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WEATHER STATION DESIGN USING ARDUINO PLATFORM

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ABSTRACT

The paper presents an application that involves the real-time acquisition of four parameters: temperature, relative humidity, pressure and light intensity. Several sensors are used that acquire these values (DHT11- temperature and relative humidity, BMP180 - pressure, BH1750 – light intensity) connected to an Arduino Uno development board equipped with the Atmega328 microcontroller, using digital and analog pins. The display of information is done on a monochrome screen attached to the Arduino board. The developed weather station is capable of measuring these four environmental parameters and providing readings at 5-minute intervals. Weather stations can be used in a variety of locations and domains from meteorology and weather monitoring, to agriculture, scientific research, navigation and aviation, or renewable energy industry. The weather stations can provide useful information on different weather parameters which is essential for providing accurate weather forecasts and monitoring climate changes, for optimizing the performance of energy installations and forecasting energy production.

Keywords: temperature sensor, humidity sensor, pressure sensor, Arduino board

INTRODUCTION

Monitoring environmental variables such as temperature, pressure and humidity has a long history. Measuring and keeping these environmental variables constant is important in industrial processes.

Temperature is the main characteristic of the climate, the value of and depends on it the regime of the other meteorological elements [2]. ***Humidity*** represents the mass of water vapor in the atmosphere. Relative humidity (R) shows the degree of air saturation with vapors, being the percentage ratio between the amount of water vapor that a volume of air contains and the amount that would saturate that volume of air. ***Atmospheric pressure*** represents a variable physical quantity depending on the different thickness of the air masses, temperature, altitude and air density. The measurement of atmospheric pressure is done with the barometer. These can be with mercury, water or gas. ***The luminous intensity*** is the luminous flux emitted in a given direction by a point light source, relative to the solid angle unit in which the source emits.

In developed countries, various satellites are orbiting in the space just to monitor the climatic conditions; but it is notable that such devices are very robust, expensive, and are associated with high-end technologies. So, there is a need for a system that can monitor the weather parameters precisely and also cost-efficient and real-time operational so that it can be installed at any place likes industries, institutions, home [7].

The all instruments which are used for measuring weather elements are expensive. So, we need a solution for solve this problem. The solution in Arduino platform. This platform collects weather elements and transmits them to digital data with the aid of a simple digital device. The data gathered over a period of time can be used to predict the atmospheric condition of a place [3, 4, 5].

In 2012 was designed a low-cost weather station which was used to measure four weather elements namely temperature, atmospheric pressure, relative humidity and wind speed using their respective sensors. The logged data was used to view the logged data using a MATLAB based graphical user interface (GUI) and some setup operations were performed on the system [7].

In 2014 was developed a prototype weather station which was used to measure the air temperature, relative humidity, dew point, wind speed, and rainfall remotely. The recorded weather data was transmitted wirelessly to a Personal Computer (PC) for logging and display by means of a graphical user interface [6].

Currently, digital weather stations that are easy to view and understand and can combine and report information has been developed. Some can even connect to smartphone apps or online services such that people can access their weather information from anywhere. It can be used to manage gardens and monitor farms and also as a hobby. Digital weather stations are more accurate and easier to use [8].

WEATHER STATION DESIGN

The block diagram of the weather station is shown in figure 1.

