ENGINEERING DOCUMENTATION

Pump Station Demo

Project Description — Siemens S7-1200 / TIA Portal V19 / WinCC Unified

PLC logic · HMI · interlocks · diagnostics · verification

Pump Station Demo - Project Description

1. Project Overview

Pump Station Demo is a Siemens PLC and HMI engineering project developed as a compact demonstration of industrial automation functions for a simulated pump station.

The project combines PLC control, analog level signal processing, automatic and manual pump operation, interlocks, equipment feedback monitoring, fault handling, operator settings, and WinCC Unified HMI.

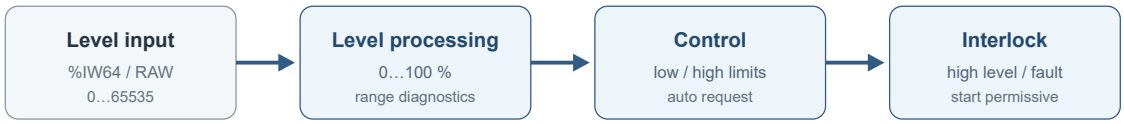
The project was developed and functionally tested as a fully simulated system. No physical field equipment is connected to the installation.

Engineering Environment

- PLC: Siemens S7-1200 CPU 1214C
- Engineering software: TIA Portal V19
- PLC simulation: S7-PLCSIM V19
- HMI: WinCC Unified
- HMI device: MTP 700 Unified Comfort
- HMI resolution: 800 x 480

2. Process Description

Process control path



Process flow from level measurement to pump start permissive.

The simulated process represents a tank with an analog level transmitter and a pump used to control the tank level.

The level transmitter provides a simulated analog signal. The raw input is validated and converted into a percentage level used by the control logic.

The pump supports two operating modes:

- Manual mode - the operator can issue START and STOP commands from the HMI.
- Automatic mode - the PLC controls the pump according to configured low and high level limits.

The automatic control uses separate low and high thresholds, providing hysteresis between the pump start and stop conditions.

3. System Architecture

> **System boundary:** the Siemens PLC/HMI simulation is the engineering core. The Falmont Edge browser demo is a separate presentation layer for demonstrating the same control concepts.

The PLC/HMI system is organized around process data, configurable settings, instance data blocks and dedicated functional control blocks.

- db_settings - configurable process and diagnostic parameters.
- db_process - current process and control data.
- fb_level_sensor / db_level_sensor - analog level processing and diagnostics.
- fb_level_control / db_level_control - automatic level control.
- fb_tank_interlock / db_tank_interlock - tank-level permissives and pump interlocks.
- fb_pump / db_pump_1 - pump command, feedback, timeout and fault logic.

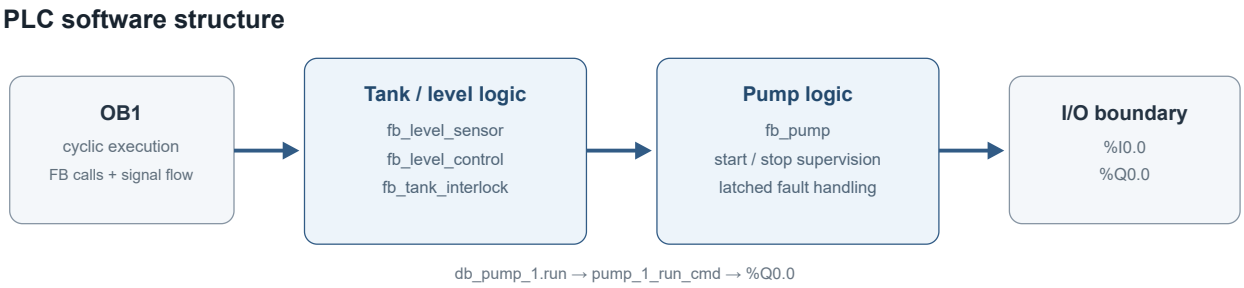
The functional relationship can be summarized as:

Analog Level Input -> Level Signal Processing -> Level Control -> Pump Control -> Pump Command

The PLC receives Running feedback from the simulated pump through the configured feedback input. Pump fault states are generated internally by the pump control block from start, stop, and running feedback diagnostics; there is no separate external pump fault input in the current PLC tag table.

