



Design of a low cost automatic meteorological weather station

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Abstract

It is obvious that the correct atmospheric information will be important for all solar applications, determining the best time of planting, climate, airport control tower, and weather forecasting. In this study, a cheap, real-time and embedded system controlled meteorological station has been designed. Arduino Mega 2560 card with Atmega 2560 microcontroller was used as an embedded system. In the developed weather station, BMP180 barometric pressure sensor and DHT11 temperature and humidity sensor were used. The DS1302 real-time clock module was used to display temperature, humidity and pressure values instantly on the LCD screen. These values from the sensors are saved to the SD card minute by minute. A daily temperature, humidity, and pressure values were saved with the designed meteorological station by measuring. The hourly maximum temperature values of the measured day have been compared with the values of the previous years taken from the Karaman State Meteorology Station. The obtained preliminary results are promising for further studies on the improvement of the proposed meteorological system.

Keywords: meteorology weather station, arduino, sensor.

1. Introduction

Atmospheric conditions and climatic information are the most significant factors affecting the quality of life and human activity [1]. The air in the atmosphere is guided by air pressure (temperature and humidity) differences from one place to another. These pressures and temperature differences can be caused by the sun angle at certain points and this temperature varies according to the geographic latitude of the tropics. Whether weather forecasters are constantly working to expand the boundaries through meteorological scientific work, it is difficult to predict more weather than a few days ago [1,2]. Weather can be assigned as the existing condition of the atmosphere over a specific area and time, measured in terms of variables including temperature, wind speed, precipitation and direction, and humidity among others [3]. In order to determine atmospheric conditions and to predict future conditions, determine the weather conditions in a region by using various scientific and technological methods is called as weather forecasting in the literature. Shortly, weather forecasting is carried out by gathering quantitative data on the present state of the atmosphere at a given location and by using a scientific perception of atmospheric processes to project how the atmosphere will develop in that place [1,2].

The right weather forecasting and some atmospheric data such as reliable humidity, temperature, pressure, wind, solar radiation, sunshine duration, cloudiness, and dustiness are needed in many areas. These areas are mainly energy, agriculture, climate, health sector, transportation, and environment. Renewable energy sources such as wind, hydrogen and solar energy are in high demand worldwide. It is very important to collect and analyze all relevant atmospheric information in order to select the possible locations of such projects, to ensure the sustainability of the project, to do feasibility studies and to calculate their efficiency. Besides, it is essential to have the past and current conditions in agricultural areas, the air models used for spraying of air, fertilizer, irrigation or harvesting. For example, several soft fruits, including strawberries, are grown under polytunnels or in glasshouses, with the warmer conditions allowing the growing seasons to be extended. When agricultural conditions surpass threshold values (e.g. maximum air temperature) then physiological stress may be a reason for the lower fruit yields [4]. In zoological science, the population of insects and larger animals are directly affected by weather conditions [5, 6]. Nowadays, weather conditions and parameters are also used effectively in the health sector. Atmospheric parameters are investigated by

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physicians in order to determine treatment and appropriate drugs, according to the weather conditions where the patients live. [6]. The accuracy of weather forecasts is vitally important in transportation. Besides that, long-term and reliable data are required in climate and environmental studies. For these purposes and many other things, it is important to take the necessary estimates and to collect, examine and analyze weather data continuously. For this reason, it is necessary to obtain appropriate weather measurement devices with the least distress in obtaining weather data [7, 8]. The present meteorological data collection tools consist of various expensive weather stations. Furthermore, it is very costly to establish these stations all over the world, perform regular calibrations of the devices, operating with expert personnel and store the data. In some countries, due to cost constraints and various drawbacks, comprehensive monitoring is not possible and this leads to a lack of data. One of the preconditions for the success of weather forecasts is the adoption of comprehensive meteorological data. If the data from the meteorological parameters are inadequate or incorrect, the weather forecast results will be inaccurate [6]. Due to the last technological developments, sensing systems become an applicable

solution for several innovative practices. Aside from integrated monitoring solutions (e.g., meteorological stations), many mechanisms that bank on low-power embedded micro-controller platforms was proposed [9]. This kind of systems makes use of the digital and analog I/O ports of platforms for sensor extensions besides custom or open source software components. Widely known microcontrollers such as Arduino and Raspberry Pi mainly used to incorporate sensing, connectivity capabilities and automation. The hardware platforms support data manipulation deployed by applications installed in both base station and sensors. Also, these platforms carry out networking through embedded connectivity protocols [10].

In this study, it is aimed to develop an embedded system based automatic meteorological station system which can accurately measure atmospheric parameters, the cost is very low, has widespread use potential and does not need to manpower work continuity. To achieve this aim, an Arduino based system is designed to measure atmospheric data, such as air temperature, relative humidity, and barometric pressure. In addition, the designed system has been tested using real data.

