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# The application of SCADA systems on wrapping machines using plc and wonderware intouch in the automotive manufacturing industry

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**ABSTRACT**

In this paper, the application of SCADA systems in the automotive product packaging process is discussed, focusing on an automotive manufacturing company that produces tires and tubes specifically for two-wheeled vehicles. The production of marketable tires involves various processes, including mixing, extrusion, bead wire, calendaring, bias cutting, manufacturing, curing, final inspection, and wrapping. The wrapping process is the final stage of packaging the outer tire, which is done using a predetermined plastic. During the wrapping process, the counter data is manually recorded using a check sheet by the machine operator. The machine operator retrieves the counter data displayed on the panel of each machine, which is then collected by the foreman at the end of the shift. Afterward, the foreman manually enters the data into a recap data system to monitor the completion of the wrapping process. This method is considered inefficient as it is time-consuming, and there is a high potential for human error. To address this, we designed a SCADA system for the wrapping machine using the Wonderware InTouch 10.6 application. This system involves data communication between a personal computer (PC) running the Wonderware application, Microsoft SQL Server, a Mitsubishi Q02H PLC (Programmable Logic Controller), connected via a QJ71E71-100 ethernet module, and a CC-Link module used as a remote input-output module. The machine counter data is stored in the Microsoft SQL Server database. The process of saving monitoring data from Wonderware InTouch to Microsoft SQL Server is achieved by creating a table in the SQL Server database, adding an ODBC (Open Database Connectivity) link to the created database, and creating a bind list in Wonderware InTouch. This SCADA system was developed to ensure high accuracy, eliminating the need for manual data entry, and allowing for automatic monitoring of production results from a PC, both through the interface and the data acquisition recorded in Microsoft SQL Server.

**Keywords:** Microsoft SQL Server, PLC, SCADA Systems, Wonderware InTouch, wrapping machine.

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## INTRODUCTION

The development of digitalization in the automotive manufacturing industry, along with the advancements of Industry 4.0, has brought significant changes to the way companies manage their production and operational processes. Industry 4.0 integrates digital and physical technologies to create more efficient, flexible, and interconnected production systems. One

application of an integrated system in the industry is SCADA. The use of Supervisory Control and Data Acquisition (SCADA) systems in various sectors is becoming increasingly widespread. SCADA is applied across industries such as automotive manufacturing, energy, agriculture, healthcare, transportation, civil engineering, and chemistry (Folgado et al., 2024). In the automotive manufacturing industry, SCADA systems are used for monitoring and controlling specific machines in production areas, and even for overseeing entire production systems (Setiawan et al., 2019). This application is reasonable because SCADA systems can enhance production operation efficiency, provide better protection for equipment, and increase manpower productivity. The SCADA framework offers accurate identification and rapid alerts to observation posts through monitoring stages, advanced communication, and sensors.

Several years ago, we conducted research on the application of SCADA in the manufacturing industry. This research included the design of a control system for an auto air remaining machine based on a programmable logic controller (Ardi & Cascarine, 2018), the modification of a control system in the loading and unloading process of an oil filling machine (Ardi & Defi, 2018), and the design of an automatic control system for the output loader of a snap gauge machine (Ardi & Zuhdi, 2020).

Other researchers have also conducted and continue to conduct studies on the application of SCADA systems in various fields. Research in Indonesia includes studies on the analysis of SCADA application in distribution system reliability (Marpaung et al., 2020). (Setiawan et al., 2019), investigated the use of SCADA systems with PLC and HMI to improve the effectiveness and efficiency of production processes. Other studies on SCADA application in specific fields include those by (Muhammad et al., 2024) who researched the boiler system. (Hajar et al., n.d.) have researched water level control simulation. (Than Min et al., 2019) have conducted research related to automation of series tank level control. (Sean et al., 2020) have researched the application of SCADA in Energy consumption analysis in wastewater treatment plants. (Deshmukh et al., 2023) have researched the Water for Injection SCADA Application. Meanwhile, SCADA research related to wind turbine applications has been conducted by (Pandit & Wang, 2024). (Atia et al., 2015) researched SCADA applications related to remote PV applications. (Chang et al., 2020) researched SCADA applications in the measurement and control platform of single-tube heat transfer experiment rig. (Avilés et al., 2023) researched SCADA applications for Monitoring a Raw Water Distribution Network. SCADA applications for temperature control and device diagnostics were conducted by (Thepmanee et al., 2022). (Hazaveh et al., n.d.) conducted research on SCADA applications related to Automating an Industrial Dishwashing System.

