Implementation of Real Time Data Collection Process Automation Control Using IIoT Applications

Suppachai Howimanporn, Sasithorn Chookaew, and Chaiyaporn Silawatchananai
Department of Teacher Training in Mechanical Engineering, Faculty of Technical Education, King Mongkut's University of Technology North Bangkok, Bangkok, Thailand
Email: {Suppachai.h, Sasithorn.c, Chaiyaporn.s}@fte.kmutnb.ac.th

***Abstract*—There is an ongoing debate between PLC and PC-based controls, and the chances are that process will benefit from integrating industrial data collection with IT. However, choosing to collect production data, specifying and programming machine controls like PLC can be a challenge. Therefore, developing to improve quality and efficiency by integrating communication technologies and databases with automation is an integral part of improving work and product quality. This research presents the application of PLC control devices that are widely used in industry. To develop and communicate with the popular database management system, SQL Server, to increase the efficiency and loss of closed-loop control systems with PID controllers for real-time liquid level control processes containing sensors. Level and a DC electric motor that can adjust the speed of 0-12 VDC using Omron NX 102 PLC according to the IEC 61131-3 standard that supports Industrial Internet of Things (IIoT) and machine-to-machine (M2M) communication to develop and prove. To the potential and ability of the work from the test results, it was found that the use of a database system to communicate control can be applied to control very well. Moreover, when experimenting with the conditions of using the actual liquid flow all the time. The database system can transmit the appropriate control gain to the process, thus satisfying the test results of the water retention of both tanks.**

***Index Terms*—database, automation, programmable logic controller, smart factory, IIoT**

I. Introduction

The important key of automation systems leading to Industry 4.0 is that the use of control devices be able to communicate for providing all the physical data from on-site production line to record and analyze in order to improve the performance. Aspects such as Operational accuracy can work to the right amount of output to be controlled. Including the durability of the control system can maintain operation under unusual circumstances that may not have been designed in advance. In addition, data can be used to increase service life with intelligent control systems. In control systems and production lines, a programmable logic controller is used to control and process devices connected to devices on machines. Industrial production line quickly and easily. All volumes of data can be programmed to meet the requirements of the workflow. In order to use the data contained in the programmable logic controller's memory for further analysis, it is necessary to communicate between controllers or send data to be stored in a form. Those are ready to be analyzed and sent back to control or make decisions for machines or production processes to be intelligent. Therefore, data communication is essential. The critical factor in signal communication is the speed and communication method to achieve the most real-time performance. In addition, the development of communication channels is another way to make industrial production lines more flexible and convenient to use.

Many research studies focus on the improvement of communication systems or implementation to industrial applications. The authors [1] applied the communication with the Open Platform Communication Unified Architecture (OPC-UA) standard architecture to apply the data to adjust the parameters to be suitable with the mechanical dynamic operating conditions. The work in [2] utilized voice command database and eye tracking techniques with Internet of Thinks to control the home appliance for elder and special needs people. Similarly, in the research [3], performance reporting data was rendered in real-time using the Android operating system's Internet. The data obtained from the communication compares predicting and quantifying vehicle movement loss in agricultural farms [4]. The research paper in [5] presented the results of the use of Wi-Fi networks accordingly. IEEE 802.11b/g was publicly available to provide positioning services with IIoT (Industrial Internet of the Things) by studying the effectiveness of Voice over IP over wireless networks. The work in [6] proposed Fuzzy Rule-Based method for adjusting the light intensity of the street lights according to the actual climate. The information is processed and communicated via the Internet of Things. The research in [7] proposed the real-time temperature monitoring systems for patients admitted to hospitals. The communication system has been connected with a microcontroller to alert physicians via text messages in case of an emergency when the patient's temperature value is exceeded.

Manuscript received August 17, 2021; revised January 4, 2022.

doi: 10.12720/jait.13.2.117-124

A. Communication Signal-Processing

Signal-processing perspectives unique signal-processing needs arise from the IoT ecosystem. These include robust working and sensing. The data created in a format that is ready to be used or in a popular communication format makes it more convenient and quicker when large storage volumes are required. The work in [8] studied the performance of Big Data Processing in Distributed Environments. The research in [9] proposed the wavelet compression by sequencing the data in wireless communication to reduce transmission. Their results showed that the compressed data within the network makes the efficiency of use better. In industrial internet of thing systems, data transmission and sharing among machines are critical to the whole system's performance. Therefore, research and investigations in this area are gaining interest as new machine-to-machine standards and protocols emerge, combined with affordable sensing and communication modules to ensure the excellent quality of the collected data and information. Fig. 1 shows the industrial controller network.