The HMI provides the operator interface while the PLC contains the process and equipment control logic.

4. PLC Software Architecture



PLC software structure and principal I/O boundary.

The PLC application is divided into functional areas instead of placing the complete process logic in one cyclic block.

The main functional areas are:

- Startup and cyclic program execution.
- Level signal processing and validation.
- Automatic level control.
- Pump control and state handling.
- Interlock processing.
- Feedback and timeout diagnostics.
- Process settings and runtime data.

The current project uses dedicated data and functional blocks for these responsibilities. This keeps process functions separated and makes the application easier to test and maintain.

5. Operating Modes

Manual Mode

In Manual mode the operator can control the pump from the HMI using dedicated START and STOP commands.

The manual command is still evaluated together with the applicable permissive, interlock and fault conditions. A manual command therefore does not bypass the protection logic.

Automatic Mode

In Automatic mode the pump request is generated by the level control logic according to the configured Low Level and High Level parameters.

The automatic sequence uses a low/high control band.

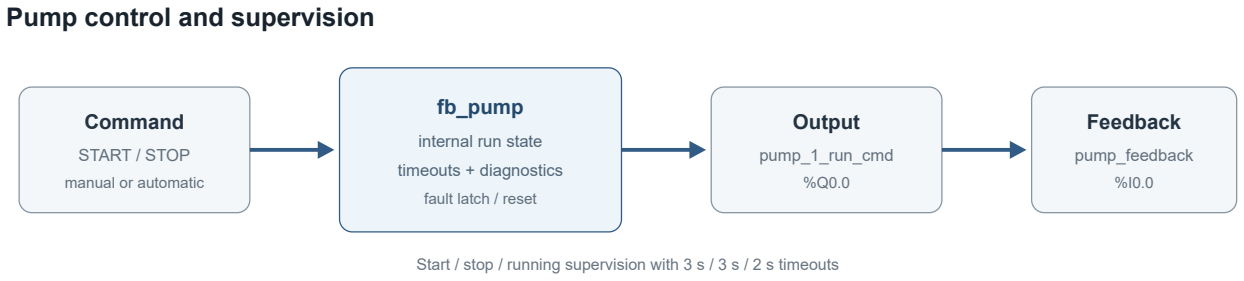
When the level is below the Low Level threshold, the level control generates an Auto Request.

When the level rises above the High Level threshold, the Auto Request is cleared.

