A Low Cost Automated Weather Station for Real Time Local Measurements

Mohamad Farhat
School of Engineering
The Australian College of Kuwait, Kuwait
m.farhat@ack.edu.kw

Mohammed Abdul-Niby
School of Engineering
The Australian College of Kuwait, Kuwait
m.nibi@ack.edu.kw

Mohammed Abdullah
School of Engineering
The Australian College of Kuwait, Kuwait
1210813@go.ack.edu.kw

Abdelbaset Nazzal
School of Engineering
The Australian College of Kuwait, Kuwait
1108945@go.ack.edu.kw

***Abstract*—In this paper, we present an automated weather station for real time and local measurements, based on an embedded system that continuously measures several weather factors such as temperature, humidity, barometric pressure, wind speed, wind direction, and rainfall. This weather station consists of two parts which are located indoor and outdoor and connected together wirelessly. The outdoor weather station measures the current temperature, humidity, barometric pressure, wind speed, wind direction and recent rain amount. The indoor station displays the outdoor reading as well as the temperature and humidity for the room it is located in, on a graphic liquid crystal display. In addition, this weather information can be accessed from any place through an iOS and Android application called Blynk.**

Keywords-Automated weather station;Embedded system

I. INTRODUCTION

Horticulture, agriculture, and ranching are all rely on weather conditions to determine when to carry a specific kind of work in a related field, such as crop irrigation, planting, harvest and spray to prevent diseases [1]. In addition, renewable energy sources such as wind, hydro and solar energy are on high demand globally. To choose the prospective location of such projects, it is crucial to gather and analyze all associated weather information to ensure the sustainability and viability of the project. For these purposes and many more, it is important to continuously collect the weather data, study and analyze them to obtain the necessary predictions. Therefore, the challenge is to find suitable weather measurement devices with the least of hassles in obtaining weather data, considering most applications are remotely located and measurements are to be carried out for long periods. Most low-cost weather stations are hand-held while the sophisticated once are quite expensive [2]. Also, weather information provided by local authorities [3] are general and inaccurate for such applications, as they are based on automated weather stations (AWS) located on specific locations. In this paper, an accurate, reliable, user friendly low cost automated weather system was developed to overcome such issues.

II. SYSTEM DESCRIPTION AND OPERATION

The system described in this paper aims to provide full weather information for certain areas through a convenient user friendly mobile device or a graphic liquid crystal display. It consists of two weather stations, indoor and outdoor connected together wirelessly. They provide the outdoor information of the current state of the weather such as temperature, relative humidity, barometric pressure, wind speed, wind direction, and rain fall. The indoor station measures the indoor temperature and relative humidity. The system is an internet of things system as all the weather measurements are uploaded to the internet for display and analysis using smartphones, tablets, PC, and even for sharing through social media. Also, the system sends notification to the user through an application if a certain weather parameter exceeds certain limits.

The system basic operation can be summurized as shown in Figure 1. The outdoor weather station measures the current weather factors and send them wirelessly to the indoor station. The indoor station displays the outdoor reading as well as the temperature and humidity for the room it is located in, on a graphic liquid crystal display. In addition, the indoor station uploads the indoor and the outdoor weather information to the internet in order to access them anywhere through an iOS and Android application called Blynk.

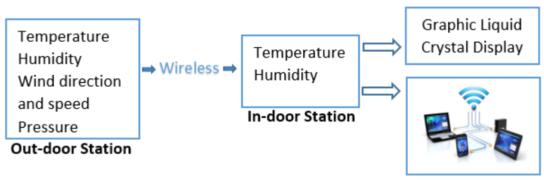

Fig. 1. Block diagram for the general system functions.

III. SYSTEM IMPLEMENTATION

The system consists of two developments boards as shown in Figure 2, in additional to several peripherals. Arduino Uno board [4] was used for the indoor weather station, where a Red board from Sparkfun [5] was used for the outdoor station. Both boards are programmed using the Arduino IDE. These two boards consist of 14 digital Input/output pins with 6 PWM pins, and 6 analog inputs. They can be powered either by USB or the barrel jack; also, they have an on-board power regulator which can handle anything from 7 to 12 V_{DC} for the Arduino and 7 to

15 V_{DC} for the Red board. These development boards are used to control the sensors, wireless modules, and the graphic screen to perform their function in this system.

Fig. 2. Main boards used for system development.