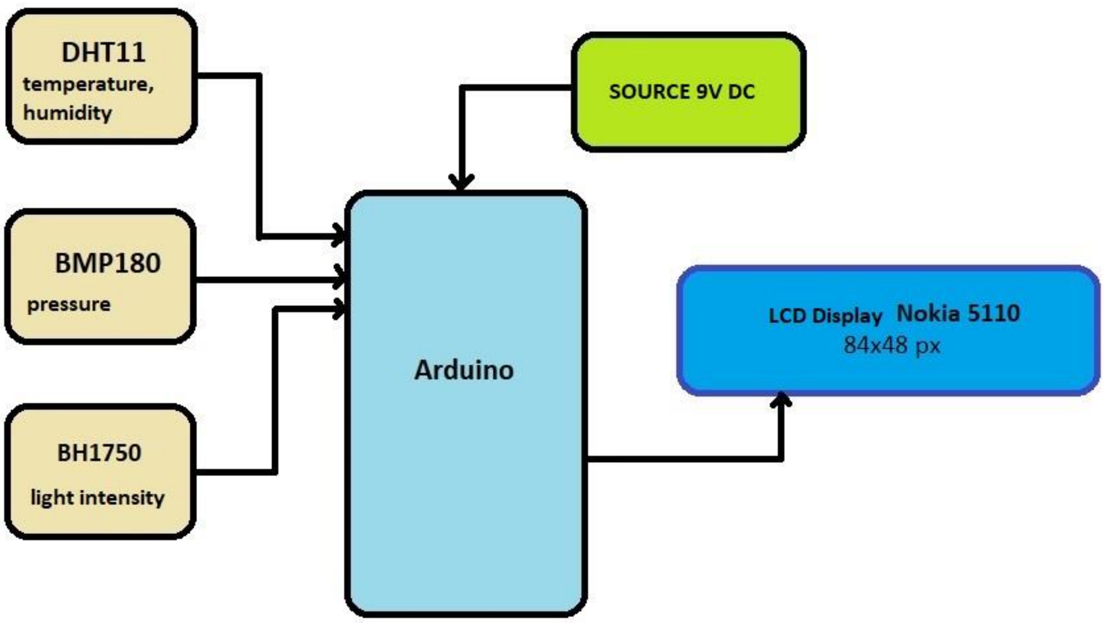


Figure 1. *Block diagram of the measurement system* [1]

The Arduino block is the most important component of the system. It contains a development board based on ATMEGA328 microcontroller. This block requires power from a 5V power supply [5].

Source block ensures the voltage supply of the assembly between 7-12 V DC. It can display graphics with a resolution of 84x84 pixels [14].

DHT11 block it contains the sensor for measuring temperature and relative humidity (Figure 2). The sensor is calibrated under laboratory conditions and transmits information through a digital interface. This sensor has two parts: a resistive component for humidity measurement and an NTC component for temperature measurement; these parts are connecting to a microcontroller. The calibration coefficients for the two components are stored in the microcontroller memory and are used by the internal process of the sensor [3].

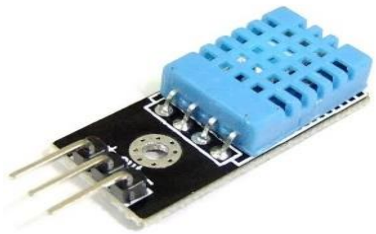


Figure 2*. The DHT11 sensor* [11]

BMP180 is a sensor module to measure pressure and altitude, with extremely low consumption and very small dimensions (Figure 3).

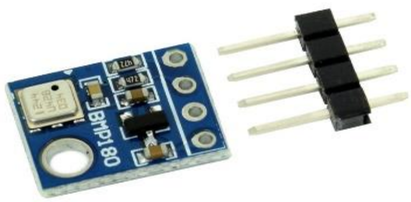


Figure 3*. The BMP180 sensor* [12]

BH1750 is a module that contains a sensor for measuring light intensity (Figure 4). Having integrated a 16-bit ADC (Analog to Digital) converter, it converts the information received from analog sensors and transforms them into a compatible digital signal that can be easily read by Arduino [11].

Figure 4*. The BH1750 sensor* [10]

Nokia 5110 LCD it is able to display alphanumeric characters, lines and other shapes or even images. All this is possible thanks to the monochrome screen with a resolution of 84x48 pixels (Figure 5). This module has an integrated PCD8544 driver that ensures compatibility with most Arduino, Raspberry Pi, etc. development boards [13].

Figure 5. *Nokia 5110 display* [13]

The assembly diagram of the sensors is presented in figure 6.

