
Development of microcontroller-based temperature and humidity data logger

Andriy Holovaty ORCID ID: 0000-0001-6143-648X

Lviv Polytechnic National University
Institute of Computer Science and Information Technologies
Department of Computer-Aided Design Systems, Lviv
email: andrii.i.holovaty@lpnu.ua

Roman Panchak ORCID ID: 0000-0002-6422-7656

Lviv Polytechnic National University
Institute of Computer Science and Information Technologies
Department of Computer-Aided Design Systems, Lviv
email: roman.t.panchak@lpnu.ua

Mykhaylo Lobur ORCID ID: 0000-0001-7516-1093

Lviv Polytechnic National University
Institute of Computer Science and Information Technologies
Department of Computer-Aided Design Systems, Lviv
email: mykhaylo.v.lobur@lpnu.ua

ABSTRACT

In this paper, the developed hardware and software of a microcontroller-based temperature and humidity data logger has been described. The device measures temperature and humidity, displays the temperature and humidity values on an LCD screen, and writes them to a microSD memory card. The microcontroller-based temperature and humidity data logger has a menu that allows users to set up its operation mode. The microcontroller-based temperature and humidity data logger consists of an Arduino Uno R3 board on an ATmega328P-PU microcontroller, an HTU21D digital temperature and humidity sensor, a RobotDyn shield with RTC IC DS1307, and an HD44780 alphanumeric LCD micro SD memory card reader. The electrical circuit of the microcontroller data logger was designed in the Proteus CAD system. An operation algorithm of the microcontroller temperature and humidity data logger was developed. The software modules for communicating with the HTU21D digital temperature and humidity sensor and outputting information to the alphanumeric LCD module (based on the HD44780 controller) have been created, along with the main data-processing software. The model of the microcontroller-based temperature and humidity data logger in Proteus ISIS was created and simulated. A prototype of the microcontroller-based temperature and humidity data logger was also created and tested.

Keywords: microcontroller-based temperature and humidity data logger, HTU21D digital humidity and temperature sensor, RobotDyn shield micro SD card reader + RTC DS1307, HD44780 alphanumeric LCD module, ATmega328P-PU microcontroller, Proteus VSM, C/C++, embedded software, Arduino IDE

1. Introduction

The current state of the development of electronics makes it possible to create cheap measuring systems that are based on microcontrollers and various sensors. In particular, a microcontroller data logger (temperature and humidity data logger) can be created. Temperature and humidity data loggers are compact stand-alone devices that record ambient temperature and humidity values for a specified time at specified intervals, store them, and transmit this data to external devices in a specified format.

Temperature and humidity data loggers are widely used in production and other activities in which there are increased requirements for the quality of the environmental parameters:

- in health care institutions – in special medical buildings, laboratories, and operating rooms;
- in repositories of valuables, objects of historical significance, and art objects;
- in premises of exact and ultrapure production;
- in agricultural premises of livestock and poultry complexes (in food storage);
- in pharmaceutical production and storage of products;
- in logistics companies for transportation and storage of products that are critical for storage conditions.

The range of the tasks that can be solved by using temperature and humidity data loggers are as follows:

- environment monitoring and detection of violations of storage conditions or production;
- use of data-logger information to organize technological process control;
- prevention of violation of technological requirements in production and storage of products.

Autonomous temperature and humidity data loggers are used to record measured temperature and humidity readings into their memory for further analysis and processing on a computer. These autonomous data loggers consist of a wide range of models that are suitable for different tasks depending on the measuring range and other characteristics (*Data loggers for temperature and humidity – the fields of application* n.d.)

The purpose of this work is to develop the hardware and software of a microcontroller-based temperature and humidity data logger.

Nowadays, many modern devices are built on microcontrollers. The important feature of microcontrollers is that their use makes it easier and cheaper to develop a device. A microcontroller can control various devices and receive data from them with a minimum number of additional nodes (because quite a lot of peripherals are already on the chip). Devices that are built on microcontrollers feature smaller dimensions and low power consumption.