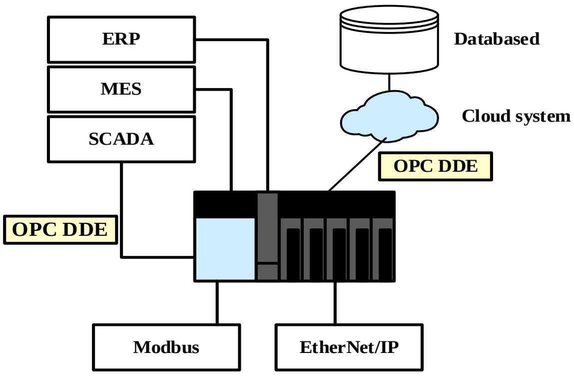

Figure 1. Industrial controller network.

Signal processing plays a critical role as Industrial Internet of Thing (IIoT) enabler despite being overshadowed by other aspects of IIoT, including communication architectures, sensing technologies, and power management. The machine learning approaches can support predictive and prescriptive analytic solutions by connecting previously stranded data from sensors, equipment, and other assets to enable condition monitoring, failure diagnostics, efficiency improvement, and downtime reduction. By anticipating failures, these approaches assist with continuous improvement at both design and manufacturing levels.

B. Industrial Internet of Things

Industrial Internet of Things (IIoT), industry 4.0 digital manufacturing, are buzz words that every marketing executive likes to use. However, their extensive adoption today has made them into applicable technologies, allowing manufacturers to achieve the universal goal of higher productivity. It has been about data from the very beginning. The plant of a factory is a need for use IIoT. For any IIoT changeover to succeed, factories need to be evident regarding goals. The objective of application IIoT is essential to a working relationship form that would allow multidisciplinary field because, after factory applies IIoT is a conjunction of multi-functions such as resources working together are engineers, technicians, System integrator, and management. Predictive analytics can evaluate data to utilize and intelligence to achieve the objective of improving efficiency. Predictive analytics involves improving the quality of processes and demand forecasting, both of which enhance an organization's productivity by real-time processing data collected from sensors spread throughout the factory. An intelligent system might use as a database of data collected increases, the extent of automation increases, allowing the intelligence of manual processes to increase. For example, systems can tune to slow down machine operation if failure is approaching automatically. Research [10] presents data management with a distributed priority for categorizing heterogeneous workloads using data through IoT, where segmentation is simplified based on complexity and works accordingly. At [11], the big data optimal delay reduction results in disaster area case studies present for solving problems, use time efficiently. Applying communication to data collection, compilation, computation, analysis, and further implementation requires consideration of the potential efficiency.

C. Programmable Logic Control

Functionality is necessary for measurement is required. Process control requires optimal parameters or information in real-time. Therefore, the control device is widely used. One of the most popular industrial and process engineering devices is PLC [12] because it is environmentally resistant and can communicate over various networks. It has IoT functionality to support real-time operation. It can also connect to the database. Programming to be intelligent using PLCs widely uses. For example, the research [13] application PLC to control the automation of liquid distillation systems involved in the methanol-water separation process. Research. [14] presents modular automation for reuse in production systems with object-oriented production automation software models. Research. [15] presents Machine Learning for Prevention Systems on PLC. Considering applications and software modules, research [16] presents the implementation of traditional PLCs for communication protocols capable of implementing IoT functions to support data communication. [17] propose a master PLC fault detection approach to detect and change the network and access control operation in transient operation.

Figure 2. Programmable logic controller factory network.

Fig. 2 shows a PLC used in an industrial network control communication which also supports IoT functionality. The intelligent control can be implemented in this PLC to increase the performance, robustness and to predictive. There are many applications of control and intelligence in research, and what requires the use of information obtained from communication or recorded for analysis. This information is used to determine the appropriate controller parameters. The research in [18] applied the working principle of PID and the artificial network to the analysis for decision-making in learning image processing. The work in [19] presented production belt speed control optimized PID controller gain by PSO. The research in [20] presented the using of data to determine the optimal parameters gain of the PID controller.

II. Methodology

A. Structure of Communication Database

In this research, the simulations of fluid flow have performed the communication for recording the experimental data in the database system. In terms of industrial process control, flow rate or level controls are necessary. Several studies have used the data communication to solve problems.

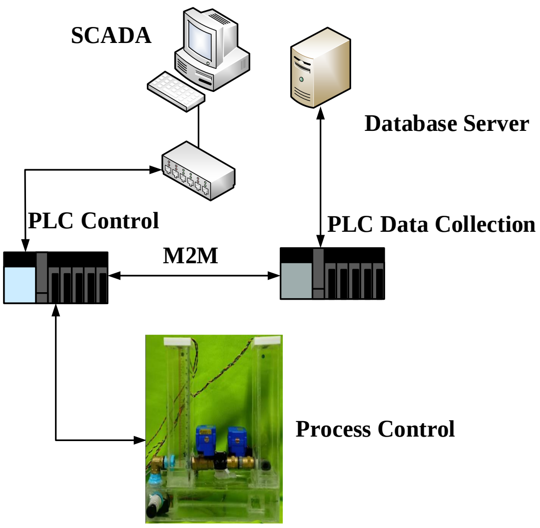

Figure 3. Communication structure of process level control.

