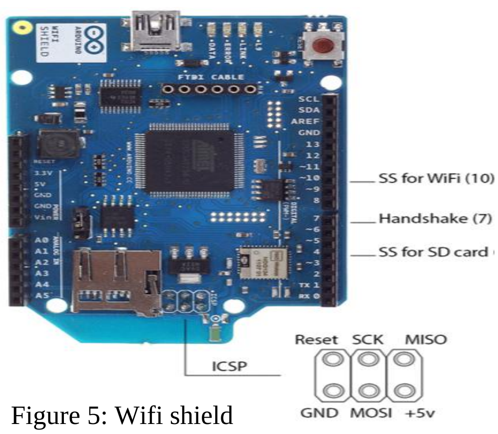


Figure 5: Wifi shield

Pin 7 is left free as it is the pin for handshake between the wifi shield and the microcontroller Speedstudio, (2002). The implemented Wifi shield is as shown in Figure 5.

3.6 Web Server

A web server is software and hardware that uses hypertext transfer protocols (http) to respond to the client's requests made over the World Wide Web. The function of the web server is to display website content through storing, processing and delivering webpages to users. This required in this system to make the readings of the weather parameters available in the cloud for users. It's hardware is connected to the internet and allows data to be exchanged with other devices, while the software controls how a user accesses hosted files. The web server implemented is shown in Figure 6.

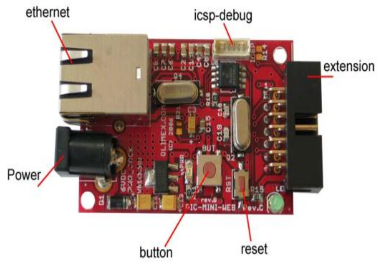


Figure 6: Web server

Power supply requires 6 – 9 Vdc and a current of 180 mA. The ICSP port comprises of six (6) pins. Pin 4 is PGD (program data), used for serial programming while pin 5 is PGC (program clock), clock used for transferring the serial data. The EXT port houses the pins for external connections. The LAN port has eight (8) pins.

Web servers have two separate directories, the document root and the server root. The document root is the root directory of all sever documents, while the server root is the root directory for all the code that implements the server.

When the server software is accessed through the domain names of websites and ensures the delivery of the site's content to the requesting user. When a user requests a weather parameter from the server, the user will specify URL in a web browser's address bar. The browser then requests the specific file from the web server by an HTTP request and offers it to the user. Hence, the web server helps the user to navigate through the stored parameter measurements stored in the cloud.

Display

A liquid crystal display (LCD) was used to present the content of the microcontroller output. An LCD is a seven-segment display system.

The designed circuit diagram is as shown in Figure 7 (the input devices are not shown).

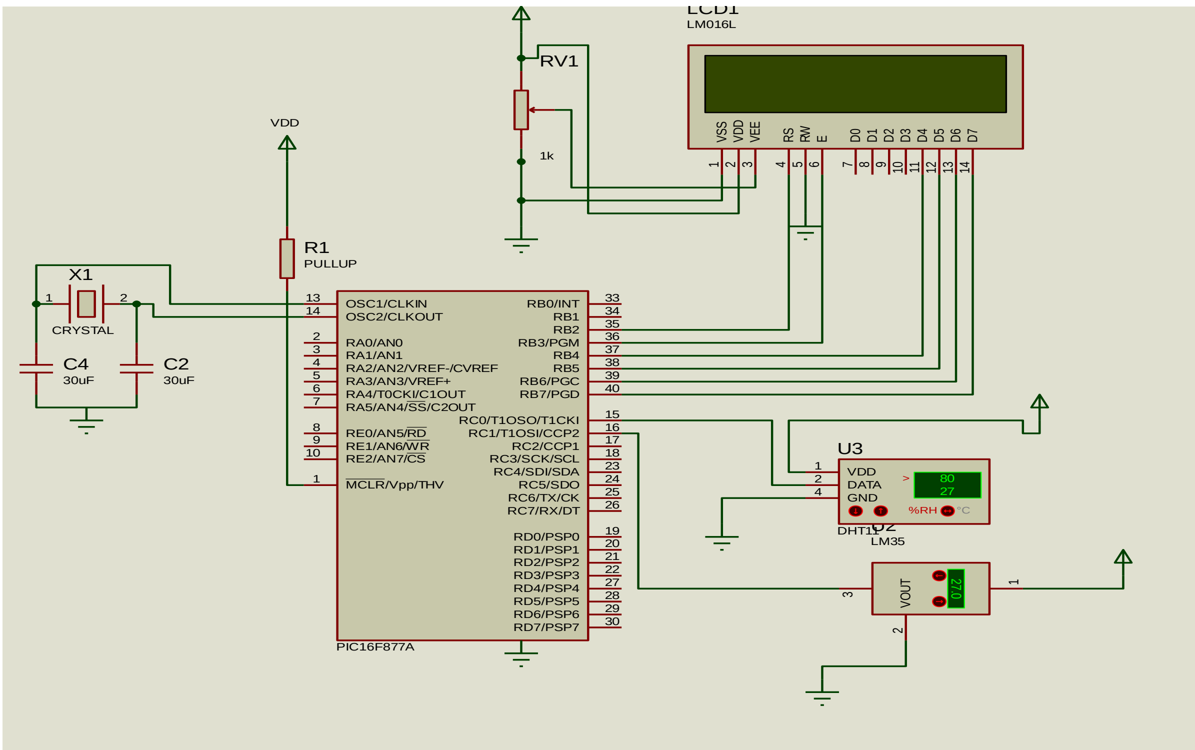


Figure 7: Cloud-based weather station circuit diagram

The circuit was implemented and packaged. Plate 2 -3 shows system's board and packaging.

