INTRODUCTION

The automation of irrigation for various types of vegetation is an important task both in everyday life and in agriculture. Traditional irrigation methods often come with a range of issues, such as the time-consuming nature of watering, the need for constant monitoring of water levels in the reservoir, the financial cost of hiring workers to handle irrigation, water wastage, and more. As technology advances, there’s a growing demand for a simple and cost-effective way to automate the watering process and address these problems.

There are several efficient automated irrigation methods available today. For example, drip irrigation uses a system of tubes and drippers to deliver water directly to the plant roots, minimizing evaporation and water consumption. Sprinkler irrigation distributes water evenly across an area using nozzles and spray heads. While these systems do automate the process to some extent, they have notable drawbacks that can make their operation complex. In addition, most of these systems lack water level monitoring capabilities, which adds another layer of inconvenience.

Despite the availability of various automated systems, they don’t always meet all user needs. This creates a demand for alternative solutions, one of which is developing a custom irrigation system. Such a system should be capable of watering plants over a sufficient period based on a precise schedule, while also displaying the water level in the well or another reservoir supplying the water. Moreover, the system should allow for manual control in case of malfunction or a missed scheduled cycle.

This type of system can be built from several components, each responsible for a specific function. For instance, the watering schedule can be controlled using a programmable outlet timer or a time relay. Water delivery can be handled by a pump that draws water from a well. A custom-built control unit can monitor water levels using sensors submerged at set depths and supply power to the pump based on timer signals.

This is the main objective of this project: to develop an water level control machine.

1. PURPOSE AND GENERAL CHARACTERIZATION OF THE DEVICE

The water level control unit will serve two main functions: supplying mains power to the pump based on a preset schedule and indicating the water level in the reservoir. The device will be connected to a socket timer, a water pump, and water level sensors.

The water level indication is based on two LEDs that light up depending on the sensor readings. Specifically:

• A green LED lights up when the water level is above half of the reservoir.

• A red LED lights up when the water level drops below the lower sensor.

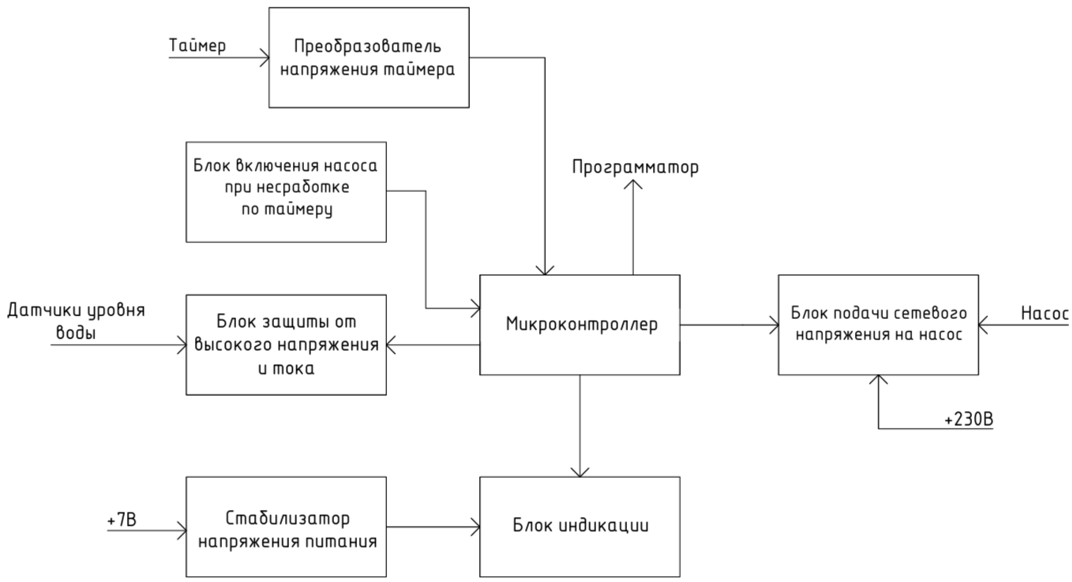
The pump will receive mains power according to signals from the timer. Based on these signals, the microcontroller in the control unit will send a command to an optoisolated circuit, which then activates the power supply to the pump.

