



RESEARCH ARTICLE

OPEN ACCESS

IMPLEMENTATION OF AN INTELLIGENT REAL-TIME SUPERVISION SYSTEM FOR INDUSTRIAL PROCESSES USING MATLAB AND MULTIPLE PLCs: A DESALINATION PLANT CASE STUDY

Bilal Benarabi¹, Mohammed Said Achbi², Boubakeur Rouabah³, Mohammed Chaker Boutalbi⁴
Mokhtar Khenfer⁵,

^{1,2,3}Department of Electronics and Telecommunications, KASDI MERBAH University – Ouargla, Algeria.

^{4,5} KASDI MERBAH University – Ouargla, Algeria.

¹<https://orcid.org/0000-0003-4413-5866>, ²<https://orcid.org/0000-0002-4991-4212>, ³<https://orcid.org/0000-0002-9319-9009>

⁴<https://orcid.org/0009-0005-2995-6828>, ⁵<https://orcid.org/0000-0002-6486-6095>

E-mail: benarabi.bilal@univ-ouargla.dz, achbi.mohammedsaid@univ-ouargla.dz, rouabah.boubakeur@univ-ouargla.dz,
mohammedchaker.boutalbi@univ-ouargla.dz, khenfermok@yahoo.fr

ARTICLE INFO

ABSTRACT

Article History

Received: January 10, 2026

Reviewed: February 20, 2026

Accepted: May 1, 2026

Published: June 30, 2026

Keywords:

Intelligent supervision,
OPC,
PLC,
MATLAB/Simulink,
Desalination.

This paper presents the design and implementation of an intelligent real-time supervision system for industrial processes, applied to a reverse osmosis (RO) desalination plant. While MATLAB-based simulations are widely used for system analysis and control design, their integration into real industrial environments may remain limited in some industrial contexts due to interoperability and real-time communication constraints. To address these challenges, an OPC-based communication framework is developed to ensure seamless data exchange between MATLAB and multiple programmable logic controllers (PLCs) from different manufacturers. The proposed system incorporates fuzzy logic and Neuro-Fuzzy (ANFIS) controllers to enhance control performance and adaptability under varying operating conditions. The approach is validated on a real desalination plant, where experimental results demonstrate improved stability, reduced overshoot, and faster settling time compared to conventional PID control. The proposed architecture provides a flexible and scalable solution for intelligent industrial supervision and control.



Copyright ©2026 by authors and Galileo Institute of Technology and Education of the Amazon (ITEGAM). This work is licensed under the Creative Commons Attribution International License (CC BY 4.0).

I. INTRODUCTION

Modern automated systems are a major technical achievement that is transforming daily life and industry. By leveraging cutting-edge technology like artificial intelligence, machine learning, the Internet of Things (IoT), and sophisticated sensors, these systems offer exceptional productivity, accuracy, and efficiency. They reduce human error, simplify processes, and enhance quality of life in many sectors. By freeing up human attention for creative, strategic, and value-added work, these systems offer a safer, more productive, and connected society. In certain nations, the demand for drinking water exceeds the availability, and water supplies are quickly depleting. This merging of industry and research has been welcomed by the business community, leading to complex industrial systems. In automated production lines, automated systems with supervision tools are essential for increased productivity, quality, and operational safety, guaranteeing the security of personnel, equipment, and processes.

Contemporary automated technologies increase water delivery and purification, minimize human error, and streamline industrial operations. They enable experts to concentrate on strategic activities, meeting the needs of the water sector. To run desalination plants efficiently, operators must comprehend installation instructions. Although they are infrequently utilized in RO desalination plant treatments, advanced control systems are necessary for lucrative sectors. The use of artificial neural networks to find problems with desalination plants was proposed in [1]. We used nanotechnology and the membrane distillation system to make a real system that was based on exact measurements. To identify system failures, discrepancies between the model outputs and system outputs were subsequently classified.

In [2], the authors proposed a Whale Optimizing Algorithm (WOA) grounded in chaos theory and fuzzy logic to identify deficiencies in wastewater treatment, aiming to reduce costs, evaluate decision rules, and uncover poorly structured domains within a dataset. A structural analysis methodology is used to describe the making of a failure detection and isolation (FDI) system for an ISROD plant in Lima, Peru, in [3]. In [4] and [5], a desalination facility is implemented with predictive control utilizing a linear model. A non-linear model-based predictive control system was created by [6], [7], and [8] and is used to monitor, find problems, and control a typical RO desalination plant. The literature [9] includes a Real-Time Fault Tolerant Control application, as well as the Fault Tolerant Control methods that are listed. Even with these efforts, only a few projects are now interested in keeping an eye on and running the RO plant. The paper [10] talks about how to use PLC and SCADA to automate an industrial RO plant. In [11], a system for monitoring and controlling reverse osmosis desalination water treatment plants was made. The authors of [12] created a test system for remote real-time communication that used MATLAB, Ethernet, and PLC.

