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An Integrated System for Smart and Efficient Irrigation of Crop Fields

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Abstract—**The widespread adoption of new technologies has led to the development of various innovative solutions in agriculture. Crop monitoring using drones for early detection of plant diseases, autonomous machinery for soil preparation, and various robotic systems for harvesting and sorting fruits are just some examples of technology application to increase productivity in agricultural production. This paper describes an integrated system solution for irrigating agricultural production plots aimed at increasing production efficiency while efficiently utilizing necessary resources. All system components (hardware and software) are custom designed, taking into account real-world aspects and constraints in the field. The paper provides a detailed description of all functional units of the system, as well as preliminary experiences with the operation of the implemented prototype system. We also provides some initial characterization of the soil moisture probe that is designed in-house by running extensive LTSpice simulations.**

Keywords-Internet of Things (IoT); Smart Agriculture; LoRa; Automated Irrigation; Soil Moisture Sensors

I. INTRODUCTION

Climate change is having an increasing impact on the agricultural sector in Bosnia and Herzegovina [1]. Given that recent projections for the region predict a decrease in precipitation, especially during the summer period, it will be of paramount importance to carefully plan water resources to ensure adequate irrigation [1]. Since most farms in Bosnia and Herzegovina are engaged in semi-intensive production, their ability to prevent unwanted events is limited. Therefore, Bosnia and Herzegovina must promote climate-resilient technology.

The accelerated development of Internet of Things (IoT) technologies over the past decade has consequently led to the development of innovative solutions in various segments of agriculture, all aimed at improving production efficiency and quality. In [2], some of the most significant challenges that can be addressed by implementing IoT technologies are highlighted: (1) water consumption management, (2) efficient irrigation systems, and (3) soil parameter monitoring (pH, moisture, etc.).

The basic concept of applying IoT solutions for irrigation control (e.g., solutions described in [3] and [4]) is based on accurately determining the soil and plant water status, upon which the optimal amount of water is applied at a given moment for a given agricultural crop. This way, optimal conditions for growth and development are provided to the plants throughout the production cycle, ultimately leading to stable and high-quality yields. By using irrigation controllers connected to soil moisture sensors, water savings ranging from 20% to 92% are achieved while maintaining stable yields [5].

Currently in Bosnia and Herzegovina, the use of automated irrigation systems is characteristic of a very small number of larger, intensive production facilities, while on smaller farms, irrigation is mostly still done manually. The main obstacles to broader adoption of these systems are high equipment costs, lack of knowledge, followed by lack of services and technical support, and farmers' resistance to new technologies. In cases where some form of irrigation automation is used, the main issues during system usage are related to the lack of devices for accurate estimation of water needs for plants (soil moisture measurement devices, evapotranspiration data, etc.), whereby water ration and irrigation intervals are determined solely based on the farmer's subjective estimation, often resulting in insufficient or excessive water consumption.

This paper describes an integrated solution for smart irrigation of agricultural parcels implemented as part of a project whose main goal was to develop an affordable, robust, and modular system adapted to local production conditions,

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which, with the provision of expert and technical support, would enable higher and better quality yields while reducing water consumption on domestic farmers' lots. The system consists of the following functional units: a) main terminal unit, b) sensor units connected to c) probes for measuring soil moisture and temperature, and d) valve control units. All functional units (hardware and software) are completely made in-house, and tested on a smaller prototype system under controlled conditions.

The paper is organized as follows. First, in Section II, we outline some work related to the topic presented in the paper. Section III presents the functional units of the system with a detailed overview of their structure, and describes interaction among them. In Section IV, basic information related to the web application, designed for configuring and monitoring the system operation by users, is provided. Finally, the last section contains main conclusions with a discussion of the obtained results during the testing of the implemented pilot system, as well as guidelines for future work in terms of system improvement and enhancement.

II. RELATED WORK

In recent years, significant advancements have been made in the field of smart irrigation systems. Following fast development and pervasiveness of IoT technologies, some authors used cost-efficient platforms such as Arduino and Raspberry Pi for developing a proof-of-concept solutions (e.g., [6] and [7]). However, the proposed solutions cannot be readily used in the field and serves solely for research purpose in the highly controlled environment and conditions.

Web-based decision support systems have also emerged as valuable tools for irrigation management, providing users with intuitive interfaces for configuring irrigation settings and accessing real-time data. Besides, alternative communication protocols such as LoRaWAN have been explored for smart irrigation systems, offering potential advantages in terms of communication range and power efficiency [8], [9].

Deep learning [10] and fuzzy logic [11] can be used to optimize smart irrigation by analyzing real-time data on weather, soil moisture, and crop needs to determine precise water usage. These technologies ensure sustainable and efficient irrigation by adapting to changing environmental conditions.

