UNIVERSITY OF LJUBLJANA

FS

Faculty of Mechanical Engineering

Automated garden irrigation system using ESP32 and KME Smart

Project work

Gašper Mihelič

Ljubljana, June 2025

Contents

List of Figures

Introduction

In modern times, efficient use of natural resources and automation of everyday tasks are becoming essential for sustainability and user convenience. Interest in smart systems is growing even in gardening. Manual watering of a garden and greenhouse can be time-consuming, inefficient, and often poorly timed according to the real needs of the plants. Watering is usually done in the evening and often involves carrying a heavy watering can, which is tiring. However, for plants, it is more appropriate to water in the morning and directly where water is really needed, using drip irrigation. Therefore, there is a growing need for efficient and automated solutions.

The aim of this seminar paper is the design, development, and implementation of an automatic irrigation system based on the ESP32 microcontroller, which is connected to the KME Smart platform. The system supports both automatic and manual control of irrigation through a mobile app, considers environmental sensor data, and uses collected rainwater. This paper presents the system design, selection and connection of hardware, software implementation, an example of automation, and testing results in a real environment.

1 Task Description

The goal of this project is to develop an automated irrigation system for a garden and greenhouse that allows efficient rainwater water usage using an ESP32 microcontroller and the KME Smart IoT platform. The system should support both automatic and manual control of two irrigation zones, respond to data from soil moisture and environmental sensors, and provide users with an overview and control via a mobile application.

1.1 Problem and Solution

Manual watering of gardens and greenhouses is often inefficient, time-consuming, and physically demanding. It typically takes place at suboptimal times, such as late evenings, and often distributes water unevenly. This can lead to poor plant growth, overuse of water, and increased effort for the user. Especially in summer, when watering demand is highest.

To solve this problem, an automated irrigation system was developed using the ESP32 microcontroller and the KME Smart platform. The solution includes two irrigation zones (garden and greenhouse), automatic and manual control via a mobile app, and time and sensor-based automation. The system collects environmental data (soil moisture, air temperature, and humidity) and uses this information to control a submersible pump and two AC solenoid valves. Main ESP32 relay unit is connected to power near the water tank, while the second is battery-powered and placed in the greenhouse. All communication and automation is handled over Wi-Fi and integrated into the user-friendly KME Smart interface.

1.2 Task objectives

- Automate irrigation of two different zones (garden and greenhouse) based on soil moisture.
- Enable manual control and time-based automation through a user-friendly mobile application.
- Ensure reliable Wi-Fi communication for using ESP32 microcontrollers.
- Measure temperature and air humidity inside the greenhouse.
- Adapt the system for use with a submersible pump and 230 V AC solenoid valves.
- Design a battery-powered unit with maximum energy efficiency.
- Integrate all sensor data into the decision-making logic for irrigation.
- Provide the user with system status monitoring, history of events, and the ability to set schedules and conditions via the KME Smart cloud platform.

2 System Description

2.1 Water Collection and Usage

Rainwater is collected from the roof of a residential house and stored in a large underground tank located beneath part of the garden. This water serves as the main source for irrigation, contributing to environmental sustainability and reducing the consumption of drinking water. Rainwater is also more suitable for plant irrigation than tap water. Watering is carried out using a simple 400 W submersible pump, which operates on 230V AC and is controlled via a ESP32 relay module.

Figure 1: Submersible pump

2.2 Irrigation Zones

The system is divided into two main irrigation zones:

- Greenhouse: Equipped with a battery-powered ESP32 unit that measures soil moisture, air temperature, and relative humidity. Based on these values, irrigation can be triggered.

- Garden: Irrigation is performed according to predefined schedules or manual commands set by the user in the KME Smart application.

Figure 2: Greenhouse

Figure 3: Garden

2.3 Central Unit

The main ESP32 unit with relays is installed near the power supply and performs the following tasks:

- Controls the submersible pump and solenoid valves.
- Communicates with the KME Smart application via a Wi-Fi connection.
- Monitors system status and receives user commands in real-time.
- Ensures safe operation of the relays with protection against voltage spikes using built-in optocouplers.