For example, the study in [21] presented the liquid level in water tanks using fractional PID controller. The work in [22] derived the equation of PID controller Characteristics for Real-Time Tank Level Control. The research in [23] presented an optimized control for two tank controls by analyzing data from real-time controls. Fig. 3 shows the data communication connection structure used to control the process flow to control the water level of two water tanks. For scenario simulation, two PLCs are required by connecting together via the network. The first PLC handles with the process control by maintaining the water level at the target value. This unit can command and display in real-time via SCADA. The second PLC handles with the communication by receiving and transmitting the parameters from the first PLC. This information is imported into the databased and for further use.

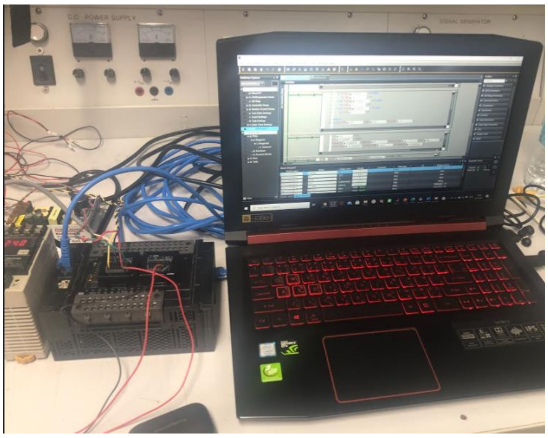

Figure 4. Communication between PLC and software program.

Fig. 4 shows the installed PLC in process control where the liquid level in the tank is sensed by converting into a quantitative electrical signal. This analogue signal is converted into a digital signal with a module inside the PLC. This PLC can communicate to computers for programming, processing and display via IP Ethernet communication for control in real-time.

B. Data Collection PLC and SQL Server

For industrial applications, PLCs are often used in production control systems or machines according to the user's requirements. In process improvement, the production data is required for analysis, increasing the performance, minimizing the loss or increasing the stability. Therefore, PLC network communication sending data to the database system has been introduced such as Structured Query Language (SQL) application. This application can be used for communication between PLC to the server, the master PLC to among PLCs, etc. Fig. 5 shows the internal settings of the master PLC communicate with the database system or Server. The details used to set up communication between PLC and SQL server are shown in Table I.

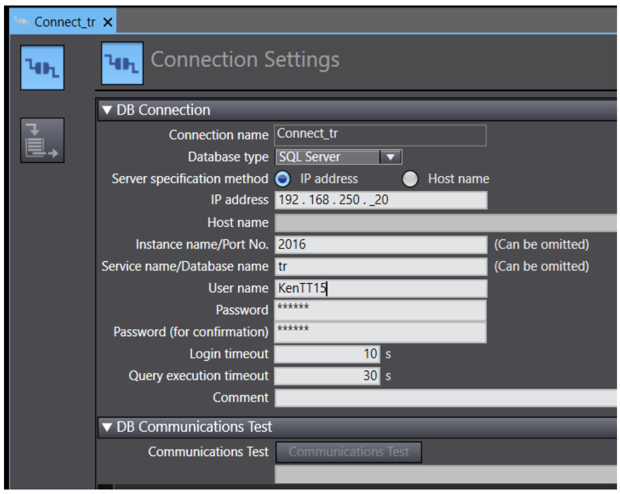

Figure 5. Connection setting PLC and SQL server.

TABLE I. CONNECTION SETTING OF PLC AND SQL SERVER

No	Function parameter of connection		
	DB connection	Example Parameter	
1	Name of data base	Connect-TR	
2	Database type	SQL Server	
3	Encrypted communication	Do not use	
4	IP Address	192.168.250.20	
5	Instance name/ Port No.	2016	
6	Service Name/Database name	IP Address	
7	User name:	KenTT15	
8	Password:	123456	

SQL server's toolbox can link the data memory inside of the PLC to the database system by defining the format of the database system. Table I presents the parameters of connection by illustrating the name of the database system, type of database, the location of the server, Instance name or port number, username and password. When PLC connected to the database system, the control parameters can be imported the database system and displayed in SQL Server as shown in Fig. 6.