This paper aims to complement state-of-the art implementations and solutions by proposing an integrated system that combine all the technologies mentioned above to enable efficient and cost-effective irrigation for the domestic agriculture producers and farmers.

III. SYSTEM DESCRIPTION

The system consists of several independent functional units that exchange data and can be configured according to the needs of the end-user. In Fig. 1, a conceptual representation of the system and its units is illustrated.

As seen in the figure, the agricultural production parcel is organized into sections. Water supply to all sections on the parcel is provided by a main pump that draws water from a water reservoir. Irrigation for each section is controlled by an electromagnetic valve, which state is controlled by the valve control unit. Water for irrigating crops within the section is distributed using appropriate hose network, as illustrated in the figure. The valve control unit contains an RS-485 interface that is use for communication with other units in the system.

Within each section, one or more probes for measuring soil temperature and moisture are placed and connected to the sensor unit. Additionally, the sensor unit provides information on air temperature and humidity. Communication with sensor units distributed in the field is conducted via the LoRa protocol. To enable flexible relocation of sensor units on the parcel according to the end-user's needs and current conditions, sensor units are battery-powered with solar panels to ensure autonomy in operation over longer periods. Therefore, special attention was paid during the design to minimize the

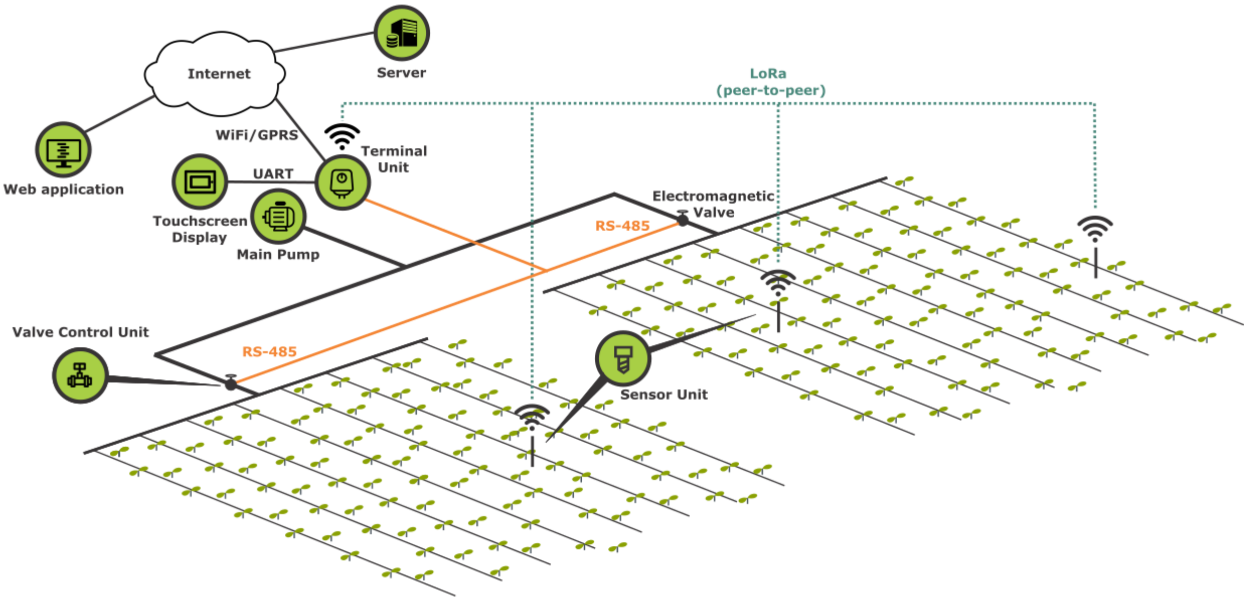


Figure 1. Conceptual representation of system functional units.

consumption of these units.

The central part of the system is the terminal unit, which communicates with all other functional units to aggregate and store collected data in a database on the server. Additionally, the terminal unit enables automated and manual management of the irrigation system according to parameters retrieved from the server. The terminal unit connects to the internet via WiFi network or GSM/GPRS modem (depending on conditions in the field). Furthermore, the terminal unit allows system configuration locally using a touch-screen LCD display integrated into the unit.

System monitoring and administration are facilitated through a dedicated web application running on the server side. This application allows system parameterization (assigning valves, sensors, and terminal units with the system, and their configuration), as well as defining schedules for activating valves inside sections that can be organized into logical groups called shifts. Each shift can be associated with a set of sensor units providing data necessary for automated irrigation mode. Besides parameterization, the web application enables system monitoring, displaying current values of relevant data, with the option to log certain critical information for later analysis.

In the following, we will explain in detail each functional unit, focusing on various aspects that were significant during their design.