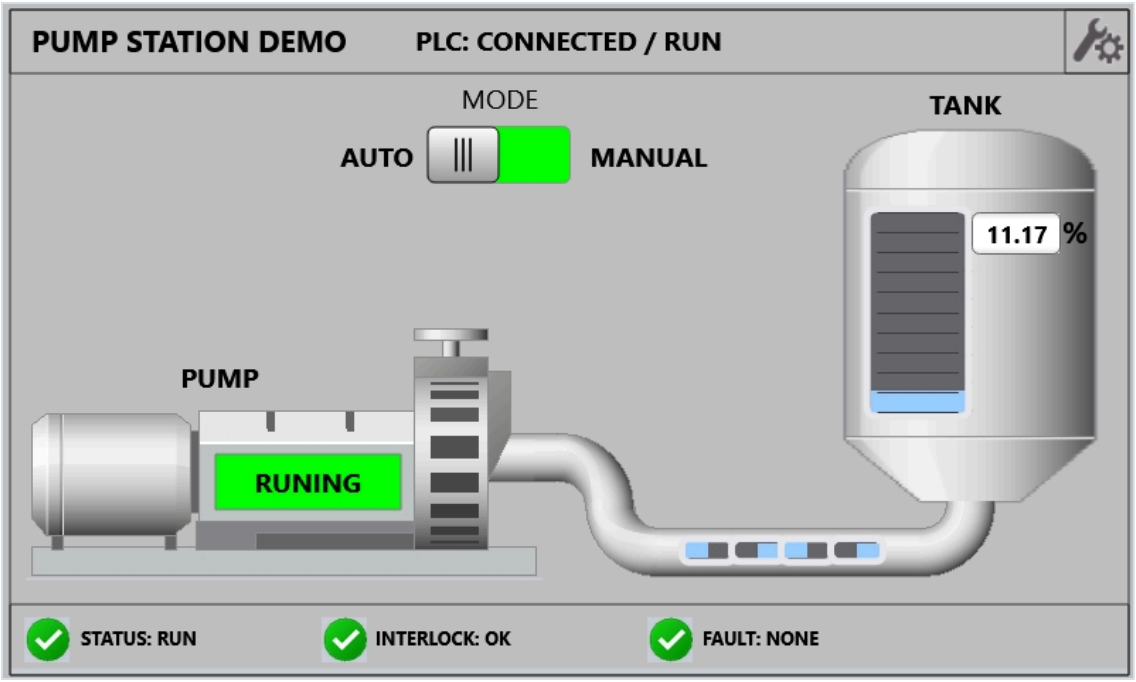
In addition, the tank interlock stops the pump at or above the configured High Level limit and removes the start permissive while the high-level condition is active.

This separation between Auto Request and the tank interlock provides the effective hysteresis and prevents unrestricted pump operation at high level.

6. Pump Control and Diagnostics



Pump command, internal run state, physical output and feedback supervision.



Pump Running — representative HMI state.

The pump is implemented as a dedicated functional block responsible for command handling, feedback monitoring and pump-related diagnostics.

The implemented pump functions include:

- Start command handling.
- Stop command handling.
- Run command generation.
- Running feedback monitoring.
- Pump fault handling.
- Start timeout monitoring.
- Stop timeout monitoring.
- Running feedback timeout monitoring.
- Fault reset.
- Interlock evaluation.

The PLC separates the requested pump state from the actual Running feedback. This makes it possible to detect situations where the PLC requests a state but the simulated equipment does not confirm the expected feedback.

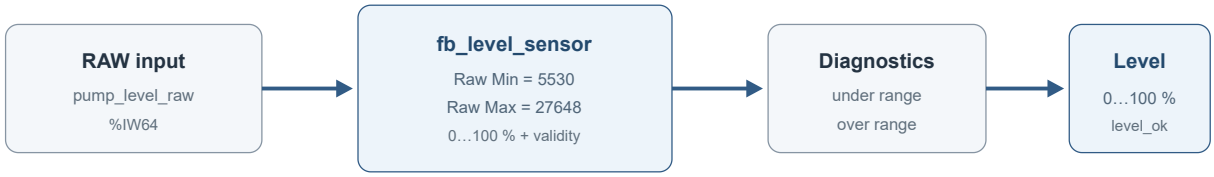
A start failure is detected when a start command is issued and the expected Running feedback is not received within the configured Start Timeout.

A stop failure is detected when a stop command is issued and the expected feedback does not clear within the configured Stop Timeout.