In this study, we focus on an automotive manufacturing company that specializes in producing two-wheeled vehicle tires, specifically within the maintenance department. This department is

responsible for performing routine maintenance, enhancing machine efficiency, and ensuring optimal machine operations to support a smooth production process. It oversees the management of wrapping machines, covering areas such as Wrapping, Setting, and Instrumentation.

Wrapping machines are used in the packaging process of motorcycle tires, where the outer tires are wrapped using a motor-driven system assisted by a roll guide and flyer. There are 40 wrapping machines with a production target of approximately 20,000 tire units per day. During this process, machine operators manually record counter data using check sheets. The foreman collects the data at the end of each shift for recapitulation and entry into the production summary. This method is inefficient, as it requires significant time. To address this issue, periodic improvements will be made by designing an automated production SCADA system that connects to the PLC and interfaces with a PC in the Wrapping, Setting, and Instrumentation section.

## METHOD

### SCADA (Supervisory Control and Data Acquisition)

SCADA is a system that monitors, controls, and acquires data from a plant. In control technology, supervisory control often refers to indirect control, but more specifically to coordination and oversight functions. In other words, the main control is still handled by the PLC (Programmable Logic Controller) or other controllers, while the control in SCADA is primarily coordinative and secondary (Kumar et al., n.d.), (DUYMAZLAR & ENGİN, 2023).

In general, SCADA consists of the following parts:

- Sensors and actuators (Field Devices): This section is a plant in the field which consists of objects that have various sensors and actuators. It is these sensor and actuator values that are generally monitored and controlled so that the object/plant runs according to the wishes of the user.
- RTU (Remote Terminal Unit)/PLC: PLC is the controller of the plant (fielded devices). This tool acts as the brain of the system.
- Communication System: a Communication System is needed to connect field devices, PLC and Master Terminal Unit.
- MTU (Master Terminal Unit): Master Terminal Unit is generally a computer that has SCADA software.

### Design Concept of Wrapping Machine

A wrapping machine is used in the process of wrapping or packaging motorbike tires. This machine is controlled by a Mitsubishi FX3G PLC. In addition to the PLC, the wrapping machine includes various supporting components, such as a selector switch, push button, pilot lamp, potentiometer, timer, proximity sensor, pneumatic cylinder, 3-phase DC motor, inverter, and breaker. There are 40 wrapping machine units distributed across plants 1, 2, and 3.

The wrapping machine can be operated in two modes: manual and automatic. Here, we will explain the automatic operation process. The sequence begins with the tire loading process, where the operator places the tire on the lower roll guide. The operator then sets the timer and adjusts the roll guide according to the tire specifications. Afterward, the operator installs the plastic wrap, ensuring it is positioned correctly so it doesn't interfere with the tire during rotation. The motor speed is then set to ensure the plastic overlap is within tolerance. Overlap refers to the distance between the ends of the plastic that are closely aligned.

Next, the operator presses the start button. The top roll guide moves downward, followed by a delay. Once the delay is complete, the roll guide driving motor and plastic turning motor start running at full speed simultaneously. The timer begins counting. When the timer finishes counting, the motor slows down. After 2 seconds, the motor stops, and the top roll guide rises.

**Problem Analysis**

After the tire has passed the final inspection, it will then be sent to the wrapping process. There are 40 wrapping machines spread across factories B, C, and H, with a production target of approximately 20,000 tires per day. This process is carried out continuously, divided into 3 shifts per day, and the counter calculation occurs each time a tire is wrapped, resetting at the end of each shift.