A. *Terminal Unit*

The block diagram of the terminal unit is shown in Fig. 2. The central part is comprised of the microcontroller module ESP32-WROVER, which controls all components and modules of the terminal unit. Since the terminal unit is fixed and located near the water pump, the main power source is the alternating electrical network. The power supply module consists of components that rectify this voltage into a direct voltage of 12V, which is then lowered using DC/DC converters and linear regulators to stable voltage levels of different values (5V, 4V, and 3.3V) necessary for powering the microcontroller and other components.

In addition to the integrated WiFi interface within the ESP32 microcontroller, the terminal unit contains three communication interfaces: the LoRa module Ra-02 (connected to the microcontroller via SPI interface), the SIM800L GSM/GPRS modem (connected to the microcontroller via UART interface), and an RS-485 transceiver (MAX485 component) for voltage level translation. As mentioned earlier, RS-485 is used as the primary communication method with valve control units, while the LoRa protocol is used for communication with sensor units in the system. The GSM modem serves as an alternative means of connecting the terminal unit to the internet if WiFi network infrastructure is unavailable. For data exchange over the LoRa and RS-485 networks, a special protocol has been developed that enables node addressing, as well as proper frame delineation and integrity checking. The detailed description of the protocol is out of scope of this paper.

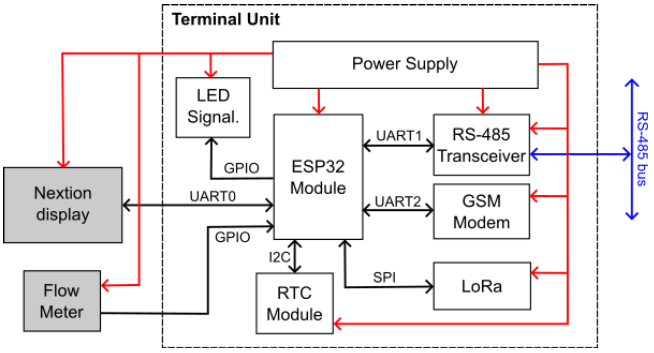


Figure 3. Block diagram of terminal unit.

The terminal unit also includes an RTC (Real-Time Clock) module for maintaining accurate time, allowing precise timestamps to be associated with all data. In this case, the DS3231 module was used, which connects to the microcontroller via the I2C interface.

In addition to basic LED indicators, the terminal unit also integrates a touch-screen LCD display manufactured by Nextion, which supports the development of advanced graphical interfaces using a free HMI (Human Machine Interface) application editor. The display is connected to the microcontroller via the UART interface, which communicates with it using a custom protocol.

Finally, the terminal unit also allows connection to a flow rate sensor located on the pump hose, enabling the estimation of daily water consumption used for irrigation.

The prototype of the terminal unit, developed for testing and evaluating the pilot system, is shown in Fig. 3. This figure also provides a sample of the graphical interface implemented using the Nextion editor.

B. *Sensor Unit*

Unlike valves, the locations of sensor units cannot be precisely planned in advance. Depending on the terrain configuration and other conditions on the parcel, the best location for sensor units usually needs to be determined experimentally. Additionally, there may be a need to change the location of sensor units over time. For this reason, this unit is designed to use battery power with the recharging option over USB adapter or solar panel. To ensure sufficiently long autonomy of operation, special attention was paid during software development to minimize power consumption.

Fig. 4 shows the block diagram of the sensor unit. Similar to the terminal unit, an ESP32 microcontroller (ESP32-WROOM module) is used for control. It is connected to a LoRa module and an RS-485 transceiver. As mentioned earlier, the LoRa protocol enables communication between the sensor unit and the terminal unit, while the RS-485 interface is connected to the measuring probe, which provides data on soil moisture and

Figure 2. Realized prototype of terminal unit.

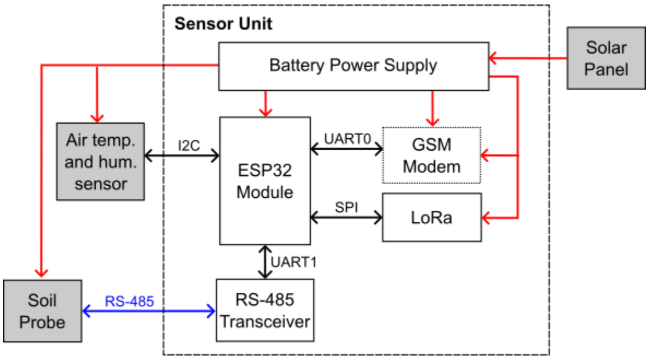


Figure 6. Block diagram of sensor unit.

temperature. Additionally, via the I2C interface, the sensor unit is connected to an air temperature and humidity sensor (AM2315C). Information on air temperature allows users to further optimize the irrigation process by adjusting valve activation thresholds based on known models or their own experience in cultivating a particular crop in the given area.