The test results show that the OPC server can be used to get real-time data exchange between MATLAB and PLC from a distance. This means that real-time remote communication between MATLAB and PLC is possible and works. An accelerometer and a microphone were used to record the sound and vibration data of an air compressor in [13]. Data has been archived by OPC's ongoing monitoring. Detection units are used to record the data. We were able to get real-time results from our recent experiment, which we applied to a genuine desalination facility. To address and fix systemic issues, we made several modifications to the SCADA (Supervisory Control and Data Acquisition) and PLC (Programmable Logic Controller) systems. The experimental study in [14] uses RSLinx communication software to verify a cascade control system that applies PID control on MicroLogix-1200 PLC and RSView-32 SCADA. It makes use of PLC, OPC, and SCADA architectures. The study in [15] offers a home intelligent management system using real-time simulation from Opal-RT, a commercially available but costly option.

II. PROBLEM STATEMENT AND CONTEXT

Desalination plants often struggle to maintain stable water quality, consistent production, and efficient energy use at the same time. Changes in salinity, temperature, and feedwater properties can noticeably influence how the system performs. One of the main challenges is finding a practical balance between minimizing energy consumption and maximizing freshwater output, since improving one aspect can negatively affect the other. Environmental considerations also play an important role, particularly regarding the disposal of brine and its potential impact on marine ecosystems. In addition, ensuring reliable operation requires well-designed control strategies that account for system reliability, operational stability, and maintenance needs. For these reasons, an integrated and well-coordinated approach is essential to achieve desalination systems that are efficient, sustainable, and dependable. When industrial systems include equipment from different manufacturers -especially Programmable Logic Controllers (PLCs)-integration becomes more complex.

Differences in communication protocols, incompatibility between devices, and limitations in interoperability can lead to reduced performance or operational issues. To address these challenges, it is important to rely on standardized communication protocols, supported by careful system architecture and thorough testing, in order to maintain reliable and consistent operation [16]. In this work, the OPC protocol is used as a standardized communication layer to ensure reliable data exchange between PLCs. By avoiding proprietary communication methods, system integration becomes simpler and more flexible. Although the use of intelligent controllers can significantly improve efficiency and overall system performance, it also introduces additional requirements such as advanced algorithms, suitable hardware, technical expertise, and adequate security measures.

Integrating PLCs with Artificial Intelligence (AI) techniques can be seen as a long-term investment: while the initial implementation may be more complex and costly, it leads to improved performance and adaptability over time. MATLAB and Simulink are employed as the primary tools for developing and testing control strategies and AI-based algorithms. MATLAB is particularly well suited for data analysis, visualization, and automation tasks [17]. When connected to industrial systems, it allows real-time data acquisition and processing, which supports more responsive and informed decision-making in control applications. In this study, an interface is developed to connect MATLAB with PLC systems.

MATLAB is used to design and simulate AI-based control algorithms that cannot be directly executed on PLC hardware. Through OPC-MATLAB integration, it becomes possible to build customized monitoring dashboards and centralized control systems capable of handling multiple PLCs. This setup improves data logging, enables historical data analysis, and contributes to better monitoring and system optimization[18]. Overall, this approach supports advancements in several areas, including embedded systems, sustainable engineering, and industrial automation. By enabling the deployment of MATLAB-developed algorithms on OPC-compatible PLCs, the proposed work creates opportunities for further research and development in intelligent and adaptive automation systems [19].

The main contributions of this work are as follows:

1. Development of a real-time OPC-based communication framework between MATLAB and heterogeneous PLC systems.
2. Design and implementation of fuzzy and ANFIS controllers for desalination process control.
3. Integration of supervision, control, and fault-handling mechanisms in a unified architecture.
4. Experimental validation on a real industrial desalination plant.
5. Performance comparison between PID and intelligent control strategies.

III. PROPOSED FRAMEWORK AND ARCHITECTURE

III.1 MATLAB/SIMULINK-PLC DATA EXCHANGE MECHANISM

Real-time control in this project was implemented through MATLAB-PLC communication based on an OPC server [20]. A dedicated gateway was developed to facilitate seamless data exchange between the OPC server and MATLAB.

Programmable Logic Controllers (PLCs) provide a wide range of capabilities and are suitable for various industrial applications. In this setup, operational data could be accessed from the PLCs via the OPC server, enabling efficient monitoring and control within the system.

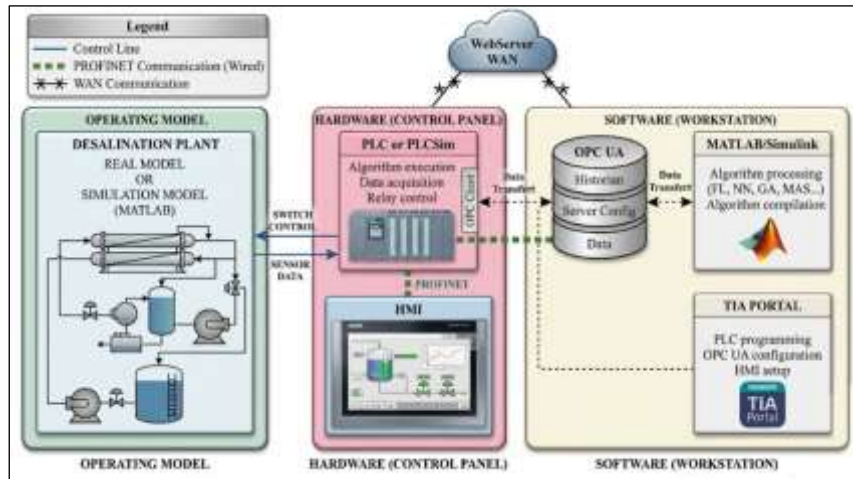


Figure 1: The Overall configuration of the proposed platform.

