11th International Conference on Electrical, Electronics and Computer Engineering (IcETRAN), Nis, 3-6 June 2024

# Smart terrarium for reptiles - Bearded dragon lizard

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***Abstract*— This paper describes how a terrarium works, which is adapted to provide ideal conditions for a pet of a specific species in home conditions using available software tools. The terrarium described in the paper is adapted reptiles of the Bearded dragon species. Bearded dragons are very resistant animals and they hardly get sick if they have optimal living conditions. To make it easier for animals and their owners, we designed a system that maintains all the optimal parameters for the life of the Bearded dragon. The paper describes the measurement and regulation of temperature, the measurement of relative humidity, the measurement of the UV index, as well as the switching on and off of certain parts of the system. The electronic scheme of the system was designed in the KiCad program, the programming part was written in the Arduino IDE programming environment. The goal of the system is to provide adequate management of executive elements based on information from sensors and additional modules.**

***Keywords*— *Smart terrarium, Temperature measurement and regulation, Atmega328, KiCad, Arduino IDE, Bearded dragon, LM31, DHT11, UVM-30A, RTC module.***

## I. INTRODUCTION

In the past few years, the awareness of animals as pets has changed drastically, today, in addition to common pets such as dogs, cats, fish and small rodents, we increasingly encounter exotic species such as various lizards, snakes, spiders and scorpions. Each pet is special in its own way and requires certain living conditions, regular nutrition and care. One of the more common types of exotic animals in Serbia is the reptile Bearded dragon lizard (Pogona vitticeps) Fig 1.

Bearded dragons are lizards 45 cm - 60 cm in full size, they originate from Australia, their habitats are predominantly semi-desert and desert regions. Bearded dragons are diurnal animals that spend a lot of time in the sun and thus produce vitamin $D_3$, which is necessary for growth and proper development.

Fig 1. Bearded dragon.

This research has been supported by the Ministry of Science, Technological Development and Innovation (Contract No. 451-03-65/2024-03/200156) and the Faculty of Technical Sciences, University of Novi Sad through project "Scientific and Artistic Research Work of Researchers in Teaching and Associate Positions at the Faculty of Technical Sciences, University of Novi Sad" (No. 01-3394/1)..

### A. *Lifestyle of the Bearded dragon in the terrarium*

Bearded dragons are quite disease-resistant reptiles, however, inadequate care can lead to health problems. Health problems that the bearded dragon can have are metabolic bone disease, hypocalcemia - lack of calcium in the body, upper respiratory tract infection and parasites. Most health problems are caused by inadequate nutrition, low temperature and inadequate UV (Ultraviolet) light.

In Serbia, there is no veterinarian specialized in reptiles, only a few who know a little about the subject, so any disease is a potential death for a lizard.

In order to prevent the occurrence of diseases in reptiles, especially in inexperienced owners, the idea of a smart terrarium was born that will maintain optimal parameters for the bearded dragon. The idea is that when making the terrarium, we insert a device that will regulate all relevant parameters, make it easier for the owners and save the lizard's life. The parameters are shown in the next section.

### B. *Terrarium conditions*

To secure optimal conditions for the growth and development lizard in the terrarium, the space must be adapted to its natural habitat. The size of the terrarium should have the following dimensions: width 50 cm, height 50 cm and length 100 cm.

The terrarium must have the following elements: a UV lamp that replaces the sun's rays, one light heater or a spotlight (a bulb that has a concentric beam of light) and one heater that does not emit light - a foil heater. In the warmer part of the terrarium under the spotlight, the temperature range should be from 40° C to 45° C, in the colder part the temperature should be from 20° C to 25° C, during the night the temperature should not be below 20° C. The relative humidity of the air in the terrarium should be below 40 %.

The goal of the system is to turn on the UV lamp and the light heater at a specified time in the morning, then maintain the temperature in the terrarium. During the night at a specified time to turn off the UV lamp and the light heater so that the lizard can sleep undisturbed.

The main problem with smart terrariums for Bearded dragons is that no commercial solution exists that includes all the necessary features. There are separate modules for all the functions, but no unified systems have been developed until now, as far as the authors know. In most cases, a socket with a mechanical timer or a smart socket is used to turn on and off the UV lamp and heater, the temperature measurement is done with an analog sensor or digital, temperature regulation is almost not

done like the other measurements we described in the paper. It is very difficult for owners to acquire all the sensors and equipment individually needed to maintain optimal conditions in the terrarium. Such systems are very unreliable, we do not have any information about the parameters in the terrarium, there is no temperature regulation and therefore health problems arise in Bearded dragons.

