Design and Implementation of a Water Purification and Quality Monitoring System

1 Project Overview

Objective: To design an automated water purification and quality monitoring system prioritizing robust filtration performance, sensor accuracy, and operational safety.

The key features of the system include:

- Multi-stage filtration (Sediment, Carbon, and Ultra-filtration).
- UV treatment for disinfection.
- Real-time IoT quality monitoring.
- Automated self-protection mechanisms.

2 System Architecture and Hardware Layout

The system is divided into two main stages to improve efficiency and safety:

- Stage 1: Filtration and Storage.
- Stage 2: Polishing and Dispensing.

2.1 Hardware Block Diagram

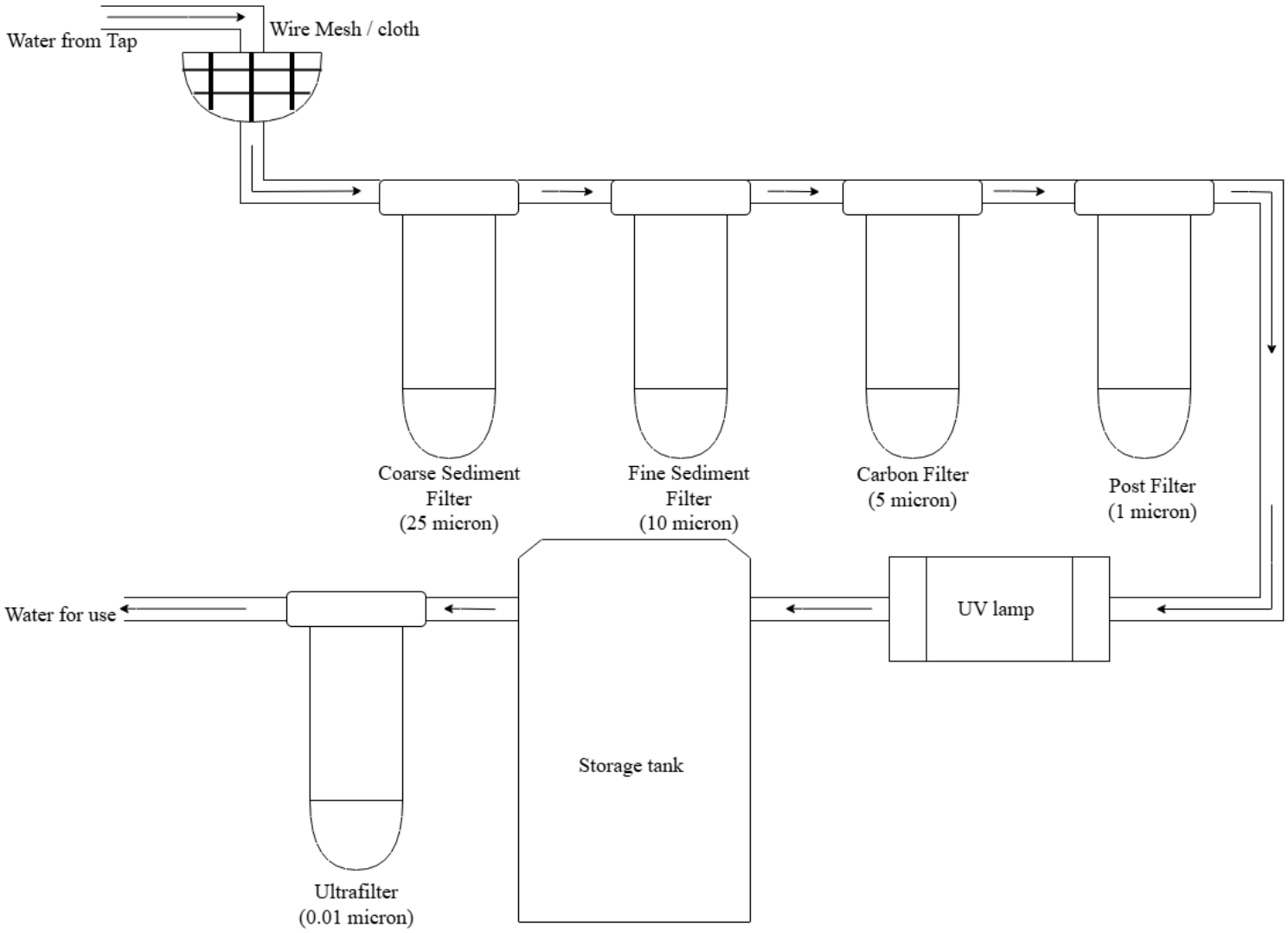

Figure 1: Hardware block diagram of the system.

