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Mobile weather station based on ATmega2560 microprocessor

E S Semenov, G S Ivanchenko, A V Kharchenko and R V Kolobanov

Volgograd state university, 100 Universitetsky ave., Volgograd, 400062, Russia

E-mail: kolobanovrv@bk.ru

Abstract. The paper is devoted to the development of a mobile meteorological station capable of sending SMS messages with data on weather conditions and their nearest changes. When developing the device, weather measurement sensors, a GSM module and a GPS module were used. The paper discusses the key points of the development and analysis of the weather station: the principle of operation, the measurement of weather conditions, sending SMS messages with weather data in real time and the weather forecast, which is formed by the Zambretti algorithm, the results of measurements for the day in the form of graphs. As a result of the work, a weather station was developed that is able to send SMS messages with weather data and a forecast for the nearest future.

1. Introduction

Weather conditions are one of the most important factors for human life. For example, a change in weather affects farming, where data on weather changes is important. In order to watering, harvesting, spraying or fertilizing in a timely manner, one need to know about the weather in the past, present and future. In addition, when moving between cities over long distances, there is a need to predict the weather, since due to the underestimation of weather conditions, the risk of accidents on roads increases.

Devices with the ability to measure weather conditions and send data to the user have been studied. For example, paper [1] uses DHT22 and BMP180 sensors for measuring temperature and humidity, but the devices are cheap and inaccurate. Paper ticle [2] considers the ZigBee network for data transmission, which does not guarantee the range of data transmission, therefore, the placement of such weather stations in the fields is impractical. As the authors of paper [3] say, to implement their device, a network of several devices is necessary, and this in turn is almost impossible in large areas of fields. The authors of paper [4] consider a system for monitoring weather conditions, but they use a wireless module, which is impossible to use in fields over long distances. Other papers [5], [6], [7] describe various methods for monitoring the weather, modern technologies and other modern systems that can really make monitoring the weather exclusive, but the settings described in these articles are too cumbersome.

To solve the problem of complex monitoring of weather conditions, data transmission over long distances, the task was set to develop a meteorological station capable of sending notifications via SMS messages with weather data in real time.

2. Device description

When developing the device, the following devices were used: Arduino Mega hardware and software, DS18B20 temperature sensor, SHT10 humidity sensor, LPS331AP pressure sensor, SEN0170 wind



speed sensor, PCE-FWS20 WD wind direction sensor, RTC DS3231 module (real time clock), micro-SD module cards, GSM-module Neoway M590, GPS-module GY-NEO6MV2.

The microcontroller processes the data transmitted in the format of a digital or analog signal from sensors on the SD card module, and then sends an SMS message with the results of weather measurements to a user number. In order for the microcontroller to provide human-readable data, a program code was developed in the Arduino IDE that contains 677 lines, occupies 37,022 bytes in the program's flash memory, and has an ATmega2560 microcontroller in the RAM.

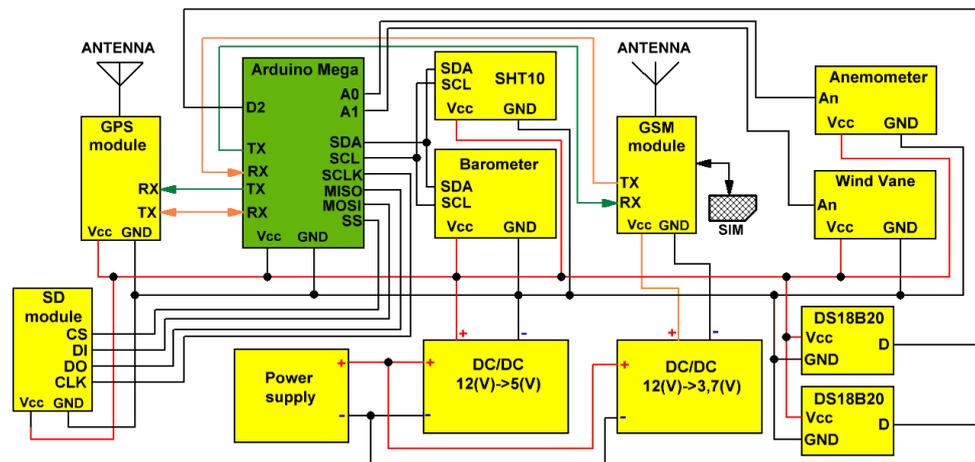


Figure 1. Weather station functional scheme.

2.1. Operation principle of a portable weather station

The developed device consists of a waterproof, insulated case, inside which the microcontroller, temperature, pressure, humidity sensors, SD card, DS3231 real-time clock module, GSM module and GPS module, as well as wind speed and wind direction sensors are located.

