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# Experimental Study and Prototyping of a Novel ESP32-Based Home Weather Station

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***Abstract* – This paper presents a new weather station for domestic use. The weather data to be acquired consist of four ambient variables, i.e., temperature, pressure, humidity and light flux. The proposed instrument is designed and virtually simulated using Proteus software. Then, its operating needs rely on data acquisition, digital processing, technical decisions and data monitoring. As technical strategies, Arduino C++ tool is used to build and compile the application software to be uploaded into an ESP32 microchip for real time instrumentation needs. Then, both virtual scheme and real prototyping workbench of the proposed instrument are outlined. Furthermore, experimental results obtained from a prototyping workbench, show instrumentation novelties of the proposed home weather station initiated in this paper.**

***Keywords - Home weather station, data acquisition, ESP32 microchip, LCD monitoring, workbench, real prototyping device***

## I. Introduction

### A. Review of Monitoring Systems for Weather Data

Meteorological instrumentation stations are very used in the world for a wide variety of needs, including planning of people's activities, comfort as well as forecasting well-being.

As an implication, significant research works have been conducted on modern types of outdoor weather stations. Figure 1 shows a common block diagram of modern weather stations. It consists of five main parts numbered as follows:

(a) Whether sensors.
(b) Data acquisition and digital processing device.
(c) Output interface support.
(d) Transmission media.
(e) Weather data monitoring system.

However, the overall performance of any weather station is dictated by the choice of its 5 building parts as outlined in Figure 1. As an implication in most practical cases (e.g. in [1], [2], [3] and [4]), the weather sensor device is a BME280 micro-board. Then, the digital data processing part being an ESP32 microchip [1], an ATMEGA2560 microcontroller [2] an ESP8266 device [3], or even an Arduino Mega2560 board [4]. Furthermore, a DHT11 device (temperature and humidity sensors) and a TSL2560 light sensor are used in some cases [5], etc.

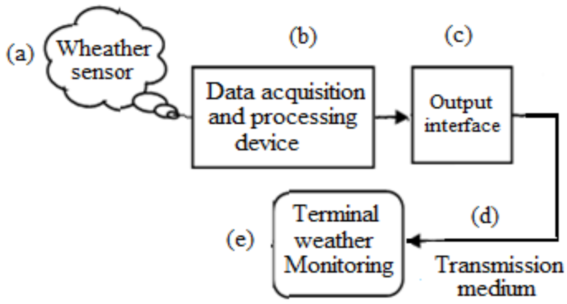


Figure 1. Block diagram of standard weather monitoring systems

At this introductive step of modern whether instrumentation stations, most of their prototyping realizations are designed for outdoor use. In addition, they involve a reduced number of output types.

### B. Main Scope and Contribution of the Paper

This paper aims to introduce a pioneering home weather station. Its pioneering nature relies on a wide variety of input and output information, e.g., temperature, humidity rate, air pressure, light flux, and alarms in case of critical operating problems. The proposed home weather station might be embedded into a customized wooden support, for automatic monitoring of home ambient weather. In Section II, the design tools and methods of the proposed home weather station model are presented. Then, the prototyping steps are outlined in Section III, followed in Section IV by experimental results obtained. Finally, the conclusion of the paper given in Section 5.

## II. Design Tools and Methods

### *A. Block Scheme of the Domestic Weather Station*

The block diagram of the proposed home weather station is shown in Figure 2. It consists of main building parts which are numbered as follows:

(a) 3 embedded sensors (temperature, humidity and atmospheric pressure).
(b) LDR (Light Dependent Resistor).
(c) ESB32 microchip with numerous embedded instrumentation resources.
(d) LED (Light Emitting Diode).
(e) Local buzzer.
(f) Local monitor of output data.