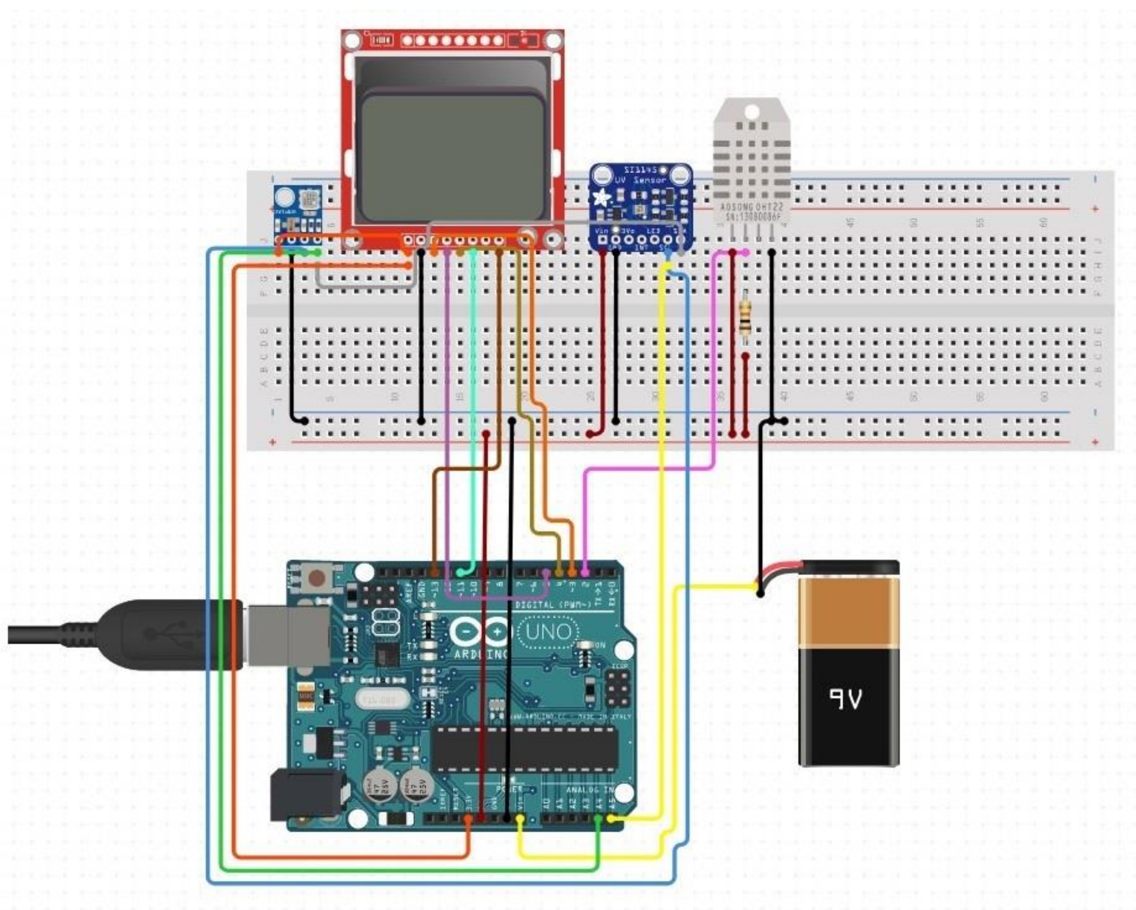


Figure 6. *Connection diagram for mounting the sensors*

HARDWARE AND SOFTWARE IMPLEMENTATION

Schematically, the connections for the LCD display and sensors with the Arduino Uno can be shown as in Figure 7. The blue line represents the ground, the red line +5V is the power, the red line +3.3V is the connection between Arduino and LCD and the black lines are the inputs Arduino from the sensors.

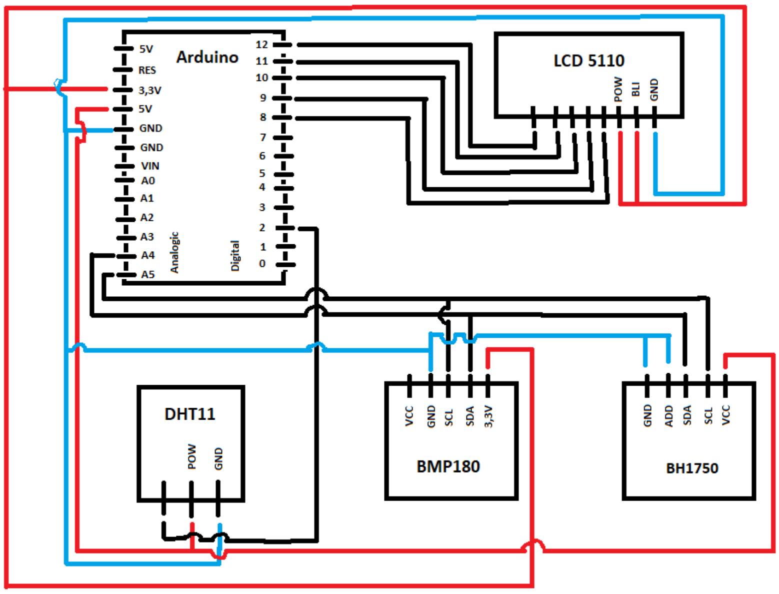


Figure 7. *Electrical connection diagram of the weather station*

For programming the Arduino microcontroller, is used the Arduino coding language. The Arduino language is based on C/C++ [9]. In fact, the program running on our weather station, collecting data from the different sensors, is written in this exact form. While the program is running, the values of the parameters provided by the sensors are displayed on the LCD (Figure 8).