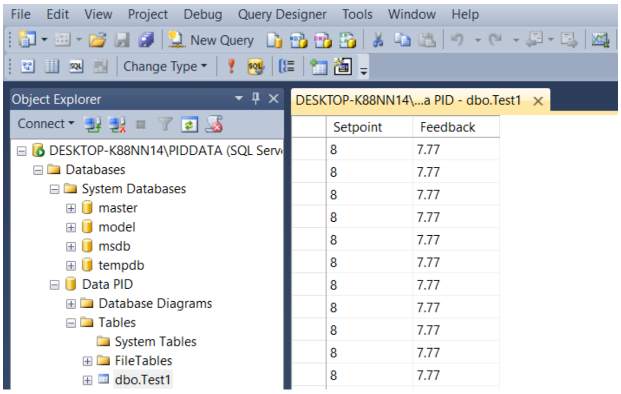

Figure 6. Result of parameter value PLC to SQL server.

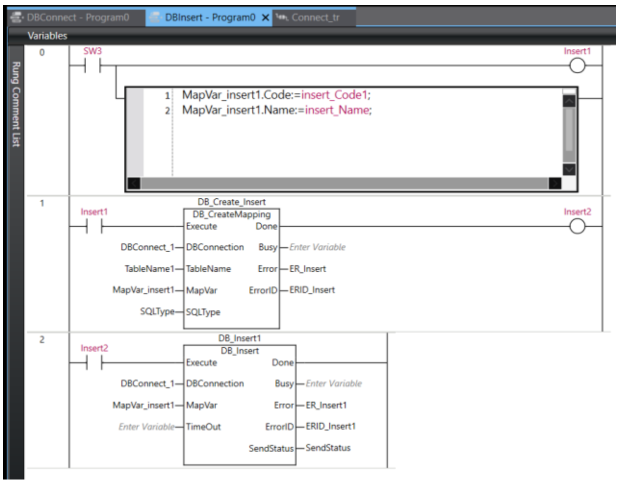

Figure 7. PLC programming communication between PLC and server.

Real-time process changing control parameters addressing in PLC memory communicate to SQL Server. Programming commands to control the connection communication can provide using ST language or function blocks to execute commands. An operating system within a PLC where signals use to instruct the database system to execute instructions sent from the PLC. Fig. 7 illustrates how to write commands to operate the database system inside SQL Server.

Programing operations can be done either in a database system or can be commanded by instruction through a PLC. It can be commanded remotely via SCADA data transmission, enabling efficient control of the process and the use of the database system.

C. *Manufacturing Process Control*

There are many types of process control in industrial application: fluid flow control or liquid level control. Due to the use of process fluids for engineering purposes, it is sensitive to the efficiency and quality of the produce. To maintain the level be stable, it could be noisy in measurement, nonlinearity and changing in condition in complex environment. In this study, two-tank level control system is chosen as industrial process scenarios such as flow rate, velocity and noise signal. Fig. 8 represents the two-tank prototype for testing communication and control.

Figure 8. Level control process prototype.

In maintaining the liquid level, let us start by installing a sensor to measure the level in both tanks. The equipment consists of a flow sensor to use for measuring parameters to analyze, calculate, and send signals to calculate and control optimal DC motor speed to maintain the level of liquid delivery into the process. The working can adjust the target level of liquid consumption, test the communication and control of the database system usage and bring it back to analysis to manage system controls further.

D. *Controller Design for Improving*

Controller design research topics aim to improve the performance and the stability of industrial processes. Even though PID controller l is the most popular and widely used, research on tuning of optimal gain controller is still a challenging topic. For example, the research topic in [24] presented data prediction of intelligent PID controller gain parameters using the NARX technique. The work in [25] proposed the decentralized PID control design to tune the parameters for each suspension point in magnetic levitation systems. In the study [26], real-time data analysis was presented to predict the optimal parameters in Fuzzy PID controller for traction control in permanent magnetic maglev trains. The work in [27] proposed PLC embedded fuzzy controller to adjust the directional wheel conveyor in real-time. Thus, the data of any process can be used for analysis via communication system, storage in the database. Fig. 9 presents the block diagram of PID controller cascaded with the mathematical model of two-tank system.

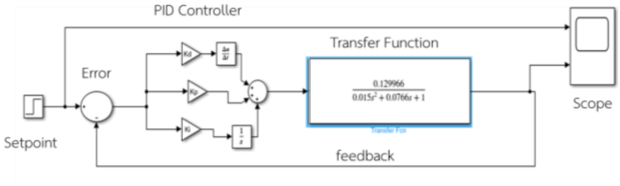

Figure 9. PID controller design to process control.

Equation (1) represented PID controller for process control in time-domain.

$$u(t) = K_p . e(t) + K_i \int_0^t e(\tau) d(\tau) + K_d \frac{d}{dt} e(t) \qquad (1)$$

where $e(t)$ is the error between the set point value and the actual output, K_p, K_i and K_d is the proportional, integral and derivative terms, respectively. $u(t)$ is the control input, which is provided by PID controller. This signal is used as the voltage input for motor. PID controller gains can be defined from the derive by closed-loop the transfer function.