Source: Authors, (2026).

Fuzzy logic is a mathematical framework designed to manage imprecise or uncertain information by allowing partial degrees of truth, rather than relying solely on the binary true/false values of classical Boolean logic. It is widely applied in areas such as control systems, decision-support systems, and image processing, where real-world data often involves uncertainty and complexity that traditional logic cannot easily handle. By enabling approximate reasoning and incorporating linguistic variables, fuzzy logic provides a flexible and effective approach for dealing with ambiguity and vagueness in practical applications.

III.2 DESCRIPTION OF THE REVERSE OSMOSIS SYSTEM

The article presents a reverse osmosis installation located in Touggourt, where demineralized water is supplied from four geothermal wells and four cooling towers to produce potable water. The raw water undergoes a series of preliminary treatments, including cooling, filtration, and conditioning, to improve its compatibility with the reverse osmosis membranes, thereby extending membrane lifespan and ensuring efficient treatment performance. A high-pressure pumping system is then used to provide the necessary operating pressure for the reverse osmosis units, enabling the transfer of treated water to storage reservoirs and distribution tanks. In addition, a remote monitoring and control system is implemented to oversee and manage the operation of the pumping equipment.

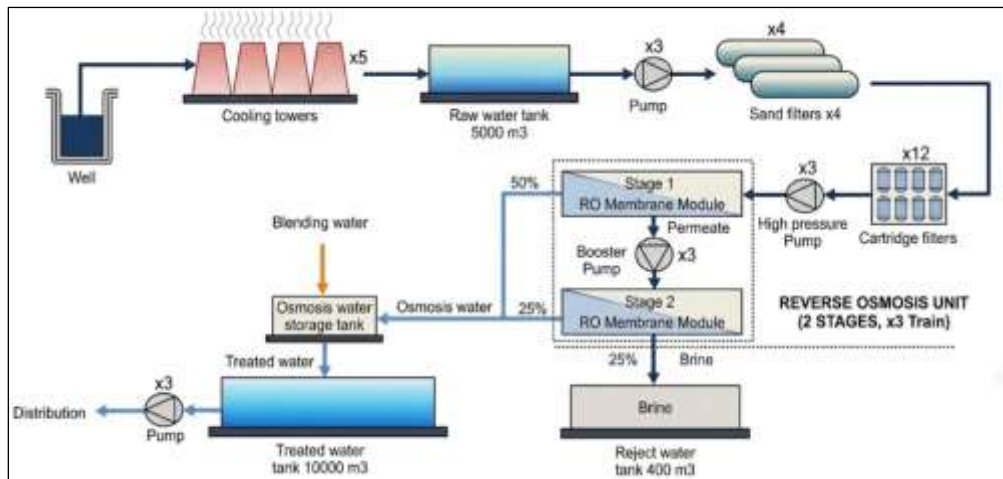


Figure 2: Synoptic representation of the desalination plant system architecture.

Source: Authors, (2026).

III.2.1 System Architecture and Communication Network Design

Figure 3 illustrates the communication architecture of the proposed SCADA-based demineralization station. The system is organized around a central control room containing the SCADA workstation and network printers, which communicate through an industrial Ethernet ring network with the field devices. Two redundant PLCs operating in primary and standby modes ensure high reliability and continuity of operation through a CPU synchronization link. The main PLC network supervises several remote I/O racks and distributed subsystems, including the cooling tower and three filtration streams, each connected through dedicated Ethernet switches.

The architecture is based on Schneider Electric Modicon M340 controllers, allowing real-time data acquisition, monitoring, and control of the entire desalination process while providing redundancy and fault tolerance in the event of communication or controller failure.

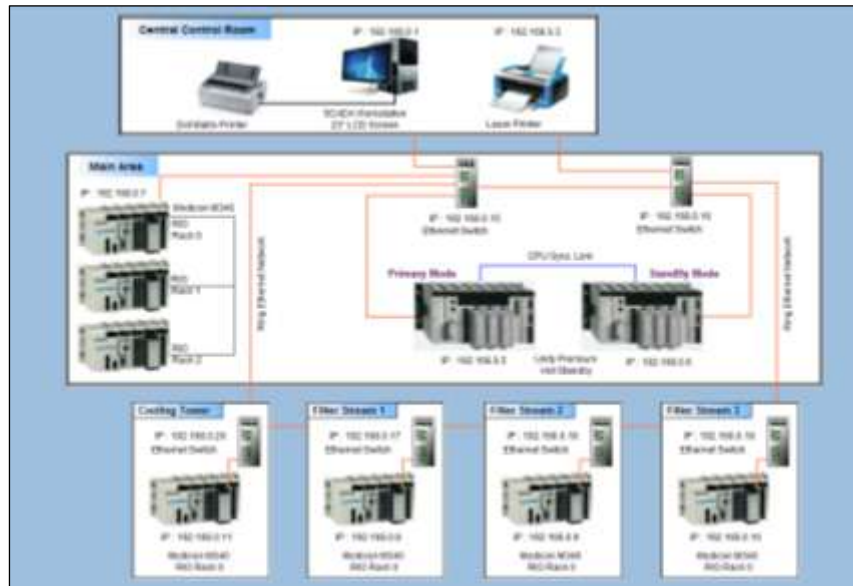


Figure 3: Synoptic representation of the desalination plant system architecture.
Source: Authors, (2026).