2. Material and method

In this study, DHT11 sensor to measure the air temperature and humidity, BMP180 sensor for the measurement of the barometric pressure value, DS1302 real-time clock module to determine the time at which the information is received from the sensors, and an SD card module to save the sensor information has been used. Arduino Mega 2560

development board has been used in the control unit of the system. The received information from the sensors has been saved on the SD card module and displayed on the 2x16 LCD screen. The sensors and modules used are detailed below.

2.1. Arduino mega 2560

Arduino is a platform that built on Atmel's AVR series microcontrollers, which facilitates the prototyping phase, with connectors for additional expansion and plug-ins called shields that can be attached to these connectors [11]. The Arduino Mega 2560 is an ATmega2560 based Arduino board (Figure 1). It has 54 digital I/O pins. 14 of them can be used as a PWM output. There are 16 analog

inputs, 4 UART (serial ports), 16 MHz crystal oscillator, USB connection, adapter input, ICSP input and a reset button [12]. The USB connection can be powered by a battery or an adapter. It is compatible with many shields developed for Arduino cards [11,12]. The technical specifications of the Arduino Mega 2560 cards are presented in Table 1.

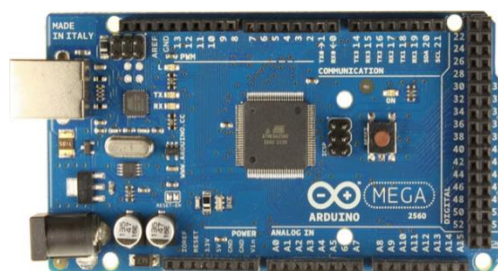


Figure 1. Arduino mega 2560 development board.

Table 1. Technical features of arduino mega 2560 development board [13].

Microcontroller	ATmega2560
Operating Voltage	5V
Supply Voltage (Recommended)	7-12V
Supply Voltage (Limits)	6-20V
Digital I/O Pins	54 (15 supports PWM output)
Analog Input Pins	16
Output Current (Per Pin)	40 mA
Output Current (3.3V)	50 mA
Flash Memory	256 KB (Bootloader is using 8KB)
SRAM	8 KB
EEPROM	4 KB
Operating Frequency	16 MHz

2.2. DHT11 temperature and humidity sensor

The system is used the DHT11 temperature and humidity sensor to measure the ambient temperature and relative humidity (Figure 2). DHT11 temperature and humidity sensor is a device that gives digital signal output [14]. DHT11 contains 8-bit

microprocessor and reacts quickly. The sensor measures the temperature with a margin of error 2 °C between 0 and 50 °C, and measures humidity with a 5 % RH error rate between 20 - 90 % relative humidity (RH) [15].



Figure 2. DHT11 temperature and humidity sensor.

2.3. BMP 180 barometric pressure sensor

BMP180 is a sensor that provides a digital output by measuring air pressure. BMP180 can measure the pressure value between 300-1100h Pa. The BMP180 digital air pressure sensor uses I2C as the

communication protocol [16]. Thus, it communicates with the control unit over only 2 pins. The BMP180 air pressure sensor used in the study is shown in Figure 3.



Figure 2. BMP180 barometric pressure sensor.

2.4. DS1302 real time clock module

The DS1302 RTC module has been used to display the date and time information on the display and to add time information to the information from the sensors to be stored on the SD card in the developed system (Figure 4). Due to the CR2032 battery on the

DS1302 real-time clock module, it continuously stores its second, minute, hour, day, month and year information [14]. The serial output is continuously outputted over the SCLK pin.



Figure 4. DS1302 RTC module.

2.5. SD card module

An SD card module is a module that makes the read and write to SD cards with the SPI protocol [17]. Due to the module has a 3.3 V voltage regulator, 5V supply can be connected. It is possible to save the

measured data by any sensor to the SD card and to access this information from the computer. The used SD Card Module is given in Figure 5.



Figure 5. SD card module.

2.6. LCD keypad shield

The LCD Keypad Shield is a module that provides simple menu designs or can be used as a control panel in an Arduino electronic system. There are 2x16 LCD screens, 5 programmable pushbuttons and 1 reset button on LCD Keypad Shield [18]. All 5 buttons connect to the Arduino A0 pin with a special structure. Thus, all of the 5 buttons can be read over one pin. The LCD contrast setting can be adjusted upon the card. In the developed system, air temperature, humidity, pressure values, and the current time and date information are transferred to the user via LCD. The Arduino Mega 2560 cards have been used as the control unit in the Arduino

based meteorological weather station. DHT11 sensor has been used to measure the air temperature and humidity values, and BMP180 barometric air pressure sensor have been used to measure the air pressure. Information from the sensors is saved in the SD card module by the Arduino Mega 2560 cards with the time information read from the DS1302 real time clock module and is also transmitted to the user by displaying on the LCD screen. The block diagram of an embedded system based automatic meteorological station system design is given in Figure 6.