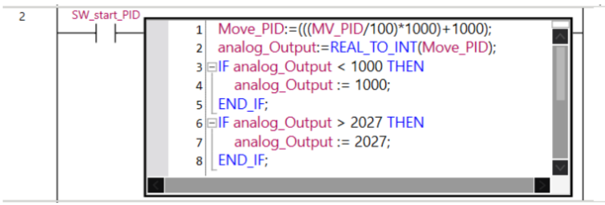

Figure 10. Closed-loop PID controller programming PLC.

The PID controller can program from the PLC by defining the working variables and correlation conditions to analyze and calculate the appropriate values. All variables store SQL database with PLC functions. Fig. 10 shows the programming of the controller onto the PLC.

III. Result and Discussion

The experimental results divide into two parts: the connection result and the transmission of data from the control function variables such as digital signal, quantitative data, character data back and forth between PLC and SQL Server. The data obtained were used in control with the PID controller by defining the targets of the liquid level in both tanks of the control by illustrating three control level targets, High, Medium, and Low, to facilitate the use. Control connection. The fluid is always on in this design, and all parameters controller the same except the target level setting. The PID control gain values are derived from mathematical model calculations and are included in the database system for utilization according to the conditions of the target signal.

A. Data Collection PLC and SQL Server

The experiment of collect data by using the control parameters calculated from the program written according to the data communication connection with SQL Server can demonstrate by using the command and how to use ST display command code and connect data with DB Connect command. Fig. 11 shows the result of process instrumentation and collection control data.

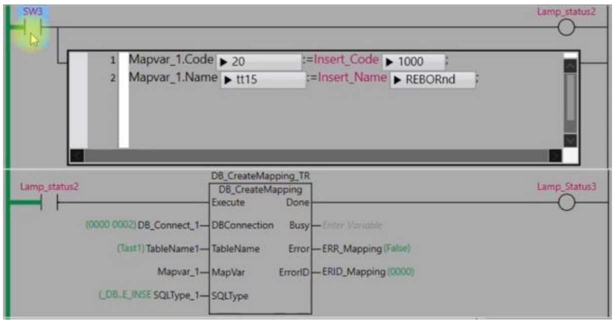

Figure 11. Result of process instrumentation and collection control data.

The sending and receiving data from SQL Server to the PLC can be done by defining insert, updating mapping or deleting data by commands from sensors, command devices, and programming conditions written to control the process according to the desired target signal. Fig. 12 shows the results of communication with each other in real-time.

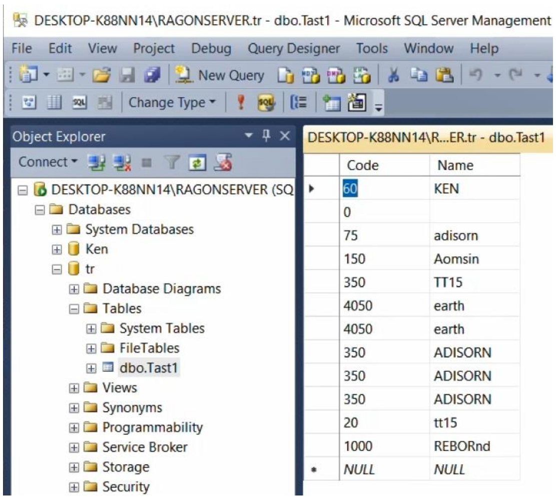

Figure 12. Result of data connection SQL server.

B. Process Control System

This research has used a closed-loop control system with a PID controller by using a control gain from a database system. The experiment determines the desired target signal. The PLC installs the gain parameters from the database system to control the running water level in real-time. The results of the liquid level process experiment in the first tank at the target values of 5, 7, and 10 cm, it can be shown in Fig. 13-Fig. 15, respectively.

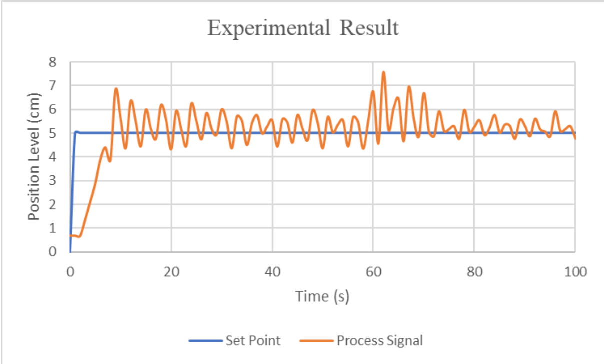

Figure 13. Experiment result PID controller of real time level control of a first tank setpoint 5cm.