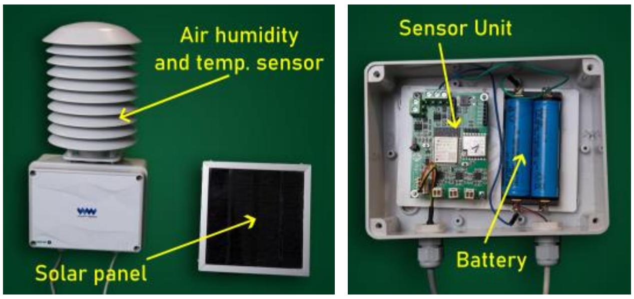
Optionally, the possibility of adding a GSM modem within the sensor unit is provided for rare cases when, due to various reasons (terrain configuration, sensor distance, etc.), communication using the LoRa protocol is not feasible. In such cases, the server can communicate with the sensor unit directly over the internet, bypassing the terminal unit.

As mentioned earlier, special attention was paid when designing hardware and software of the sensor unit to minimize power consumption and ensure prolonged unit autonomy. In this regard, the hardware was designed so that the microcontroller can cut off the power in software for all connected components, and afterwards enter a low-power consumption mode. In this case, the deep-sleep mode of the ESP32 microcontroller was used, in which, according to the specification, the current from the power source ranges from 10μA to 150μA. In this mode, only a minimal set of internal devices necessary to reactivate the microcontroller using a timer remains operational. Periodically, at user-adjustable intervals, the microcontroller exits the low-power mode, turns on the power and initializes system components to collect the required data, which are then transmitted to the terminal unit. After data transmission, the microcontroller returns to the low-power mode, and the cycle repeats. To reduce the possibility of simultaneous data transmission by multiple sensor units, data transmission is checked before sending to see if any station is already transmitting data (so called *listen-before-talk* communication mechanism).

Fig. 5a shows the prototype of the implemented sensor unit connected to a temperature and humidity sensor, while Fig. 5b shows the interior of the sensor unit connected to the battery power. As seen in Fig. 5a, the sensor for measuring air parameters is housed in a casing that allows natural air flow, reducing the chance of incorrect readings due to direct exposure to sunlight.

C. Soil Moisture and Temperature Measurement Probe

The soil moisture and temperature measurement probe is connected to the sensor unit via the RS-485 interface. A similar protocol is used for communication as for communication with valve control units with the exception that node addressing here is not required as it employs a point-to-point connection. Due to size constraints, the probe uses the ESP32-S3-MINI-1 microcontroller with an RS-485 transceiver, directly connected to temperature sensors (DS18B20) and soil moisture sensors.



(a) (b)

Figure 5. Realized prototype of sensor unit: (a) connected to solar panel and temperature sensor, and (b) sensor unit internal structure.

For soil moisture measurement, a sensor based on measuring capacitance between electrodes was selected for its greater robustness, lifespan, and accuracy. Namely, the dielectric constant of dry soil is 2-3, while in pure water it is 80. Therefore, fully saturated soil will have a dielectric constant of around 30 [11]. From this, we can conclude that the capacitance of the probe immersed in the soil will be greater as the soil moisture increases. Thus, by measuring this capacitance, we can also measure the relative soil moisture.

The principle of measurement is based on the electrical circuit shown in Fig. 6 [12]. At the output of the square wave signal generator with a frequency of about 500kHz and a 50% duty cycle (e.g., astable multivibrator), the coplanar capacitor C_{probe}, whose electrodes form the probe immersed in the soil for moisture measurement, is connected via resistor R_p. With lower capacitance (drier soil), the capacitor C_{probe} can charge and discharge more quickly, resulting in a higher peak-to-peak voltage value at its output. Conversely, when the capacitance increases, the capacitor cannot fully discharge, leading to decrease in the voltage value. This voltage is then input into a peak detector circuit consisting of diode D_1, resistor R_1, and capacitor C_1. By extracting the peak value, an analog voltage proportional to the current soil moisture can be obtained.

This voltage is then converted into digital data using the A/D converter in the microcontroller, which can then be further processed. The astable multivibrator can be realized, e.g., using a 555 timer, but the square-wave voltage with the required frequency can also be generated by using a timer module available within ESP32 .

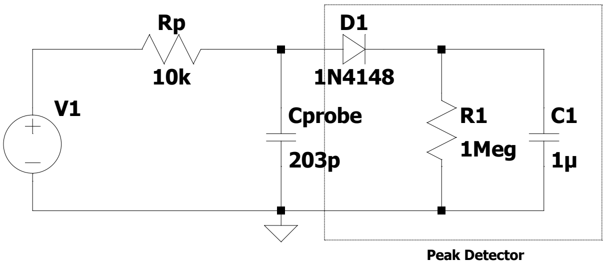


Figure 4. Principal schematic for soil moisture measurement using a capacitive sensor.

