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Design of Mobile Meteorological Station with Embedded System Control

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ABSTRACT

Meteorological events have become an indispensable part of our daily life. The estimation/analysis of the meteorological data helps us to put our daily work on the track. Thanks to weather forecasts made by meteorological stations, we take precautions in many areas of our lives and prevent weather events from adversely affecting our lives. In this study, a mobile meteorological station was designed by using Arduino embedded system control board. Meteorological parameters such as temperature/humidity, pressure and wind parameters were measured with Arduino Mega 2560 control card, momentarily. Firstly, the measurement of meteorological parameters was carried out separately to each other. After stable and appropriate measurements were observed by making individual measurements, all measurements in the established meteorological station were combined and recorded. The designed intelligent system was utilized for the measurement in the field of Engineering Faculty at the KaramanoğluMehmetbey University, Yunus Emre Campus. The results obtained with the designed mobile meteorological station show that the system can be successfully used to measure the weather conditions.

Keywords*—Meteorology, Meteorological Station, Embedded System, Arduino*

I. Introduction

The environmental conditions of the habitats in which they live are vital for the survival of living forms on earth. The most important factors in these environmental conditions are the meteorological data that determine the weather conditions. Therefore, weather forecasting is based on meteorological data. Meteorology, examining all the events and changes occurring in the atmosphere surrounding the earth, is also a science that explores the consequences of living things and the world as a result of these events and changes [1]. Meteorological stations are mechanical and electronic units for this purpose. These units are mainly composed of the central control unit, sensors, memory unit and visualization unit [2]. Thanks to these stations, a system that can detect and process weather events and changes can be created. Obtaining these meteorological data will make it easier to take precaution against the negative impacts on the habitats of living things and even minimize the harm that will be experienced. According to climate scientists, the air is dependent on changing processes in the atmosphere and covers all of the atmospheric events at any place on earth or at any time [3]. Therefore, many parameters such as temperature, rains, humidity, wind, pressure, and evaporation in any part of the earth play an important role in determining the instantaneous state of the atmosphere. These momentary situations that occur in the atmosphere have a significant effect on human life. Many events in human life are shaped and changed depending on weather events [4]. Therefore, considering these factors, making short-term or long-term forecasts is very important for human life. Weather condition is effective in many areas such as transportation, safety, health, food, and energy production in human life. Its effects can spread over a wide area and can be affected very quickly. So, changes in weather events are important for every minute of human life. For this, when meteorological data are collected, the variables that affect the course of the weather condition must be accurately identified and measured. By means of real-time meteorological weather measurements and data obtained by geographic information systems, prewarning and precautionary systems against weather events can be developed. In order to obtain meteorological data, many methods have been developed using these units. In an automatic weather station (AWS) design, data collection and processing processes were carried out at the station equipped with flexible and high-performance software and long-lasting devices. The remote control can also be provided for changes in this system [5].

In this study, an intelligent meteorological station with a mobile platform was tried to be established in order to determine the weather conditions of the Engineering Faculty of KaramanoğluMehmetbey University. The control of the produced station was made via the embedded system on the mobile platform. Temperature, humidity, pressure and wind sensors in the system are measured and stored on the Arduino embedded system board.

II. Design Of Portable Meteorological Station

A mobile and intelligent meteorological station was designed to observe the factors affecting the weather conditions such as temperature, humidity, pressure and wind speeds in the Karamanoğlu Mehmetbey University Yunus Emre Campus. The block diagram in Fig. 1 was performed and recorded in the meteorological station.

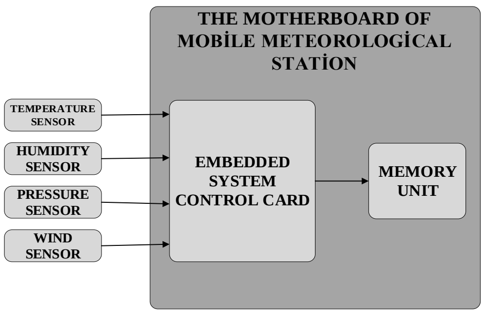

Fig.1. Block diagram of Mobile Meteorological Station design

A. Embedded System Control Board

The Arduino Mega 2560 embedded system control card, as shown in Fig. 2, was used as the control unit in the mobile meteorological station. It is an Arduino card based on ATmega2560 and has 54 digital input/output pins. 14 of them can be used as a PWM output. There are also 16 analog inputs, 4 UART (serial ports), 16 MHz Crystal Oscillator, USB connection, adapter input, ICSP output, and a Reset button. The Arduino Mega 2560 can be powered by a USB and an external adapter or battery. The power supply is automatically selected. The optimum supply voltage range of the card is between

7-12V. The unique feature of the Arduino Mega2560 from other cards is that the FTDI USB-to-serial drive connector is not used. The USB-to-Serial connector is programmed as an ATmega16U2 USB-to-serial converter. All 54 digital I/O pins operate at 5 volts and can be used as input or output using pin Mode (), digital Write (), and digital Read () functions. Each pin provides a maximum of 40mA input or output current. Pins have 20-50 kOhm pull-up resistors (normally disconnected). Each Mega 2560 has 16 analog inputs in 10-bit resolution. By default, it operates in the range 0-5V, but the reference voltage range can be changed with the AREF pin and analog Reference () function.