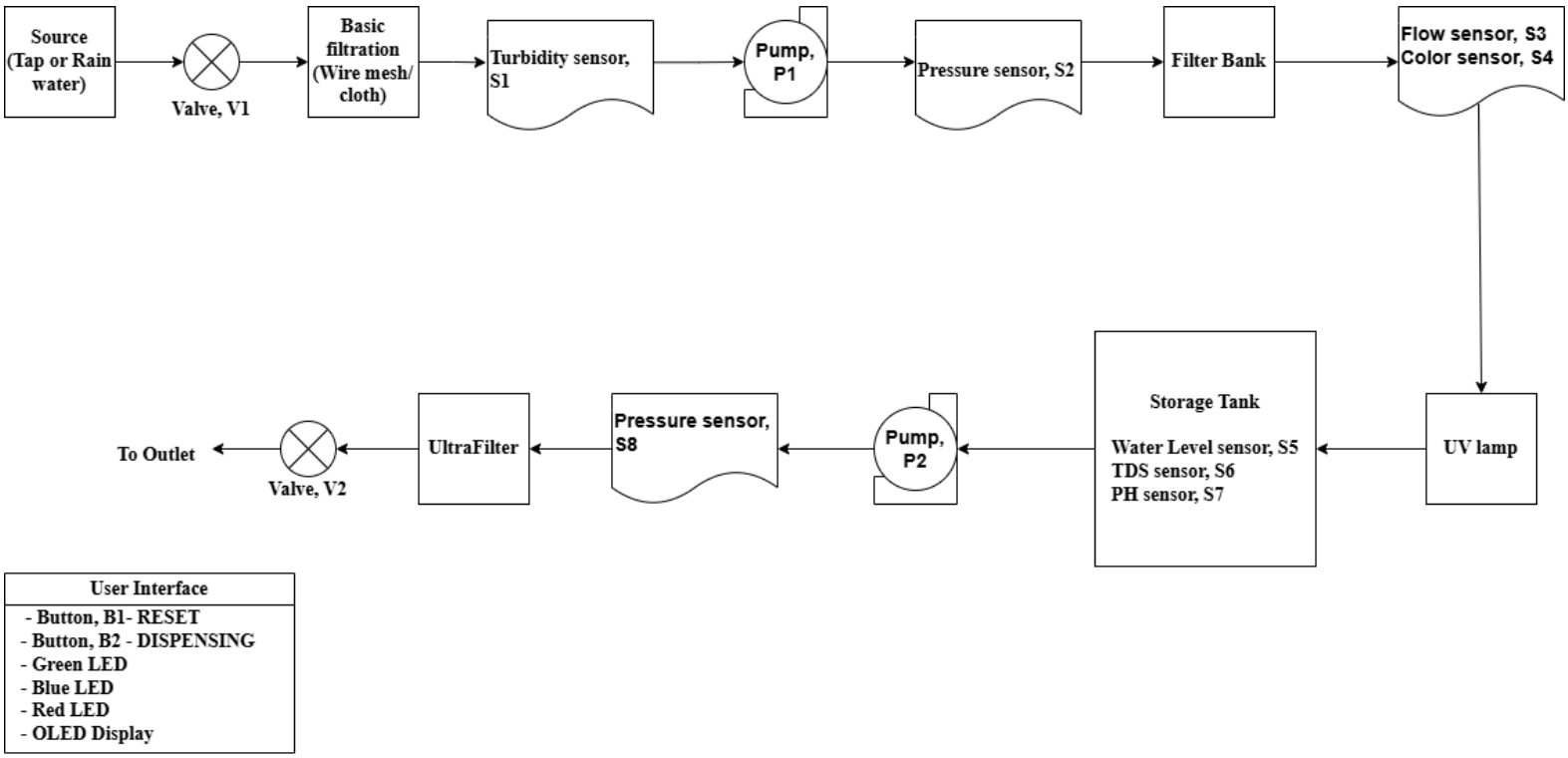

Figure 2: Overall system schematic representation.

2.2 Stage 1: Source to Storage Tank

During this stage, raw water is treated before storage. The process includes:

- **Filtration:** Water is drawn by pump P1 and passed through a filter bank consisting of two sediment filters (25 µm and 10 µm), an activated carbon 5 µm filter, and a 1 µm post-filter.
- **System Protection:** A pressure sensor (S2) and flow sensor (S3) monitor the system conditions to detect clogs.
- **Disinfection:** A UV lamp is installed after the filter bank to reduce microbial load before water enters the storage tank.

2.3 Stage 2: Storage Tank to End-User

The second stage ensures final polishing and safe delivery to the end-user.

- **Polishing:** Pump P2 drives water through a 0.01 µm ultrafilter membrane before it is dispensed as a last line of defense.
- **Safety Monitoring:** Pressure sensor S8 monitors membrane pressure to detect pressure buildups (clogs) or potential membrane ruptures.

3 System Operational Modes

The system is designed with a microcontroller to monitor parameters and automate operations.