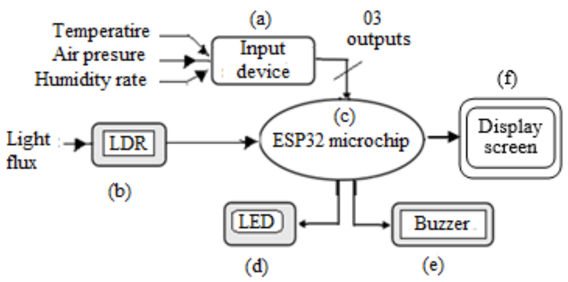


Figure 2. Block diagram of a multichannel digital instrument based on ESP32 microcontroller

It will be shown in next sections of this paper that compared to several existing research works on weather stations, the home model initiated in this paper behaves as an automated programmable instrumentation device, involving four output characteristics of the weather and two control indicators of real time operating conditions.

### *B. Virtual Design Works of the Proposed Home Weather Station Model*

Figure 3 shows the hardware architecture of main electronic parts of the proposed home weather station, with building parts chosen in the available technical electronic literature ([6], [7], [8], [9], [10]). It consists of suitable components in term of minimum size, higher performance and lower costs compared to common building materials used in outdoor weather stations.

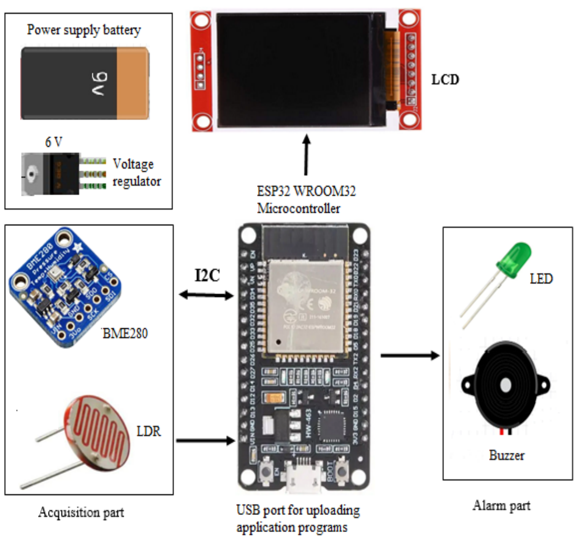


Figure 3. Hardware architectural of the proposed home weather station

Then, TABLE I shows the main characteristics of hardware parts depicted on Figure 3. Its central electronic core is an ESP32 WROM microchip with main technical characteristics summarized in Table 1. Its CP2102 software driver must be preinstalled into the PC to be used for real time communication between the two. In addition, the input interface consists of a custom BME280 device with embedded instrumentation inputs and outputs. Even in this case, the BME280 library *bme280.h* must be preinstalled and declared in the Arduino C++ application to be used. Furthermore, the overall DC power needs can be either a supply by an upstream 9 V battery via a piece of 7806 integrated circuit involving 6 V outputs, or a ready to use DC voltage supplied via an active USB link of ESP32 microchip.

| HARDWARE | MAIN CHARACTERISTICS |
|---|---|
| Battery | 9V output |
| Voltage regulator | 7806V model with 6V output |
| BME280 | Embedded sensors including (temperature, pressure, humidity, I2C, SPI, etc.) |
| LDR | 10-1000 Lux |
| ESP32 | Dual core with 32 bits, Wi-Fi, Bluetooth, USB connector |
| LCD (Liquid Crystal Display) | Standard type |
| Buzzer | Rated Voltage: 6V DC, Operating Voltage: 4-8V DC |

TABLE I. TECHNICAL CHARACTERISTICS OF PARTS DEPICTED ON FIGURE 3.

Figure 4 shows the virtual electronic circuit of the home weather station model, implemented in this research work under Proteus 8 professional framework. All electronic components needed for the virtual design are embedded into Proteus 8.