Also, the device should be compact enough to be installed in a location that's convenient for the user.

2. DEVELOPMENT AND ANALYSIS OF AN ELECTRICAL STRUCTURAL DIAGRAM

The first stage of designing the device involves developing a electrical structural diagram which provides an overview of the system's architecture and the functions it performs. This diagram serves as a visual representation of how the main parts are interconnected and interact with each other.

The electrical structural diagram of developed water level control machine you can see below (It is placed in a separate file in the folder with all design documentation):



As you can see, all drawings are in Russian. This is due to the fact that in this project I bring the original project documentation, which was carried out in Russian, and not a copies, translated into English.

Let's move on to the description of the scheme. Before the device can begin operating, the microcontroller must be programmed. To do this, the device includes an interface for connecting it to a programmer.

The system operates on a +7V power supply. When power is applied, it is stabilized and then delivered to the indicator module, which signals that the device is powered on.

At startup, the microcontroller sends a signal to the reference-level sensor. The mid-level and low-level sensors detect whether this signal passes through, and based on the current water level, they send corresponding feedback signals to the microcontroller. The microcontroller then activates the LED indicator module, illuminating the appropriate LED depending on the water level:

- Green LED for sufficient water (above half the reservoir),

- Red LED for critically low water (below the lower sensor).

To prevent unwanted effects on water quality and to ensure safe operation, the signal from the microcontroller passes through a protection circuit before reaching the sensors. This circuit protects against high voltage and current, allowing the device to operate in a low-current (microcurrent) mode.

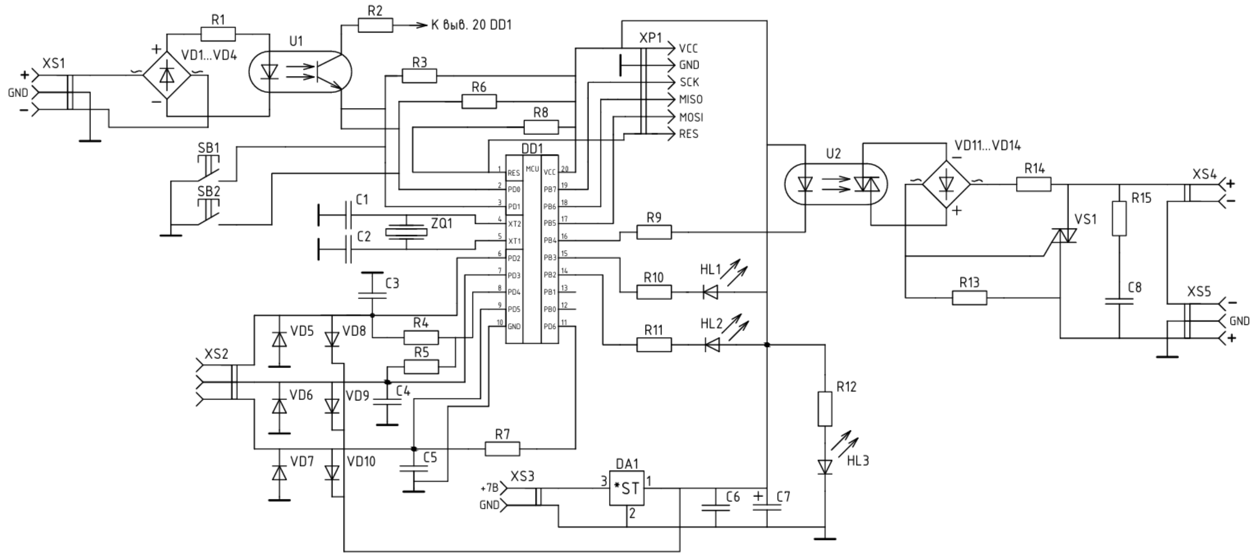
The pump is activated by a signal from the external timer, which is connected to the device via a dedicated input. Since the socket timer outputs 230V AC, which is far too high for direct use with the microcontroller, the device includes a voltage converter that steps down the 230V to a safe 7V for the control circuitry.