Figure 4: Central unit

2.4 Remote Unit in the Greenhouse

The remote unit is designed for energy-efficient operation using rechargeable batteries. Its functions include:

- Soil moisture measurement with a resistive sensor.
- Temperature and humidity measurement with a DHT11 sensor.
- Measurements are performed periodically.
- Data is sent to the cloud via Wi-Fi within a predefined time window or in real time.

Figure 5: Greenhouse unit

2.5 Communication and Cloud Service

The ESP32 units communicate via a Wi-Fi network. The KME Smart cloud service enables:

- Viewing current measurements (moisture, temperature, valve and pump status).
- Remote irrigation control (on/off).
- Automation based on time schedules and sensor data.
- Notifications in case of abnormal conditions (e.g., low moisture)

2.6 Automation via the KME Smart Application

The KME Smart application allows the user to:

- Set irrigation schedules for each zone.
- Define logic for irrigation based on sensor readings.
- Monitor plant needs through data and adjust settings accordingly.
- Access the system from anywhere via the internet.

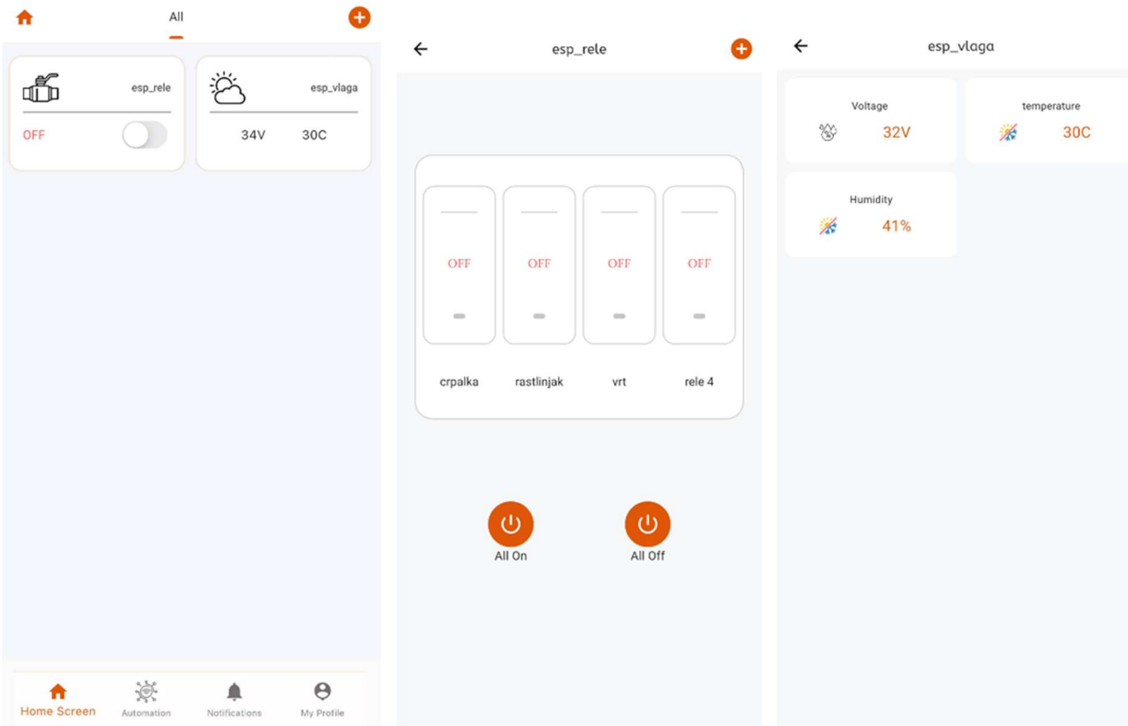

Figure 6: KME Smart mobile application

3 Hardware

- ESP32 board with 4-channel relay module
- ESP32 development board
- 400 W submersible pump (230 V AC)
- Solenoid valves (230 V AC)
- Resistive soil moisture sensor
- DHT11 sensor for temperature and relative humidity
- Rechargeable 5V DC power supply for ESP32
- Enclosure for battery and ESP32
- Enclosure for ESP32 with relays and other wiring
- Connection and extension cables, connectors
- Drip irrigation hose
- Garden hose
- Hose connectors and fittings

