SOCIETY FOR SCIENCE AND EDUCATION
UNITED KINGDOM

TNC TRANSACTIONS ON NETWORKS AND COMMUNICATIONS

VOLUME 9, NO. 1
ISSN: 2054 -7420

Low-cost Wireless Personal Weather Station for Rural Farmers

[1]André Rodrigue Tchamda, [2] Merlain Boris Djousse K., [3]Anselme Maffo Koumetio, [4] Mathias Fru Fonteh, [5]François Becau Pelap, [6]Robert Tchitnga, [7]Martin Kom

[1,2,4]Department of Agricultural Engineering, Faculty of Agronomy and Agricultural Sciences, University of Dschang, Cameroon;

[3]Program for the consolidation and sustainability of agropastoral counselling, Cameroon;

[5,6]Department of Physics, Faculty of Science, University of Dschang, Cameroon

[7]Department of Electrical Engineering and Telecommunication, Polytechnic, University of Yaounde I, Cameroon

andre.tchamda@eaphysud.org; djoussemerlain@gmail.com; maffoansel@gmail.com; matfonteh.yahoo.com; fbpelap@yahoo.fr; robert.tchitnga@eaphysud.org; kommart@yahoo.com

ABSTRACT

This document presents the design of a prototype of a low-cost personal weather station suitable for farmers in rural areas who are or may not be engaged in rudimentary agriculture. This prototype measures several weather data: temperature, relative humidity, wind speed, wind direction, rainfall. For further data analysis, these are transmitted for recording to a remote server via wireless communication. The server offers data extraction possibilities in multiple file formats. A prototyping of the personal weather station is designed and commissioned. An extract of the results over two days is presented in the results section of this document.

Keywords: Microcontroller; Weather Station; Server; Rural Area; Farmer.

1 Introduction

Seventy-five percent of the world's population living under the poverty threshold dwell in rural areas. Most of them earn their living through agriculture and in most cases, the income they earn from their work is insufficient to meet their basic needs. Whereas they make up almost half of the world's population. Increasingly, climate variability increases the risk of failure in agricultural production. Climate remains the greatest factor of variability in agricultural products, either direct or indirect. With respect to the level of development, 20 to 80% of the year to year changes in yields is due to climate change. Losses from pests, diseases and weeds are estimated around 15% [1]. Post-harvest losses represent nearly the same percentage. The weather station is a key tool to monitor crop weather conditions and help farmers take decisions. In other words, allows for more assertive agricultural planning because it can collect information on the climate and thus analyze its history.

Today's weather stations are digital. A portable weather monitoring station that provides digital data typically consists of weather-sized sensors and a microcontroller that integrates remote monitoring protocols. A digital weather station may be for personal or professional use. The weather station for personal use is characterized by a relatively low cost with limited capacity. Equipped sensors are less

DOI: 10.14738/tnc.91.9647
Publication Date: 11th Jan 2021
URL: http://dx.doi.org/10.14738/tnc.91.9647

sensitive and generally do not have the ability to record or transmit data. On the other hand, the station for professional use is more expensive. These are typically wireless and autonomous stations capable of recording data automatically and transmitting it directly to a cloud through mobile operator services. Its various features make this type of station very expensive and less accessible to rural farmers.

The lack of mobile network coverage is also one of the consequences of the non-use of professional stations in these rural areas. It should also be noted that some municipalities in rural areas are characterized as network dead zones, because no mobile network coverage is available in these municipalities. The high cost of deploying infrastructure in rural areas, coupled with limited demand for mobile services among rural populations, results in a balance of demand and supply that results to a lack or low coverage of the population. Supply and demand policies are complementary and mutually reinforcing. The level of poverty of people living in rural areas and sparsely populated municipalities in rural areas are the cause of a limited demand for mobile services.

With a conformed weather station, the producer will have access to historical weather data in each area. The aim of this research is to develop a personal and less expensive weather station with capacities close to a professional station, autonomous adapted for rural areas with network dead zone and which can transmit wirelessly, data to a remote server for later viewing and interpretation. The proposed weather station measures parameters such as: temperature, relative humidity, wind speed, wind direction and rainfall.