A. Particle photon Kit

To link the system to the internet, the particle photon kit Figure 3 was used. It has a 120 MHz ARM Cortex M3 microcontroller with a Broadcom Wi-Fi chip in a tiny thumbnail sized module called the p-zero. Each photon comes with headers to be easily installed on breadboard and access to the particle cloud which have great features for building a connected system like over the air updates and data storage. There are two ways to program the photon using either an online or local IDE. The photon is ideal to build an internet of things system.

Fig. 3. Particle photon kit

B. Weather shield and Sensors

The weather shield (Figure 4b) is an Arduino shield with sensors to measure the temperature, relative humidity, and barometric pressure. It has HTU21D humidity and MPL3115A2 barometric pressure sensors. Also, it has optional RJ11 connections to other sensors like a wind speed, wind direction, rain gauge and GPS. This connector used to connect the wind direction, speed and rain fall sensors to the board (Figure 4c). Each shield can operate from 3.3V up to 16V and has built in voltage regulators. The shield is designed to work with the sparkfun and Arduino Uno. The Indoor station use DHT11 (Figure 4b) which is a low-cost temperature and relative humidity sensor. It has a digital output on the data bin based on the readings of a capacitive humidity sensor and a thermistor to measure the surrounding air.

C. 434MHz Wireless Module

These 434MHz wireless modules (Figure 5) fit into breadboards and configures with microcontrollers to create a simple wireless data link. The theoretical communication range of these two modules is 152.4 meters given perfect conditions. They also have 4800 bps data rate and operate with 5V supply voltage, thus this module is ideal for this system.

D. Power Source

The system uses multi-voltage power sources that provide each component with its corresponding power. The outdoor station uses solar power, while the indoor uses 9 Volt battery or power adapter.

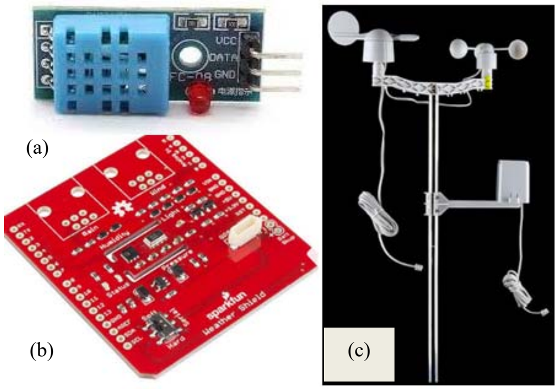

Fig. 4. Weather shield, DHT11, and wind-rain sensor.

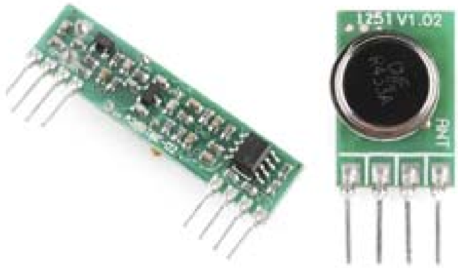

Fig. 5. Wireless module

IV. SYSTEM OPERATION IN DETAIL

A. Outdoor station

The outdoor station is connected according to Figure 6. The Data pin is connected to pin 12 on the Red Board, while the rain gauge, wind direction and wind speed sensors are connected through RJ 11 cables. Gnd and Vcc are connected to power source.

B. Indoor station

The indoor weather station is connected as shown in Figure 7. The receiver, Photon and DHT11 are connected to Arduino board through their desired pins. A nine-volt adaptor or battery is used to power up the circuit.

C. System operation

To reduce power consumption, both stations takes reading every 10 minutes as explained in Figure 8. First, the outdoor station takes all outdoor weather information and sends them wirelessly to the indoor station. The indoor station receives the outdoor measurements and measure the indoor temperature and relative humidity. Then it displays all information using the graphic LCD. Information then moved to the particle photon through serial connection to upload them to the internet. Therefore, an application called Blynk [6] which is a Platform with iOS and Android to control Arduino, particle photon and the likes over the Internet. It's a digital dashboard where a graphic interface simply can be built by dragging and dropping widgets. Thus, benefitting from these features of Blynk, a user-friendly interface was built (Figure 9), where all information can be accessed from anywhere using smart devices. In addition, the weather information data can be saved using blynk app servers or any computer server for study and analysis. Furthermore, having data on the internet, opens many possibilities for system enhancements, such as sharing weather information publicly over social media. Therefore a Twitter account that tweets all these information automatically once per hour was developed for this purpose (Figure 10). Also, the system has the ability to send a warning message through Blynk app if a certain weather parameters exceed any preset limits (Figure 11). Actual pictures from the stations are shown in Figures 12 and 13.