DS18B20 sensors are used to measure the ambient temperature in the range from -55°C to $+125^{\circ}\text{C}$ with an accuracy of $\pm 0.5^{\circ}\text{C}$ at $t = -10$ to $+85^{\circ}\text{C}$.

The SHT10 sensor allows to measure the temperature in the range from -40°C to $+125^{\circ}\text{C}$ with an accuracy of $\pm 0.5^{\circ}$ (at $t = 25^{\circ}\text{C}$ with a step of 0.01°C) and ambient humidity with an accuracy of $\pm 4.5\%$ (at humidity values from 20 to 80% in increments of 0.03%), which is an excellent indicator of measurement accuracy among budget sensors.

The LPS331AP sensor allows determining the atmospheric pressure in the range from 260 to 1260 mbar (26 kPa to 126 kPa) with a step of 0.00025 and an absolute accuracy of ± 0.020 mbar (0.2 kPa). Since $1\text{ mmHg} = 1.33322\text{ mbar}$, respectively, it will not be difficult to convert pressure from mbar to usual millimeters of mercury used by meteorologists.

The electronic anemometer model SEN0170 is used to measure wind speed in the range from 0 to 30 m / s with an accuracy of $\pm 3\%$. The anemometer consists of blades, a waterproof case, inside which the electronic components of the sensor are hidden.

LPS331AP sensor allows to determine the atmospheric pressure in the range from 260 to 1260

The PCE-FWS20 WD sensor is an electronic vane and is designed to measure wind direction.

Additional modules connected to the Arduino Mega, allow to analyse, process, transmit data obtained from sensors measuring weather conditions.

The DS3231 real-time clock module is designed to take into account the time data of the current time. The DS3231 module contains a built-in power source, thanks to which the device monitors the time without interruptions.

In order to carry out the experimental studies for a long time, it was necessary to add a micro-SD module with a connected SD card to the device, on which a CSV is created, containing an array of experimental data. Using this file, it is possible to build the necessary graphics.

GSM-module Neoway M590 is required to send SMS-messages to users with indication of weather data in real time and weather forecast for the near future.

The GY-NEO6MV2 GPS module is used to determine the location of the weather station, to know where the weather conditions were measured from.

3. Results of weather measurements

This section of the paper presents the results of temperature measurements of temperature, atmospheric pressure, air humidity, wind direction and speed. For reliability of measurements, a comparison was made with the weather archive in Volgograd for a specified period of time from the meteonovosti.ru site.

Studies were conducted from 01/22/2019 8:44:14 to 01/23/2019 8:02:49 every 2 seconds. As a result of research, 45,598 measurements were obtained.

Figures 2-6 show the graphs of measurements per day with averaged values every hour; weather archive charts in Volgograd for a specified period of time.

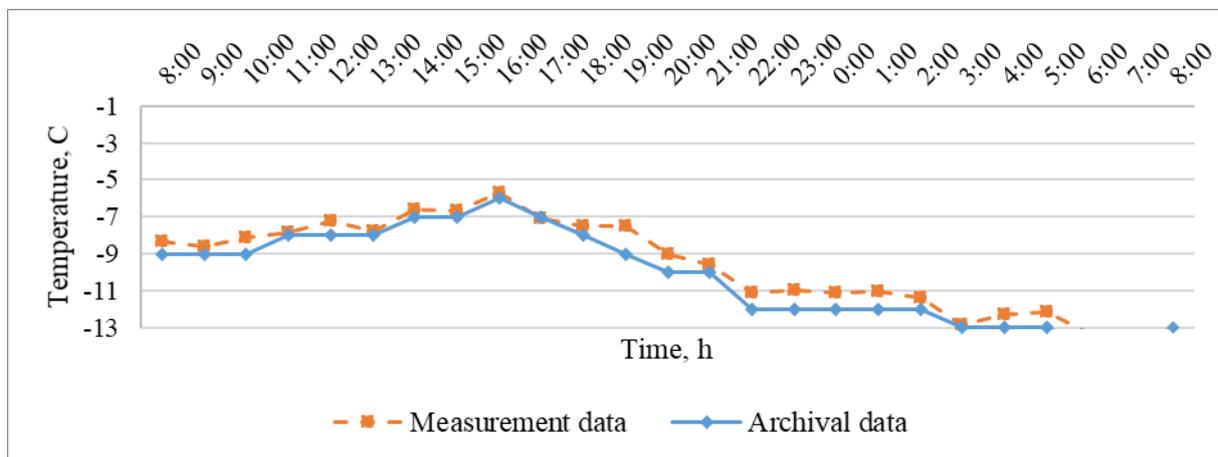


Figure 2. Temperature measurement chart from DS18B20 sensor in comparison with archived data.