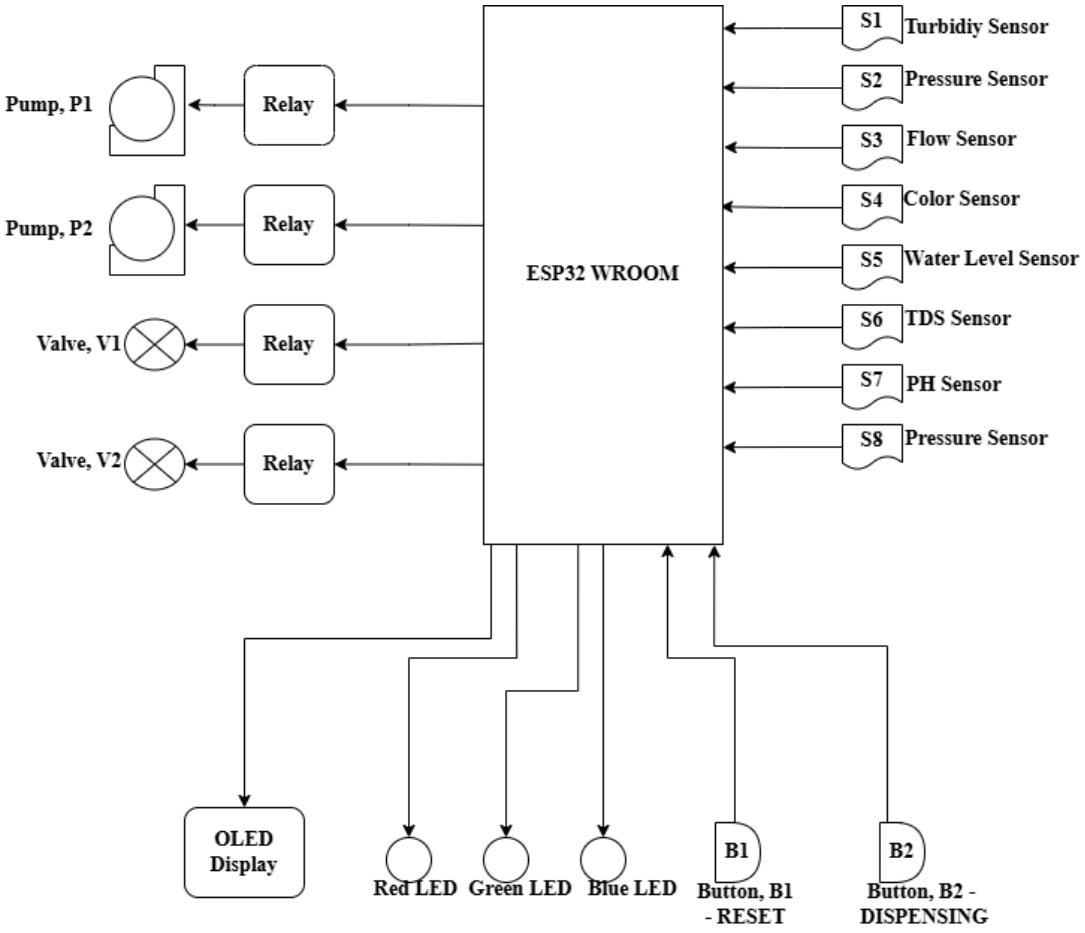

Figure 3: Microcontroller and component integration.

The microcontroller operates in four distinct modes to ensure safety, fault isolation, and energy efficiency:

3.1 Filtration Mode

Objective: To automatically fill the storage tank while protecting hardware components.