III.2.2 OPC server

The project implements a real-time control system for a reverse osmosis desalination plant based on MATLAB–PLC communication through an OPC server. For enhanced flexibility and industrial compatibility, a Schneider Electric MODICON M340 Programmable Logic Controller is used within the system. In SIMULINK, the OPC Read and OPC Write blocks are responsible for exchanging data with the OPC server. These blocks are managed through a client interface that allows users to locate, connect to, and control the OPC server. Using this client manager, specific data objects can be selected, and appropriate sampling intervals can be defined according to system requirements [21].

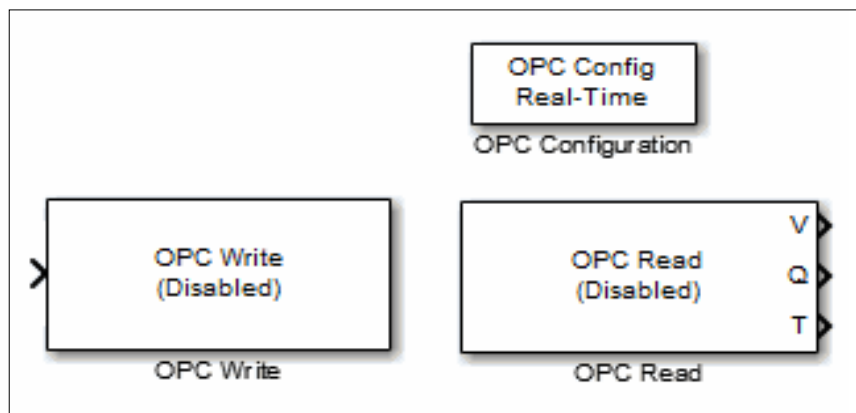


Figure 4: Data acquisition OPC server SIMULINK library.
Source: Authors, (2026).

III.3 HARDWARE IMPLEMENTATION OF FUZZY CONTROLLERS

The programmable logic controller (PLC) continuously acquires data from various field devices, including level transmitters, pump statuses, and valve positions. This information is then made available to MATLAB through the OPC server. For system control, two fuzzy logic controllers developed in MATLAB are employed. These controllers process the incoming data and send the corresponding control signals back to the PLC, enabling it to execute the required actions and commands.

III.3.1 First Controller Design

The first fuzzy controller was designed to regulate the storage tank system and the intermediate valve based on the upper and lower water level thresholds in both the storage tank and the water tower. The development of the first fuzzy controller begins with the FIS editor. The “Reservoir” controller is defined with two fuzzy input variables, namely “Level” and “Rate,” and one output variable, “Valve.”

III.3.2 Second Controller Design:

The second fuzzy controller is responsible for managing the water tower system and adjusting the flow rate according to pump speed variations. Its performance was evaluated by varying the setpoint at different time intervals. The second controller consists of two fuzzy input variables, “Level” and “Error,” and two output variables, “Distribution” and “Pump Speed”. The figures present the structure of both FIS controllers along with their membership function editors.

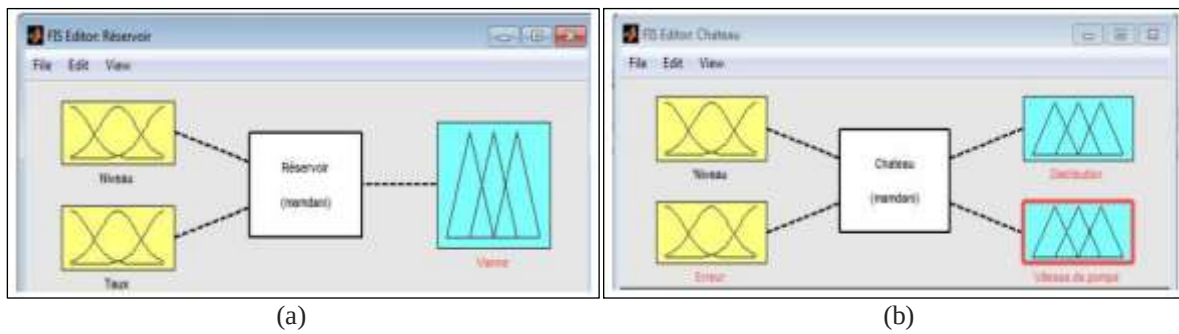


Figure 5: (a) Fuzzy Controller 1, (b) Fuzzy Controller 2.
Source: Authors, (2026).