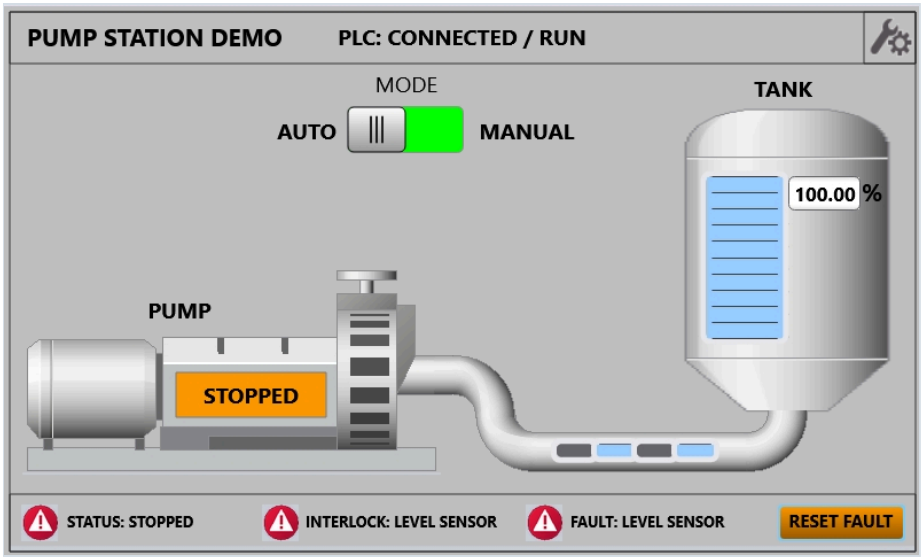
Additional Running feedback supervision is provided by the configured Running Timeout.

7. Level Measurement and Diagnostics

Level measurement path



RAW level acquisition, scaling and diagnostic validity.



Under Range — HMI diagnostic state.

The simulated level transmitter is represented by a raw analog input value corresponding to a 4-20 mA measurement range.

The configured engineering conversion range is:

- Raw minimum: 5530
- Raw maximum: 27648

The signal processing converts the valid raw input into a percentage level.

The level diagnostic state distinguishes three principal conditions:

- Under Range - the raw signal is below the configured minimum.
- Valid - the raw signal is inside the configured range.
- Over Range - the raw signal is above the configured maximum.

The project retains Under Range and Over Range as separate diagnostic states. This allows the HMI to present the specific reason for an invalid level signal instead of displaying only a generic sensor fault.

When the level signal is invalid, the calculated level must not be treated as a valid process measurement for functions that depend on a trustworthy level signal.

8. Interlocks

> **Primary start permissive:** level valid and high-level condition not active. A pump fault is generated and latched internally by `fb_pump`; RESET FAULT is required before restart.

The pump command is subject to interlock and permissive conditions.

The interlock concept separates the operator or automatic request from the final permission to run the pump.

Important blocking conditions include an invalid level signal and conditions that indicate that pump operation is not permitted by the control logic.

The project also prevents an inappropriate start when the process is already in a high-level or full-tank condition.

The resulting control path can be summarized as:

Start Request -> Interlock and Permissive Evaluation -> FB_Pump -> db_pump_1.run -> pump_1_run_cmd (%Q0.0)

The physical feedback path is:

pump_feedback (%I0.0) -> FB_Pump.running_feedback

If the required interlock conditions are not satisfied, the final pump command is inhibited even when a start request exists.

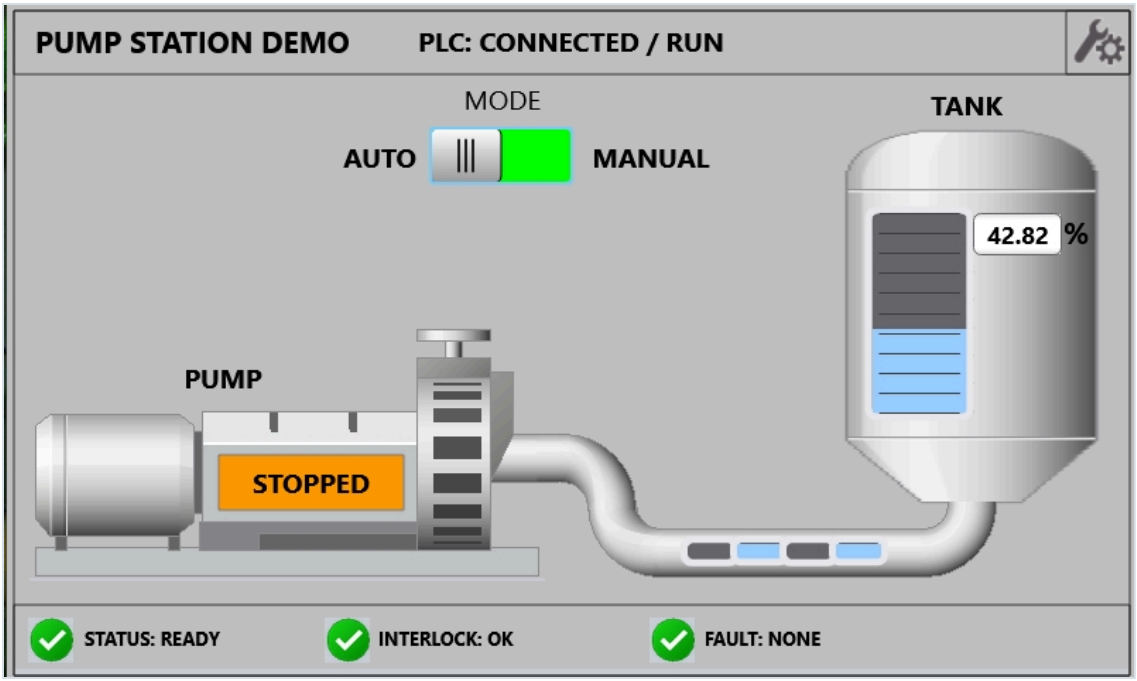
This distinction allows the HMI to show both the requested operating mode and the reason why the pump is not permitted to run.

