

# Design and Implementation of an Automated Oil Transfer Monitoring and Control System Using PLC Technology

## 1. Project Overview

- Designed and implemented a PLC-based automated control system for an industrial oil transfer process.
- System monitors two storage tanks using ultrasonic level, IO-Link flow, and pressure sensors in real-time.
- Siemens S7-1200 PLC programmed in TIA Portal V17 using structured Function Blocks (FBs).
- Automated pump control sequences fluid transfer between tanks based on live sensor feedback.
- All faults latch and prevent pump restart until acknowledged — protecting equipment and process integrity.
- HMI operator interface provides real-time visibility of system status, sensor readings, and active alarms.
- Modular FB architecture (FC\_DOL\_Motor, FC\_Alarms, FC\_Instrumentation) allows independent testing of each subsystem.
- System successfully validated through simulated test scenarios covering normal operation and fault conditions.

## 2. Aims & Objectives

**Aim:** To develop a reliable and efficient PLC-based control system that enhances the performance and safety of oil transfer operations.

**Objectives:**

- Analyse existing oil transfer control systems and identify limitations
- Design and implement PLC-based control logic for pump regulation
- Integrate flow, level, and pressure sensors for real-time monitoring
- Develop fault detection mechanisms for leaks, blockages, and pump failures
- Evaluate system performance against conventional control approaches

## 4. Methodology & System Overview

The project follows a system design and development approach. The oil transfer system comprises two tanks connected by a pump and pipework with integrated instrumentation.

**Sensors:** Flow Transmitter (FT1) — IFM SBY318 IO-Link; Level Transmitter (LT100) — ultrasonic (0–1200L); Pressure Transmitter — inline monitoring.

**PLC Platform:** Siemens S7-1200, TIA Portal V17. Structured FBs for modularity. HMI developed for operator control.

## 3. Literature Review

- Bolton [1] established that PLCs are widely used in industrial automation due to their robustness and flexibility in controlling sequential and continuous processes.
- Khandare et al. [2] demonstrated improved efficiency using automated liquid level control with PLC and SCADA.
- Patil & Patil [3] demonstrated PLC-controlled pumping systems for industrial fluid transfer, showing improved flow regulation and reduced operator intervention.
- Boyer [4] highlighted how SCADA enables operators to monitor variables, detect anomalies, and make informed decisions.
- Sharma et al. [5] proposed sensor-based pipeline leakage detection; Ahmed et al. [6] showed that combining pressure and flow sensors significantly improves reliability.
- Gap Identified: Limited research exists on compact, cost-effective PLC systems integrating both automated control and fault detection in a single platform — the focus of this project.

## References

- [1] Bolton, W. (2015). Programmable Logic Controllers. 6th ed. Newnes.  
[2] Khandare, S. et al. (2016). Automated liquid level control using PLC and SCADA. IJERT, 5(3).  
[3] Patil, S. & Patil, R. (2017). PLC-controlled pumping system for industrial fluid transfer. IJSRD, 4(12).  
[4] Boyer, S.A. (2010). SCADA: Supervisory Control and Data Acquisition. 4th ed. ISA.  
[5] Sharma, A. et al. (2018). Sensor-based pipeline leakage detection. Sensors & Actuators, 12(4).  
[6] Ahmed, K. et al. (2019). Pressure and flow-based fault detection methods. IEEE Trans. Ind. Electron., 66(9).

## Physical Setup / Hardware Photo



## HMI Screen / Operator Interface



## 5. PLC Implementation

- FC\_DOL\_Motor:** Direct Online motor starter control block — pump start/stop sequences, interlocks, run feedback.
- FC\_Alarms:** Alarm management block — high/low level, pressure, flow alarms with fault latching and reset.
- FC\_Instrumentation:** Sensor scaling block — converts IO-Link raw data to engineering units (litres, m/s, L/min) with totaliser integration.
- Sequence Control:** Step-based sequencer managing Empty and Refill procedures with totaliser reset on completion.

## 6. Fault Detection & Alarm System

**Multi-layer fault detection:**

**Level Alarms:** HH and LL thresholds trigger pump shutdown to prevent overflow and dry running.  
**Flow Monitoring:** No-flow during pump run indicates blockage or pipe failure. Over-limit flow indicates potential leak.

**Pressure Monitoring:** Abnormal pressure rise indicates blockage; sudden drop may indicate line rupture.

All fault conditions latch an alarm, prevent pump restart until acknowledged and cleared, and provide visual HMI indication.

## 7. Results & Testing

- Normal Transfer:** System successfully automated pump control based on level sensor feedback without manual intervention.
- Alarm Response:** All alarm conditions correctly triggered pump shutdown and HMI indication within the expected PLC scan cycle.
- Sensor Accuracy:** IO-Link readings scaled accurately to engineering units; totaliser correctly accumulated and reset.

## 8. Discussion

The project demonstrates a compact PLC-based system effectively integrating real-time monitoring and fault detection. IO-Link sensors provided reliable digital communication. The Function Block structure proved highly effective — each subsystem tested independently, improving commissioning efficiency. Compared to relay-based systems, the PLC approach provides significantly enhanced diagnostics. Limitations: prototype scale only; industrial deployment would require additional hardening and SIL-rated hardware.

## 9. Conclusion

A functional PLC-based oil transfer monitoring and control system was successfully designed, implemented, and tested — achieving automated pump control, real-time sensor integration, and multi-condition fault detection within a modular, scalable architecture. Future work could extend to SCADA integration, OPC-UA remote monitoring, and predictive maintenance.