The collected data is transmitted to a server via a transmitter called HC12. Once at the server, this data is stored in the MySQL database. Figure 9 shows the prototyping of the customized meteorological data station.

Paper is organized as follows. Section II presents a review of the literature on weather stations. The different techniques of temperature sampling, relative humidity, wind speed, wind direction and rainfall will be unveiled in Section III. Section IV presents the designed prototype and its different parts, followed by the experimental results obtained after testing. Finally, Section V presents the conclusion.

2 Related Work

The authors of [2] designed a prototype station using a microcontroller as a treatment unit. This prototype monitors soil moisture, soil temperature, air temperature. Depending on the prices of the components presented, this prototype is much cheaper. It was designed to monitor certain soil parameters in cultivated fields. Previous researchers [3] present a prototype weather station with a TEMT600 light sensor, a SCP1000 pressure sensor, a temperature and humidity sensor. Other researchers [4] also present a station model with a temperature sensor, gas sensors, dust detector, Ambient Light Intensity, water sensor, Ultraviolet Sensor and Hall Effect Sensor. But these two stations are not suitable for farmers living network dead zones for the simple reason that the transmission system uses the Global System for Mobile (GSM) network. A low-cost prototype to collect environmental parameters such as: temperature, humidity and wind direction was also presented in another paper work [5] present where internet is the means used for data transfer. This requires the presence of a mobile internet service provider. The weather station presented by other authors [6] serves as real-time radio frequency monitoring. The device measures the wind speed, temperature and intensity of solar radiation, then the data is sent by radio frequency and viewed in a computer. No database was implemented for further prediction. The sensors

used have no resistance to vibrations. So, if there is interference, the values of the vibration sensors can be altered.

3 Methodology

Block diagram of the proposed weather station is illustrated in Figure 1. Left diagram collects the various data and transmits them to server. Microcontroller on left diagram receives data from the sensors, then routes them to the wireless transmission module. The latter will transmit these data to the right diagram.

Right diagram will receive the data by its wireless transmitter / receiver module. Then, its microcontroller will take care of recovering the data and transmitting them to the server.

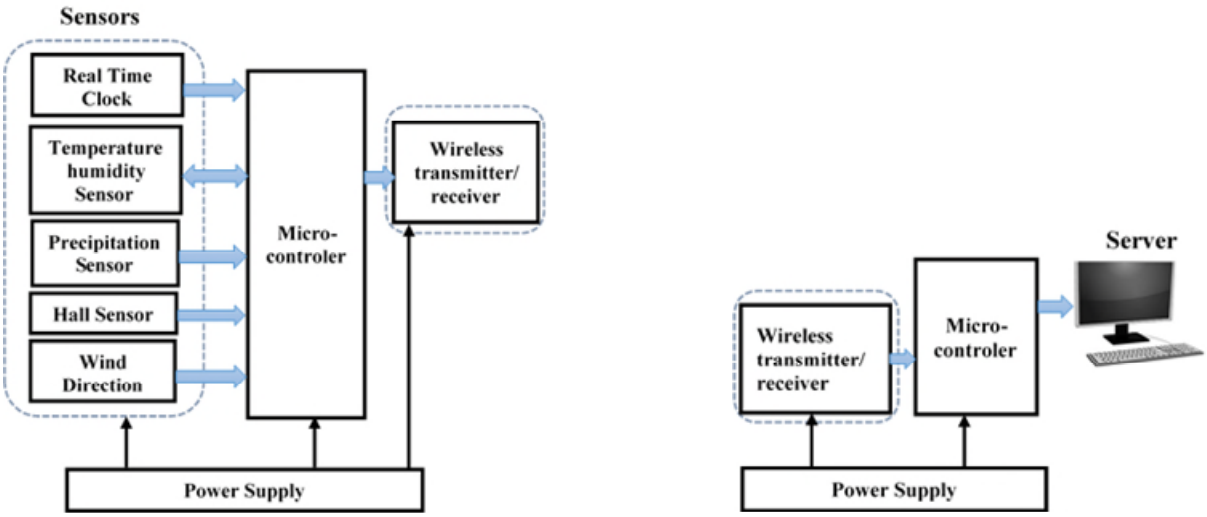


Figure 1: weather station block diagram

3.1 Sampling of humidity and ambient temperature

Relative humidity can be defined as the ratio of the amount of water in the air to a given temperature on the maximum amount of water that the air can hold. Temperature is a physical magnitude of heat or cold measured against a known scale. Figure 2 shows the use sensor to measure both parameters. Table 1 illustrates the characteristics of this sensor [7].