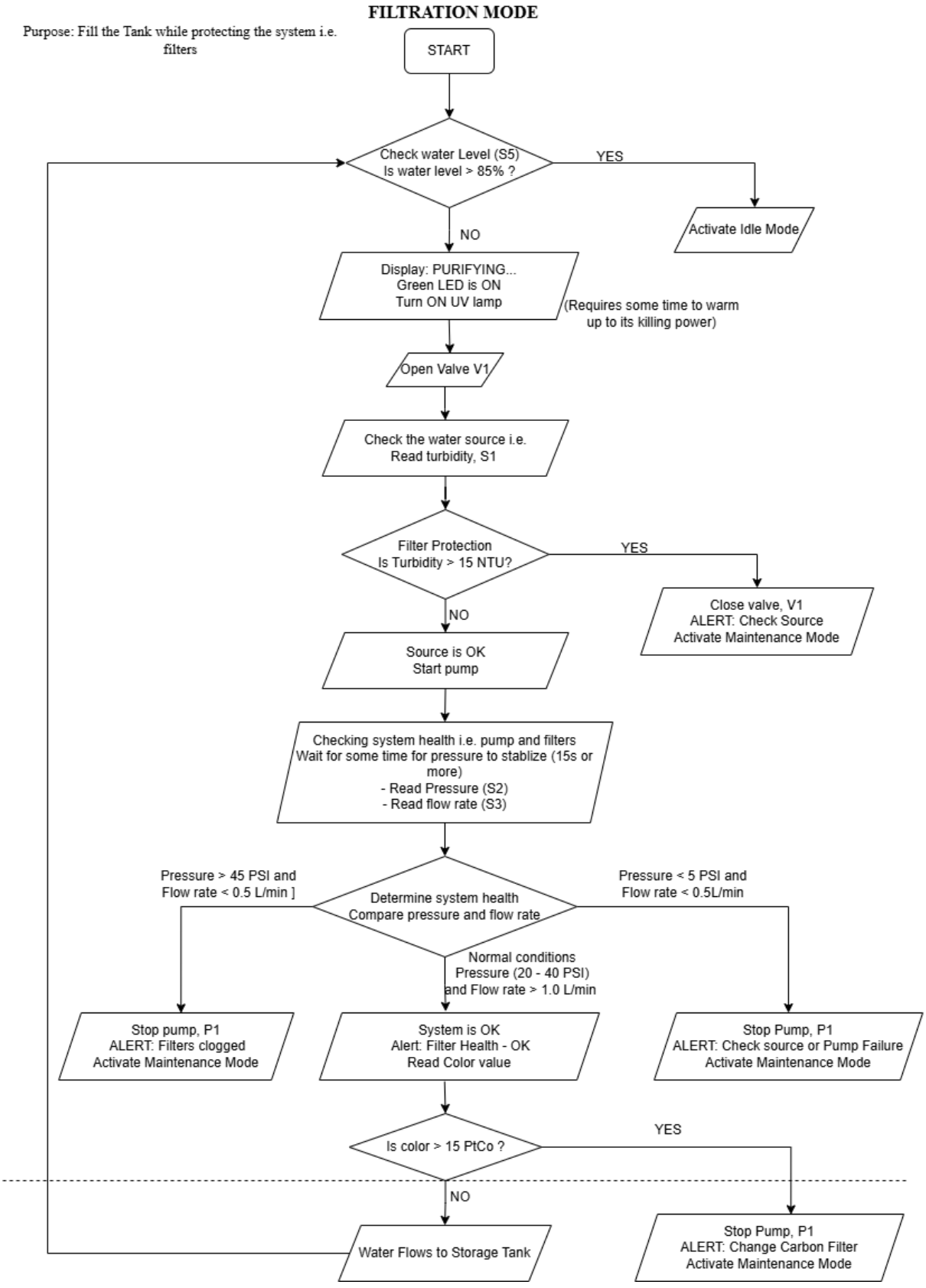

Figure 4: Filtration mode.

- **UV Warm-up:** The UV lamp activates before the pump starts to ensure no

untreated water enters the storage tank.

- **Clog and Dry Run Detection:** The system differentiates faults by comparing Pressure (S2) and Flow Rate (S3).
