

# Hardware and Software of Automated Control System of Plants' Water Well-Being

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**Abstract**— The hardware of the automated control system of plants' water well-being and the software for all components of the system have been developed.

**Keywords**— hardware; software; automated control system; control unit; mobile application; plants' water well-being; moisture.

## I. INTRODUCTION

Moisture plays the most important role in ensuring the vital activity of soil biota, the formation and development of a soil regimes complex. It is known that in natural conditions the soil moisture content can vary over a wide range. It was found that during the growing season at the optimum humidity range, the soil has the most favorable conditions for the plants growth and development in terms of availability of moisture, nutrients, gas exchange in the soil-atmosphere system [1].

Supplying plants with moisture according to their needs is possible only under the condition of a properly organized irrigation regime, the formation of which requires online information on the moisture state and its availability to plants in the soil root layer at any time of the growing season.

Therefore, in irrigation agriculture the plants irrigation management is extremely important. It can be reduced to maintaining a given function of the biological time of the moisture reserves trajectory taking into account the dynamics of environmental factors [2], i.e. weather forecasting, one of the main aspects of precision agriculture (PA).

The PA realization involves the development and implementation of automated control system (ACS), using intelligent control methods for plants' water well-being. Today, Intelligent Irrigation Systems (IIS) is a rapidly growing segment of the agricultural technology market and a promising area that proves its effectiveness in practice. The number of participants on the market is constantly growing and many startups will receive funding. The most famous in the field of intellectual irrigation are Hortau, Smart Farm Systems, HydroPoint Data System.

Intelligent or smart irrigation technologies are seen as a promising tool for saving water resources and increasing crop capacity, such IIS can work without human intervention. IIS uses a set of innovative tools to deliver effective functioning:

block chain technology, Artificial Intelligence (AI), drones, Internet of Things (IoT) and big data [3]

## II. IMPLEMENTATION

The hardware of plants' water well-being ACS represented by a microprocessor control unit (Fig. 1), which consists of a microcontroller, power supply and control ADC multiplexers, landslide registers, real-time clock, and display drivers valves

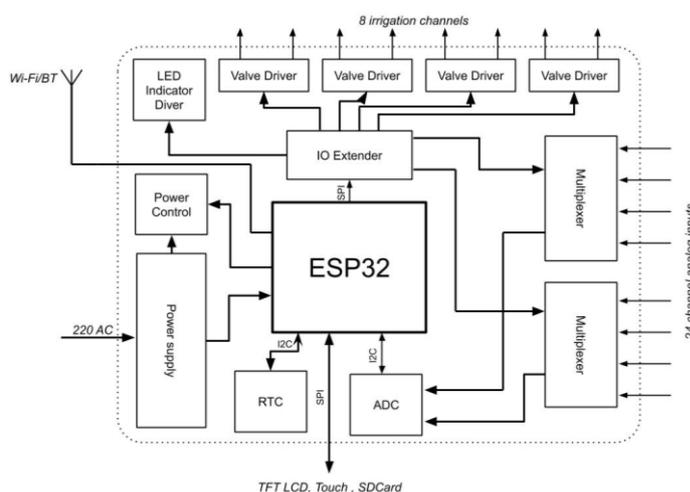


Figure 1. Microprocessor control unit

The system is based on ESP32, a high-performance dual-core microcontroller with Wi-Fi and Bluetooth wireless interfaces. Bluetooth wireless technology is used to communicate with mobile devices and control the system through a mobile application. Additionally, Wi-Fi can be used to constantly connect to the Internet, synchronize data, archive and remotely manage it. If Wi-Fi is not available, all data is stored in external memory (SD or microSD card) and downloaded when connected via Bluetooth. The transformer power supply is used to obtain the required input voltage. It is connected to AC 220-240 V and has an output voltage of 16 V and 35 V, in addition impulse converters are available to obtain a voltage of +5 V and +3...32 V. The power controller unit is used to programmatically set the supply voltage for the sensors, valves, control of mains voltage and current consumption. Two independent CD4067BM96 multiplexers allow you to connect soil moisture sensors at three different depths up to eight

independent channels, which are connected via eight five-pin connectors. In this case, the voltage is set programmatically (3.3 V, 5 V, 16 V, 32 V), the input signal is 0...10 V. The analog-to-digital converter uses a 16-bit ADS1115IDGSR high-speed ADC with I2C interface.

