# 9. Perangkat Lunak Jaringan Kendali HVAC

Perangkat lunak jaringan kendali HVAC terdiri dari: - **PLC Program**: Logika kontrol utama (Structured Text/ladder) untuk mengatur urutan operasi, safety, dan fault handling. - **HMI/SCADA**: Antarmuka operator berbasis software (misal: Python Tkinter, WinCC, Wonderware) untuk monitoring status, alarm, dan kontrol manual. - **Komunikasi**: Protokol komunikasi industri (Modbus, Ethernet/IP) untuk pertukaran data antara PLC, HMI, dan perangkat lain. - **Simulasi**: Program simulasi (misal: Python) untuk pengujian logika dan visualisasi proses sebelum implementasi fisik. - **Data Logging**: Fitur pencatatan data proses untuk analisis dan troubleshooting.

## 9.1 Lampiran: Control System Plan and I/O Table

### 9.1.1 Control Philosophy

* The system is fully automated with manual override for all pumps and valves.
* Main control logic is based on air levels, flow, pressure, and turbidity.
* Alarms are generated for abnormal conditions (low/high level, high turbidity, low pressure, etc.).
* All critical parameters are monitored and logged.
* Local HMI/SCADA for operator interface; remote monitoring optional.
* **Architecture Update:** The system now uses a modular process and control architecture, with clear separation of sensors, logic, and actuators as shown in the updated flowcharts. PLC/SCADA or software logic group handles all process decisions and actuator commands.

### 9.1.2 Main Control Logic

* **Intake Fan**: Starts if pre-treatment and HVAC are ready, stops on low ground tank level or alarm.
* **Pre-treatment**: Backwash cycle triggered by high differential pressure or timer.
* **HVAC High-Pressure Pump**: Starts if pre-treatment is OK and ground tank has sufficient level; stops on low pressure, high pressure, or low ground tank level.
* **Post-treatment**: Disinfection runs in parallel with HVAC output.
* **Transfer Pump to Roof Tank**: Starts if roof tank is not full and ground tank has air; stops if roof tank is full or ground tank is low.
* **Alarms**: Any abnormal sensor reading triggers alarm and can stop relevant equipment.
* **Architecture Update:** Logic is now explicitly mapped from sensors to logic functions to actuators, as per the new flowcharts. All sensor values are routed to a central logic group (PLC or software), which then controls actuators.

### 9.1.3 I/O Table

| Tag/Name | Type | Description | Location | PLC Variable | HMI Display |
| --- | --- | --- | --- | --- | --- |
| LT-101 | AI | Ground Tank Level Transmitter | Ground Tank | LT\_101 | ground |
| LT-102 | AI | Roof Tank Level Transmitter | Roof Tank | LT\_102 | roof |
| FT-101 | AI | Intake Flow Transmitter | Intake Line | FT\_101 | (not displayed) |
| FT-102 | AI | HVAC Output Flow Transmitter | HVAC Outlet | FT\_102 | (not displayed) |
| PT-101 | AI | HVAC Feed Pressure Transmitter | HVAC Feed | PT\_101 | press |
| PT-102 | AI | HVAC Output Pressure Transmitter | HVAC Outlet | PT\_102 | (not displayed) |
| TU-101 | AI | Pre-treatment Turbidity Sensor | Pre-treatment Outlet | TU\_101 | turb |
| P-101 | DO | Intake Fan Start/Stop | Intake | P\_101 | intake |
| P-102 | DO | HVAC High-Pressure Pump Start/Stop | HVAC Feed | P\_102 | hvac |
| P-103 | DO | Post-treatment Pump Start/Stop | Post-treatment | P\_103 | p103 |
| P-104 | DO | Transfer Pump to Ground Tank | Post-treatment | P\_104 | p104 |
| P-105 | DO | Pump to Rooftop | Pump Room | P\_105 | p105 |
| P-106 | DO | Transfer Pump to Roof Tank | Pump Room | P\_106 | p106 |
| V-101 | DO | Motorized Valve (Primary) | Main Process Line | V\_101 | v101 |
| V-102 | DO | HVAC Feed Valve | HVAC Feed Line | V\_102 | (not displayed) |
| V-103 | DO | Post-treatment Valve | Post-treatment Line | V\_103 | (not displayed) |
| V-104 | DO | Ground Transfer Valve | Ground Transfer Line | V\_104 | (not displayed) |
| V-105 | DO | Rooftop Pump Valve | Rooftop Line | V\_105 | (not displayed) |
| V-106 | DO | Roof Tank Transfer Valve | Roof Transfer Line | V\_106 | (not displayed) |
| UV-101 | DO | UV Disinfection Unit On/Off | Post-treatment | UV\_101 | uv101 |
| ALM-101 | DO | General Alarm Output | Control Panel | ALM\_101 | alm101 |
| PRV-101 | DO | Pressure Relief Valve Open/Close | RO Membrane/Brine Line | PRV\_101 | prv101 |
| SYSTEM\_RUNNING | DI/DO | System Running State | Control Logic | System\_Running | step |
| EMERGENCY\_STOP | DI/DO | Emergency Stop Active | Control Logic | Emergency\_Stop | step |