The Fig 2. shows an illustration of a smart terrarium system. A smart terrarium provides all the optimal conditions for the life of a bearded dragon. More about the system itself in the next chapter.

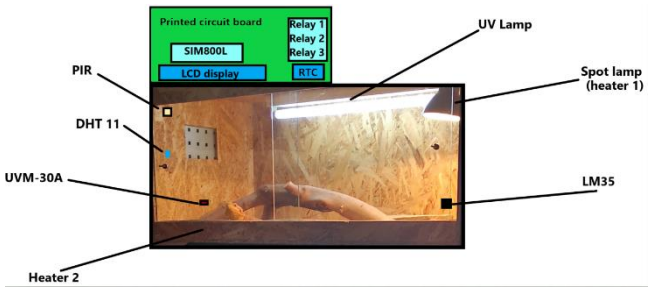


Fig 2. Illustration of the system.

### C. *Operation mode of system*

The operation of the system is based on the fact that the microcontroller receives information from the sensor modules, then processes that information and controls the relays. The block diagram of the system is shown in Fig 3.

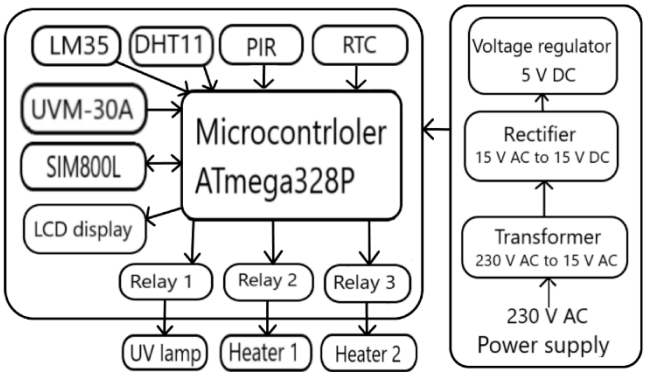


Fig 3. Block diagram of the system.

The RTC (Real-time clock) module is used to set the time of turning on and off the UV lamp and the heater. The system turns on the UV lamp and the light heater at a specified time in the morning, the foil heater works during the day in case the temperature drops below 20° C in the cooler part of the terrarium. During the night, turn off the UV lamp and the light heater at a specified time so that the lizard can sleep undisturbed. In case the temperature drops below 20° C during the night, the system includes a foil heater that maintains the temperature in the range of 20° C - 25° C.

UVM-30A is a module that measures the UV radiation index. Bearded dragons are exposed to a UV lamp that has a radiation index of 3-6. If a lower radiation index is detected, it means that the UV lamp is ready to be changed. Lamps used in terrariums have a lifespan of 9 months to a year.

SIM800L is a module that sends a message to the user in case of an unwanted effect. That is, systematic deviations from the way the microcontroller is programmed to regulate the entire system..

## II. Analysis of System Parts

### A. *Electronic schematic of the system*

The electronic scheme of this system was designed in the KiCad program [1]. KiCad is an open source software package for electronic design.

The device is powered from a 230 V AC mains supply, transformer T1 converts 230 V to 15 V. Greco's connector is used to convert AC voltage into DC voltage, the output voltage is +15 V DC. The 2200 uF capacitor is a large electrolytic capacitor used to filter out slow and large disturbances, the 470 uF capacitor connected to the output of the regulator is also electrolytic. Ceramic capacitors of 100 nF are placed at the input and output of the regulator, they are used to filter fast and small disturbances. When stabilizing the voltage, stabilizers from the LM78XX series are used, the last two digits inform about the value of the stabilized voltage. The power supply of the stabilizer must have at the input at least 3 V above the expected voltage at the output. The LM7805 [2] produces a stable voltage of +5 V at the output. The Fig 4. shows the power supply.

The component responsible for managing the entire system is the ATmega328P microcontroller [3]. Fig 5. shows the connection diagram of the microcontroller. In the right corner of the schematic is the reset circuit. Component Y1 represents a quartz crystal, which provides the microcontroller with an operating clock, while capacitors C9 and C10 allow the quartz crystal to oscillate..