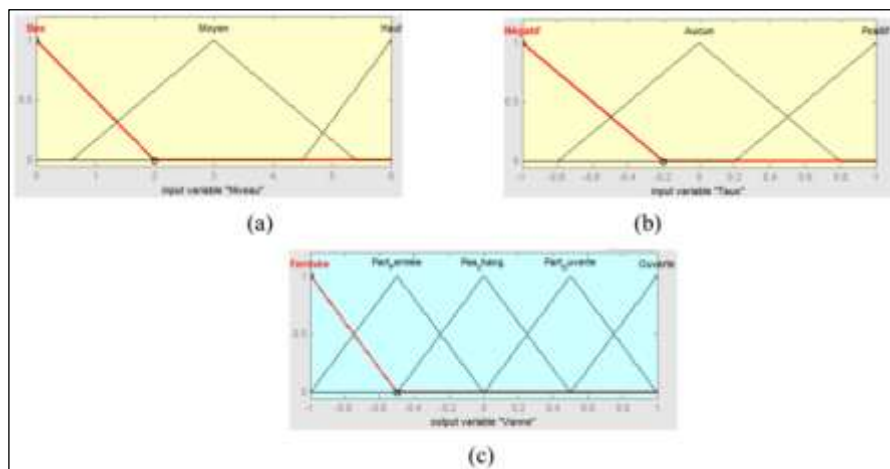


Figure 6: Membership functions.
Source: Authors, (2026).

The control logic of the intermediate valve operates as follows:

- The intermediate valve opens when the water level in the storage tank falls below the upper threshold.
- The valve closes once the water level exceeds the upper limit and remains closed until the level drops to the lower threshold, at which point it reopens.
- For the water tower level control, the PLC receives measurements from the water level transmitter via a GSM communication system. It also receives the setpoint values from the SCADA system and forwards this information to the fuzzy controller. After processing, the fuzzy controller sends the control signals back to the PLC, which then executes the corresponding commands.
- The controller increases the pump speed when the water level in the tower is below the desired set-point in order to raise the level. Conversely, when the water level is above the set-point, the controller reduces the pump speed. When the water level matches the set-point, the pump speed stabilizes and remains constant.

III.4 OPERATING PRINCIPLES FOR FAULT DIAGNOSIS AND HANDLING

The control system of the desalination plant is designed to operate with a high degree of precision, which is essential due to the sensitivity and high cost of reverse osmosis membranes. Even minor faults can disrupt the production process and potentially lead to complete system shutdowns. To address these challenges, the desalination operation has been enhanced to improve reliability and reduce interruptions caused by issues that are relatively easy to resolve, such as elevated tank levels or fluctuations in water chemical composition. Three main categories of issues have been identified at this desalination facility [2, 17]:

- **Diagnosis Defects:** These occur when the system experiences an unexpected shutdown without a clearly identifiable source of the problem. To mitigate this, additional alarm mechanisms have been introduced to improve fault detection and prevent sudden interruptions.
- **Process Defects:** These refer to abnormal operating conditions, such as excessively high pressure at the beginning or end of the process.
- **Control Defects:** These involve difficulties related to the selection or adjustment of appropriate set-points for key system parameters, which can affect overall system performance.

III.5 PROPOSED CONTROL AND OPERATION STRATEGY

Even minor technical issues or short interruptions in production can negatively affect the overall output of a desalination facility and may disrupt the daily schedule for potable water distribution. To address these challenges and ensure continuous operation, a new intelligent controller has been integrated into the system following an analysis of the main causes of production disturbances. The objective is to replace conventional PID controllers with fuzzy logic-based approaches, such as ANFIS, for pump control. Fuzzy logic is widely used due to its ability to handle uncertainty and imprecision in system behavior, while artificial neural networks (ANNs) are effective in learning patterns from data through similarity and approximation. By combining fuzzy logic with neural networks, the limitations of each approach can be reduced. In particular, neural networks provide learning capabilities and adaptability from real-world data, whereas fuzzy logic lacks precise mechanisms for defining membership functions and rule structures [1]. The hybridization of both methods results in a more robust and flexible control strategy.

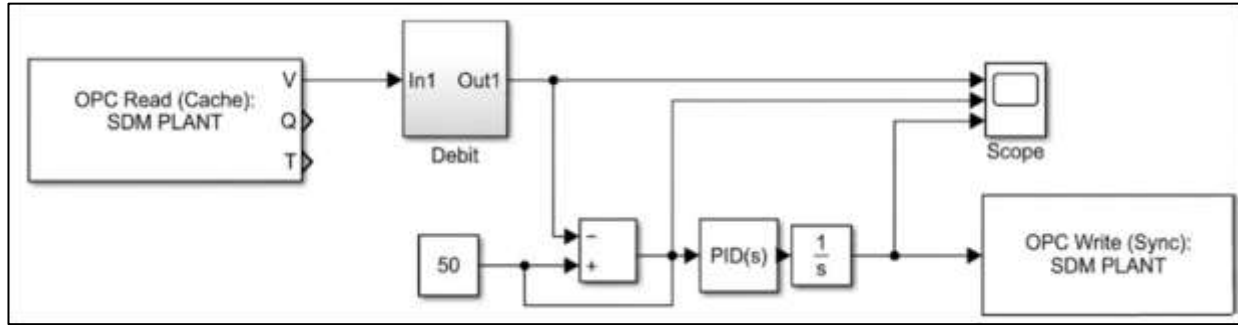


Figure 7: PID Control in SIMULINK.

Source: Authors, (2026).