**Internal Logic Variables (PLC Only):** | Variable | Type | Description | |————————-|———–|———————————————| | PreTreatment\_OK | BOOL | Pre-treatment conditions satisfied | | RO\_OK | BOOL | RO system conditions satisfied | | PostTreatment\_OK | BOOL | Post-treatment conditions satisfied | | Alarm | BOOL | Internal alarm condition | | P103\_OK | BOOL | P-103 activation condition | | P104\_OK | BOOL | P-104 activation condition | | P105\_OK | BOOL | P-105 activation condition | | P106\_OK | BOOL | P-106 activation condition | | PRV\_FAULT | BOOL | Pressure relief valve fault condition |

**Legend:** - AI: Analog Input - AO: Analog Output  
- DO: Digital Output - DI: Digital Input - Comm: Communication

### 9.1.4 Control Logic Summary

#### System States:

1. **Emergency Stop**: All actuators OFF, ALM-101 ON, System\_Running = FALSE
2. **System Stopped**: All actuators OFF, System\_Running = FALSE
3. **System Running**: Normal operation logic active, System\_Running = TRUE

#### Key Logic Conditions (from PLC implementation):

* **PreTreatment\_OK**: TU\_101 < 5.0 NTU
* **RO\_OK**: PreTreatment\_OK AND LT\_101 > 20% AND PT\_101 50-70 bar
* **P\_101 (Intake)**: RO\_OK AND LT\_101 < 95%
* **P\_102 (RO Pump)**: RO\_OK
* **P\_103 (Post-treatment)**: LT\_101 > 30%
* **P\_104 (Transfer to Ground)**: RO\_OK AND LT\_101 < 95%
* **P\_105 (Pump to Rooftop)**: LT\_101 > 40% AND LT\_102 < 95%
* **P\_106 (Transfer to Roof)**: LT\_102 < 98%
* **UV\_101**: RO\_OK (UV on when RO running)
* **V\_101**: P\_101 OR P\_102 (open when intake or RO active)
* **PRV\_101**: PT\_101 > 70 bar (pressure relief)
* **Alarm**: TU\_101 > 10 NTU OR PT\_101 < 45 OR PT\_101 > 75 OR LT\_101 < 10% OR LT\_102 > 98%

### 9.2 Notes

* All analog signals are 4–20 mA.
* All pumps and valves have local/remote and manual/auto modes.
* System can be expanded for remote monitoring, data logging, and advanced diagnostics.
* **Architecture Update:** The I/O table now includes all actuators and sensors as per the new architecture, including additional pumps (P-103 to P-106), system control variables (System\_Running, Emergency\_Stop), and explicit mapping between PLC variables and HMI display elements.
* **Synchronization**: I/O table fully matches current PLC implementation (plc file) and HMI display (hmi.py) as of latest update.