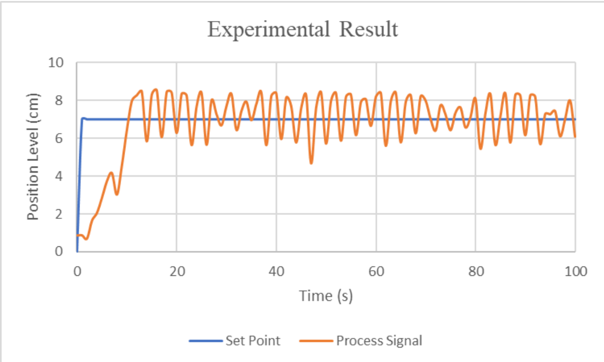

Figure 14. Experiment result PID controller of real time level control of a first tank setpoint 7cm.

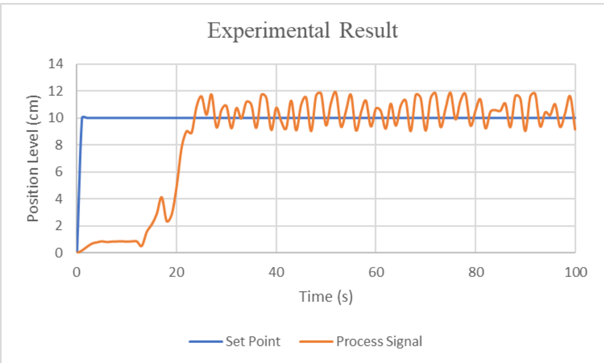

Figure 15. Experiment result PID controller of real time level control of a first tank setpoint 10cm.

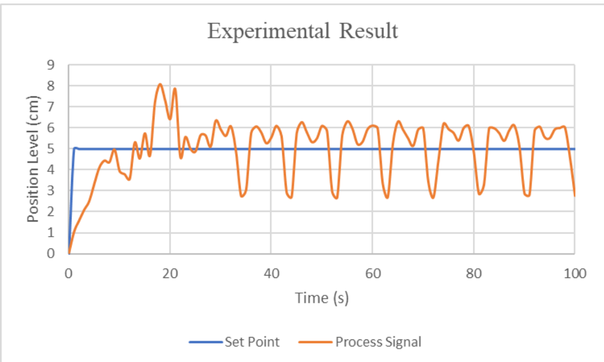

Figure 16. Experiment result PID controller of real time level control of a second tank setpoint 5cm.

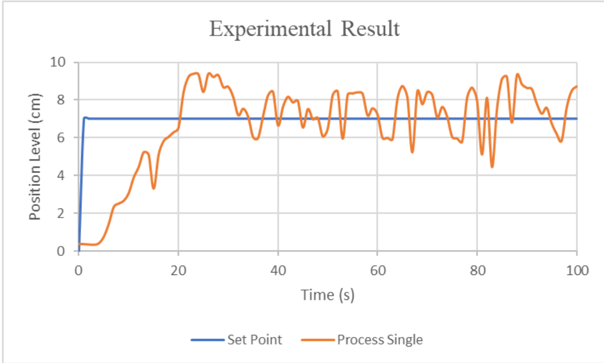

Figure 17. Experiment result PID controller of level control of a second tank setpoint 7cm.

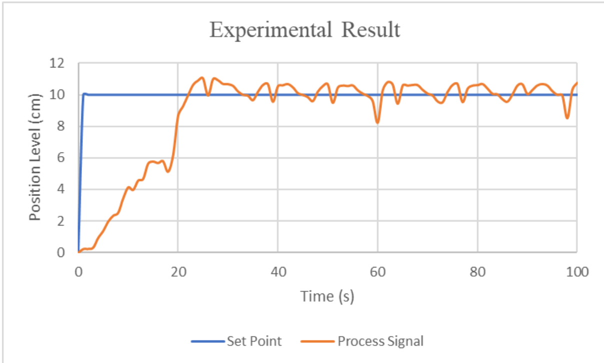

Figure 18. Experiment result PID controller of real time level control of a second tank setpoint 10cm.

Fig. 16-Fig. 18 show the results of the closed-loop control experiment to control the water level of the 2nd tank at target values of 5, 7, and 10cm by using the PID control gain from the SQL database, respectively.

The process control experiment presents that the process control is able to maintain the liquid level in both tanks. The data from the database system can support to control of real-time effects. The data collection and control of the PID controller attempts to communicate between the PLC and SQL Server with fluids on the process throughout the experiment.