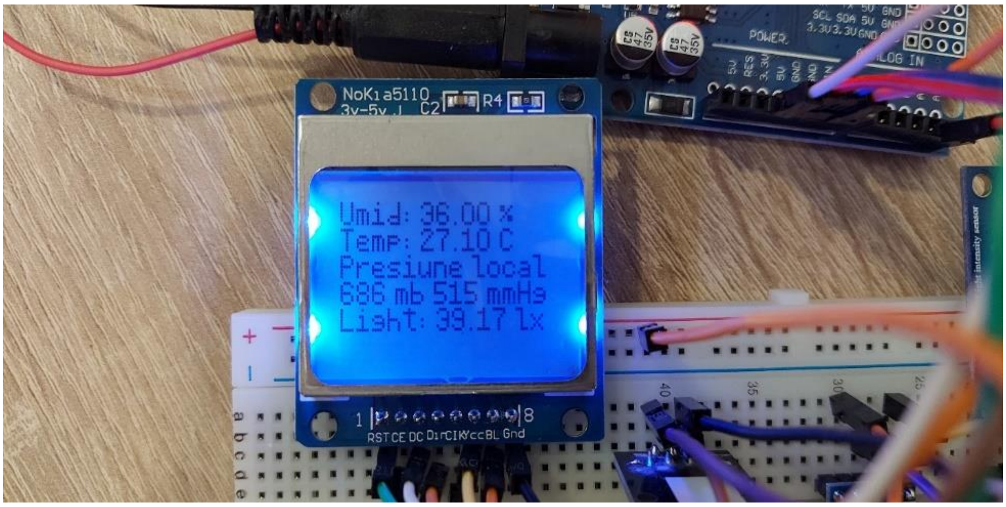


Figure 8. *Values of the parameters provided by the sensors displayed on the LCD*

The logic flowchart for the program loaded into the microcontroller is shown in the Figure 9.