Figure 7: Central unit

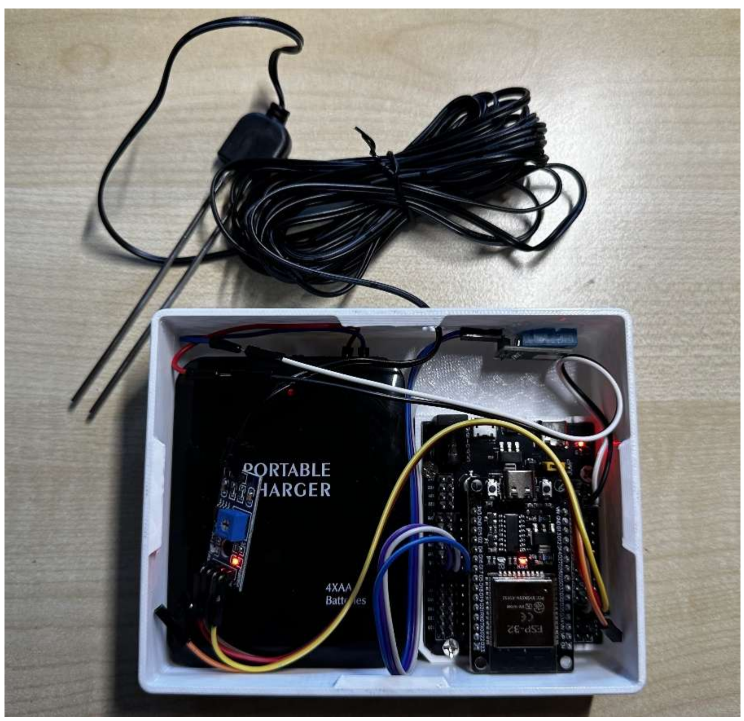

Figure 8: Greenhouse unit

4 Electrical Schematic

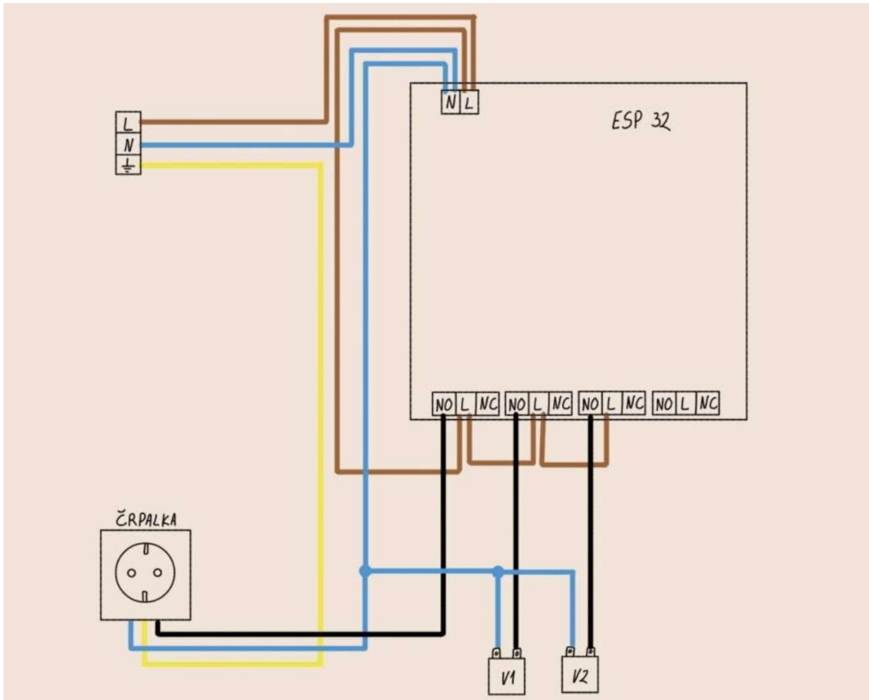

Figure 9: Central unit circuit diagram

5 Software Design

The program is uploaded to the ESP32 using the KME Config desktop application.
The software is available on the KME Smart website.

Usage:
Connect the ESP32 to a computer using a data cable, select the correct COM port in the program, name and “Connect” the device, and then press "Install" to upload the program to the ESP32.