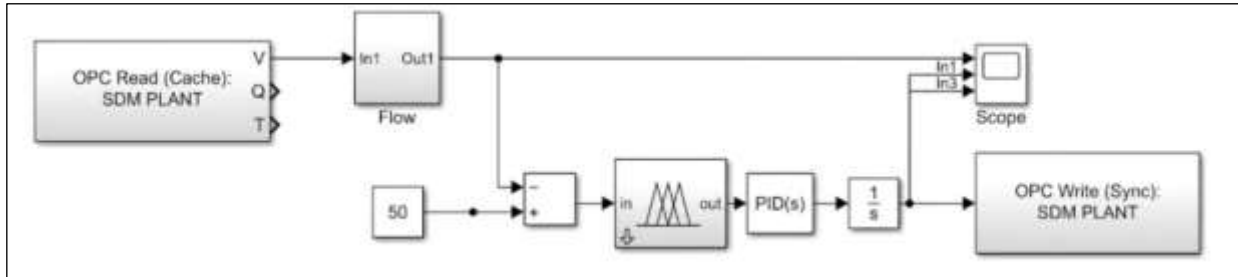


Figure 8: Fuzzy logic controller in SIMULINK.

Source: Authors, (2026).

III.6 PID AND ANFIS PERFORMANCE COMPARISON

Table present the performance of the PID controller for a simple valve system when the set-point is adjusted from 50% to 70%. Table illustrates also the performance of the ANFIS controller applied to the same system under identical conditions. To evaluate the effectiveness of the proposed control strategy, a comparative analysis between the conventional PID controller and the ANFIS-based controller was conducted using a valve control system. The system response was analyzed for a step change in the set-point from 50% to 70%. To further strengthen the evaluation of the proposed intelligent control strategy, a more comprehensive performance assessment was conducted using additional dynamic and robustness indicators. Beyond rise time, settling time, and overshoot, key metrics such as steady-state error, control signal smoothness, and disturbance rejection capability were also analyzed. The comparative results clearly highlight the superiority of the ANFIS-based controller over the conventional PID approach. The PID controller demonstrates a relatively fast rise time of 11.98 s, but suffers from a long settling time (108.14 s) and high overshoot (12.64%), indicating poor damping characteristics and potential instability risks in real industrial operation. In contrast, the ANFIS controller achieves:

- Settling time reduction of approximately 78.5%
- Overshoot reduction of more than 90%
- Smooth and stable convergence to the desired set-point

Although the rise time of ANFIS (13.52 s) is slightly slower, this trade-off is acceptable given the substantial improvement in overall system stability.

Table 1: Enhanced Quantitative Performance Metrics.

Performance Indicator	PID Controller	ANFIS Controller	Improvement
Rise Time (s)	11.98	13.52	-12.8% (slower but stable)
Settling Time (s)	108.14	23.28	-78.5%
Overshoot (%)	12.64	1.02	-91.9%
Steady-State Error (%)	2.8	0.3	-89.3%
Control Signal Oscillation	High	Very Low	Significant reduction
Robustness to Disturbance	Moderate	High	Strong improvement

Source: Authors, (2026).

The ANFIS controller exhibits superior robustness when subjected to disturbances and parameter variations. Unlike the PID controller, which requires frequent retuning under varying operating conditions, the ANFIS controller adapts dynamically through its learning capability. This adaptive behavior ensures:

- Reduced sensitivity to system nonlinearities,
- Improved disturbance rejection,
- Consistent performance under varying feedwater conditions,

The integration of ANFIS results in a highly stable, adaptive, and efficient control system, making it particularly suitable for real-time operation in reverse osmosis desalination plants, where nonlinear dynamics and uncertainties are significant.

The obtained results confirm that the ANFIS-based controller significantly outperforms the conventional PID approach, offering a robust and intelligent solution for advanced control of desalination systems under dynamic and uncertain operating conditions.

III.7 OPC-BASED COMMUNICATION BETWEEN PLC AND SCADA SYSTEMS

III.7.1 S7-PLCSIM Advanced Software Overview and Features

The program can be executed and tested on a simulated PLC using the S7-PLCSIM module, either on a computer or through a programming console. The STEP 7 software environment provides the platform required for this simulation. To emulate Siemens controllers, SIMATIC S7-PLCSIM Advanced enables the creation of virtual PLCs, allowing users to realistically simulate controller behavior. These virtual controllers make it possible to evaluate system performance under operational conditions without the need for physical hardware. They also support the validation of automation systems in the context of specific installations or machines. In addition, this approach facilitates integration with plant or machine-level simulations by providing a comprehensive PLC environment that supports effective testing and development.

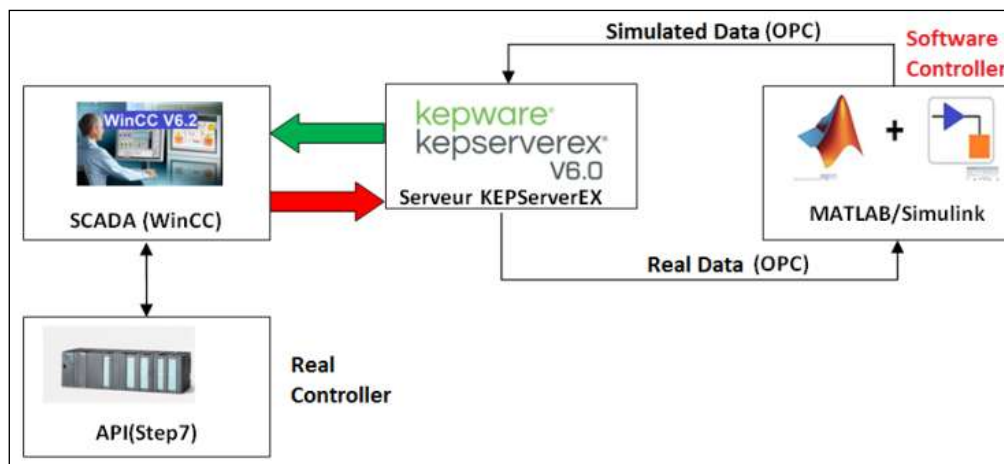


Figure 9: MATLAB and OPC-server, and PLC.