IV. Conclusion

This research presents communication of real-time level process control using a database system using PLC as a control device. The results showed that data communication from PLC and SQL Server could be used in control work very well. Experimenting with closed-loop control by PID controllers and liquid flow can control signal quality in real-time operating conditions by communicating stored and used data with SQL Server. All data can be stored onto the server and used to deliver the appropriate control gain to the server PLC central control. It is also possible to use PID controllers that need to enter the appropriate gain value from mathematical modeling and put it in the database to control according to the specified conditions. The results demonstrated the benefits of using a database system in real-time control.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

S. Howimanporn conducted the research. S. Chookaew and C. Silawatchananai analyzed the data and approved the final version. The authors were involved in the drafting of drafting of the manuscript and had approved the final version.

ACKNOWLEDGMENT

This research was funded by King Mongkut's University of Technology North Bangkok. Contract no. KMUTNB-64-DRIVE-20.

REFERENCES

[1] Y. H. Lai, Y. H. Huang, C. F. Lai, S. Y. Chen, and Y. C. Chang, "Dynamic adjustment mechanism based on OPC-UA architecture for IIoT applications," in *Proc. 2nd International Conference on Computing, Analytics and Networks*, 2020, pp. 335-338.

[2] A. F. Klaib, N. O. Alsrehin, W. Y. Melhem, and H. O. Bashtawi, "IoT smart home using eye tracking and voice interfaces for elderly and special needs people," *Journal of Communications*, vol. 14, no. 7, pp. 614-621, July 2019.

[3] D. A. Martillano, J. M. R. Dita, C. G. Cruz, and K. S. Sadhra, "Android based real-time industrial emission monitoring system using IoT technology," *Journal of Communications*, vol. 12, no. 11, pp. 623-629, December 2017.

[4] S. Duangsuwan and M. M. Maw, "Comparison of path loss prediction models for UAV and IoT air-to-ground communication system in rural precision farming environment," *Journal of Communications*, vol. 16, no. 2, pp. 60-66, February 2021.

[5] D. P. Cerio, J. L. Valenzuela, and M. G. Lozano, "Audit of a real Wi-Fi deployment to provide data, VoIP communications and an IIoT item location service," *Journal of Communications*, vol. 12, no. 10, pp. 565-571, October 2017.

[6] K. Sultan, "Fuzzy Rule Based System (FRBS) assisted energy efficient controller for smart streetlights: An approach towards Internet-of-Things (IoT)," *Journal of Communications*, vol. 13, no. 9, pp. 518-523, September 2018.

[7] S. K. Gharghan, "Energy-Efficient remote temperature monitoring system for patients based on GSM modem and microcontroller," *Journal of Communications*, vol. 12, no. 8, pp. 433-442, August 2017.

[8] W. Li and W. W. Guo, "The experimental study of performance impairment of big data processing in dynamic and opportunistic environments," *Journal of Communications*, vol. 15, no. 11, pp. 776-789, November 2020.

[9] Y. Nie, H. Wang, and Y. Qin, "Data-Smoothness based preprocessing strategy for wavelet data processing in wireless sensor networks," *Journal of Communications*, vol. 9, no. 10, pp. 762-770, October 2014.

[10] D. Rustem, and S. Distefano. "Automating IoT data-intensive application allocation in clustered edge computing," *IEEE Transactions on Knowledge and Data Engineering*, vol. 33, no. 1, pp. 55-69, June 2019.

[11] J. Wang, K. Sato, S. Guo, W. Chen, and J. Wu, "Big data processing with minimal delay and guaranteed data resolution in disaster areas," *IEEE Transactions on Vehicular Technology*, vol. 68, no. 4, pp. 3833-3842, April 2019.

[12] B. F. Adiego, D. Darvas, E. B. Viñuela, J. C. Tournier, S. Bliudze, J. O. Blech, and V. M. G. Suárez, "Applying model checking to industrial-sized PLC programs," *IEEE Transactions on Industrial Informatics*, vol. 11, no. 6, pp. 1400-1410, Dec. 2015.

[13] M. Farrukh, I. A. Halepoto, B. S. Chowdhry, H. Kazi, and B. Lal, "Design and implementation of PLC based automatic liquid distillation system." *Indian Journal of Science and Technology*, vol. 10, no. 29, pp. 1-6, December 2017.

[14] M. Obermeier, S. Braun, and B. Vogel-Heuser, "A model-driven approach on object-oriented PLC programming for manufacturing systems with regard to usability," *IEEE Transactions on Industrial Informatics*, vol. 11, no. 3, pp. 790-800, June 2015.

[15] T. Alves, R. Das, and T. Morris, "Embedding encryption and machine learning intrusion prevention systems on programmable logic controllers," *IEEE Embedded Systems Letters*, vol. 10, no. 3, pp. 99-102, September 2018.