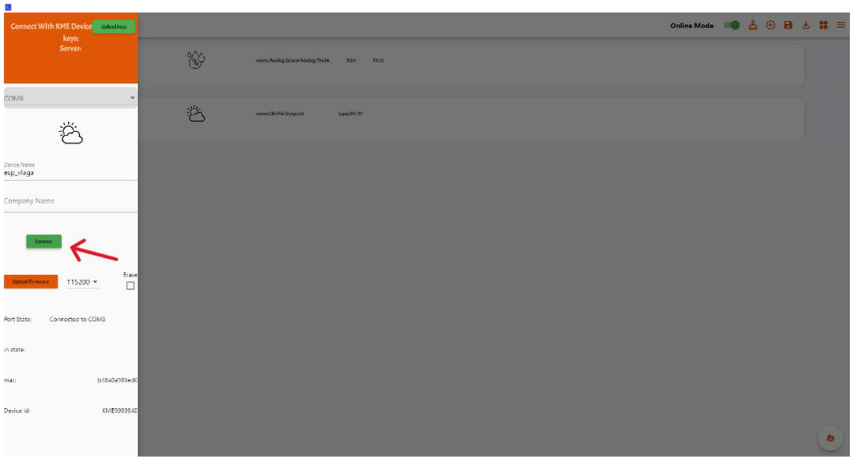

Figure 10: Connecting and installing

5.1 Device Configuration

In the KME Config desktop application, the following setup steps are performed:

- For each relay, the user selects its function, assigns the corresponding GPIO pin, and names it.
- For the resistive soil moisture sensor, the operating mode is set to analog input reading.
- For air temperature and humidity, the DHT11 sensor is selected from the predefined sensor options, and the appropriate GPIO pin is assigned.

Then you press “Upload”.