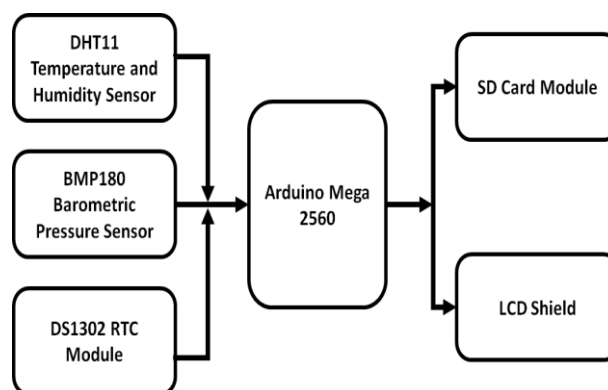


Figure 6. Block diagram of embedded system based automatic meteorological station system design.

3.Results and discussion

The embedded system (Arduino) based automatic meteorological station system is shown in Figure 7. The designed system can measure the desired atmospheric parameters (pressure, temperature, and humidity) in a stable way. The air temperature, relative humidity, and air pressure values are stored in the .txt file format on the SD card module. Also,

hourly maximum and minimum temperature, humidity and pressure values are saved. The performance of the system, which was designed by using measured data for the years 2010-2014 taken from the State Meteorological Service, was compared to Karaman province.

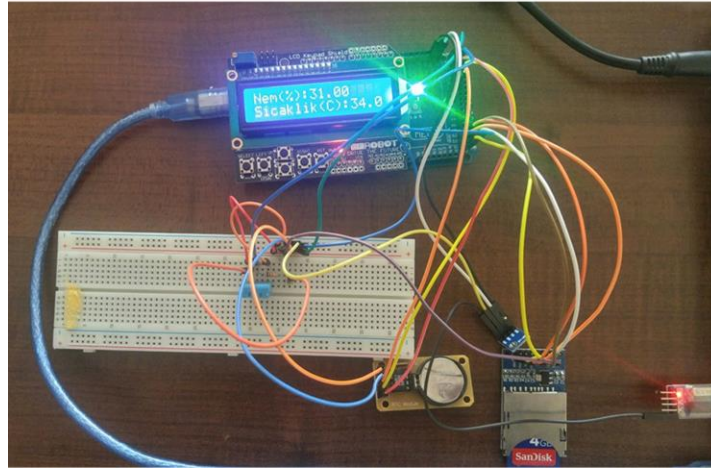


Figure 7. The Embedded System (Arduino) Based Automated Meteorological Station System Design

Due to the used LCD screen is 2x16, all the information from the sensors didn't fit to the screen. Therefore, with three-second intervals, at first, the date and time information, then the air temperature and humidity information and lastly the air pressure information has been displayed on the screen (Figure

8). All of the information obtained from the sensors to the SD card module is saved on an hourly basis. With each minute, all sensor information has been read and the averages of temperature, humidity, and pressure values have been saved.



Figure 8. Designed Embedded System Based Automatic Meteorological Station System LCD Screen Images.

4. Conclusion

With the developed Arduino based automatic meteorological station, the maximum temperature values obtained from the temperature data saved hourly of 12.08.2017 have been compared with the maximum measured temperature values in the same date at 2010-2014 (total 5 years). Figure 9 is shown the results of a daily measurement for these years and the values saved in 2017 for the same day. The maximum temperature values of the year 2017 on the graph are the values obtained by Arduino based

automatic meteorological station. The developed system can be placed in a box, and transported with a battery. In addition, by adding an ESP8266 Wi-Fi module to the system, the received information from the sensors can be stored on a server, and used in a remotely accessible form. Wind speed can be measured by adding anemometer to the development system. Gas sensors can also be added to the system to measure air quality.

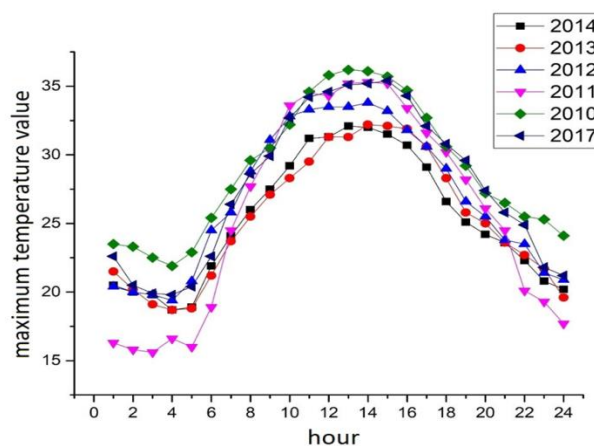


Figure 9. The maximum daily temperature for august 12, 2017.

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