2. Hardware design of microcontroller-based temperature and humidity data logger in Proteus VSM

A microcontroller-based data logger must measure temperature and humidity and write these values on a microSD memory card. In Figure 1, a block diagram of a microcontroller-based temperature and humidity data logger is shown. The data logger hardware consists of an Arduino Uno R3 board with an ATmega328P-PU MCU (Banzi 2011; Gertz, Di Justo 2012; Oxel, Blemings 2009), an HTU21D digital temperature and humidity sensor (*Temperature and humidity sensor HTU21D datasheet* n.d.), a RobotDyn module with RTC IC DS1307 and microSD card reader (*Description of RTC+microSD-card shield from RobotDyn* n.d., *Real-time Clock DS1307 datasheet* n.d.), a four-key keypad, and an HD44780 alphanumeric 16×2 LCD module (*Liquid-Crystal Display HD44780 controller/driver datasheet* n.d.). The Arduino Uno microcontroller reads data from the HTU21D sensor, processes it, and writes it to the memory card

according to its operation algorithm in real time. The current temperature and humidity values and date are displayed on the alphanumeric LCD module.

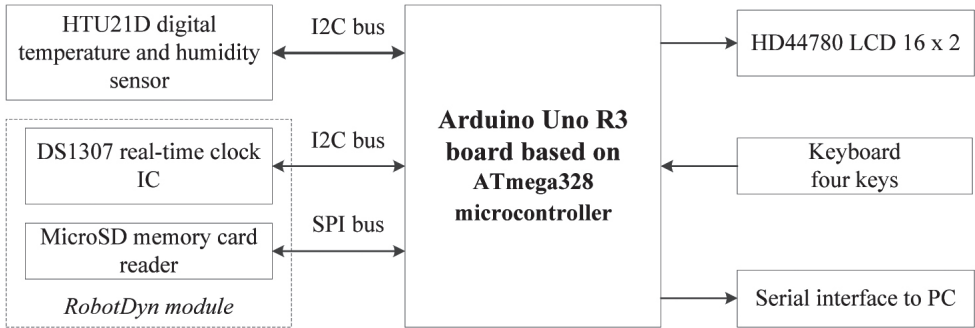


Fig. 1. Block diagram of microcontroller-based temperature and humidity data logger