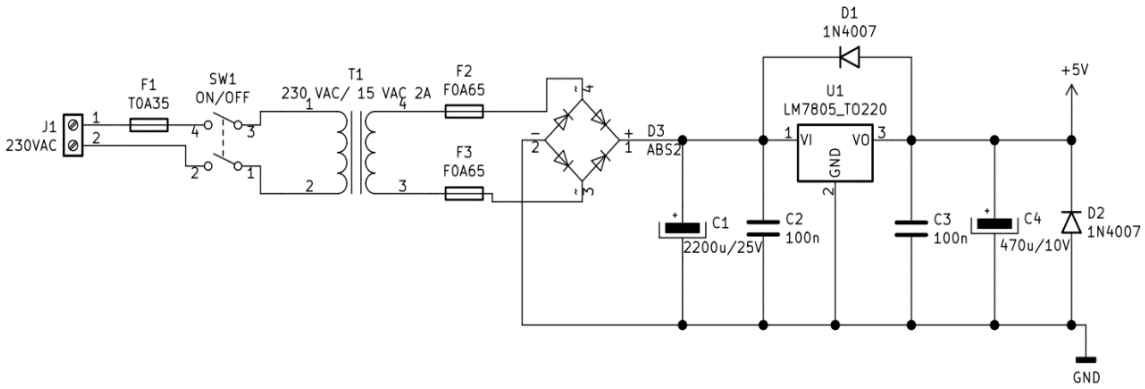


Fig 4. Power supply.

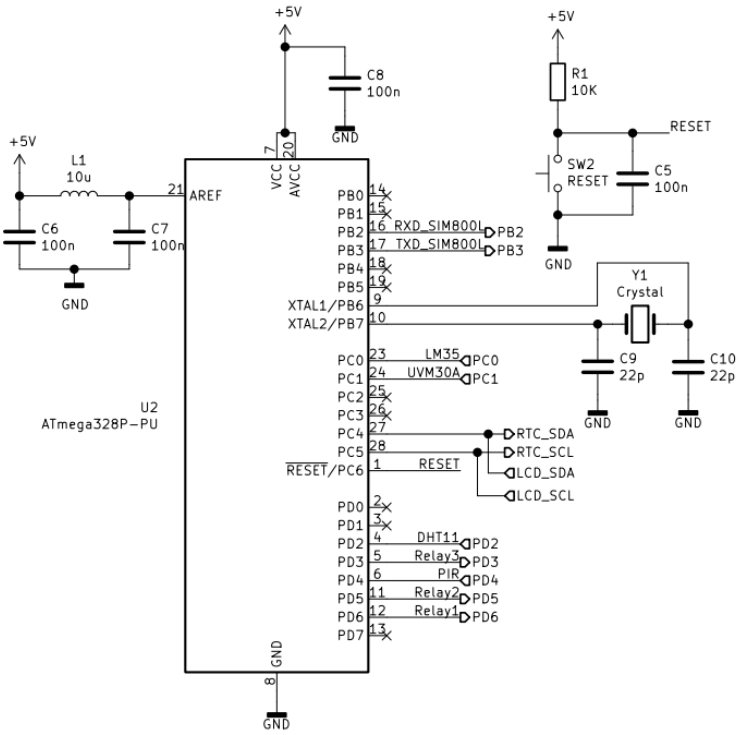


Fig 5. Connecting the ATmega328P

The sensor responsible for measuring the temperature and relative humidity of the air in the cooler part of the terrarium is the DHT11. The DHT11 is a commonly used temperature and humidity sensor that comes with an 8-bit microcontroller to output temperature and humidity values as serial data. The DHT11 sensor can be purchased as a sensor or as a module. In both cases, the performance of the sensor is the same. The sensor will come in a 4-pin package, of which only three pins will be used, while the module will come with three pins as shown in Fig 6.

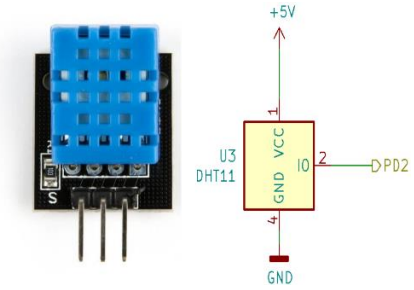


Fig 6. DHT11 module (left) [4], connection method (right).

To measure the temperature in the warmest part of the terrarium, we use the LM35 temperature sensor. LM35 is a sensor whose output signal is proportional to the current temperature. The main feature of this sensor is that it does not require additional calibration. LM35 shown in Fig 7.