A drawback of commercially available measurement probes, with relatively affordable prices, is that they are mainly designed for measuring moisture at shallow depths. For this reason, it was decided to design a dedicated probe capable of measuring moisture at three different depths: 10cm, 20cm, and 40cm from the soil surface. Fig. 7a shows a rendered image of the 3D model of the designed probe with indicated electrode locations, while Fig. 7b shows the probe after fabrication. The probe was designed to be easily mounted and unmounted in various types of soil with different terrain configurations, with minimal disturbance to the natural soil structure.

At the locations where moisture measurement electrodes are mounted, soil temperature sensors are also installed. Soil temperature information is useful for compensating moisture measurement results, considering the sensitivity of capacitive sensors to temperature [13], but also for making important decisions in crop cultivation on the plot (e.g., optimal timing for planting, etc.).

To characterize the probe operation, we measured the capacitances placed at shown locations after fabrication. Two values were measured: (1) when the probe is placed in air, and (2) when the probe is completely immersed in water. Then, we used the measured values to conduct a number of simulations using LTSpice simulation tool for characterizing the probe behavior for different conditions using a model for the circuit shown in Fig. 6. Measurements are provided in Table I.

TABLE I. MEASURED SOIL PROBE CAPACITANCE

Depth	**L1 (10cm)**	**L2 (20cm)**	**L3 (40cm)**
In air	18pF	28pF	43pF
In water	23pF	50pF	203pF

We simulated circuit behavior for measured capacitance values provided in Table I. In Fig. 8, we provide the simulation results for the L3 probe capacitance. The presented results represent the circuit behavior after transient response is finished and output voltage is stabilized (simulations are run for 500ms, but output voltage stabilizes after roughly 100ms). We also conducted simulations for 10cm and 20cm locations, but we do not show the results here for two reasons: (1) to save the space, and (2) because the results are qualitatively very similar as the reported ones.

(a) (b)

Figure 7. Soil probe prototype: (a) rendered 3D model with marked locations of capacitor electrodes at three depths, and (b) fabricated probe.

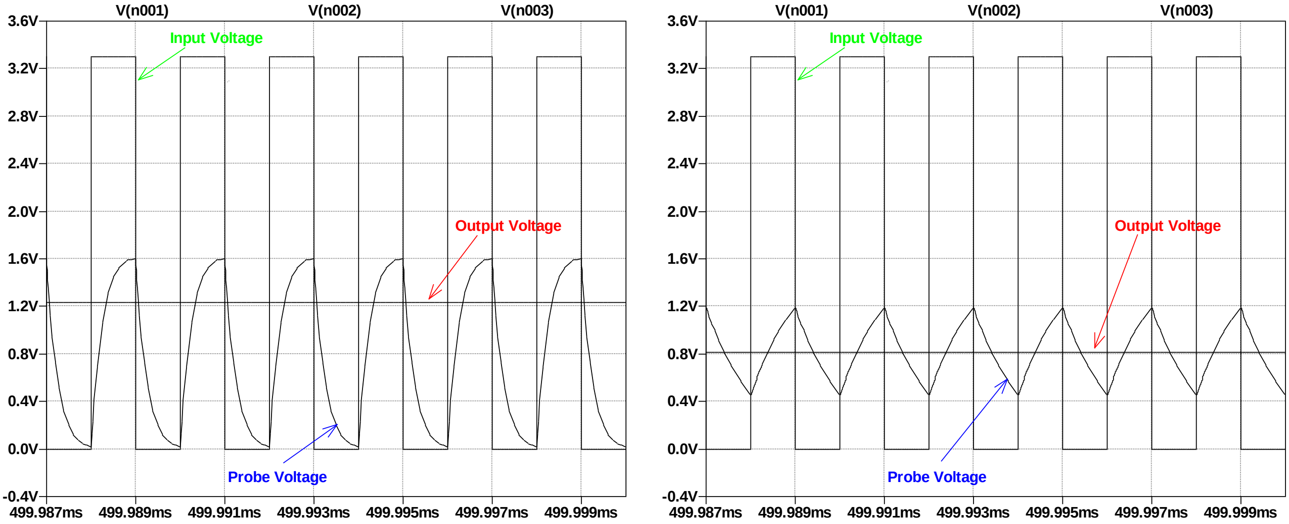
It is clear from the simulation results that output voltage, to be measured using A/D converter, decreases from about 1.2V (Fig. 8a) when the probe is in air to about 0.8V (Fig. 8b) when the probe is completely immersed in water. This is directly affected by the capacitance value, as the peak-to-peak voltage decreases when capacitance is increased. Input voltage is a 500kHz square-wave with 50% duty factor, which can be generated either by a timer in microcontroller or external 555 circuit. Finally, probe voltage is a voltage measured on C_{probe} capacitance.

Simulation results for two other locations (10cm and 20cm) are provided in Table II.