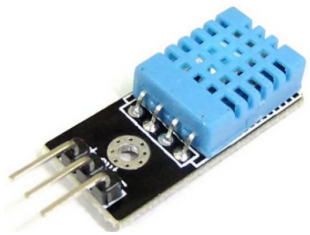


Figure 2: Relative temperature and humidity sensor

Table 1. DHT11 Sensor Characteristics

Copyright © Society for Science and Education, United Kingdom

Humidity (%)	20 ~ 80%
Precision (humidity)	+/- 5%
Temperature	0 ~ +50°C
Precision (temperature)	+/- 2°C
Max measurement frequency	1Hz (1 measure per second)
Power supply	3 ~ 5 volts
Long term stability	+/- 1% per year

For the measurements to be valid, the sensors must be in direct contact with the air, but also protected from the sun and rain. The shelter must therefore be well ventilated, but also protective enough so that the sensors should not get wet by rain. We use overturned plastic flowerpot plates. Figure 10 shows the designed weather shelter. Each plate is separated from its neighbor by a 2 cm long brace. The hollow ledge of each plate is pierced with holes to avoid the accumulation of rainwater or dew [8].

3.2 Anemometer

Wind speed is expressed in meter per second. A recovery anemometer consisting of 3 buckets was used to measure wind speed. To know the wind speed, we need to know the number of rotations of the blades during a well-defined time. To do this, we use a logical sensor with Hall Effect. Figure 3 shows the digital sensor with Hall Effect and figure 12 the design of the anemometer.

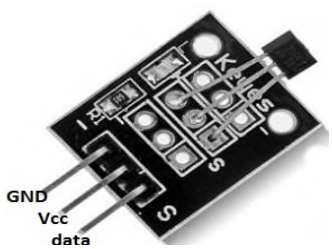


Figure 3: The Hall Effect Sensor

This sensor detects the presence of a magnet. The number of turns per second gives the n, the rotation frequency of the anemometer. From this frequency and circumference (C), the linear velocity is based on the next equation (1) where R is radius in meter, N is the frequency expressed in tr/s and V is the speed in m/s.

$$V = 2\pi RN \tag{1}$$

3.3 Wind Vane

Wind direction is expressed in degree. The wind vane is used to give the direction of the prevailing winds. All directions are available on the compass rose. The MPU6050 Module of figure 4 is a three axis gyroscope with a Digital Motion Processor™ (DMP™) circuit. This DMP™ circuit allows you to solve alignment problems without encountering errors generated by discrete components. The module uses the I2C series bus for easy interfacing with a microcontroller.

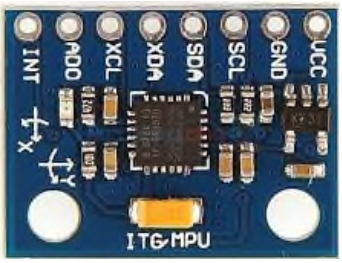


Figure 4: MPU6050 Module

3.4 Precipitation

Precipitation is the height of water that a soil received after a rain. They are expressed in millimeters. To measure the height of the rainfall with the microcontroller, a rain gauge with tilting buckets is suitable. The microcontroller then measures the number of tipping and converts to millimeters of rainfall. The height of the rains is given by equation 2 where n is the number of tipping.

$$P = 0.2794 \times \mathrm{n} \tag{2}$$

3.5 Real Time Clock

Data are collected and recorded with the date and time it was taken. Tiny RTC (Real Time Clock) module in figure 5 is capable of managing the time (hours, minutes, seconds) and date (days, months, years) while dealing with 30 or 31 days and leap years. Communication with the master microcontroller is done via an I2C bus. The module has everything you need to remember the time in case of a power outage thanks to an external battery. A simple battery keeps the time and date up to date for several years without power.