V. CONCLUSION

The weather station described in this paper provides a low cost, flexible and user friendly system for different applications. The weather information provided by this system can be accessed through different ways, such as LCD, smart devices, PC, social media and alert messages. The outdoor station was power using solar power while the indoor station can be powered using main power.

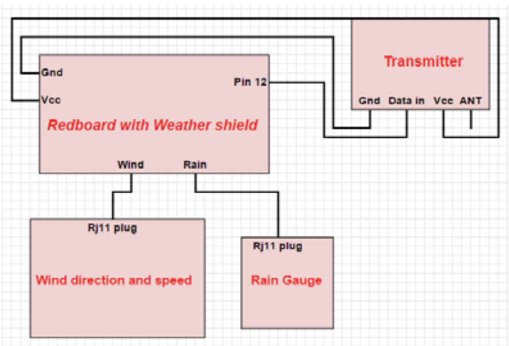

Fig. 6. Outdoor practical connection between the different circuitry

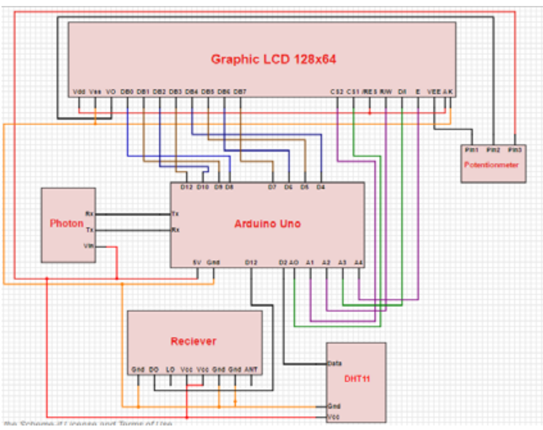

Fig. 7. Indoor practical connection between the different circuitry

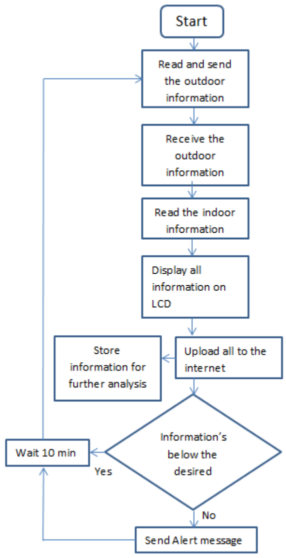

Fig. 8. System operational flow chart

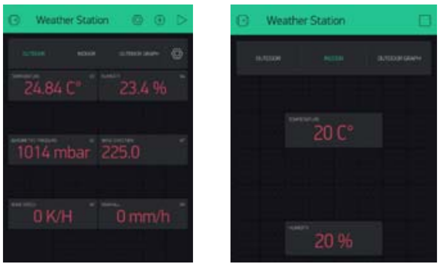

Fig. 9. Blynk interface for indoor and outdoor information

Fig. 10. Sharing weather measurements through automatic tweets

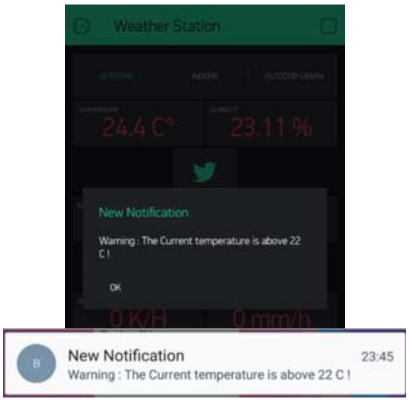

Fig. 11. Sending mobile notification inside and outside the application

Fig. 12. The outdoor station

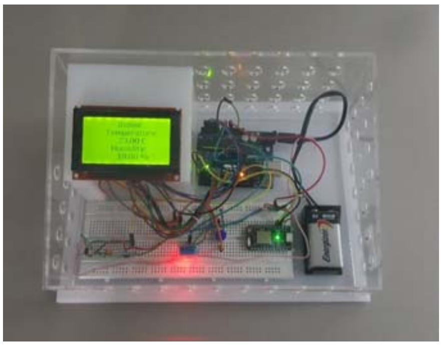

Fig. 13. The indoor station

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