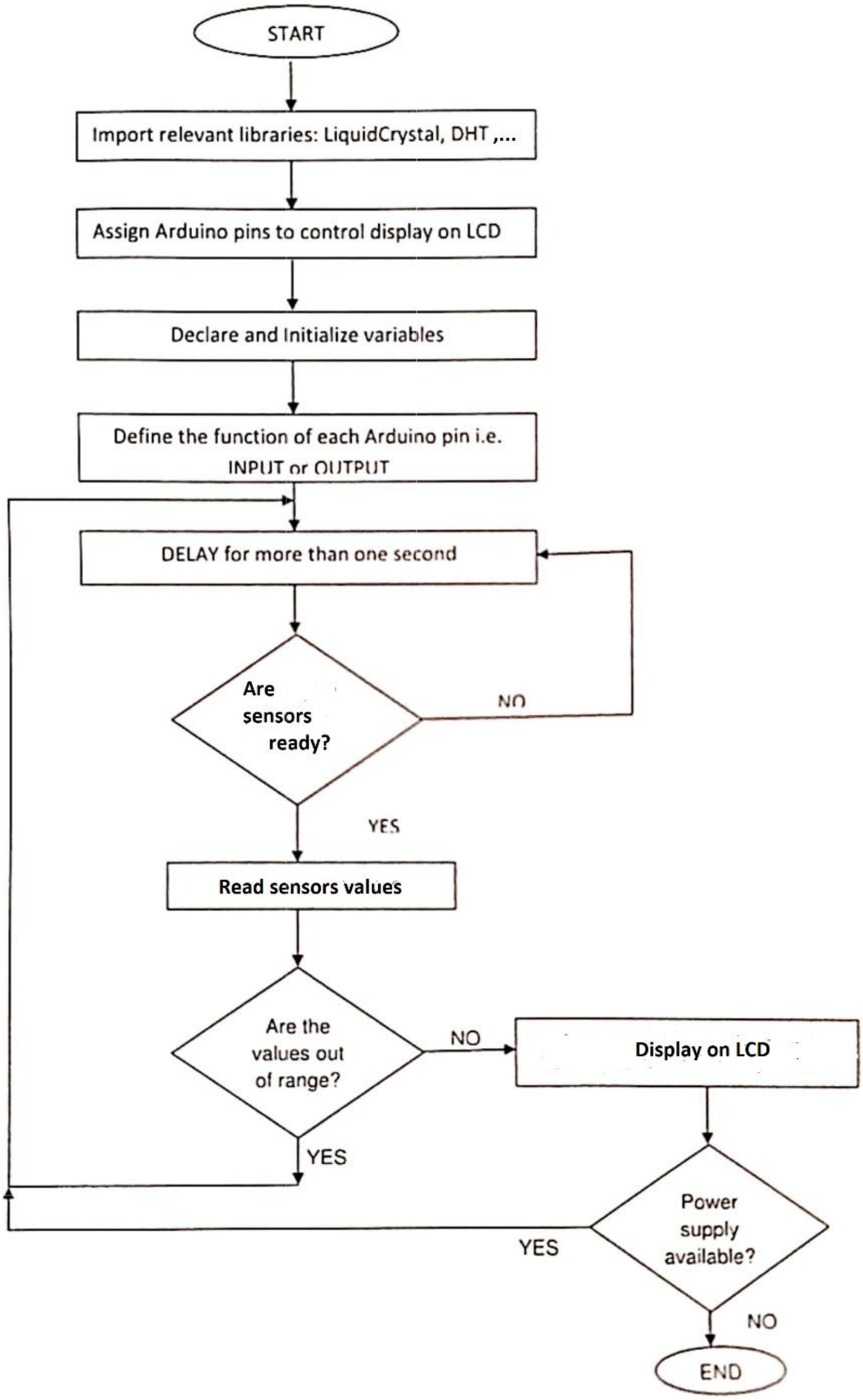


Figure 9. *Logic flowchart for the program loaded into the microcontroller*

Some important parts of the microcontroller program are presented below:

- *Import library LCD 5110*

```
#include "Nokia_5110.h"
#define RST 12
#define CE 11
#define DC 10
#define DIN 9
#define CLK 8
Nokia_5110 lcd = Nokia_5110(RST, CE, DC, DIN, CLK);
```

- *Import library DHT 11*

```
#include <DHT.h>
#define Type DHT11
int sensePin=2;
DHT HT(sensePin, Type);
float umiditate;
float tempC;
```

- *Declare and initialize variables*

```
void loop() {
 umiditate=HT.readHumidity();
 tempC=HT.readTemperature();
 lcd.clear();
```

- *Display on LCD*

```
 lcd.print("Umid: ");
 lcd.print(umiditate);
 lcd.print(" %");
 lcd.setCursor(0, 1);
 lcd.print("Temp: ");
 lcd.print(tempC);
 lcd.print(" C");
  float lux = lightMeter.readLightLevel();
 lcd.setCursor(0, 4);
 lcd.print("Light: ");
 lcd.print(lux);
 lcd.println(" lx");
 delay(2000);  // 2 seconds delay
```

EXPERIMENTAL RESULTS

In order to study the performance characteristics of the completed assembly, several tests were carried out, under different conditions. The first test was carried out inside a room, the second inside an isolated plastic enclosure and the third test took place in the outside environment. The measurement data were analyzed using the Excel program.

Table 1. *Test 1: measured values inside the building*

Time [min]	0	5	10	15	20	25	30	35	40	45	50	55
Temperature [°C]	27.1	27.2	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1
Relative humidity [%RH]	36	35	36	36	35	35	36	36	36	35	35	35
Pressure [mmHg]	515	515	513	515	514	516	516	515	515	514	514	515
Light intensity [lx]	39	39	37	34	36	37	38	36	39	37	34	36