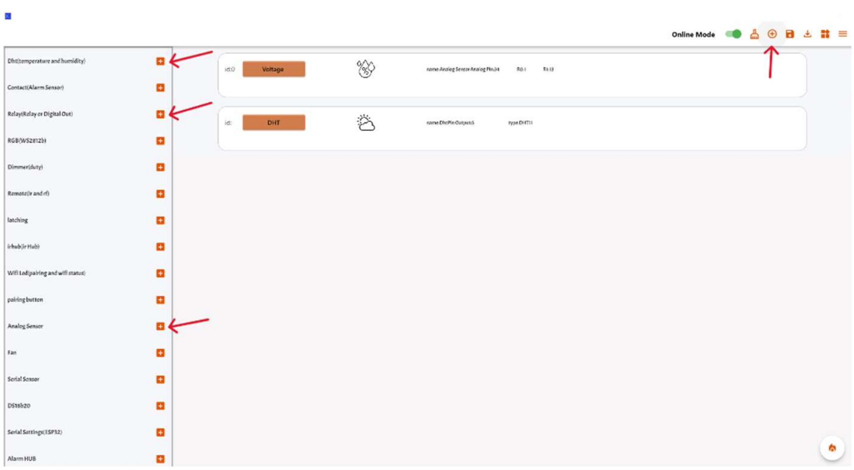

Figure 11: Operation mode

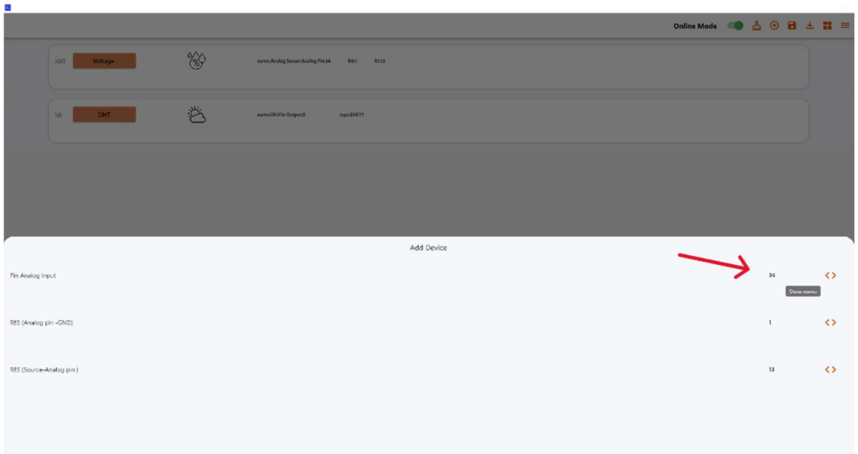

Figure 12: GPIO pin setting

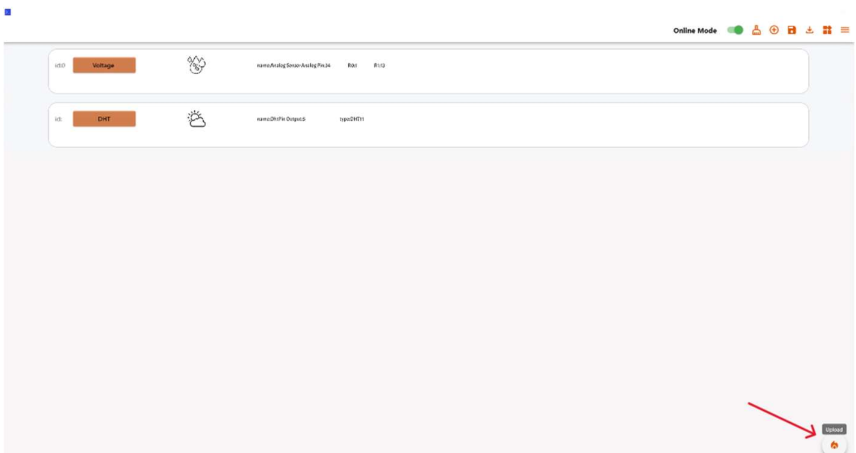

Figure 13: Uploading

5.2 Initial Setup and Wi-Fi Connection

After configuration, the KME Smart mobile application is installed on a smartphone. To connect the ESP32 device to the home Wi-Fi network:

- Open the application and log into your user profile.
- Select the option to add a new device.
- Enter the SSID and password of your home Wi-Fi network.
- Use the "Smart Connect" feature to detect and link the ESP32 device, which will appear on the screen when found.

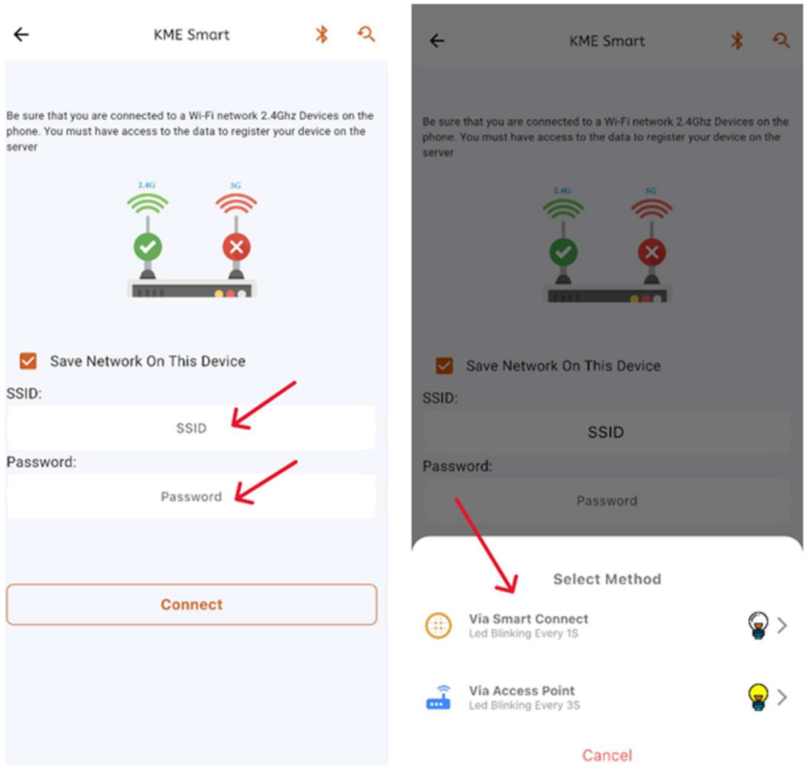

Figure 14: Connecting device to Wi-Fi

5.3 Application Use and Automation Setup

Once the ESP32 device is selected in the app, the main screen shows:

- Digital switches for manual control of relays.
- Live sensor readings of soil moisture, temperature, and humidity.

Automation set up:

Conditions can be defined based on switch states, sensor values, time, and timers.
When the specified conditions are met, the selected automation is triggered - for example, changing the state of relays.