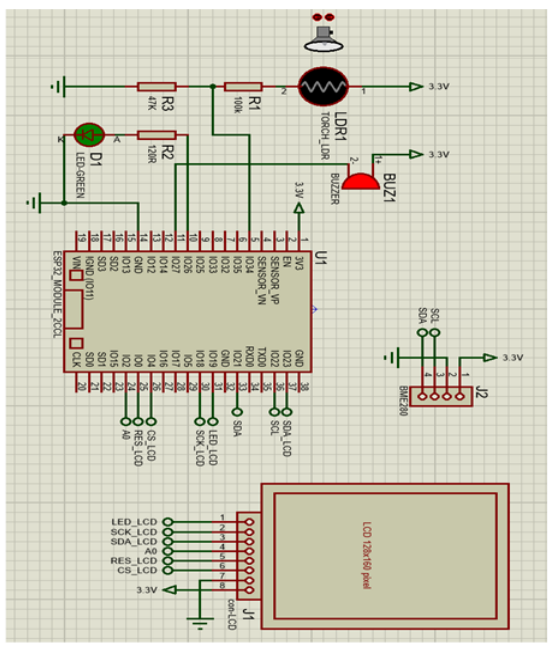


Figure 4. Virtual electronic scheme for ESP32-based home weather station

In addition, Figure 5 shows the main virtual board of the proposed home weather station. At this point, it is important to outline the fact that it consists of low cost and low size as well as high performance electronic parts. Recall that the BME280 mini board embeds three sensors (i.e., temperature, pressure, humidity rate) and I2C/SPI communication bus.

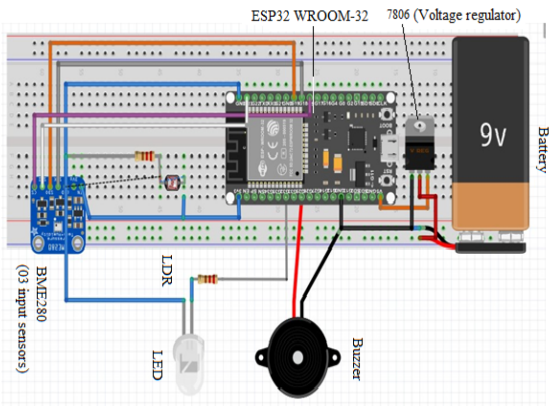


Figure 5. Virtual main board of the prototyping home weather station

Furthermore, the BME280 mini board does not require other additional components since it is pre-calibrated already by its manufacturer [11]. Furthermore, the LDR part inserted on the mini board is a high precision light flux sensor. As it will be seen later in Section 4 of this paper, it is important to mention at this point that the use of both an external 7809 circuit as external voltage supply and an external 9V battery, become unnecessary if the ESP32 board and a computer are online connected via an active USB cable. As a relevant finding in this case, the overall size and cost of the ESP32-based main board are minimized.

### *C. Programming Scheme of Instrumentation Tasks for ESP32 Target*

The programming tasks for ESP32-WROOM32 target microchip are organized in this paper, according to the processing scheme presented in Figure 6. It consists of:

1) An upstream sequence with four serial steps {a, b, c and d}, required for setting up and initialization of software and hardware resources needed by the real time application program to be implemented.
2) A downstream dual loop structure with step numbers {a, b, c, d} for conditional processing of real time instrumentation processes, includes:
   - Data acquisition from sensors channels.
   - Digital data processing and testing.
   - Outputs data to be monitored.