- **Source Quality:** Turbidity (S1) is checked to prevent fouling the filters. Color (S4) is monitored to ensure effective UV transmission.

3.2 Idle Mode

Objective: To ensure energy conservation while monitoring the system.

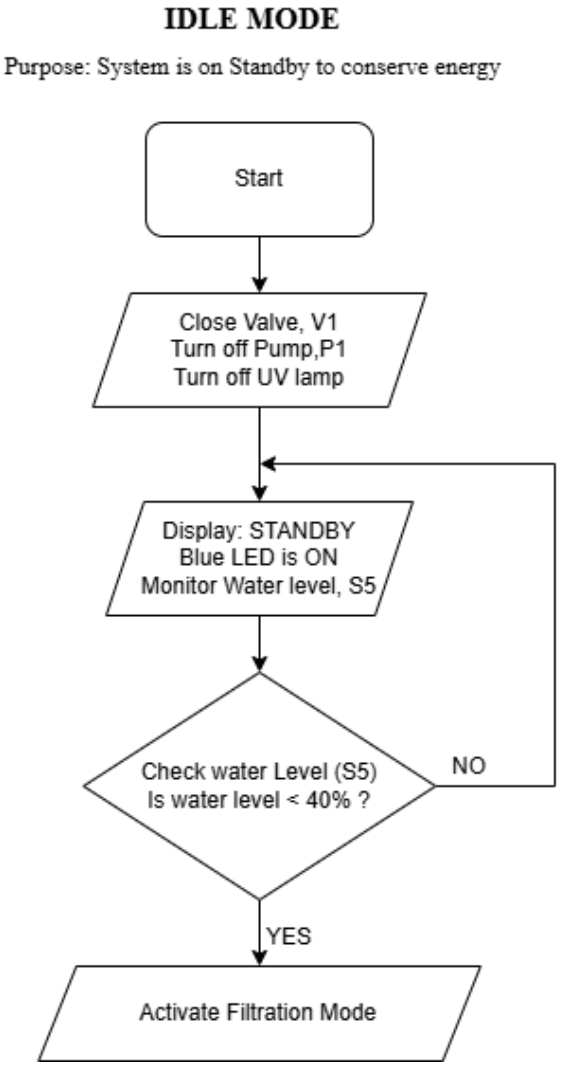

Figure 5: Idle mode.