Plate 2: System board

Plate 3: Packaged system

Results and Discussion

Each stage was tested before coupling them all together. The system was put to operation to measure the identified weather parameter over a period of twenty-four hours at an interval of 30 mins. The data was obtained from the cloud when the documentary root directory was applied to the web server. The parameters are as plotted in Fig. 8.

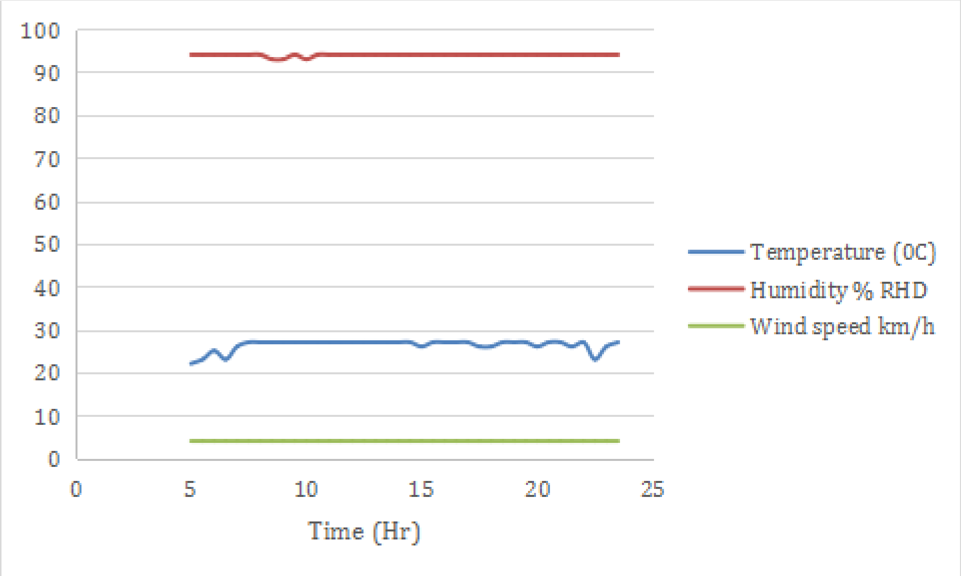


Figure 8: System's parameters analysis

Figure 8 reveals that the system supplies the readings of the parameters requested at the prescribed interval. The parameters were available throughout the period of examination.

Conclusion & Recommendation

The weather parameter measuring system presented in this work presents the real time measurement of temperature, humidity and wind speed. The knowledge of these parameters over time will facilitate the forecasting capability of the farmer in determining what preparation should be made for the farming season. Understanding these parameters will enhance the farmers faming activity, thus improving farm produce for the supply of man's food. It will further help the farmer in identifying what crop to be planted for maximum yield.

This system should be made available to farmer cooperative societies and an extension officer be saddled with the responsibility of interpreting the meaning of the measurands to farmers. The extension officer should also train the farmers on how to access this information form the system.

References

Balasubramanian, A. (2014). Measurement of Meteorological Variables. *Wmo*, *I-Cap.4*(March), 127–164. https://doi.org/10.13140/RG.2.2.21633.66405

Emran, M. Al, Rahman, M. A., & Pavel, A. A. (2020). *A Microcontroller Based System for Determining Instantaneous Wind Speed and Direction Using Optical Sensor*. 1–10.

Gahlot, N., Gundkal, V., Kothimbire, S., & Thite, A. (2015). Zigbee based weather monitoring system. *The International Journal Of Engineering And Science*, *4*(4), 2319–1813. www.theijes.com

Kalsi, S. R. (2018). Satellite Based Weather Forecasting. *Satellite Remote Sensing and GIS Applications in Agricultural Meteorology*, 331–346.

Lambebo, A., & Haghani, S. (2014). A Wireless Sensor Network for Environmental Monitoring of Greenhouse Gases. *ASEE 2014 ZONE 1 Conference*, 4.

Microchip. (1997). Pic 16F87XA. *Datasheet*, *25*(6), 5. http://www.ncbi.nlm.nih.gov/pubmed/19359153

Reddy, Nukala Rohit, A.Naveen Kumar, K. J. O. (2018). Climate Monitoring System and Transmission of Data Without Internet. *Internationa Research Journal of Engineering and Technology*, *05*(08), 1559–1562.

Speedstudio. (2002). Wi-Fi Shield. *Datasheet*. https://www.seeedstudio.com/item_detail.html?p_id=1220

Susmitha, P. (2014). Design and Implementation of Weather Monitoring and Controlling System. *International Journal of Computer Applications*, *97*(3), 19–22.

Uk, D. (2010). Temperature Sensor DHT 11 Humidity & Temperature Sensor. In *Datasheet*.