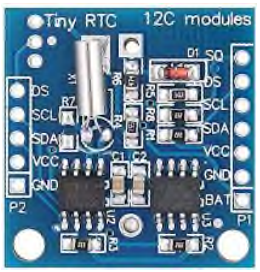


Figure 5: Module RTC Tiny

3.6 Transmission of data to the server

Transmission and recording of data in a database is carried out at regular intervals of time. The station sends data via a transmitter/receiver to a computer. The two HC-12 wireless communication modules are used for this purpose. HC-12 (figure 6) is a semi-duplex wireless series communication module with 100 channels in the 433.4 - 473.0 MHz range, capable of transmitting up to 1 km. A 4-pin UART interface (Vcc, Gnd, Tx, Rx) makes it compatible with a microcontroller.

Copyright © Society for Science and Education, United Kingdom



Figure 6: Module HC12

As shown in Figure 7, transmitter sends the data from the station and a receiver connected to a microcontroller receives it and transmits it to the server via the USB port. Once the data arrives at the USB port, a program written using the IDE 2.2.1 processing software retrieves and backs up in a MySQL database. Communication between the processing program and MYSQL is possible thanks to the BezierSQLib library.

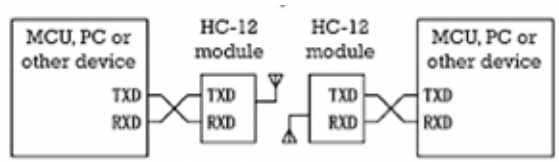


Figure 7: Wireless transmission block scheme

3.7 Microcontroller

The electronic part of the weather station is designed around the Atmega328P microcontroller. ATmega328P is an 8-bit circuit based on RISC's architecture. This microcontroller has an external interruption on input/output pins. This allows to implement precisely the measurement of wind speed via the hall sensor. The I2C port of this microcontroller allows it to communicate with the RTC module and the MPU6050 module. Regarding the transmission of the data collected, the microcontroller communicates with module HC12 from its communication port RS232. On the server side, Another ATmega328P microcontroller/module HC12 card is used as a receiver to receive and transmit the information to the server. Figure 8 shows the connections between the microcontroller and the components.

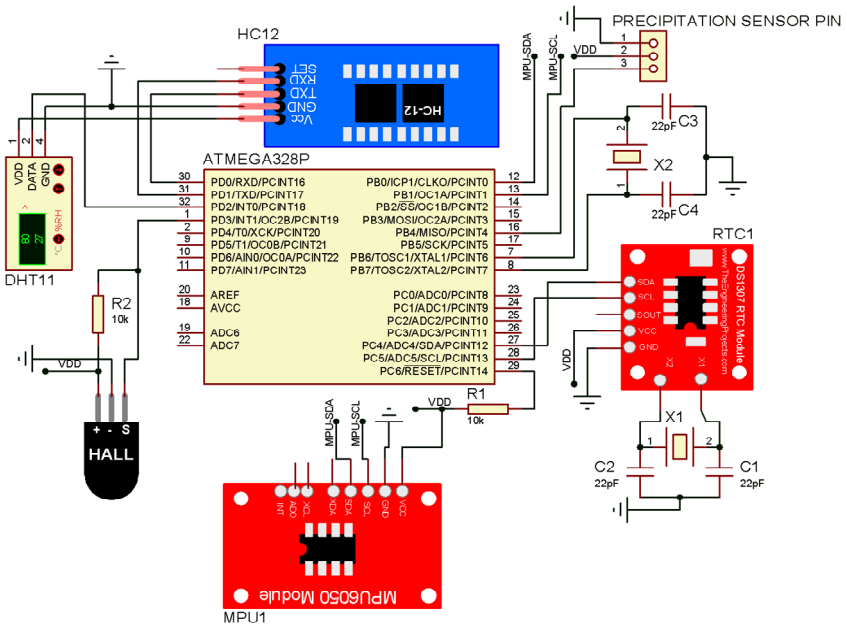


Figure 8: Connections between microcontroller and components

4 Experimental Results

4.1 Prototype Design

The final prototype presented in figure 9 consists of a two-meter high support and all the elements intended to collect the parameters over time.