When the timer stops supplying mains voltage, the microcontroller sends a control signal to the power supply relay unit, which in turn enables 230V power to be delivered to the pump, starting its operation. Conversely, when the timer resumes supplying mains voltage directly to the control circuit, no control signal is sent to the power unit, and the pump is turned off.

In this way, the system ensures safe, automated irrigation based on both a preset schedule and real-time water level monitoring.

3. DEVELOPMENT AND ANALYSIS OF SCHEMATIC DIAGRAM

Based on the block diagram, a schematic diagram is developed. This diagram illustrates the operating principles of the device and serves as the foundation for selecting the necessary components for further development and assembly. The schematic diagram of the proposed device can be seen below (it is also included as a separate file in the folder with design documentation):



To connect the system to a battery, holes labeled XS3 are drilled on the PCB. The DA1 chip is used as a voltage regulator, ensuring a stable +7V supply, while capacitors C6 and C7 are used to suppress high-frequency noise.

The yellow LED HL3 serves as a power indicator, showing when the device is energized. To indicate water levels used green LED HL1 and red LED HL2. Current-limiting resistors R10–R12 are connected in series with the LEDs to protect them from overcurrent.

To program the microcontroller DD1, a pin header connector XP1 is used. The quartz crystal ZQ1 provides the clock signal for the microcontroller, while capacitors C1 and C2 ensure the stable start-up of the oscillator and reduce high-frequency interference affecting the microcontroller.

For connecting the control unit to the water level sensors, a three-pin terminal block XS2 is used. The protection circuit—consisting of resistors R4, R5, R7, diodes VD5–VD10, and capacitors C3–C5—protects the microcontroller from voltage spikes and unwanted currents, ensuring that signals from the sensors don't negatively affect water quality or system operation.

To interface with the external timer, connector XS1 is used. The diode bridge VD1–VD4 and power resistor R1 convert the 230V AC output from the timer into a safe DC signal for the optocoupler U1. This galvanically isolates the timer from the microcontroller and feeds a logical signal to the microcontroller inputs via the optocoupler's phototransistor emitter.

• Resistor R2 limits the current to the optocoupler U1 and helps form the proper logic level.

• Pull-up resistors R3, R6, and R8 ensure that the microcontroller receives a stable high logic level when needed.

For manual pump control in case the timer fails, momentary push-buttons SB1 and SB2 are included.

To control pump power switching, the system uses optocoupler U2 to galvanically isolate the 230V AC power circuit from the microcontroller. The microcontroller sends a control signal to the bridge rectifier VD11–VD14, which then triggers the gate of the TRIAC VS1. Resistor R9 limits the current to optocoupler U2. TRIAC VS1 allows mains voltage to pass through to the pump when its gate is activated. The TRIAC control and noise suppression circuit includes resistors R13–R15 and capacitor C8:

- R13 limits the gate current.
- R14 limits current in the optotriac's load circuit.
- R15 and C8 form an RC snubber circuit to protect the TRIAC from electrical noise and voltage spikes.

For connection to the 230V power supply, connector XS5 is used. The pump is connected to the system via a two-pin terminal block XS4, where the phase and neutral wires from the power outlet are screwed in.

This layout ensures the system is safe, reliable, and capable of handling both control signals and high-voltage switching necessary for automated irrigation.

All electronic components that have been selected to create this device, you can see in the list of elements, it is located in the folder with the design documentation.

After completing the development of these diagrams, the next step is creating the PCB layout and the assembly drawing, which are also included in the design documentation for this project.

The project is intended for medium-scale production, so all materials and components were selected with manufacturability and cost-efficiency in mind, as well as for use in non-demanding environments that do not require extensive additional protection.

For home implementation, the project is not particularly complex. However, it is essential to use all the specified electronic components and materials listed in the design documentation. Special attention should also be given to the quality of the double-sided PCB, as proper fabrication and assembly are crucial for the reliable functioning of the device.