[16] E. Municio, S. Latré, and J. M. Marquez-Barja, "Extending network programmability to the things overlay using distributed industrial IoT protocols," *IEEE Transactions on Industrial Informatics*, vol. 17, no. 1, pp. 251-259, January 2021.

[17] D. Formby and R. Beyah, "Temporal execution behavior for host anomaly detection in programmable logic controllers," *IEEE Transactions on Information Forensics and Security*, vol. 15, pp. 1455-1469, September 2020.

[18] R. Ma, B. Zhang, Y. Zhou, Z. Li, and F. Lei, "PID controller-guided attention neural network learning for fast and effective real photographs denoising," *IEEE Transactions on Neural Networks and Learning System Systems, (Early Access)*, pp. 1-14, January 2021.

[19] S. Howimanporn, S. Thanok, S. Chookaew, and W. Sootkaneung, "Speed control technique for conveyor using PSO based PID with programmable logic controller," in *Proc. IEEE/SICE International Symposium on System Integration*, 2016, pp. 670-675.

[20] B. Verma and P. K. Padhy, "Robust fine tuning of optimal PID controller with guaranteed robustness," *IEEE Transactions on Industrial Electronics*, vol. 67, no. 6, pp. 4911-4920, June 2020.

[21] C. Jauregui, M. D. Mermoud, G. Lefranc, R. Orostica, J. C. T. Torres, and O. Beytia, "Conical tank level control with fractional PID," *IEEE Latin America Transactions*, vol. 14, no. 6, pp. 2598-2604, June 2016.

[22] U. M. Nath, C. Dey, and R. K. Mudi, "Desired characteristic equation based PID controller tuning for lag-dominating processes with real-time realization on level control system," *IEEE Control Systems Letters*, vol. 5, no. 4, pp. 1255-1260, October 2021.

[23] T. Xu, H. Yu, J. Yu, and X. Meng, "Adaptive disturbance attenuation control of two tank liquid level system with uncertain parameters based on port-controlled hamiltonian," *IEEE Access*, vol. 8, pp. 47384-47392, March 2020.

[24] J. Liu, T. Li, Z. Zhang, and J. Chen, "NARX prediction-based parameters online tuning method of intelligent PID system," *IEEE Access*, vol. 8, pp. 130922-130936, July 2020.

[25] Q. Chen, Y. Tan, J. Li, and I. Mareels, "Decentralized PID control design for magnetic levitation systems using extremum seeking," *IEEE Access*, vol. 6, pp. 3059-3067, December 2018.

[26] Y. Liu, K. Fan, and Q. Ouyang, "Intelligent traction control method based on model predictive fuzzy PID control and online optimization for permanent magnetic maglev trains," *IEEE Access*, vol. 9, pp. 29032-29046, February 2021.

[27] S. Howimanporn, S. Chookaew, and C. Silawatchananai, "Real-Time evaluation position control of directional wheel conveyor using fuzzy embedded PLC and SCADA," *International Journal of Mechanical Engineering and Robotics Research*, vol. 10, no. 6, pp. 328-336, June 2021.

Suppachai Howimanporn was born in Bangkok, Thailand in 1975. He received B.Eng. in electrical engineering, M.Eng. in control engineering from King Mongkut's Institute of Technology Ladkrabang, Thailand in 1999 and 2004, and D.Eng. degree in mechatronics at School of Engineering and Technology, Asian Institute of Technology, Thailand in 2014. From 2005 to 2014, he was a lecturer in Department of Electrical Engineering, Faculty of Industrial education, Rajamangala University of Technology Phra Nakhon Bangkok, Thailand. Since 2015, he has been an Assistant Professor with Major of Mechatronics Engineering, Department of Teacher Training in Mechanical engineering, Faculty of Technical Education, King Mongkut's University of Technology North Bangkok, Thailand. His research interests include control systems, robotics, automation and mechatronics.

Sasithorn Chookaew is currently Assistant Professor at the Department of Teacher Training in Mechanical Engineering, Faculty of Technical Education, King Mongkut's University of Technology North Bangkok, Thailand. She received the B.S. degree in technology education and the M.S. degree in computer and information technology from King Mongkut's University of Technology Thonburi, Bangkok, Thailand, in 2005 and 2008, respectively. She received the Ph.D. degree in science and technology education from Mahidol University, Bangkok, Thailand, in 2015. She is interested in technology enhanced learning, technology in engineering education, personalize learning, professional development and training, educational robotic.

Chaiyaporn Silawatchananai graduated bachelor's degree in engineering major in electrical engineering from Sirindhorn International Institute of Technology, Thammasat University. He was received master's and doctoral degree in mechatronic engineering from Asian Institute of Technology. He is lecture at department of teacher training in mechanical engineering, faculty of technical education, King Mongkut's University of Technology North Bangkok. His research works in field of robotics and automation system, model-based control.