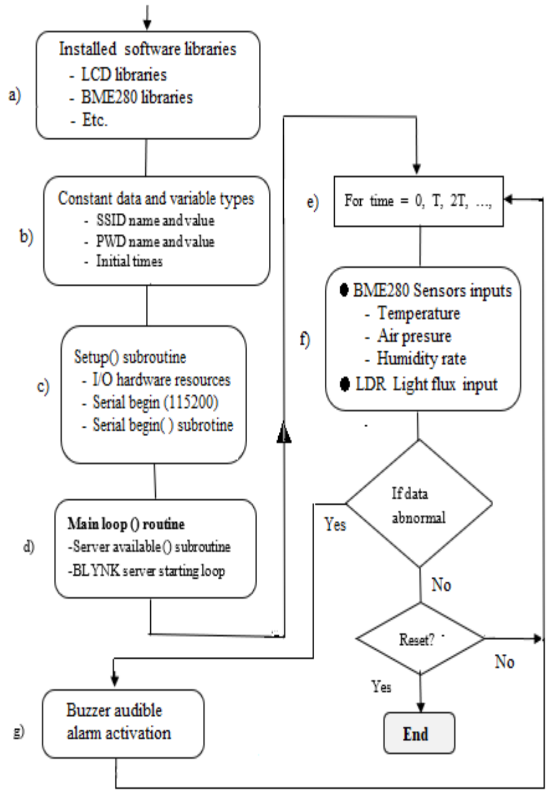


Figure 6. Diagram algorithmic of sketch Arduino/C++ of the instrument

In this research work, the resulting digital instrumentation program, has been implemented and successfully compiled under C++ platform. Then, the resulting C++ executable sketch has been uploaded into ESP32 WROOM32 microchip, for real time tests of our pioneering home whether station under a prototyping workbench.

## III. Custom Workbench Of The Proposed Home Weather Station

Figure 7 shows a custom workbench built and used to perform experimental tests on the first prototyping realization of the home weather station.

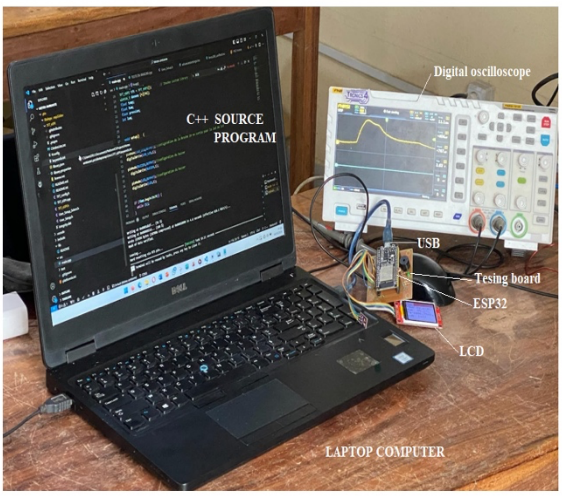


Figure 7. Didactic workbench for home weather instrumentation station

It consists of many building parts including:

- PC/Laptop computer with installed C++ framework.
- Custom testing board use as a prototyping home weather station.
- USB cable used to connect the PC to the ESP32 microchip for:
  - Either uploading the executable C++ application the C++ compiler framework into ESP32 space memory.
  - Or as an online Vcc link of power supply to the ESP32 board when an external 7806 voltage regulator is not available.
- Storage memory oscilloscope, with probes connected to the ESP32-based testing board.

## IV. PROTOTYPING HOME WHETHER STATION

As shown in Figure 8, the final prototyping device of the proposed home weather station consists of two relevant main parts, i.e., the ESP32-based main breadboard and the LCD-based monitoring device.