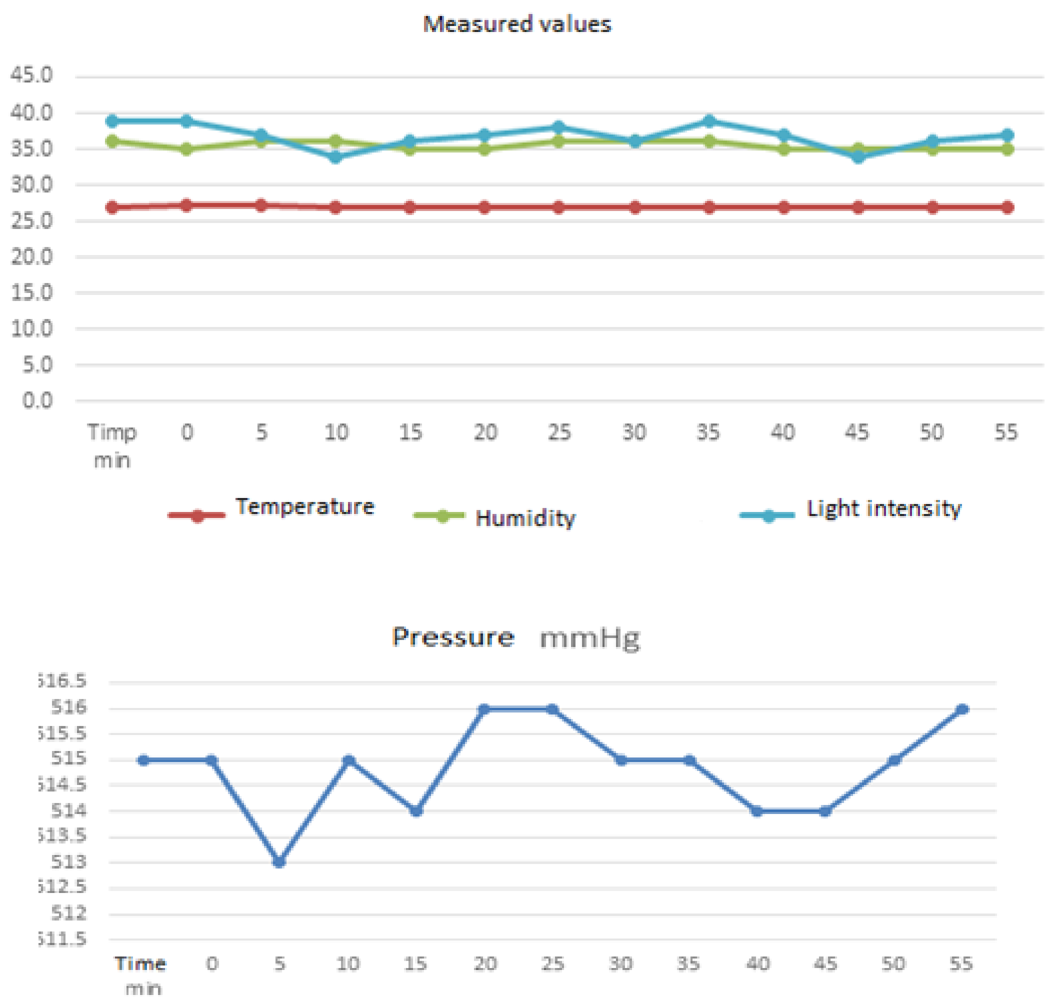
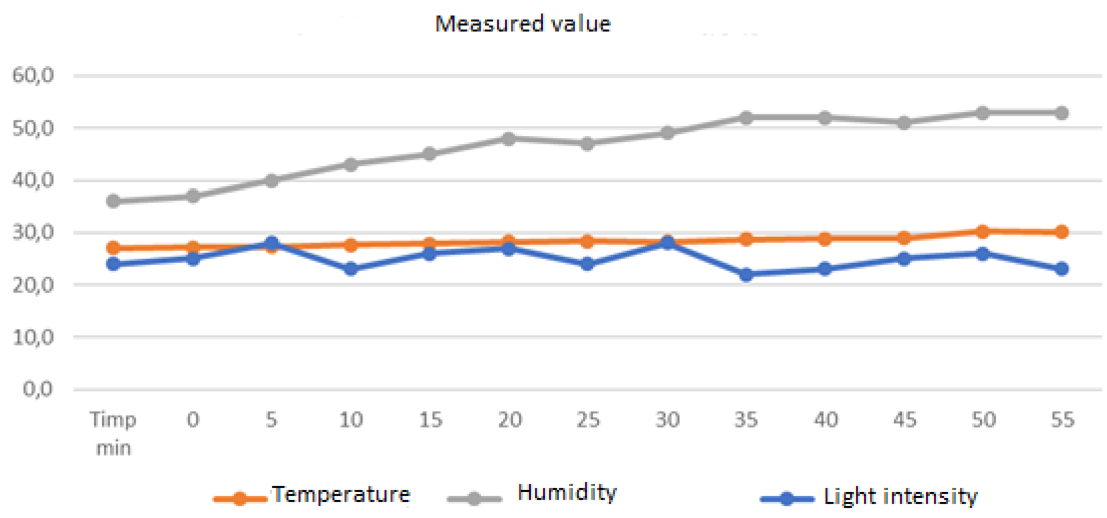


Figure 10. *Test 1: measured values graphics inside the building*

Table 2. *Test 2: measured values in an isolated enclosure*

Time [min]	0	5	10	15	20	25	30	35	40	45	50	55
Temperature [°C]	27.1	27.2	27.3	27.7	27.9	28.2	28.4	28.2	28.7	28.8	28.9	30.2
Relative humidity [%RH]	36	37	40	43	45	48	47	49	52	52	51	53
Pressure [mmHg]	515	515	513	515	514	516	516	515	515	514	514	515
Light intensity [lx]	24	25	28	23	26	27	24	28	22	23	25	26