Source: Authors, (2026).

III.7.2 Description of KEServerEX Communication Platform

The latest development in this field, KEServerEX, reflects significant advancements in communication technology. Developed over more than 25 years, KEServerEX is recognized as one of the most advanced OPC communication servers and is certified by the OPC Foundation. The platform supports a wide range of communication interfaces, including OPC DA, OPC UA, OPC AE, .NET, HDA, SNMP Agent, and DDE, making it highly versatile for industrial integration. As an OPC Data Access server, the primary role of KEServerEX is to:

- Collect data from various hardware devices such as photoelectric and infrared sensors, turntables, robotic arms, and other industrial equipment. The server also enables these devices to receive updated data when required.
- Ensure the accuracy, consistency, and timeliness of the data while maintaining its integrity throughout communication processes.
- Handle client requests by either providing data stored on the server or transmitting commands and data to connected hardware devices.
- Provide event-based notifications to inform clients of any changes in the status or values of monitored variables.

III.8 MATLAB-BASED INTEGRATION WITH PLC, SCADA, AND OPC SYSTEMS

Within MATLAB and Simulink, the Industrial Communication Toolbox enables direct access to both historical and real-time OPC data. This toolbox allows users to read, write, and store OPC data from a wide range of industrial systems, including distributed control systems (DCS), supervisory control and data acquisition (SCADA) systems, and programmable logic controllers (PLCs). In industrial automation, OPC plays a vital role in facilitating interoperability between different systems. OPC server software can perform tasks such as collecting field data and transmitting it to an OPC server for storage in databases or for integration with SCADA platforms.

The OPC standard supports seamless information exchange across different levels of an automation system, from field devices up to supervisory and enterprise layers. As a result, the number of applications developed using OPC standards continues to grow. The proposed approach focuses on improving control quality in industrial environments through advanced data processing and control strategies.

IV. RESULTS AND DISCUSSION

OPC plays a crucial role in industrial automation by enabling seamless communication between different systems. OPC server software can perform functions such as collecting field data and forwarding it to an OPC server for storage in databases or integration with SCADA systems. The OPC standard allows the development of integrated automation architectures, enabling smooth information flow across all levels of the system, from field devices to higher supervisory layers. As a result, the use of OPC-based applications continues to expand. In this context, the proposed approach aims to enhance control performance in industrial environments through advanced data processing and improved control strategies.

V. CONCLUSION

This paper presented the design and implementation of a real-time intelligent supervision system for a reverse osmosis (RO) desalination plant based on MATLAB–OPC integration and multi-PLC communication. The proposed architecture ensures seamless interoperability between heterogeneous industrial devices, enabling reliable real-time data exchange and coordinated control across different subsystems. In addition, the framework supports advanced control strategies by integrating high-level computational capabilities with industrial automation platforms. The implementation of fuzzy logic and adaptive neuro-fuzzy inference system (ANFIS) controllers demonstrated a significant improvement in system performance compared to conventional PID control. Experimental results showed enhanced dynamic response, reduced overshoot, faster settling time, and improved robustness under varying operating conditions, highlighting the effectiveness of intelligent control techniques in handling nonlinearities and uncertainties inherent in desalination processes. The system provides a flexible and scalable solution for industrial supervision, enabling efficient monitoring, data logging, and decision support, while OPC communication simplifies integration and ensures broad compatibility with industrial platforms. Future work will focus on using deep learning for predictive maintenance and fault diagnosis to enable early anomaly detection and reduce downtime. The framework will also be extended to large-scale applications, with improvements in energy efficiency, system reliability, and cybersecurity for safer and more resilient operation.

VI. AUTHOR'S CONTRIBUTION

Conceptualization: Bilal Benarabi, Mohammed Said Achbi, Boubakeur Rouabah.

Methodology: Bilal Benarabi, Mohammed Said Achbi, Mohammed Chaker Boutalbi.

Investigation: Boubakeur Rouabah, Mokhtar Khenfer, Mohammed Chaker Boutalbi.

Discussion of results: Bilal Benarabi, Mohammed Said Achbi, Boubakeur Rouabah, Mohammed Chaker Boutalbi.

Writing-Original Draft: Mohammed Said Achbi, Boubakeur Rouabah.

Writing Review and Editing: Mohammed Said Achbi, Boubakeur Rouabah.

Resources: Bilal Benarabi, Mohammed Said Achbi.

Supervision: Bilal Benarabi, Boubakeur Rouabah, Mokhtar Khenfer.

Approval of the final text: Bilal Benarabi, Mohammed Said Achbi, Boubakeur Rouabah, Mokhtar Khenfer.