9. HMI

The operator interface is implemented in WinCC Unified and is designed for an MTP700 Unified Comfort device with an 800 x 480 display resolution.

The HMI is divided into two primary screens: Main and Settings.

Main Screen



Normal Operation — main HMI screen.

The Main screen is the primary operator and process screen. It combines process visualization, operational commands and diagnostic information.

The Main screen provides:

- Tank level indication.
- Graphical pump status.
- AUTO / MANUAL mode selection.
- START and STOP operator commands.
- Interlock or permissive status.
- Pump fault indication.
- Running feedback indication.
- RESET FAULT command.
- PLC connection and operating state indication.
- Navigation to the Settings screen.

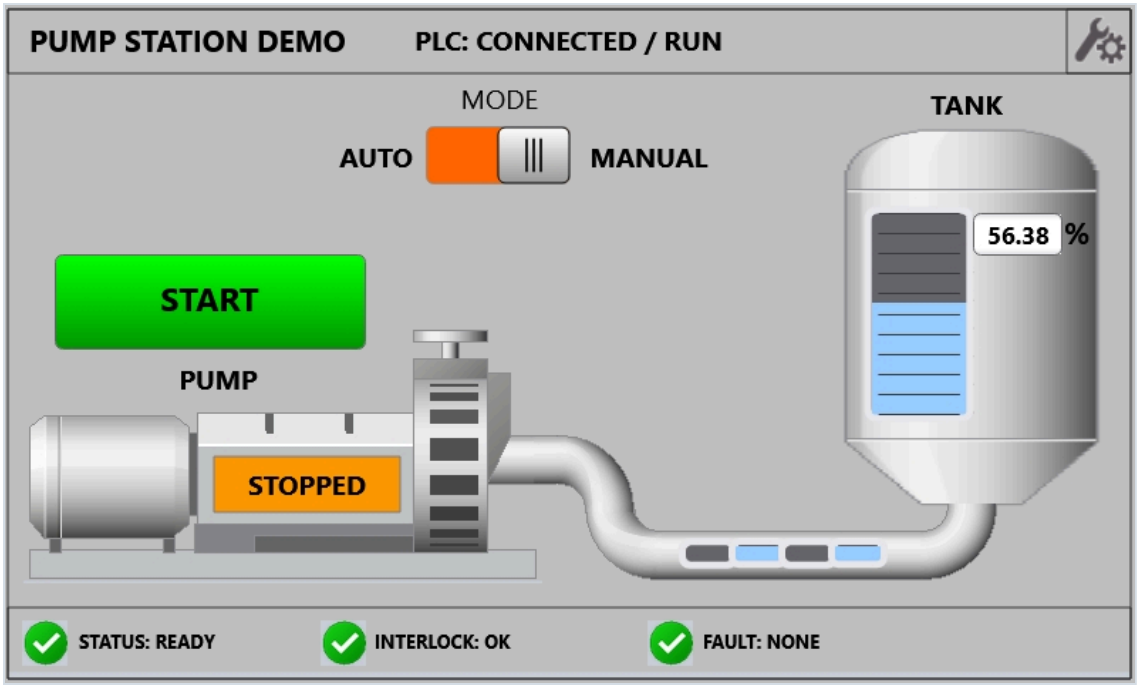
The displayed level is the processed engineering value rather than the raw analog input.