In the wrapping process, the machine operator manually records the counter data using a check sheet. After recording the data, the foreman collects it at the end of the shift. The data is then recapitulated and input into the recap data for the wrapping process achievement by the foreman at the end of each shift. The purpose of data recording is to determine whether there is a discrepancy between the number of products coming out of the wrapping process and the EBS (E-business switch) products, as well as to control the number of products to be produced and verify whether the target is met. However, manual recording has several drawbacks: the data recorded on the check sheet is often invalid due to errors in recording, writing, or data entry. Figure 1 shows an analysis of the existing conditions.

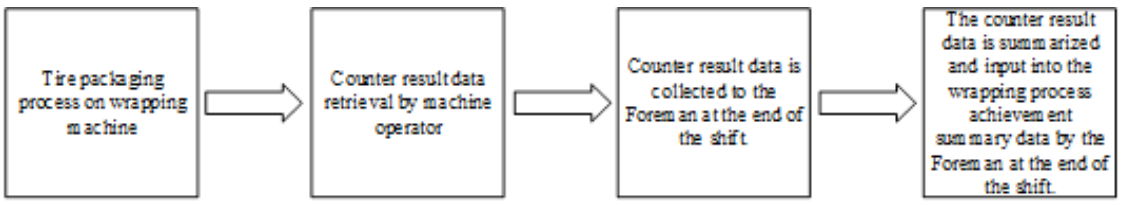



Figure 1. Analysis of the existing conditions

Based on the analysis, the issue identified is the lack of time effectiveness in monitoring the production data of the wrapping machine. This is because the machine operator still collects

counter data manually using a check sheet. After recording the data, the foreman collects it at the end of the shift, then recapitulates and inputs the data into the recap system to track the achievement of the wrapping process. As a result, the foreman inputs data three times a day. The machine operator retrieves the counter data, which is displayed on the panel of each wrapping machine.

**Improvement Plan**

Based on the analysis of the issues above, it can be concluded that the main problem lies in the manual retrieval of data from the wrapping machine counter. The solution to this problem is to implement a SCADA system on the wrapping machine. The authors selected a sample of five wrapping machines, numbered 1 to 5, for this system. For this SCADA system, the authors use Wonderware InTouch software, which is supported by various features such as historical graphs, alarms, and other tools useful for system development. With the implementation of this system, machine operators will no longer need to manually retrieve counter data, as the data will be recorded automatically in the Microsoft SQL Server database. The goal of implementing this system is to automate the retrieval of counter data through the SCADA system. The benefits of this implementation include the ability to remotely control the production process, more accurate production data, and easier tracking of production results by the foreman.

## RESULTS AND DISCUSSION

### Results

Based on the problems that have been described, the following are the system criteria needed in order to reduce the existing problems:

- Create a system that can be monitored remotely.
- On the interface, displays the counter value and indicates whether the wrapping machine is being operated or not.
- User-friendly interface.
- Having a security system so that not everyone can access the database.
- Be able to record production data on a wrapping machine for 3 shifts 24 hours.
- Can record accurate data.

Figure 2 shows the network topology of the system. It illustrates that each wrapping machine is controlled by a Mitsubishi FX3G PLC, which has an additional CC-Link slave input and output module installed, specifically the FX3U-16CCL. The data from the PLC is then transferred to the master PLC, the Mitsubishi Q02H PLC, via CC-Link. The master PLC has two extension modules installed: the QJ71E71-100 Ethernet module and the QJ61BT11N CC-Link master module. The data obtained from the Mitsubishi FX3G PLC is processed by the master PLC, and the processed data is streamed to HMI PC 1 via the Ethernet module, passing through the hub first.

Furthermore, the data can be processed and monitored via PC 1, where DASMEthernet and Wonderware InTouch are installed. The data is then stored on PC 2, which has Microsoft SQL Server installed. The reason for using two PCs is that the PC used for SCADA cannot be the same as the one used for the database. DASMEthernet is an OPC (Object Linking and Embedding) that functions as a translator or interpreter between the PLC GX Works 2 software and Wonderware. For simulation purposes, the OPC client System Management Console and the OPC server MX OPC Configurator are used with the FS Gateway connection driver. Wonderware's role is to read input-output by changing the register or memory values of the PLC, while Microsoft SQL Server functions as the database processor.