TABLE II. OUTPUT VOLTAGE FOR DIFFERENT CONDITIONS

Depth	**L1 (10cm)**	**L2 (20cm)**	**L3 (40cm)**
In air	1.29V	1.27V	1.23V
In water	1.28V	1.21V	0.82V
Difference	0.01V	0.06V	0.41V

From Table II, it is clear that we get maximum difference between dry and wet condition in case of L3 probe, which is greatly affected by the range of the probe capacitance. This is important for accurately determining soil moisture given that A/D converter has a fixed voltage resolution (about 0.8mV in our case). Smaller capacitance values for other two locations



(a) (b)

Figure 8. Simulation results for L3 probe capacitance: (a) when the probe is in air, and (b) when probe is completely immeresed in water.

can be explained by the construction of the probe. Since the length of the wire (which electrode plates are consisted of) is shorter, the capacitance is also proportionally smaller. Also, the area covered by water is larger for deeply located electrodes, which affects the total capacitance range.

Given all above, we can conclude that most accurate soil moisture estimation can be obtained with L3 probe. Other two locations have very small range and, consequently, worse accuracy. Therefore, the probe should be redesigned to properly address this issue in future.

To further characterize probe operation sensitivity, we also simulated circuit behavior (for L3 probe) with variable frequency and duty factor. In Fig. 9, output voltage is shown when generated frequency changes in the range from 400kHz to 600kHz (with 50kHz step) and duty factor is fixed at 50%. We can see that the voltage difference remains almost constant (about 0.4V) over this frequency range. On the other hand, Fig. 10, which provides the same voltage when duty factor is changed at fixed frequency of 500kHz, shows different behavior. Clearly, the maximum voltage difference (about 0.6), and therefore the best measurement accuracy, is obtained when duty factor is around 25%. This is very important information for making certain decisions when square-wave generator is designed.

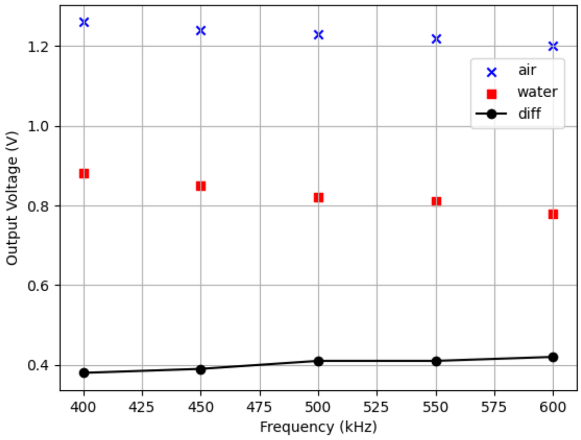


Figure 9. Dependence of output voltage on frequency (50% duty factor).

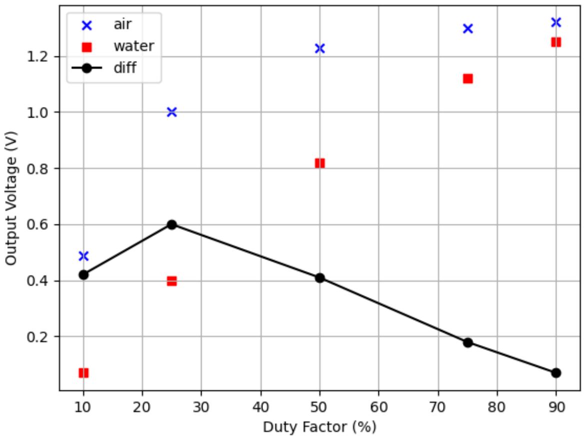


Figure 10. Dependence of output voltage on duty factor (500kHz).

D. *Valve Control Unit*

Like the previous functional units of the system, the valve control unit (Fig. 11) contains a microcontroller (ESP32-WROOM module) connected to other required components. Communication with this unit primarily occurs via the RS-485 bus, which can be shared by multiple devices. Since this is a half-duplex connection, it is necessary to provide the ability to address devices on the bus using a master-slave paradigm to manage multiple-access to the shared medium.

The maximum cable length in the RS-485 network is 1200 meters with reduced bit rate and the use of higher-quality cables. For units located at greater distances, communication via LoRa wireless link, similar to the sensor unit, is provided as an option.

Like in the terminal unit, alternating current power from the grid is used as a main power supply, with an option of providing a lower DC voltage (e.g., 24V or 48V), which is recommended to use wherever possible for safety reasons.

Finally, it is worth mentioning that the digital output pin of the microcontroller does not provide sufficient sink and source current to drive the electromagnetic valve directly. Therefore, it is necessary to provide a suitable driver circuit for driving inductive loads. In this regard, two types of outputs are provided, transistor and relay, which allow control of a wide range of available electromagnetic valves.