Figure 9: Weather station prototyping

This weather station collects several parameters: temperature, humidity, wind direction, wind speed, rainfall at regular intervals. It consists of six parts: the anemometer, the wind vane, the rain gauge, the weather shelter and finally the command case. The different parts are illustrated by figures 10, 11, 12, 13.

Copyright © Society for Science and Education, United Kingdom

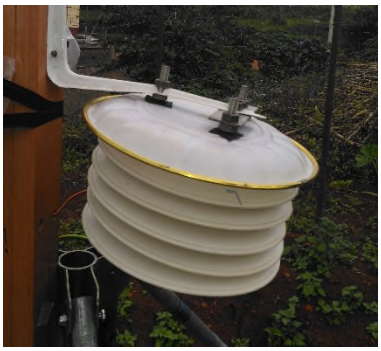


Figure 10: Weather Shelter



Figure 11: Rain gauge



Figure 12: Anemometer



Figure 13: Wind vane

Figure 14 shows the construction of the electronic card around the ATmega328P microcontroller.

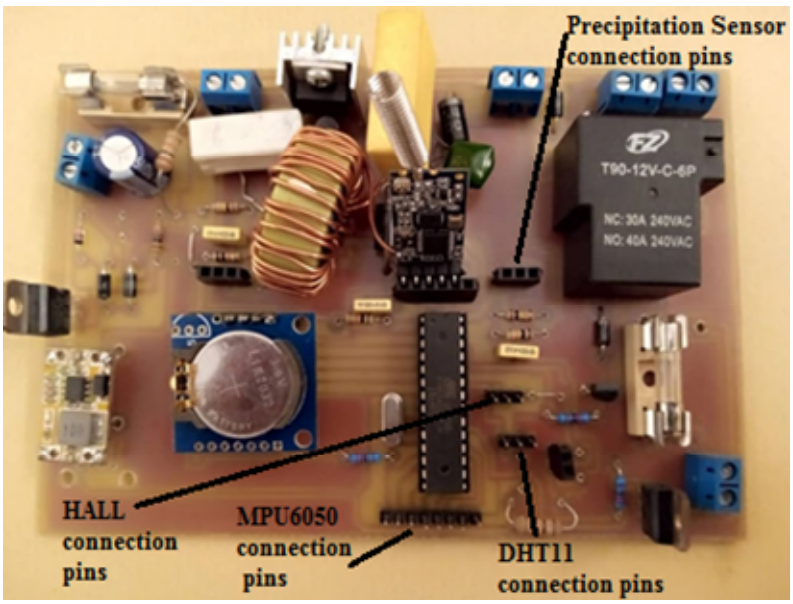


Figure 14: Electronic control card

The cost of this equipment table 2 was estimate to USD 82.45. This is relatively low compared to prices of equipment collecting similar data generally found in specific market places. In addition, all the accessories used are available locally and most of them made with local materials.

Table 2. Estimated price of weather station

Components	Quantity	Unit Price (USD)	Total Price (USD)
DHT11	1	5.84	5.84
Hall Sensor	1	1.67	1.67
MPU6050	1	5	5
Precipitation Sensor	1	0.5	0.5
Support SD	1	5.84	5.84
Carte SD	1	2.5	2.5
RTC Tiny Module	1	5.84	5.84
HC12	2	8.34	16.68
ATmega328P	2	5.84	11.68
Resistors	11	0.05	0.55
Voltage Regulator	2	0.25	0.5
Relais	1	0.84	0.84
Connectors	5	0,17	0,85
Capacitors	5	0,17	0,85
Fuses	2	0,34	0,68
Diode 1A	4	0.17	0.68
Diode 3A	3	0.34	1.02
Transistor	1	0.17	0.17
plates	6	0.34	2.04
Tige filetée	2	2.17	4.34
Shelf support	1	0.84	0.84
Bolts	41	0.09	3.69
PVC Pipe	1	0.84	0.84
Funnel	1	0.67	0.67
Socle	1	8.34	8.34
Total			82.45

4.2 Data

Figure 15 shows data reception test by server. A serial monitor on server is used to view data received. Server receives data from the receiver (ATmega328P microcontroller / HC12 module) by USB port.