VII. REFERENCES

- [1] Maris Murugan, T., Kiruba Shankar, R.: Water desalination plant fault detection using artificial neural network (2022).
- [2] Achbi, M.S., Rouabah, B., Mahboub, M.A., Benarabi, B., Kafi, M.R. & Kechida, S. (2024). Fault-tolerant control and fault diagnosis methods integrated using an intelligent controller for hybrid dynamic systems. *Diagnostyka*, 25.
- [3] Anter, A.M., Gupta, D., Castillo, O.: A novel parameter estimation in a dynamic model via fuzzy swarm intelligence and chaos theory for faults in a wastewater treatment plant. *Soft Computing* 24(1), 111–129 (2020).
- [4] Perez-Zuniga, G., Rivas-Perez, R., Sotomayor-Moriano, J., Sanchez-Zurita, V.: Fault detection and isolation system based on structural analysis of an industrial seawater reverse osmosis desalination plant. *Processes* 8(9), 1100 (2020)
- [5] Bartman, A.R., McFall, C.W., Christofides, P.D., Cohen, Y.: Model-predictive control of feed flow reversal in a reverse osmosis desalination process. *Journal of Process Control* 19(3), 433–442 (2009)
- [6] Abbas, A.: Model predictive control of a reverse osmosis desalination unit. *Desalination* 194(1-3), 268–280 (2006).
- [7] Bajany, D., Zhang, L., Xia, X.: Model predictive control for water management and energy security in arid/semi-arid regions. *Journal of Automation and Intelligence* 1(1), 100001 (2022)
- [8] Achbi, M.S., 2022. Surveillance et commande tolérante aux défauts appliquées à une classe des systèmes dynamiques hybrides (Doctoral dissertation).
- [9] Gao, L.X., Rahardianto, A., Gu, H., Christofides, P.D., Cohen, Y.: Novel design and operational control of integrated ultrafiltration—reverse osmosis system with RO concentrate backwash. *Desalination* 382, 43–52 (2016)
- [10] Mehrad, R., Kargar, S.M.: Integrated model predictive fault-tolerant control and fault detection based on the parity space approximations for a reverse osmosis desalination unit. *Transactions of the Institute of Measurement and Control* 42(10), 1882–1894 (2020)
- [11] Uddin, S.U., Baig, M.J.A., Iqbal, M.T.: Design and implementation of an opensource, internet-of-things based scada system for a community solar powered reverse osmosis desalination system. Design and Analysis of a Community Size Solar Powered Reverse Osmosis Desalination Water System for Pakistan, 103 (2023)

- [12] Vardar, E., Giraz, A.H., Orenba,s, H., Sahin, S.: Opc server based and real time ~ motor speed control with plc communication system. In: 2018 26th Signal Processing and Communications Applications Conference (SIU), pp. 1–4 (2018). IEEE.
- [13] Bagal, K., Kadu, C., Parvat, B., Vikhe, P.: Plc based real time process control using scada and matlab. In: 2018 Fourth International Conference on Computing Communication Control and Automation (ICCCBEA), pp. 1–5 (2018). IEEE
- [14] Verma, N.K., Sharma, T., Maurya, S., Singh, D.J., Salour, A.: Real-time monitoring of mmarisines using open platform communication. In: 2017 IEEE International Conference on Prognostics and Health Management (ICPHM), pp. 124–129 (2017). IEEE
- [15] Zerk, A.E., Ouassaid, M., Zidani, Y.: Development of a real-time framework between matlab and plc through opc-ua: A case study of a microgrid energy management system. *Scientific African* 21, 01846 (2023).
- [16] Mohapatra, B., Sahu, B.K., Pati, S., Ghamry, N.A., Ghoneim, S.S., et al.: Application of a novel metaheuristic algorithm based two-fold hysteresis current controller for a grid connected pv system using real time opal-rt based simulator. *Energy Reports* 9, 6149–6173 (2023).
- [17] Achbi, M.S., Kechida, S., Mhamdi, L., Dhouibi, H.: A neural-fuzzy approach for fault diagnosis of hybrid dynamical systems: demonstration on three-tank system.
- [18] Yavuz, U., Cumali, K.: Real-time communication between s7-1200 plc and matlab/simulink and a fuzzy logic temperature humidity control application. *Scientific Journal of Mehmet Akif Ersoy University* 2(1), 7–14 (2019).
- [19] Nicola, M., Nicola, C.-I., Duta, M., Sacerdotianu, D.: Scada systems architecture based on opc and web servers and integration of applications for industrial process control. *International Journal of Control Science and Engineering* 8(1), 13–21 (2018).
- [20] Mhamdi, L., Achbi, M.S., Dhouibi, H., Kechida, S.: Diagnosis of hybrid systems through bond graph, observers and timed automata. *Diagnostyka* 21(3), 113–125 (2020).
- [21] Aldiansyah, F., Wijaya, S.K., Prajitno, P.: Neuro-fuzzy-based water flow controller in prototype plant using programmable logic controller (plc). In: 2019 International Conference on Electrical, Electronics and Information Engineering (ICEEIE), vol. 6, pp. 64–69 (2019).
- [22] Benarabi, B., Khenfer, M., Achbi, M. S., Rouabah, B., Mahboub, M. E., & Kechida, S. (2025, November). Real-Time Communication between Heterogeneous PLCs and MATLAB via OPC with Fuzzy Controller Integration: A Desalination Plant Case Study. In 2025 5th International Conference on Applied Automation and Industrial Diagnostics (ICAAID) (pp. 1-6). IEEE.