The control unit contains a real-time clock that generates tasks by time (start-up time, duration, and frequency), logging, etc., with a standalone power source (lithium-ion battery). The unit contains four independent drivers that allow independently control the eight valves that connect via three-pin connectors. It is possible to connect different types of valves: direct current and alternating current, with impulse control. An LED that is controlled by the TM1637 LED driver indicates the status of the channel. Shift registers are used to obtain enough managed outputs from the microcontroller.

Four analog inputs and four digital inputs (I2C, I2S, CAN) are available to connect the weather station sensors. The input range of the analog input is 0...5 V or 0...16 V (programmable divider).

For directly control and display the status of the system, an SPI interface is available to connect the LCD monitor and SD card to store statistics.

ACS of plants' water well-being in irrigation areas is provided in automatic, automatic water and energy saving, manual on-site and remote modes, for which software is developed for all nodes of the control system.

Firebase ecosystem has been chosen to implement cloud storage, synchronization, and real-time data updating. Cloud Storage for Firebase is a powerful, easy-to-use, economic and effective storage solution built on Google's scale that makes it easy to scale the system up to production sizes. The Firebase SDK for Cloud Storage provides safe and fast work regardless of network quality. Loading and unloading are reliable, that they recovered from the moment they stopped, saving resources and accelerating the synchronization. The mobile client for the Android operating system is written in Java. In order for the application to be easily expanded and maintained, it is necessary to define well-separated layers: model, logic and appearance, so the application is written using the MVP architecture. Google authorization is available to connect from any device. Once authorized, all previously connected systems are automatically synchronized with the new device. The options for connecting a new device are: 1) connecting the microcontroller to the Wi-Fi point and connecting the device via the Internet; 2) connecting to the microcontroller using Bluetooth. The first option has the benefit of a permanent network connection and the ability to view data in real time remotely. Simply press a button on the controller device and enter the code in the mobile application that will be displayed on the screen. When adding a new plot, indicate on the map the boundaries of the plot (but it is not necessary), then specify the name of the object, select the type of soil and plant. In addition,

the current growing season can be chosen. If the sensors are connected to the system, their identification will happen automatically by it. If this has not happened, user can open the Control menu and specify for each of the connected sensors and valves their type, power parameters

The interface of the mobile application consists of three main fragments (Fig. 2): home page, irrigation sections, profile.

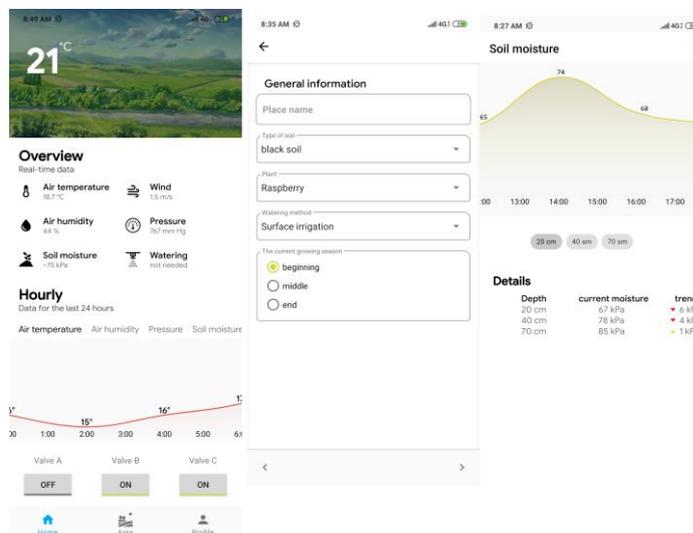


Figure 2. An example of mobile application to control watering

The software also implements the function of transferring process data to the Internet network in real time. In addition, the weather and parameters are constantly logged to the local database, which allows the user to view the history as interactive graphs even when the server is not connected.

### III.CONCLUSION

Therefore, developed ACS of plants' water well-being will improve irrigation efficiency and get recommendations on the rules and timing of irrigation. Of course, the widespread use of intellectual irrigation will save a significant amount of excess water without the threat of insufficient watering.

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