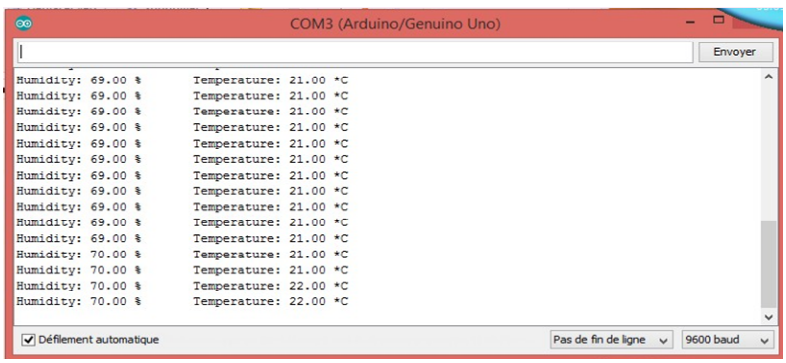


Figure 15: Data reception test by the server

Copyright © Society for Science and Education, United Kingdom

Data stored in the database can be extracted and exported in different formats. The extraction is done directly in MySQL through queries or through the graphic interface. Table 3 presents some of the data collected by the proposed prototyping.

Table 3. Station Recorded Data

Date	Hour	Humidity (%)	Temperature (°C)	Wind Speed (m/s)	Rainfall	Wind Direction
25/Oct/2016	04:30:00	95	18	0	0	0
25/Oct/2016	05:30:00	95	16	0	0	0
25/Oct/2016	06:30:00	95	17	0	0	0
25/Oct/2016	07:30:00	95	17	0	0	0
25/Oct/2016	08:30:00	95	20	0	0	0
25/Oct/2016	09:30:00	74	24	0	0	0
25/Oct/2016	10:30 :00	55	27	0	0	0
25/Oct/2016	11:30 :00	59	27	0.1	0	0
25/Oct/2016	12:30 :01	53	29	0.37	0	0

5 Conclusion

The low-cost personal weather station. with a wireless communication device here presented. It is based on a microcontroller and measures five climatic variables. These data are then transmitted to a server 700 to 1000 meters apart. Data transmitted by radio transmitter is received by a server and stored in a database. For further analysis. Data is accessible via the MYSQL graph interface in several formats.

REFERENCES

[1]. E.C. Oerke, H.W. Dehne, F. Schoenbeck and A. Weber. Crop production and crop protection.Elsevier. Amsterdam. 1994, pp. 72-741.

[2]. D.K. Fisher, H. Kebede. A low-cost microcontroller-based system to monitor crop temperature and water status. Comput. Electron. Agri. 2010, 74, pp. 168-173.

[3]. M. Popa, C. Iapa. Embedded weather station with remote wireless control. in:19th Telecommunications forum TELFOR. IEEE. 2011, pp. 297–300.

[4]. S.H. PARVEZ. A Novel Design and Implementation of Electronic Weather Station and Weather Data Transmission System Using GSM Network. WSEAS TRANSACTIONS on CIRCUITS and SYSTEMS. 2016, 5, pp. 21–34.

[5]. M.A. Joshi, M.R. Jathar, S.C. Mehrotra. Distributed system for weather data collection through TINI microcontroller. Int. J. Environ. Sci. Develop. 2011, 2(1), pp. 70–72.

[6]. Iswanto H. Muhammad. weather monitoring station with remote radio frequency wireless communications. International Journal of Embedded Systems and Applications (IJESA). 2012, 2(3), pp. 99–106.

[7]. Mouser Electronics. DHT 11 Humidity & Temperature Sensor. Retrieved from https://www.mouser.com/datasheet/2/758/DHT11-Technical-Data-Sheet-Translated-Version-1143054.pdf. 2016/09/09 at 12:30.

[8]. De Montalivet. Un abri pour sondes. Retrieved from http://montpellier.meteo.free.fr/Soucabris/Soucabri.htm. 2016/08/03 at 15:45.

Copyright © Society for Science and Education, United Kingdom