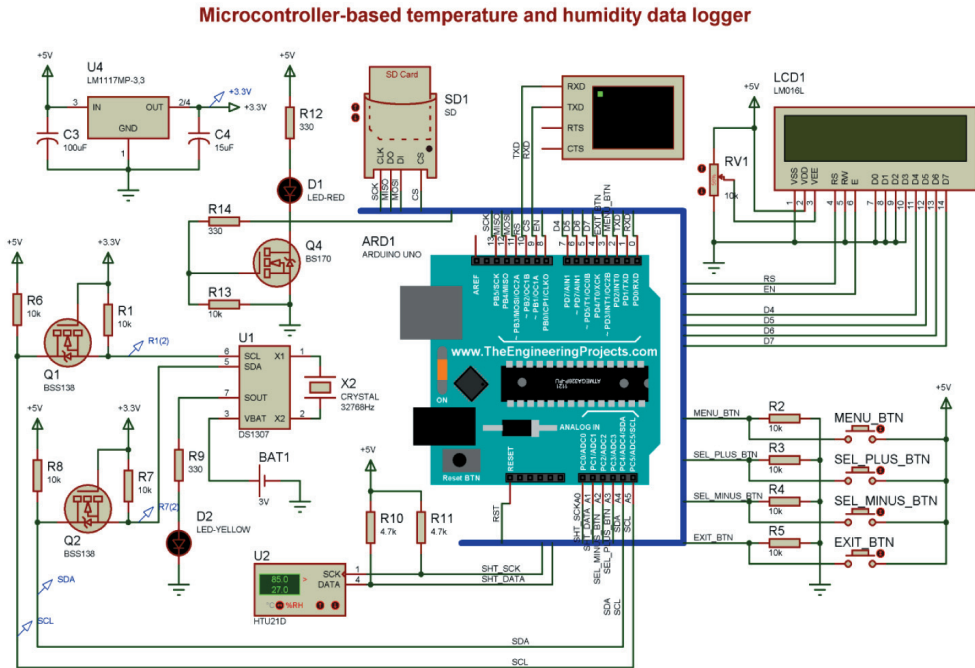


Fig. 2. Hardware of microcontroller-based temperature and humidity data logger designed in Proteus VSM

In Figure 2, the designed hardware of the data logger in CAD Proteus is shown. The HTU21D temperature and humidity sensor module is connected to the Arduino Uno board using the I2C interface. The synchronization (SCK) and data (SDA) pins of

the sensor are connected according to the A4 (SDA) and A5 (SCL) pins of the I2C bus of the Arduino Uno board. The RTC IC DS1307 is connected to the Arduino Uno board on the I2C bus. The synchronization (SCL) and data (SDA) lines of the I2C interface bus on the Arduino Uno board are located on Pins 19 (A5/SCL) and 18 (A4/SDA). The microSD card reader is connected to the Arduino Uno card via the SPI interface. The SCK pin of the card reader is connected to Pin 13 (PB5/SCK), the MISO pin – Pin 12 (PB4/MISO), the MOSI pin – Pin 11 (~ PB3/MOSI/OC2A), and the CS pin – Pin 9 (CS) of the Arduino Uno board.

The HD44780 LCD module is connected to the pins of the PBx and PDx ports. The RS output of the LCD module is connected to Pin 10 (PB2) of the Arduino Uno board. The LCD E output is connected to Pin 8 (PB0) of the Arduino Uno board. Data outputs D4...D7 are connected to Pins 7...4 (PD7/AIN1, ~ PD7/AIN2, PD5/T1/OC0B, PD4/T0/XCK) of the Arduino Uno board. The MENU_BTN button is connected to Pin 2 (PD2/INT0), the SEL_PLUS_BTN (select/enlarge) button – Pin 17 (PC3/ADC3), the SEL_MINUS_BTN button (select/reduce) – Pin 16 (PC2/ADC2), and the EXIT_BTN for exiting from the menu to the operation mode – Pin 3 (~PD3/INT1/OC2B) of the Arduino Uno board. When the MENU_BTN button is pressed, the INT0 interrupt will be generated, and the program will call its processing function.

3. Operation algorithm of microcontroller-based temperature and humidity data logger

In Figures 3 and 4 (on the interleaf), the block diagrams of the operation algorithm of the microcontroller-based temperature and humidity data logger are shown.

4. Simulation and prototype testing of microcontroller-based temperature and humidity data logger

The data-logger software is compiled and linked to the hex file that is programmed into the MCU flash memory. The data-logger software is written in C/C++ using Arduino IDE (Arduino n.d.). Before downloading the firmware to the device (data logger), its operation can be checked on the created model in Proteus ISIS. A simulation of the device allowed us to detect existing errors in the software and eliminate them without loading it several times into the microcontroller's flash memory. In Proteus, the simulation and debugging of quite complex projects can be performed that can have several microcontrollers and even from different families. In Figure 5, the simulation of the microcontroller temperature and humidity data logger is shown.