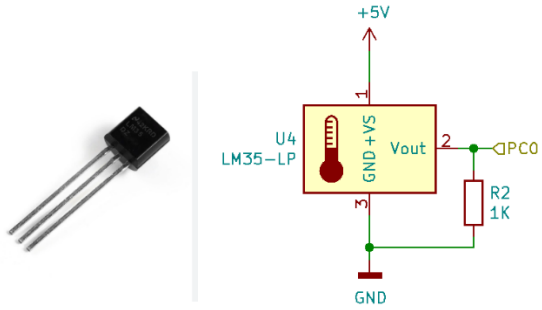


Fig 7. LM35 (left) [5], connection method (right).

To check if everything is fine with the animal in the terrarium, we use a PIR (passive infrared) sensor, it detects movement in the terrarium. Fig 8. shows the PIR HC-SR501 sensor module.

Fig 8. PIR sensor [6].

To check the correct operation of the UV lamp, we use the UVM30A. The UVM30A is the UV sensor module used to detect the intensity of ultraviolet radiation. This module has an

analog output that change with the intensity of the UV light. In Fig 9. we can see the look of the module.

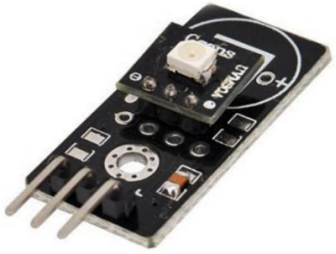

Fig 9. UVM30A module [7].

We use the SIM800L module to send SMS messages. Fig 10. shows SIM800L module.

Fig 10. SIM800L module [8].

To turn the UV lamp on and off at specific times, an RTC module is required. The RTC module is a clock that manages the time and date with high precision. The module has a built-in battery for backup power and a built-in crystal oscillator. The RTC module works by counting the oscillator clocks to obtain time and date information. RTC module shown on Fig 11.

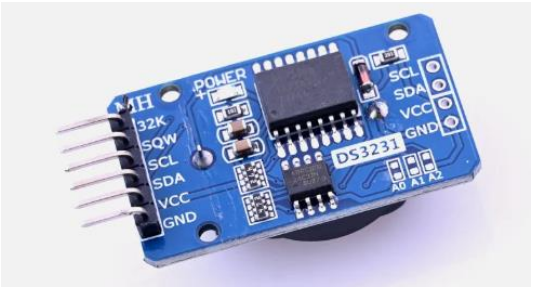


Fig 11. RTC module [9].

The screen that displays the values from the sensor is the LCD (Liquid-crystal display) RC1602A [10]. At least four data lines and two control lines are required to communicate with the microcontroller and print data on the display. Since there are not enough pins on the microcontroller to connect the LCD and all other system components, it was necessary to use an I/O expander. The display connection is shown in the Fig 12.

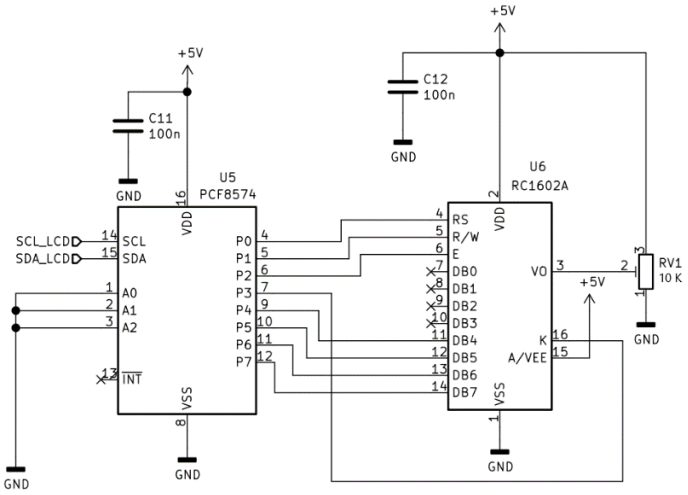


Fig 12. LCD display connection.

Relays are used to control actuators powered by 230 V AC. A relay is a device used to break or make a circuit using an electromagnet that opens and closes current contacts. Relays with NO (normal open) contact were used in the work [11]. Fig 13. shows a convenient way of controlling a relay via a transistor. The relay is switched on and off using an NPN transistor. If a voltage is applied to the base of the transistor, the heater will turn on. If there is no voltage on the base, the relay will turn off. By means of resistor R3, the base is connected to the digital output of the microcontroller, from where it receives the ON/OFF signal. Diode D9 is a protective diode, its function is to protect the transistor from the voltage of the reverse electromagnetic force, which occurs when the current is interrupted. The LED (Light-emitting diode) gives a light indication that the relay is working. Relays in the same configuration include heaters and a UV lamp.