- Activated when the storage tank is full (water level > threshold).
- High-power consumption components (Pump P1, UV Lamp) are turned OFF.
- **Continuous Monitoring:** The system wakes periodically to check the tank water level.

3.3 Dispensing Mode

Objective: To ensure safe, on-demand delivery to the end-user.

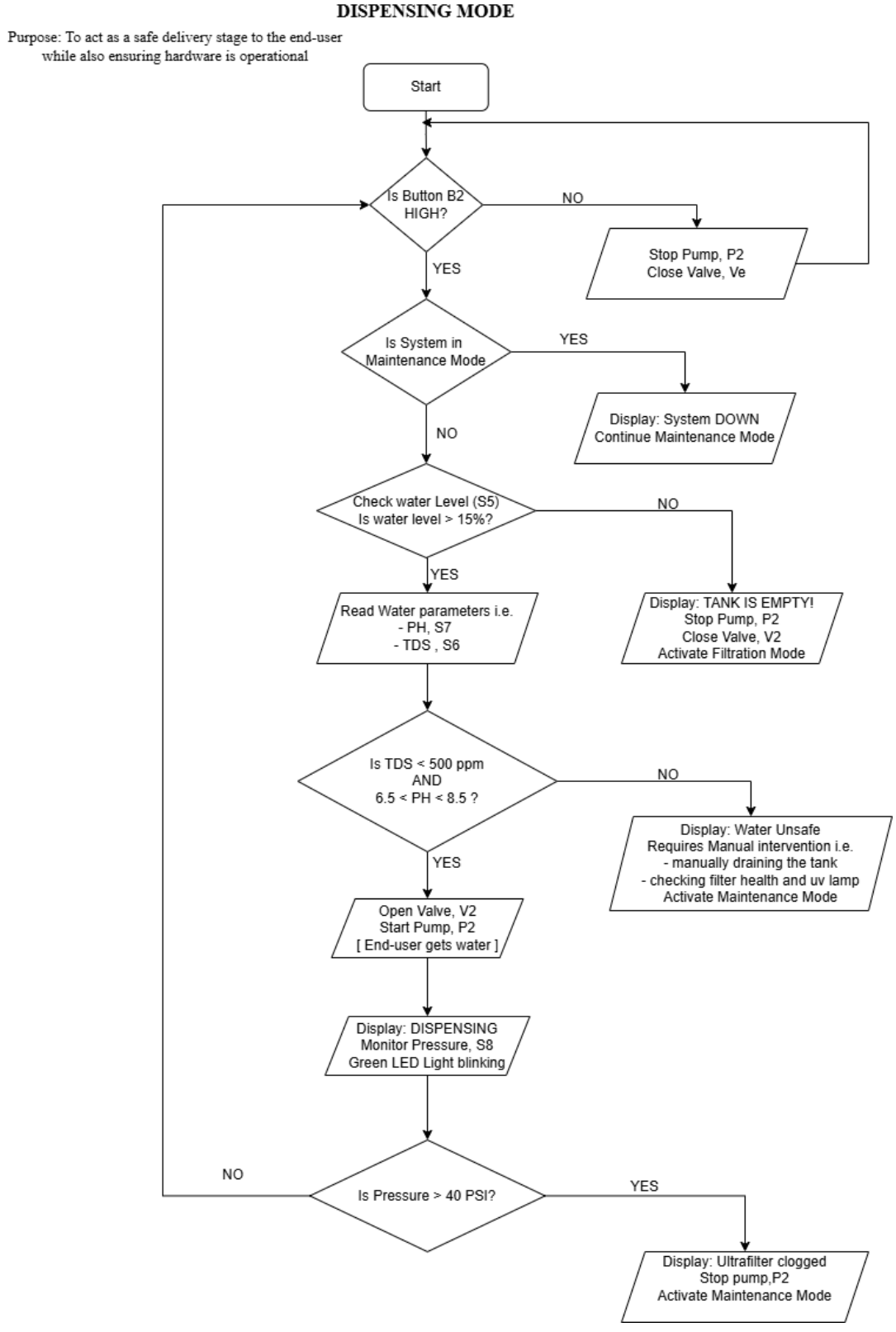

Figure 6: Dispensing mode.