IV. DESCRIPTION OF WEB APPLICATION

For the purpose of managing and monitoring the system, as well as for storing and presenting data obtained from the previously described functional units of the system, a dedicated web application has been developed to run on the web server side. The development utilized the following components and technologies based on the Python programming language:

- ASGI (Asynchronous Server Gateway Interface) Uvicorn as the web server,
- FastAPI for developing the backend part of the application,
- PostgreSQL as the database management system,
- SQLAlchemy for communicating with the database,
- A combination of HTML, Tailwind CSS, JavaScript, and Jinja2 Templating Language for developing the frontend part of the application, and
- Bcrypt for protecting user passwords.

The architecture of the application relies on the REST (REpresentational State Transfer) architecture with clearly

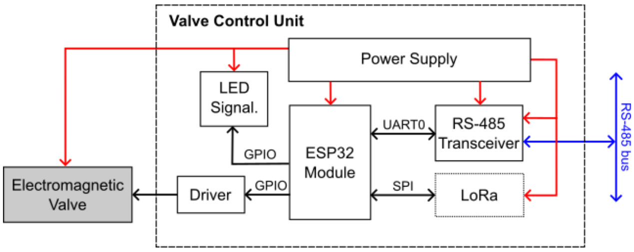


Figure 11. Block diagram of valve control unit.

defined RESTful API endpoints that allow access to the application services via the standard HTTP protocol. In this regard, the application provides the following services:

- User administration,
- Device administration (system, pump, valve, shift, sensor),
- Data visualization, and
- User authorization and authentication.

To access the data, an authorized user first needs to register the terminal unit representing the system within the web application. Registration is carried out by an authorized operator with administrative privileges using the appropriate options in the configuration mode on the terminal unit. During this process, the terminal unit generates a unique system identifier and provides it, along with other relevant data (location, name, and username of the system owner), to the web application.

Once the system is initialized, users can log in to the web application with their username and access the previously registered resources belonging to their system. Upon logging in, they are presented with various options for configuring the system operation and displaying stored data. In Fig. 12, a segment of the user dashboard is shown, displaying menu options and basic information about sensor and water tank status. Other options (not shown in the image) include basic information about shifts, measured air temperature and humidity, and battery level for each sensor (information for each sensor can be viewed by scrolling through the sensor list). By selecting the *Devices* option, users can review devices associated with the system (pumps, valves, and sensors) and configure them according to their needs (Fig. 13).

Pumps are associated with data regarding water tank capacity and daily consumption obtained from the terminal unit based on readings from the water flow sensor, which measures how much water goes through the pump. Users can check the current tank status and manually update its capacity to the desired value (e.g., after refilling the tank). Additionally, the history of daily consumption is stored in the database so that it can be displayed to users when requested. The example display of the history is illustrated in Fig. 14.

For valves, only the current status (open or closed) provided by the terminal unit can be checked, as well as the shift to which the valve belongs. However, controlling the valve's state is not possible from the web application.

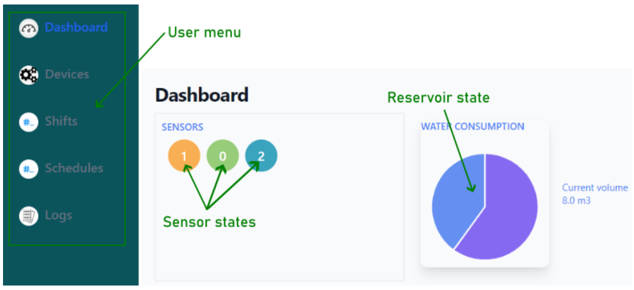
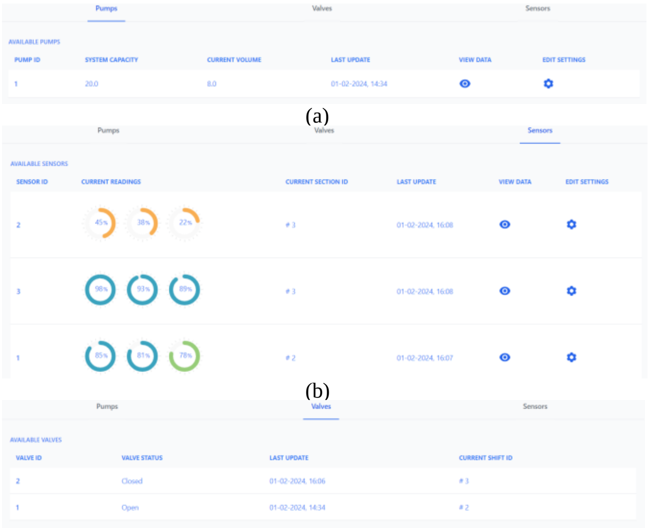


Figure 15. User dashboard showing available options.