In Automatic mode, the pump is controlled according to the configured Low Level and High Level thresholds. In Manual mode, the operator can issue direct START and STOP commands, while the applicable interlock and fault conditions remain active.

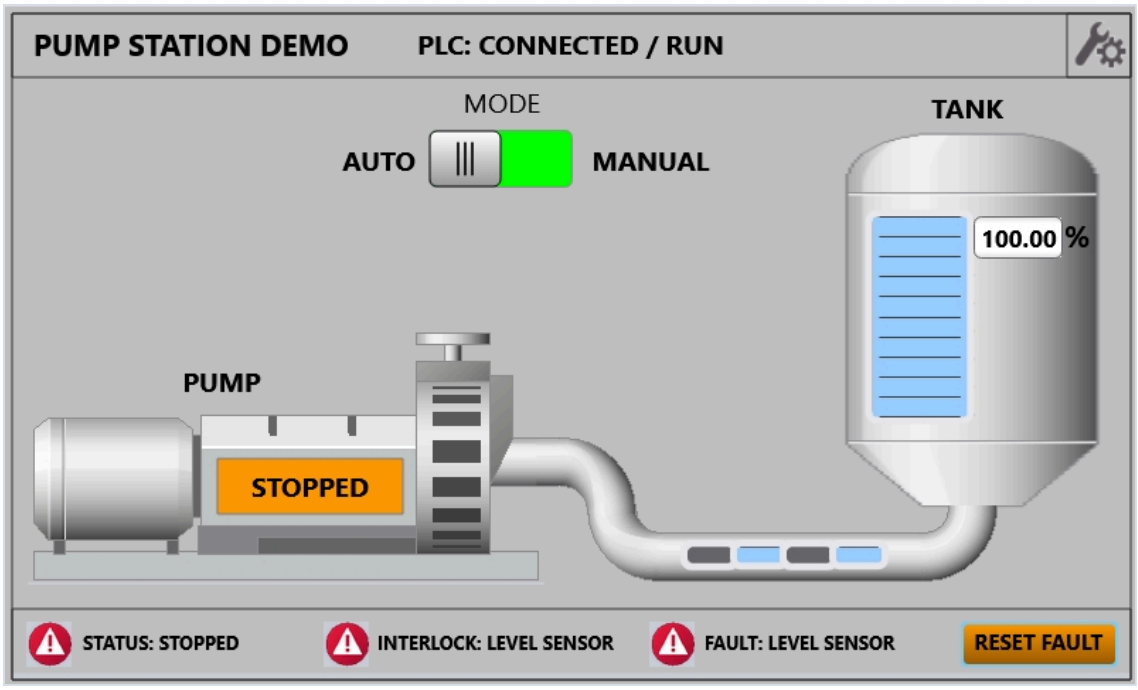
The Main screen also distinguishes between PLC state and pump state. For example, a PLC in CONNECTED / RUN state can correctly coexist with a stopped pump.

The PLC operating state is obtained through the HMI PLC operating-state tag and is presented as operator-readable status information.