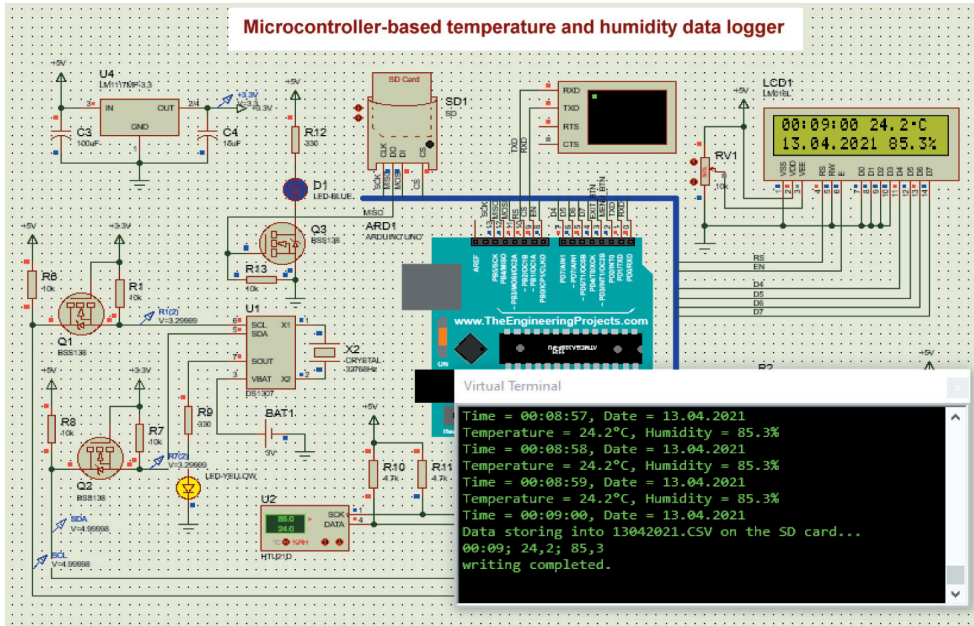


Fig. 5. Simulation of microcontroller-based temperature and humidity data logger in Proteus ISIS

In Figure 6, the test circuit (prototype) of the microcontroller-based temperature and humidity data logger is shown. In Figures 7 and 8, the obtained results of the testing of the microcontroller-based temperature and humidity data logger are shown

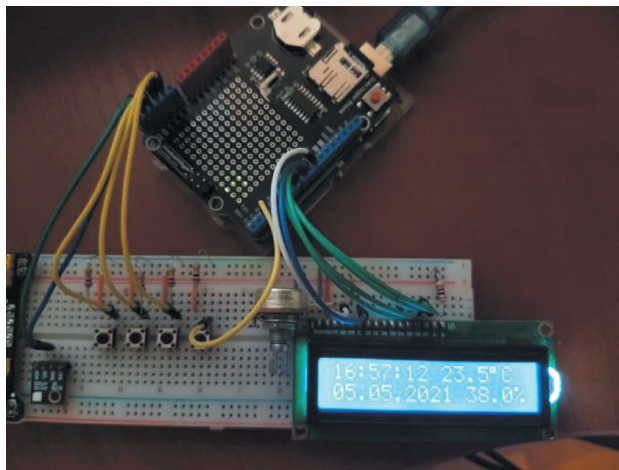


Fig. 6. Test circuit (prototype) of microcontroller-based temperature and humidity data logger