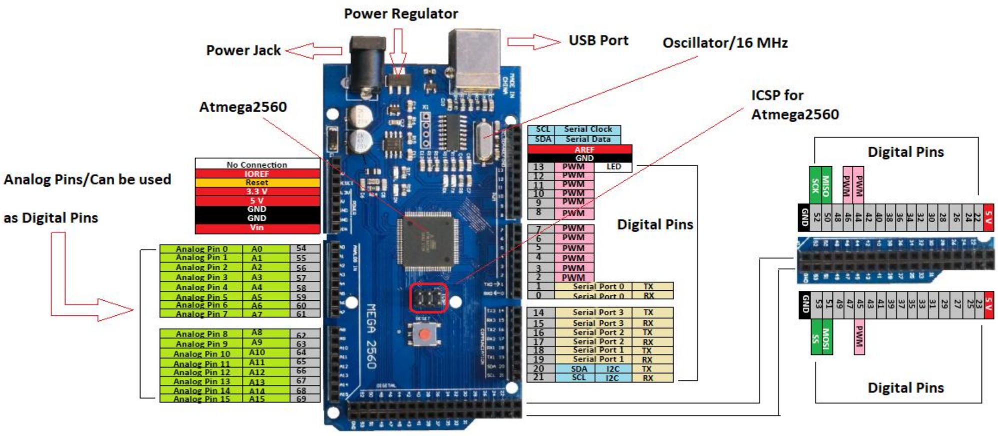

Fig. 2. Overview of the Arduino Mega 2560 [6].

The card is programmed via ArduinoIDE. The bootloader comes on a piece of code to install software on the card. You can also skip the bootloader and program the microcontroller directly via ICSP. It also has USBovercurrent protection. Normally, each computer has this protection, but the Mega2560 also has a fuse that blows out if more than 500mA of current is applied. These features are briefly summarized in Table 1.

TABLE I. FEATURES OF THE ARDUINO MEGA 2560

Microcontroller	ATmega2560
Operating voltage	5V
Supply Voltage (Limit) / (Recommended)	6-20V / 7-12V
Digital I / O Pins	54 (14 in PWM output)
Analog Input Pins	16
Current of I / O Pins	40 mA
3.3V Pin current	50 mA
Flash Drive	256 KB (uses 8kB of bootloader)
SRAM	8 KB
EEPROM	4 KB
Clock Frequency	16 MHz

B. Temperature/Humidity Measurement

For the measurement of temperature and humidity, the DHT22 temperature and humidity sensor, which is shown in Fig. 3, is used. DHT sensors consist of two parts: a capacitive humidity sensor and thermistor. The DHT22 temperature and humidity sensor is an advanced sensor unit that provides calibrated digital signal output. The operating voltage is between 3,3 and 5 V. It has high reliability and stable structure in long term studies. With8-bit microprocessor, it can respond quickly and accurately. It can measure the temperature with an error margin of +/- 1° C between -40-80° C and can measure the humidity with an error margin of +/- 5%RH between 0-100% RH. Depending on the data collection period of the sensor, measurement results can be taken in 2 second periods.

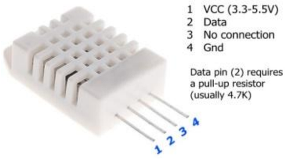

Fig. 3. DHT22 sensor and pin structure

C. Pressure Measurement

The BMP180 digital air pressure sensor image used for pressure measurement in the mobile meteorological station is given in Fig. 4.

Fig. 4. BMP180 digital air pressure sensor

The BMP180 digital pressure sensor is a useful product that digitally outputs the air pressure in the environment and also compatible with many microcontroller cards. It can measure the pressure value between 300 and 1100hPa, and give the height information between 500 and 9000 meters. Input voltage is 3.3V. It also supports the I2C protocol.

D. The speed of Wind Measurement

The wind sensor (anemometer) with analog voltage output is as shown in Fig. 5. It is used to measure the wind speed in the weather measurement stations. It is designed to work outdoors and has a water and rain resistant connector. To use this device, you can connect the black cable to the ground and brown cable to the 7-24V DC voltage to obtain the analog output from the blue cable. The output voltage is in the range of 0.4V to 2.0V and the winding measurement range is in the range of 0m/s to 50m/s. In addition, wind measurement sensitivity is 0.1m/s.