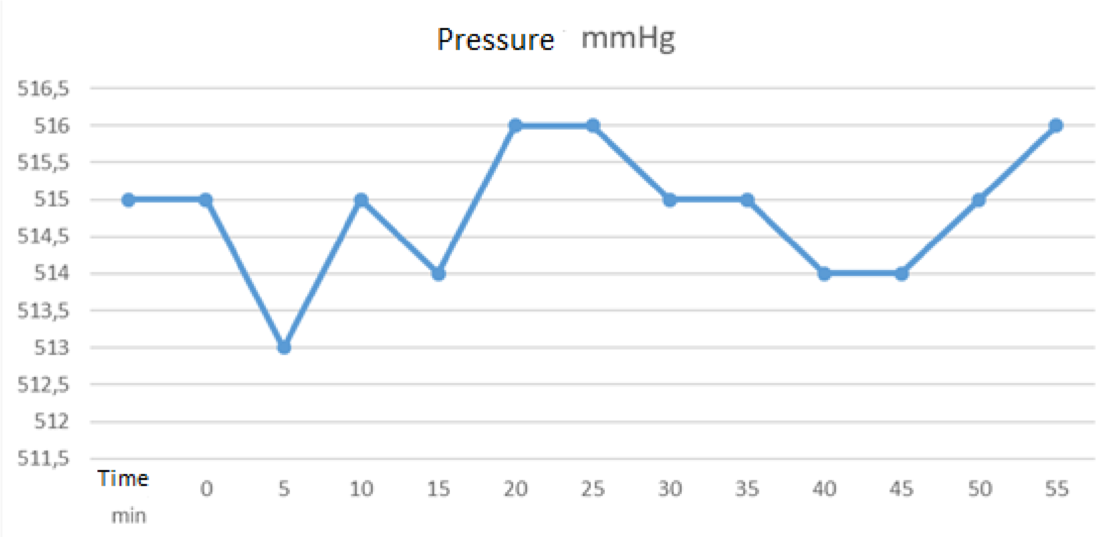
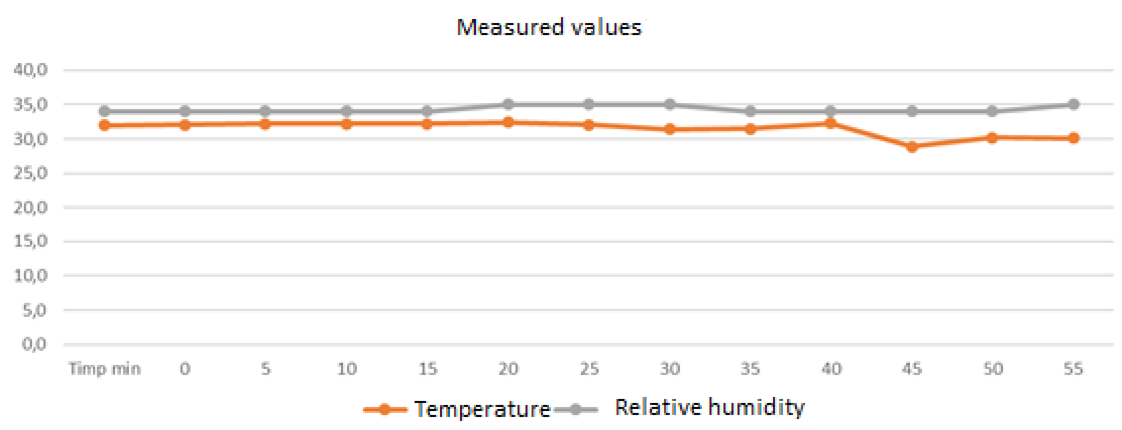
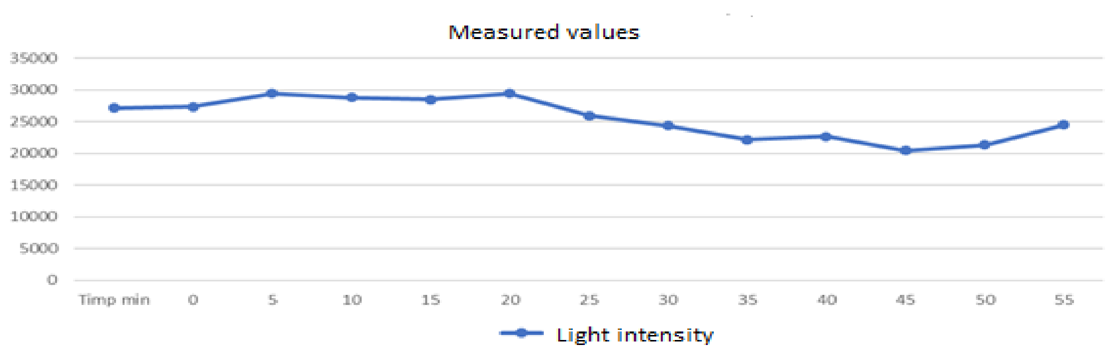