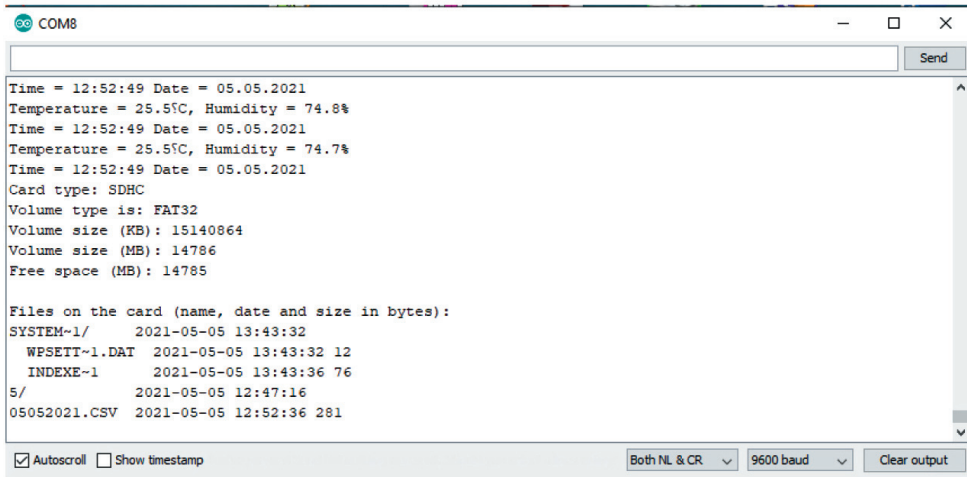


Fig. 7. Information output to serial monitor

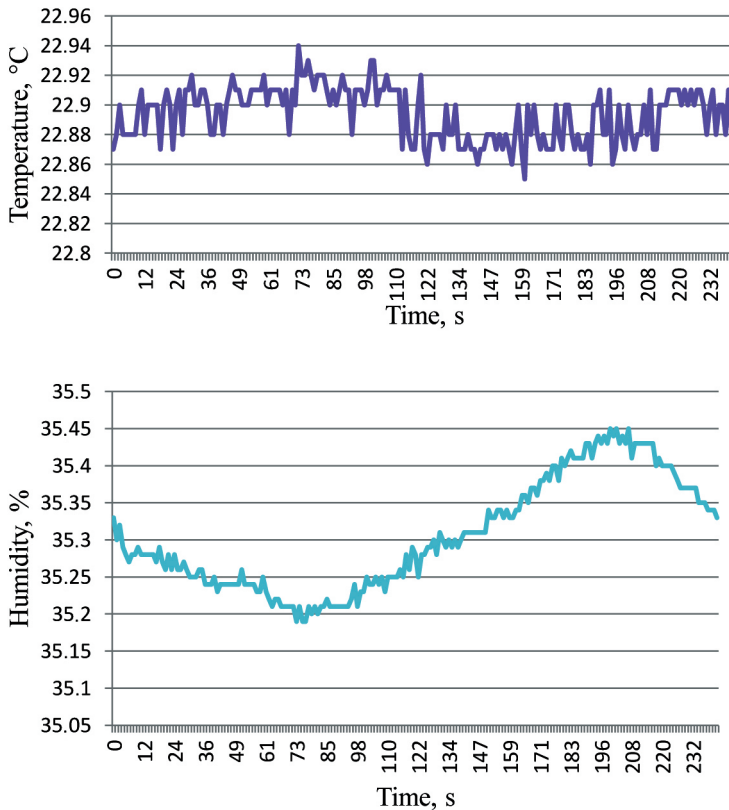


Fig. 8. Excel graphs of temperature and humidity data that was collected by data logger

5. Conclusions

In this work, the hardware and software of a microcontroller temperature and humidity data logger have been developed. The device measures temperature and humidity, displays the measured temperature and humidity values on an HD44780 alphanumeric 16×2 LCD module, and writes them in a .csv file to a microSD memory card. An electronic circuit of the microcontroller temperature and humidity data logger in the Proteus CAD system has been designed. The operation algorithm and data-processing software of the microcontroller-based temperature and humidity data logger have been developed. The software modules for communicating with an HTU21D digital temperature and humidity sensor for outputting information to the HD44780 alphanumeric LCD module have been created. The model of the microcontroller-based temperature and humidity data logger in Proteus ISIS has been created and tested.

The prototype of the microcontroller-based temperature and humidity data logger has been developed and tested.