An example of irrigation logic implemented in the system:

- If the soil moisture is below 30% at 5:30 AM, the system turns on the pump and the greenhouse valve.
- Irrigation runs for 30 minutes, until 6:00 AM, after which the pump and valve are automatically turned off.

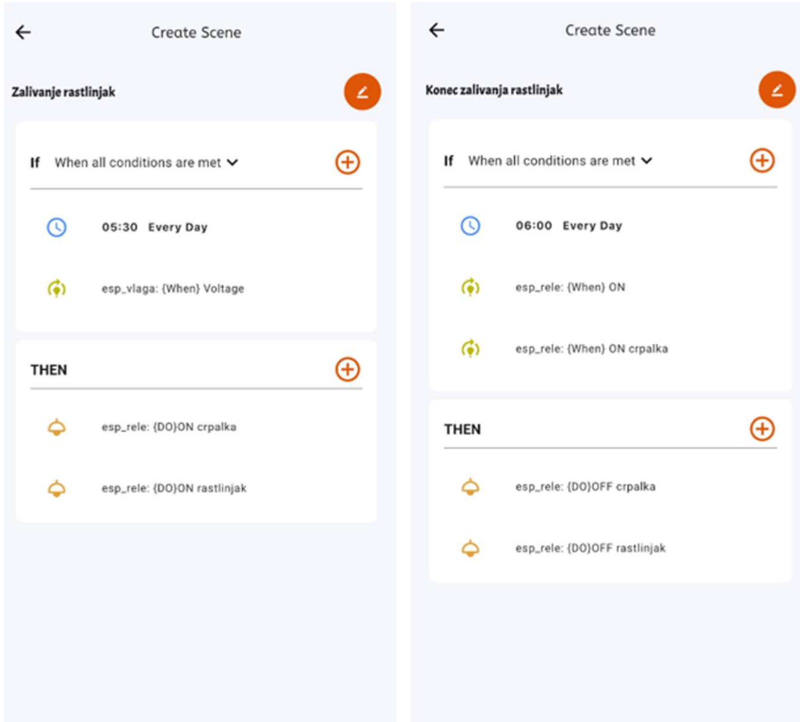

Figure 15: Automation in application

6 Testing and Results

The system was tested in a real environment over several consecutive days. The results are as follows:

- Soil moisture was measured with acceptable accuracy, and irrigation was triggered correctly.
- The KME Smart application allowed for smooth monitoring and control.
- Automation routines (e.g., morning irrigation) were successfully executed through the app.
- The valves and pump operated in sync and without any malfunctions.

7 Possible Improvements

Possible future upgrades include:

- Integration of weather forecasts for advanced irrigation decision-making.
- Upgrading sensors to more accurate models.
- Adding voice control via Google Assistant or Alexa.
- Adding a third irrigation zone.
- Measuring water level in the reservoir.
- Local (touch) display on the central unit.

Conclusion

This project successfully designed and implemented an automated garden irrigation system based on the ESP32 microcontroller and integrated with the KME Smart cloud platform. The system efficiently manages two irrigation zones — the greenhouse and the garden — using soil moisture sensors and environmental data to optimize watering schedules. It allows both automatic and manual control via a user-friendly mobile application, providing real-time monitoring and remote management capabilities.

The use of collected rainwater and energy-efficient battery-powered sensors supports sustainability and reduces reliance on mains water and electricity. Testing in a real environment showed reliable operation of pumps, valves, and sensors, as well as smooth communication with the cloud platform.

Future enhancements such as integrating weather forecasts, voice control, and additional irrigation zones can further improve system functionality and user experience. Overall, this project demonstrates a practical and adaptable solution for smart garden irrigation that promotes water conservation and convenience for the user.

References

[1] KME Smart. (n.d.). *KME Smart Platform – Documentation & Tools*. Retrieved June 20, 2025, from https://kmesmart.com

[2] Espressif Systems. (n.d.). *ESP32 Series Datasheet*. Espressif Systems. Retrieved June 20, 2025, from https://www.espressif.com/en/products/socs/esp32

[3] AC/DC powered ESP32 Relay Board x4. (n.d.). *devices.esphome.io*. Retrieved June 22, 2025, from https://devices.esphome.io/devices/AC-DC-ESP32-Relay-x4