Main Screen Diagnostics



Manual Mode



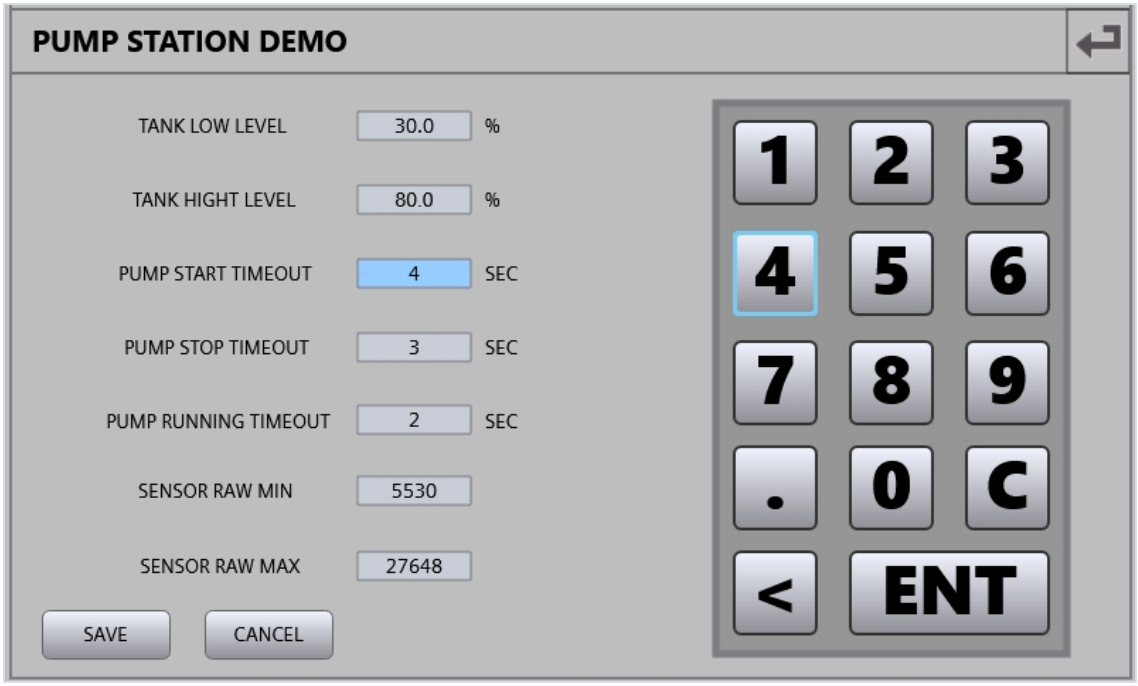
Under Range

The Main screen includes dedicated diagnostic areas for process status, interlock state and fault state.

The diagnostic information is intended to provide the operator with the reason for blocked or abnormal operation rather than only indicating that the pump is OFF.

RESET FAULT is a functional PLC command. It is not simply a visual acknowledgement of a message; it is connected to the corresponding fault-reset logic.

Settings Screen



Settings Screen — parameter editing with integrated keypad.

The Settings screen is a dedicated configuration interface for parameters that affect the PLC control logic.

The implemented parameters are:

- Low Level: decimal value, 0 to 100 %.
- High Level: decimal value, 0 to 100 %.
- Start Timeout: integer value, 0 to 60 s.
- Stop Timeout: integer value, 0 to 60 s.
- Running Timeout: integer value, 0 to 60 s.
- Raw Min: integer value, 0 to 65535.
- Raw Max: integer value, 0 to 65535.

The parameters are grouped conceptually into process thresholds, pump diagnostics and analog sensor configuration.

The operator first selects a parameter and then enters a value using the dedicated numeric keypad.

The keypad provides digit entry, decimal input, clear, backspace and entry confirmation functions.

Settings Transaction Model

Editing does not immediately overwrite the saved configuration.

The operator works with an editable draft of the settings. The draft can be modified and then either saved or cancelled.

The SAVE operation validates the complete parameter set before accepting the changes. Only a valid configuration is committed as the new saved configuration.