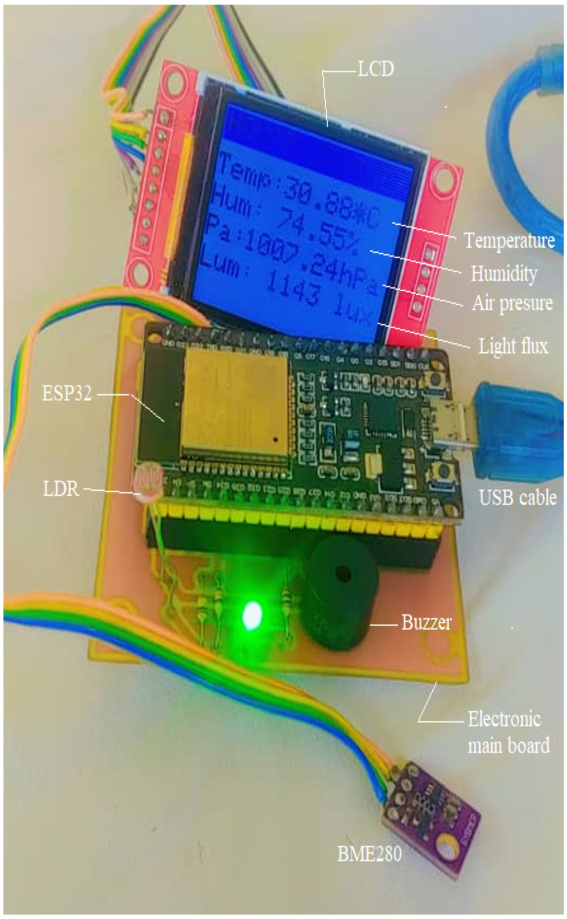


Figure 8. Prototyping four outputs monitoring device and experimental results

As a practical remark, the building components of this first prototyping home whether station are quite visible onboard, except thee two, e.g., {7806 voltage regulator, 9V Battery}. However, let recall from the technical comments provided earlier in the last paragraph of Section 2.3, that both DC power supply components become unnecessary under an active USB link between a Laptop computer and the ESP32 board.

A sample of experimental results displayed on the LCD when testing our real prototyping device, under living room conditions, are as follows:

- Temperature: 30.88 ºC, with standard value inside the set [1000 – 5000] Lux.
- Humidity rate = 74.55%, the standard value been in the set [40% – 60%].
- Atmospheric pressure = 1007.24 hpa with standard value 1013,25 hpa.
- Light Flux = 1143 Lux, with standard value depending on areas and activities.

These data characteristics obtained under real operating contexts, show the realistic behavior as well as technical qualities, of the pioneering home weather station initiated in this paper. However, it is necessary to compare our proposed home weather station, with similar existing devices. The comparative study is presented in TABLE II, where four groups of technical criteria, i.e. Operating station, inputs signals to be captured, processing core and output media.

| | **Comparison criteria** | | | |
|---|---|---|---|---|
| Research Works | Station | Input types to process | Digital Core | Output Media |
| This paper | Indoor | Temperature<br>Pressure<br>Light flux<br>Humidity | ESP32 | LCD<br>Buzzer |
| [3] | Outdoor | Humidity<br>Pressure<br>Pressure | ESP 8266 | Wi-Fi |
| [5] | Home | Temperature<br>Humidity | ESP32 | Wi-Fi |
| [10] | Indoor | Pressure<br>Temperature<br>Humidity | ESP32 | Wi-Fi |
| [11] | Outdoor | Temperature<br>Pressure<br>Humidity | ESP 8266 | Wi-Fi |
| [15] | Outdoor | Pressure<br>Humidity<br>GPS | Raspberry PI | Wi-Fi |

TABLE II. COMPARATIVE STUY WITH A SAMPLE OF WEATHER STATIONS

The relevant findings emerging from TABLE II is that the final version of our proposed weather station will be low size, low cost and dedicated to indoor use, while offering a wide range of weather characteristics. However, given the technology trend emerging ([12], [13]) in the last colon of TABLE II, it is necessary to reinforce the weather LCD monitoring to the IoT technology.

## V. Conclusion

The aim of this paper was to outline a pioneering device for home weather station applications. It consists of a low-cost ESP32-based signal acquisition core, with low cost and high-quality instrumentation and monitoring devices. The professional tools used to conduct virtual simulation tasks and real time programming of the C++ applications, are 100% freeware tools. In addition, the resulting programmable and well tested home weather station, behaves as a four-input instrumentation device, equipped with a LCD for visual monitoring of weather data {temperature, atmospheric pressure, light flux, humidity rate}. However, even though experimental tests conducted on our pioneering home weather station have been quite satisfactory, the extended IoT-based device will become a priority of our future research works.

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