REFERENCES

- Arduino [electronic resource on Arduino IDE]: <https://www.arduino.cc/en/Main/Software> [10.11.2021].
- Banzi M., 2011, *Getting Started with Arduino*, 2nd Edition, O'Really Media Inc., Sebastopol, CA, USA.
- Data loggers for temperature and humidity – the fields of application* [electronic resource]: <https://www.testo.com/en-IN/products/datalogger-humidities> [10.11.2021].
- Description of RTC+microSD-card shield from RobotDyn* [electronic resource]: <https://arduino.ua/prod2645-shild-rtc-sd-card-dlya-arduino-uno-ot-robotdyn>, <https://copperhilltech.com/blog/robotdyn-data-logger-shield-for-arduino-development-resources/> [10.11.2021].
- Gertz E., Di Justo P., 2012, *Environmental Monitoring with Arduino: Building Simple Devices to Collect Data about the World around Us*, O'Really Media Inc., Sebastopol, CA, USA.
- Liquid-Crystal Display HD44780 controller/driver datasheet* [electronic resource]: <https://www.sparkfun.com/datasheets/LCD/HD44780.pdf> [10.11.2021].
- Oxer J., Blemings H., 2009, *Practical Arduino: Cool Projects for Open Source Hardware*, Springer-Verlag, New York.
- Temperature and humidity sensor HTU21D datasheet* [electronic resource]: <https://datasheetspdf.com/pdf-file/1087268/TE/HTU21D/1>, https://cdn-shop.adafruit.com/datasheets/1899_HTU21D.pdf [10.11.2021].
- Real-time Clock DS1307 datasheet* [electronic resource]: <https://pdf1.alldatasheet.com/datasheet-pdf/view/123888/DALLAS/DS1307.html>, <https://datasheets.maximintegrated.com/en/ds/DS1307.pdf> [10.11.2021].