Figure 11*. Test 2: measured values graphics in an isolated enclosure*

Table 3. *Test 3: measured values outside the building*

Time [min]	0	5	10	15	20	25	30	35	40	45	50	55
Temperature [ºC]	32.0	32.1	32.2	32.2	32.2	32.4	32.1	31.4	31.5	32.3	28.9	30.2
Relative humidity [%RH]	34	34	34	34	34	35	35	35	34	34	34	34
Pressure [mmHg]	505	505	505	506	506	504	505	505	504	504	506	505
Light intensity [10^3·lx]	27.1	27.3	29.4	28.7	28.4	29.4	25.9	24.3	22.1	22.6	20.4	21.3





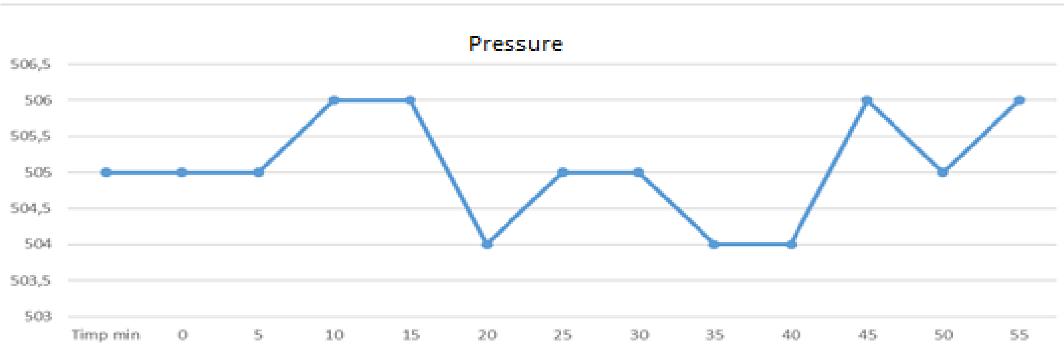


Figure 12*. Test 3: measured values graphics outside the building*

These three tests were performed to check the sensitivity and accuracy of the transducers used, in the sense that distinct values are obtained when the environmental conditions change easily.

Considering that the blocks on which the sensors are mounted for the acquisition of the measurements carried out in this paper are already calibrated in the laboratory, the accuracy of the measurements carried out is the one declared by the sensor manufacturers as is presented in the Table 4.

Table 4. *Accuracy values declared by the sensor manufacturers*

Sensor	**Measurement range**	**Accuracy of measurement**
DHT11 – temperature	0-50 C	+/- 2C
DHT11- relative humidity	20-90%	+/- 5% RH
BMP180 – pressure	300-1100 hPa	+/- 2 hPa
BH1750 – light intensity	1 – 65535 lx	+/- 1.2 lx

CONCLUSIONS

The developed Arduino-based weather station was effective in collecting various weather element, displayed the data, and processed the data into information. The system is portable due to the use of the Arduino microcontroller, unlike the conventional weather station.

To increase the performances of this weather station, the measured data can be stored in the long term, in order to make statistics on the evolution of weather parameters in the analyzed areas, in order to determine the optimal conditions of an environment corresponding to various applications. The measurement of environmental factors is essential to control the microclimates necessary in the development of human activities as well as in various industrial processes. This functional system, in terms of hardware and software, allows us to measure temperature, relative humidity, pressure and light intensity in a room.

To improve the assembly, sensors with a higher measurement accuracy and resolution can be implemented. Also, alerts can be implemented to inform users about exceeding certain predefined parameters. It can be implemented, using the pressure already read, and a calculator to calculate the altitude.

Uncertainty in temperature and humidity measurements can come from various causes. This depends in part on the instruments, which may suffer from drift, short-term "noise", operating limits, resolution and so on. Calibration uncertainty must be taken into account.

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