- Triggered by the user holding button B2.
- The system verifies that pH (S6) and TDS (S7) are within safe limits before opening Valve V2.
- Active Ultrafilter health monitoring via pressure sensor S8.

3.4 Maintenance Mode

Objective: To lock the system during critical faults.

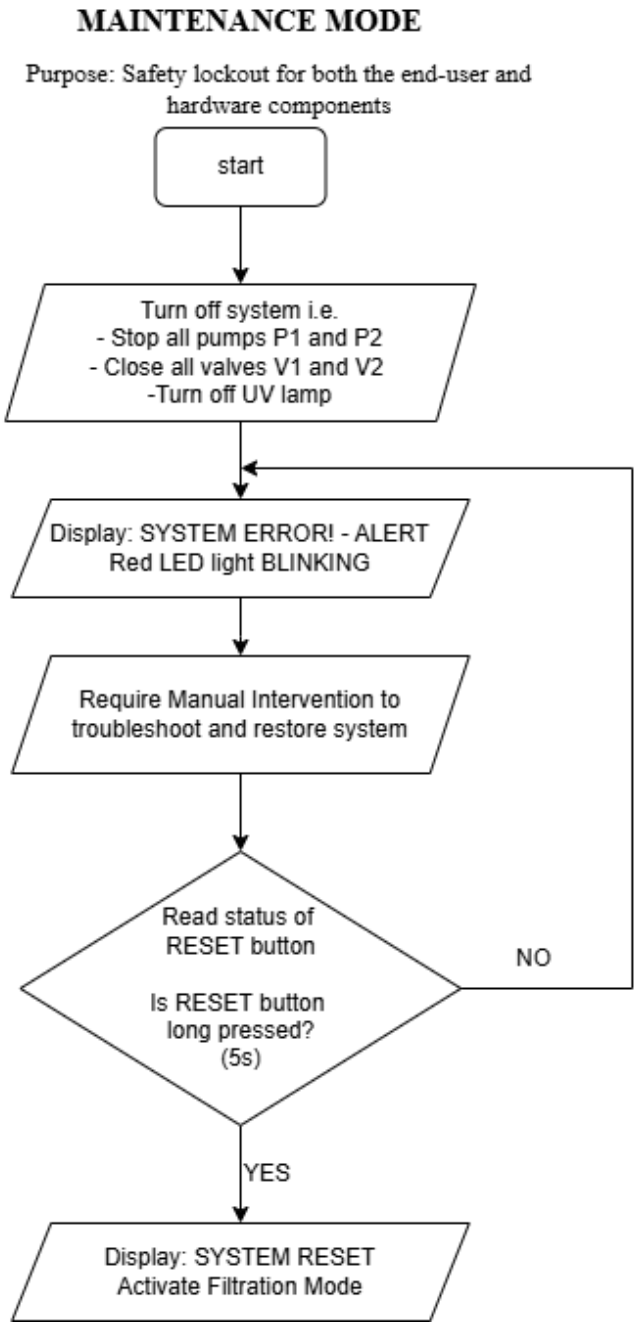

Figure 7: Maintenance mode.

- Activated by critical errors such as clogged filters or unsafe water parameters.
- System enters a full shutdown state, requiring manual intervention/reset from an operator.

4 User Interface and Water Quality Standards

4.1 Status Indicators

The system communicates its operational state using an LED light interface and an OLED screen.

Table 1: System Status Indicators

LED Color	**Mode**	**Description**
Blue	Idle	System ready / Tank full
Green	Filtration / Dispensing	System active and purifying
Red (Blinking)	Maintenance	Critical fault (Technician required)