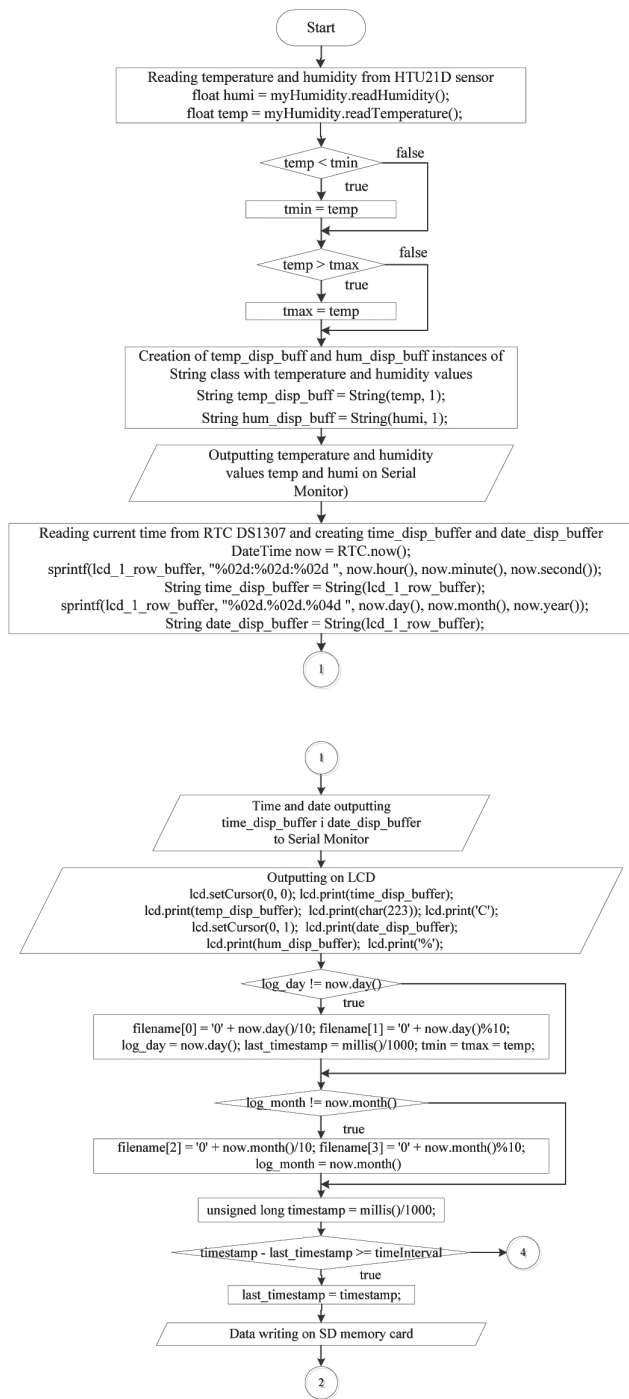


Fig. 3. Operation algorithm of microcontroller-based temperature and humidity data logger

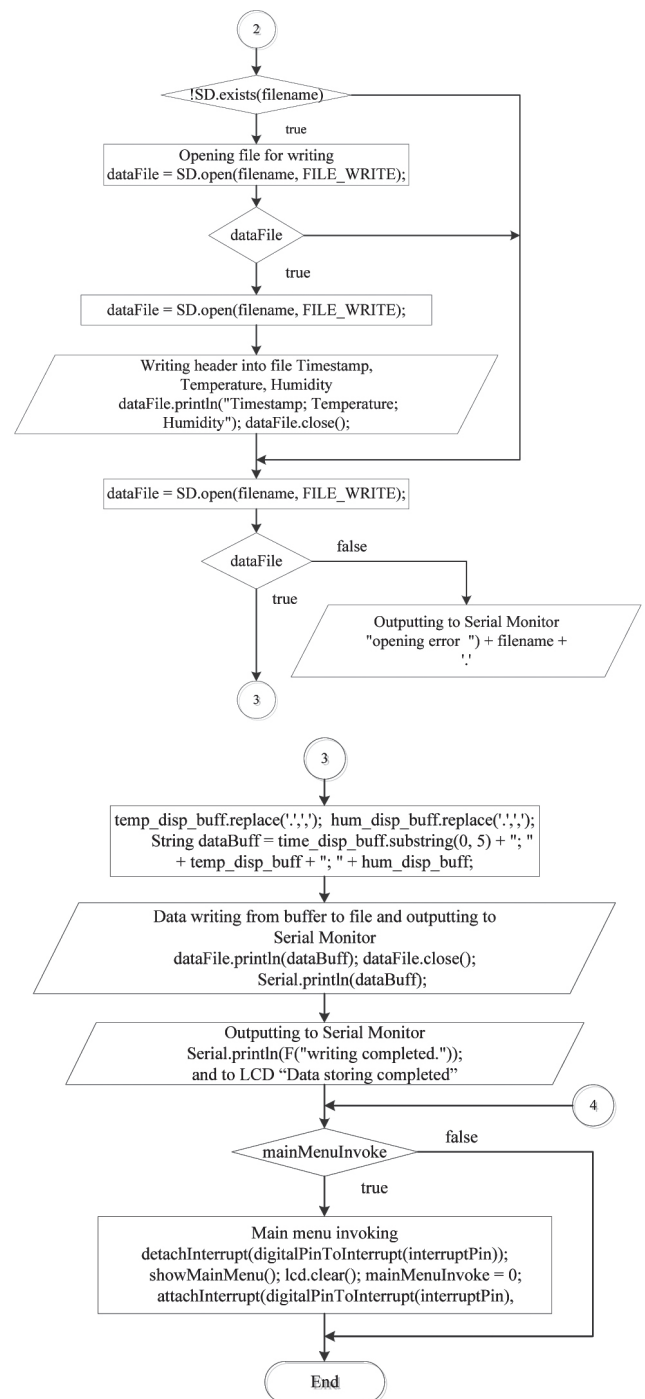


Fig. 4. Operation algorithm of microcontroller-based temperature and humidity data logger