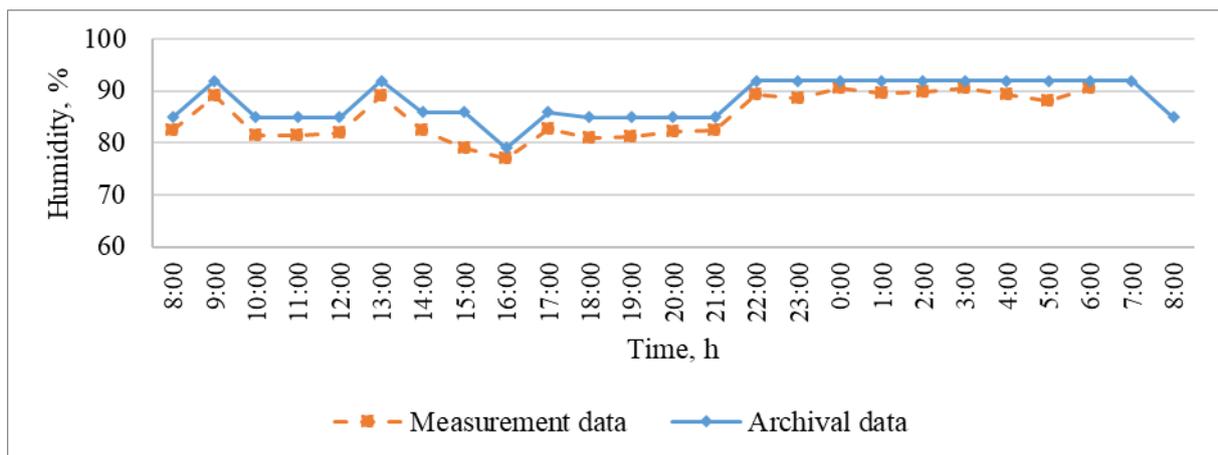


Figure 3. Humidity measurement chart from SHT10 sensor versus archived data.

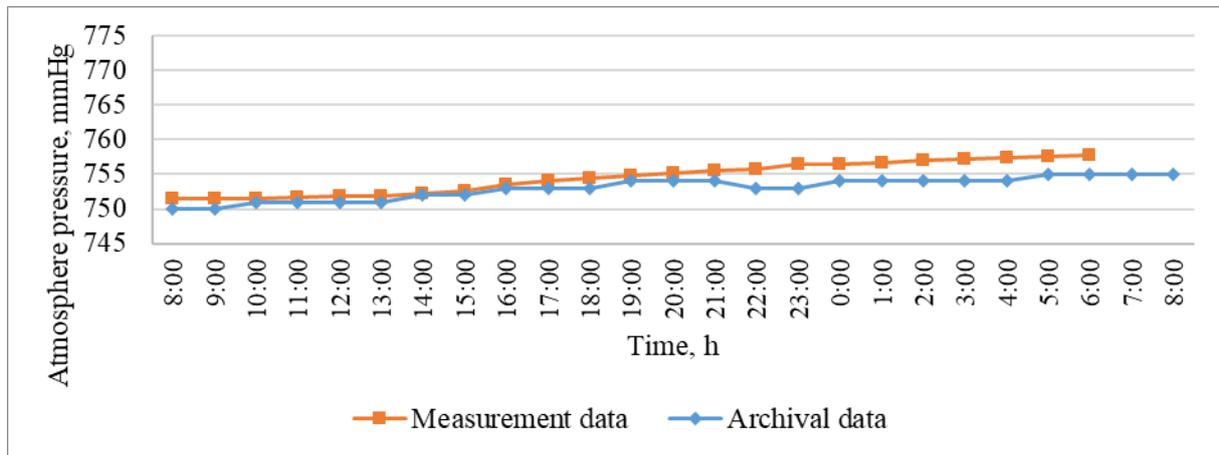


Figure 4. Graph of atmospheric pressure measurements from LPS331AP sensor in comparison with the archive data.