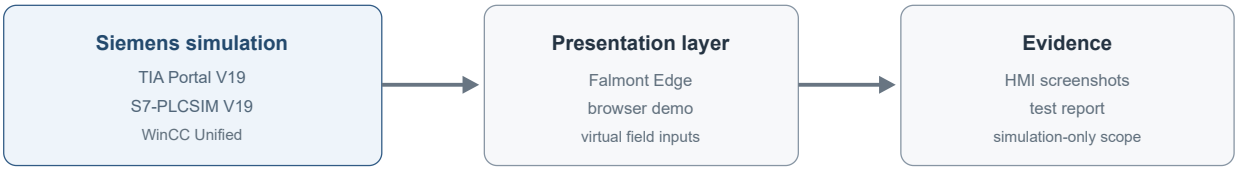
The CANCEL operation discards the current edits and restores the previously saved values.

A dedicated Settings Error popup is used when validation fails. The popup blocks normal interaction until the operator acknowledges the error.

When the Settings screen is opened, a short INITIALIZING state with a Please wait message is shown before the configuration interface becomes available.

10. Simulation Environment

Simulation boundaries



Separation between the Siemens engineering simulation, Falmont Edge browser presentation layer and project evidence.

The PLC and HMI application was developed and functionally verified in a simulated Siemens environment.

The engineering environment consists of:

- TIA Portal V19.
- Siemens S7-1200 CPU 1214C.
- S7-PLCSIM V19.
- WinCC Unified.
- MTP700 Unified Comfort HMI configuration.

PLCSIM is used to provide the simulated PLC runtime and to modify or monitor simulated process inputs and equipment feedback during functional testing.

The simulation allows the implemented control functions to be exercised without physical field equipment.

The verified functional areas include analog signal scaling and validation, Under Range and Over Range diagnostics, Manual and Automatic operation, interlocks, pump feedback, pump fault handling, timeout diagnostics, HMI commands, HMI settings and displayed PLC/process states.

11. Browser Demonstration

> **Presentation layer:** the browser demo reproduces the control behaviour for portfolio viewing. Its virtual field-input panel is not part of the Siemens HMI and is intentionally documented separately.

A separate browser-based implementation was developed for the Falmont Edge portfolio.

The browser demonstration reproduces the principal behavior and operator interaction model of the Siemens PLC/HMI project in a web environment.

The browser implementation is a separate presentation and simulation layer. It does not replace the original TIA Portal, S7-PLCSIM, S7-1200 or WinCC Unified project.

The browser version contains an additional Simulation Control panel used only to emulate field-side signals for the web demonstration.

Simulation Control is not part of the Siemens HMI. It provides simulated values corresponding to signals that would normally originate from field equipment, such as the level transmitter and pump feedback.

The relationship is:

Original Engineering Project -> Browser Demonstration

TIA Portal / S7-1200 / PLCSIM / WinCC Unified -> Web-based demonstration layer

The original Siemens project remains the engineering reference. The browser demonstration provides an immediately accessible way to observe and interact with the same control concept without requiring Siemens engineering software.

12. Scope and Limitations

> **Simulation-only scope.** The project demonstrates PLC logic, HMI behaviour, interlocks, alarms and verification using simulated inputs. No physical hardware, wiring, calibration or commissioning is claimed.

This project is a simulation and engineering demonstration rather than a commissioned industrial installation.

The project does not claim physical field wiring, cabinet construction, real instrument calibration, field commissioning, SAT, or operation of connected process equipment.

The PLC and HMI functions described in this document refer to the implemented simulated project.

The browser demonstration is an independent portfolio presentation layer and should not be interpreted as the original PLC runtime.

The project demonstrates:

- PLC functional programming.
- Analog signal processing and validation.
- Manual and automatic control.
- Interlocks and permissives.
- Equipment feedback monitoring.
- Fault and timeout diagnostics.
- WinCC Unified HMI development.
- Operator parameter handling with validation and save/cancel behavior.
- Simulation-based functional verification.

The purpose of the project is to demonstrate a complete PLC/HMI control concept in a controlled simulated environment and to provide a compact engineering example for portfolio presentation.

Appendix A - PLC Program Structure (OB1)

The complete OB1 export is provided separately as Main.pdf in the release package.