In the sensor list, users can obtain information about the current soil moisture level for the enabled levels of the given sensor, the identifier of the section where the sensor is located, and view measurement history as illustrated in Fig. 15. In this case, measurements for all three levels are displayed, but only levels of interest to the user can be selected in the sensor configuration (e.g., only measurements at depths of 20cm and 40cm).

As mentioned, each valve irrigates only a specific section, but they can be logically grouped into shifts (*Shifts* option) as shown in Fig. 16a. The irrigation mode within a shift can be automatic, meaning valve activation (deactivation) is determined by the lower (upper) soil moisture threshold value, with various variants definable: any sensor in the shift has reached the threshold value, the average sensor value has reached the threshold value, or all sensors have reached the threshold value. Additionally, shifts can be configured to control irrigation temporally by setting a weekly schedule in the *Schedule* menu option (Fig. 16b).



AVAILABLE PUMPS

PUMP ID	SYSTEM CAPACITY	CURRENT VOLUME	LAST UPDATE	VIEW DATA	EDIT SETTINGS
1	20.0	8.0	01-02-2024, 14:34	👁	⚙

(a)

AVAILABLE SENSORS

SENSOR ID	CURRENT READINGS	CURRENT SECTION ID	LAST UPDATE	VIEW DATA	EDIT SETTINGS
2	45% 38% 22%	# 3	01-02-2024, 16:08	👁	⚙
3	98% 93% 89%	# 3	01-02-2024, 16:08	👁	⚙
1	85% 81% 78%	# 2	01-02-2024, 16:07	👁	⚙

(b)

AVAILABLE VALVES

VALVE ID	VALVE STATUS	LAST UPDATE	CURRENT SHIFT ID
2	Closed	01-02-2024, 16:06	# 3
1	Open	01-02-2024, 14:34	# 2

(c)

Figure 12. Information about configured system components: (a) pumps, (b) sensors, and (c) valves.

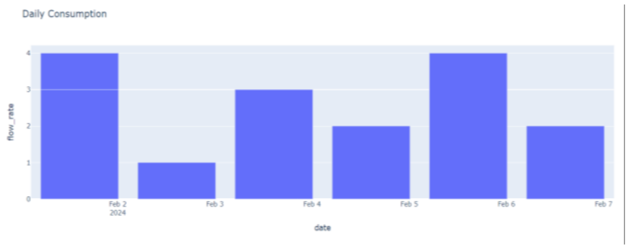
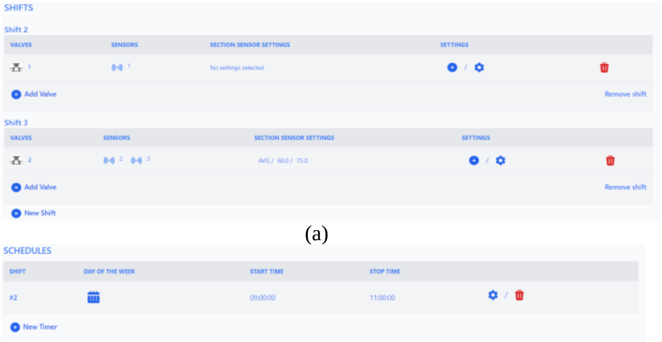


Figure 13. Information about daily water consumption on pump.

Figure 14. Information about soil moisture for three depths.



SHIFTS

Shift 2

VALVES	SENSORS	SECTION SENSOR SETTINGS	SETTINGS	
1	1	No settings selected	⊕ / ⚙	🗑

Shift 3

VALVES	SENSORS	SECTION SENSOR SETTINGS	SETTINGS	
2	2 3	AVG / 68.0 / 75.0	⊕ / ⚙	🗑

(a)

SCHEDULES

SHIFT	DAY OF THE WEEK	START TIME	STOP TIME	
#2	📅	09:00:00	11:00:00	⚙ / 🗑

(b)

Figure 16. Settings configured for: (a) shifts and (b) schedules.

V. CONCLUSIONS AND FUTURE WORK

The designed solution has been tested under controlled conditions on a smaller pilot system consisting of a terminal, valve, and sensor. During these tests, the correctness of operation of each functional unit was verified for different test scenarios. Additionally, the system was tested in conditions of mutual cooperation between functional units and when connected to the services of the implemented web application. The functionality of the web application was further tested using synthetic data and scenarios.

A period of detailed testing of the prototype functionality in the field conditions is forthcoming. In 2024, within the framework of the EU4Agri support program, the installation of the system and its testing at the experimental farm of the agricultural faculty in Aleksandrovac is planned. This activity will be carried out as part of the "Itree" project, through cooperation between the Agricultural Cooperative "Smart Village" from Knežica and the Faculty of Agriculture from Banja Luka. Additionally, redesign of the initial soil moisture probe prototype as well as its laboratory calibration in locally dominant soil types is planned. Redesign and creating calibration curves for local soils should ensure better accuracy of the results and, consequently, more precise irrigation management.

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