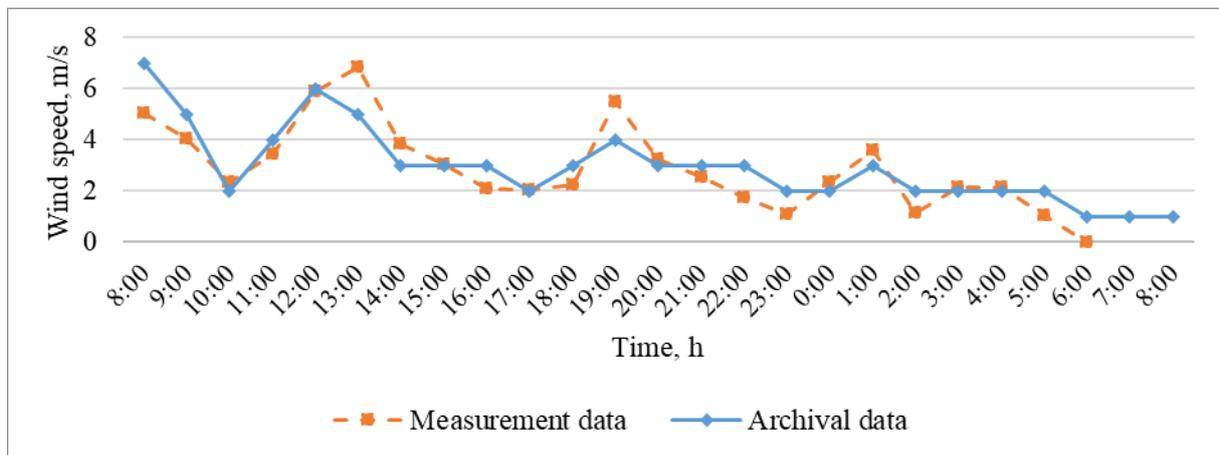


Figure 5. Graph of measurements of wind speed from SEN0170 sensor in comparison with archival data.

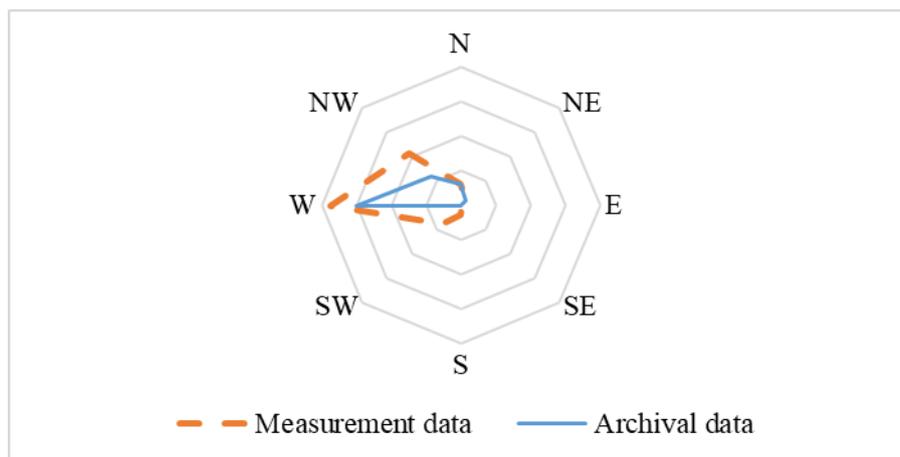


Figure 6. Graph of wind direction measurements from CE-FWS20 WD sensor versus historical data.

Analysing the results of measurements of weather conditions, we can conclude that the sensors are working properly, since the measurement results of the developed weather station and the archive are almost the same, the trend of changing weather conditions is the same in all cases.

Since the device carried out measurements at one point in the city, and the site data gives the average value of weather conditions for the city of Volgograd, it is possible to observe small differences between the obtained and archived data.

To achieve this goal, it is not enough to obtain the results of measurements of weather phenomena, and it is necessary to predict the weather for the near future. For the weather forecast, the Zambretti algorithm was chosen, the probability of which is 90%, which is a good indicator. [8] This algorithm in its simplest form uses three parameters: the current atmospheric pressure, the trend of pressure change and the direction of the wind.

Having made calculations based on weather measurement data for January 23, 2019 using the Zambretti algorithm, it was obtained that the weather on January 24, 2019 will be rainy and overcast. After analysing the weather diary on the specified date, we can conclude that the algorithm is a reliable way to predict the weather.

Currently, data is being transferred from the weather station to the user's mobile phone. In the SMS message, the data is found: temperature and humidity, atmospheric pressure, wind direction and speed at the time of sending the message and weather forecast in the “fog is expected”, “it will be sunny”, etc.

4. Conclusion

Thanks to the developed portable meteorological station, we can get the current weather data of the environment at a specific point (Volgograd) and predict the weather using the Zambretti algorithm with high probability for neighbouring points (Volgograd region). The advantage of the developed device is that the device is portable and designed for a wide range of temperature measurements and other parameters. In addition, portability allows one to expand the scope of the weather station and use it on different terrains in the temperate climate zone of the Earth.

At present, we can send both current data on temperature, air humidity, atmospheric pressure, wind direction and speed, and weather forecast for the next 24 hours.

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