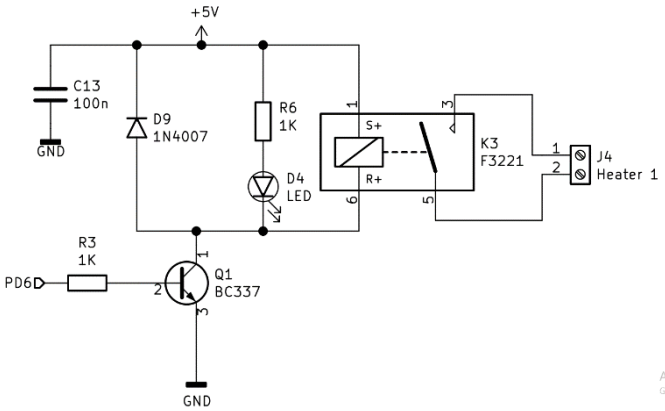


Fig 13. Relay connection.

The PCB (Printed circuit board) of the system is also realized in the KiCad program [12]. All components are arranged on a printed circuit board measuring 140 mm x 130 mm. Fig 14. shows the layout of the printed circuit board, Fig 15. shows the 3D (Three-dimensional space) model of the circuit board [13].

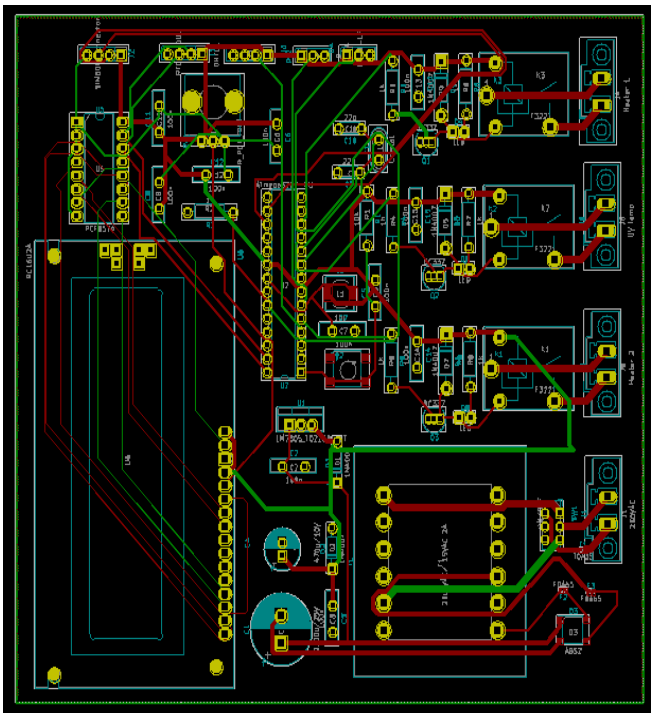

Fig 14. PCB layout.

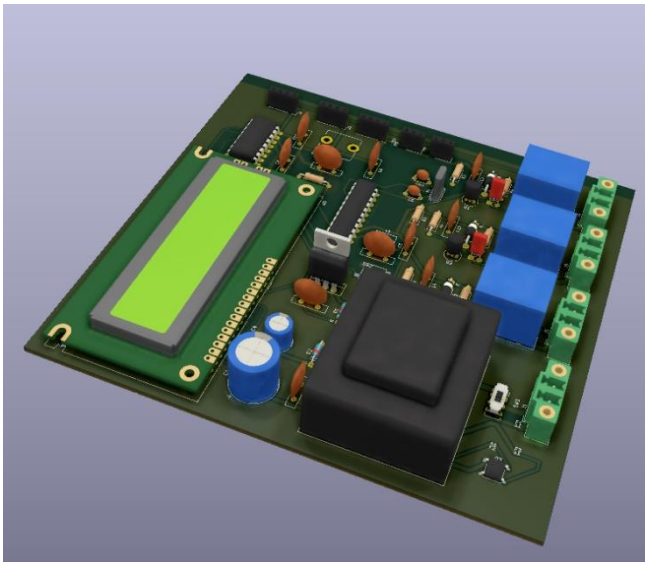

Fig 15. PCB 3D model.