Fig. 5. The sensor used for wind measurement (Anemometer)

E. Memory (SD Card) Module

The SD card module used in Fig. 6 was used to record the measurement results from the temperature, humidity, pressure and wind sensors.

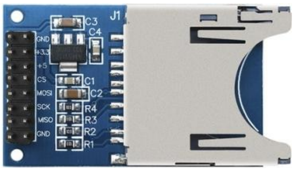

Fig. 6. SD card module used to record measurement results

III. DESIGNED MOBILE METEOROLOGICAL STATION SYSTEM

Arduino Mega 2560 embedded system control card is used as a central control unit in the mobile design. DHT22 temperature and humidity sensor, BMP180 digital air pressure sensor and Analog Voltage Output Wind Sensor (Anemometer) are used to measure air changes such as temperature, humidity, pressure and wind speeds. The mobile meteorological station designed was established on the Faculty of Engineering and measurements were taken. Photographs of the mobile meteorological station established for measurement are shown in Fig. 7.

Fig. 7. Photos of the designed system at the measuring point

Measurement controls are controlled via the workstation and calibration settings are made. Sensitivity and time settings have been performed on the workstation before the exact measurements have been made. The energy requirement of the station was met by a battery. While the measurements were continued, controls were made occasionally over the workstation and the energy conditions of the batteries were checked. These measured parameters were recorded in an SD card memory unit and transferred to the workstation at from time to time.

IV. RESULTS OF MEASUREMENT

Within the scope of this study, an embedded system controlled mobile meteorological station was designed and implemented. Temperature, humidity, pressure and wind measurements were performed in the Karamanoğlu Mehmetbey University Yunus Emre Campus. The wind, humidity, pressure, and temperature values were measured and the data set was formed from the measurements. Measurements were made and recorded for each minute, also daily averages were taken within this period. Some values of these measurements are given in Table-2.

TABLE II. DATA SET OBTAINED AS A RESULT OF MEASUREMENTS

Year	Month	Day	Temperature [°C]	Pressure[hPa]	Humidity [%]	Wind [km/hour]
2018	6	1	19.7	900.6	59.3	0.6
2018	6	2	15.4	901.4	68.6	0.1
2018	6	3	17.3	900.1	71.5	0.5
2018	6	4	18.1	898.7	65.8	0.8
2018	6	5	18.3	898.2	62.1	0.6
2018	6	6	19.9	899.8	60.4	0.6
2018	6	7	20.7	902.1	61.7	0.6
2018	6	8	22.8	899.2	54.8	0.7
2018	6	9	23.5	897.2	43	1.0
2018	6	10	21	896.2	44.9	0.9
2018	7	11	27.3	896.5	38.4	1.4
2018	7	12	25.3	895.5	50.6	1.4
2018	7	13	24.5	897.4	43.8	1.6
2018	7	14	26	897.4	37.6	0.6
2018	7	15	26.3	898.6	38.6	1.2
2018	7	16	26.4	899.3	39	1.3
2018	7	17	24.8	900.2	37.4	1.9
2018	7	18	24.3	899.2	42.5	1.3
2018	7	19	25.7	898.5	35	1.2
2018	7	20	26.6	896	32.6	0.6
2018	8	21	30.9	897.1	33.4	0.5
2018	8	22	30.1	895.2	37.3	0.7
2018	8	23	27.7	894.7	45.3	0.8
2018	8	24	24.6	896.9	51.8	0.9
2018	8	25	23.5	898.8	38.1	1.5
2018	8	26	22.2	899.5	36.9	1.5
2018	8	27	22.8	900.8	41.9	1.2
2018	8	28	23.3	902.4	43.5	0.8
2018	8	29	22.4	902.5	37.6	1.7
2018	8	30	23.3	901.4	38.2	1.9

V. CONCLUSION

Within the scope of this study, an embedded system controlled mobile meteorological station was designed and implemented. Temperature, humidity, pressure and wind measurements were performed in the Karamanoğlu Mehmetbey University Yunus Emre Campus. Wind, Humidity, Pressure, and Temperature values were measured and the data set was formed from the measurements. Measurements were made and recorded for each minute, also daily averages were taken within this period. In the next phase of this project, longer-term measurements will be made to expand the data set. Measurements can be made by means of Temperature, Humidity, Wind or Pressure values. Besides this, estimates can be made from the data set in regions where adequate measurements cannot be obtained for forecasting the weather.

Acknowledgment

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