### B. *Program code*

The system program is written in the C programming language, in the Arduino IDE (Integrated Development Environment) development environment. The Arduino IDE [14] is an environment used to develop software for various types of Arduino platforms. It is based on open-source, and includes a large number of libraries of useful functions. Libraries with RTC management functions as well as a library for communication with the SIM800L module are included in the system program. Functions are written that read and then print data from the sensor as well as time and date data. The function for RTC is written in such a way, that first the time of turning on the system and turning it off by the user is entered, and then the information whether the time is set or not is printed.

## III. INDYSTRY 4.0 IN HOME

Industry 4.0 implies the fourth industrial revolution. It stands for the complete digitization of everyone's production processes and application of digital technologies. Industry 4.0 was created with the Internet of Things (IoT) and Internet of Services (IoS) [15].

Internet of things is a concept that consists of a network of devices that have one or more sensors. IoT has an increasingly widespread application in all areas of life in smart home applications, medicine, agriculture and the chemical industry.

This paper presents a device in the Industry 4.0 concept for home use. The device was realized in the concept of Industry 4.0. as a device that connects several different measurements, temperature regulation, display on the LCD display of the most important parameters to sending SMS (short message service) messages to the user in case one of the parameters goes out of the set range. The information measured by the sensors is sent to the microcontroller. Based on this information and the program code that has been loaded, the microcontroller sends information to the relays about their states, regulates the temperature, turns on and off the UV lamp, sends information to the SIM800L module to send an SMS if any of the parameters go out of the set range, and sends information to be printed on the LCD display. Smart terrarium joins other smart devices that are created to help humans and animals.

## IV. CONCLUSION

This paper presents a conceptual description of a smart terrarium that is currently in the realization phase. As we all mentioned earlier, there is no unified system for maintaining optimal parameters in a terrarium for bearded dragons, but only separate elements. The idea was created by the author who keeps the Bearded dragon as a pet.

The terrarium described in the paper meets the bearded dragon's basic needs for a proper life. Temperature regulation prevents diseases such as inflammation of the upper respiratory tract and the appearance of parasites. Monitoring the operation of the UV lamp contributes to the fact that the lizard always has a sufficient source of light necessary for the creation of vitamin $D_3$, thereby preventing bone diseases and calcium deficiency. This kind of terrarium would be basic.

An improved version of the terrarium would have a video camera, which would allow us to see what is happening in the terrarium at all times. Also an electronic lock that would send a message that the terrarium is closed properly.

The hardware for this terrarium is specialized for Bearded dragons, but with minor modifications it can be used for other reptiles. The main difference with some reptiles is the temperature that is optimal, then whether they use a UV lamp or need a diffuser to increase the relative humidity of the air. All

these problems can be solved relatively easily only by changing the program code and certain elements.

The idea of the commercial system is based on writing program codes for different animals, then when the terrarium is intended for a specific animal, certain elements connect to the relay and the code for that animal is loaded. With such a system, the user would be sure that his pet has optimal living conditions.

## REFERENCES


[1] KiCad : https://www.kicad.org/.

[2] Texas instruments LM7805 datasheet: https://html.alldatasheet.com/html-pdf/838007/TI1/LM7805/53/1/LM7805.html.

[3] ATMEL Atmega328P datasheet: https://www.alldatasheet.com/datasheet-pdf/pdf/313218/ATMEL/ATmega328P.html.

[4] AOSON DHT11 figure taken from https://www.cytron.io/p-dht11-sensor-module-breakout .

[5] Texas instruments LM35 datasheet: https://html.alldatasheet.com/html-pdf/517588/TI1/LM35/108/2/LM35.html.

[6] PIR HC-SR501 sensor figure taken from https://www.electronicwings.com/arduino/pir-sensor-interfacing-with-arduino-uno.

[7] UVM30A figure taken from https://electropeak.com/uvm-30a-uv-light-sensor .

[8] SIM800L figure taken from https://www.electroschematics.com/introducingsim800l/.

[9] RTC DS3231 module figure from https://opencircuit.shop/product/real-time-clock-module-ds3231 .

[10] RAYSTAR LCD RC1602A datasheet: https://www.mgelectronic.rs/ProductFilesDownload?Id=7093 .

[11] OMRON relay datasheet: https://www.mgelectronic.rs/ProductFilesDownload?Id=7606.

[12] Dr Peter Dalmaris, KiCad like a Pro, Tech Explorations, 2019.

[13] R. A. Penfold, How to design and make your own PCBs, Babani electronics books, 1983.

[14] Arduini IDE software: https://www.arduino.cc/en/software .

[15] Marcelo T. Okano, IOT and Industry 4.0: The Industrial New Revolution, International Conference on Management and Information Systems, 2017;