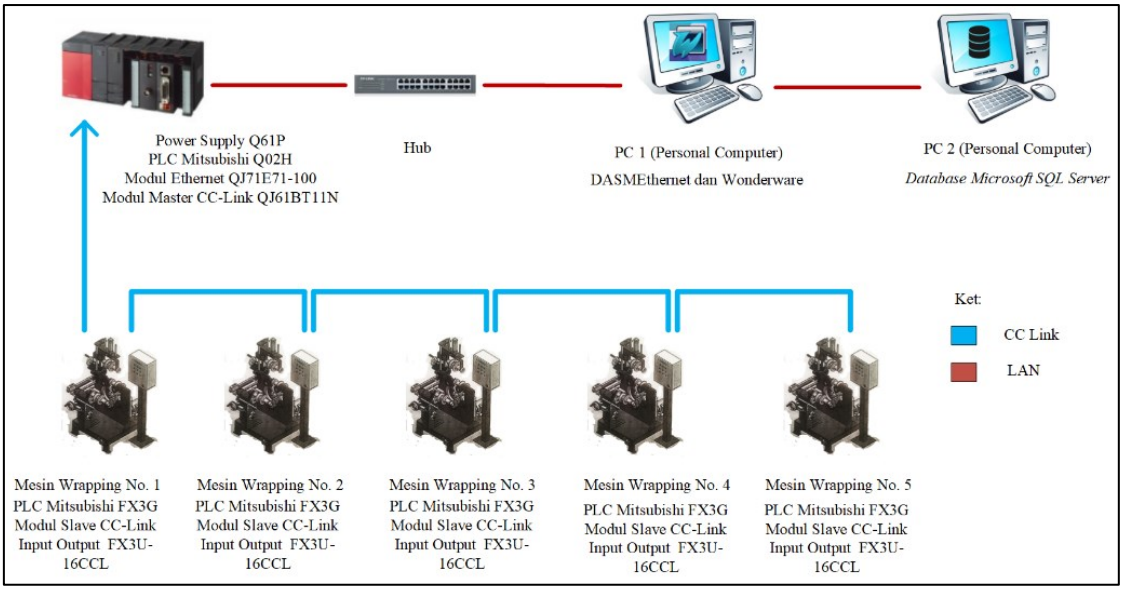



Figure 2. Network Topology

The modules we use are: Q61P power supply, Q02H PLC CPU, QJ61BT11N cc-link master module, QJ71E71-100 ethernet module all attached to the base unit with type QB12.

- Power Supply. This power supply functions as a DC voltage distributor on the PLC base unit. The power supply used in this design is the Mitsubishi MELSEC POWER SUPPLY MODULE Q61P.
- PLC CPUs. This wrapping machine control system will use a modular type of PLC with a Mitsubishi MELSEC Q02HCPU CPU which functions as a control center that will process the input signal from the input module and process it according to the program and provide a signal for the output module.
- Ethernet module. The communication terminal makes it possible for the PLC to obtain program uploads from a PC or other programming device. The communication terminal or

module that the author uses to connect the CPU with the interface is the Mitsubishi MELSEC ETHERNET MODULE QJ71E71-100.

- CC-Link Master Module. This module is used to retrieve data and process data from the FX3U-16CCL module. The cc-link master module that the author uses is the Mitsubishi MELSEC CC-LINK MODULE QJ61BT11N.
- FX3U-16CCL Module. This cc-link slave module acts as a remote input/output device. The cc-link input output slave module that I use is the Mitsubishi CC-LINK SLAVE MODULE FX3U-16CCL.

The interface design on Wonderware InTouch will be adjusted to the criteria needed by the foreman. Here are the things that will be displayed:

- Displays the number of production results in 1 machine. The counter value will increase if the machine has completed its production process in 1 cycle.
- Displays the graphic counter contained in the wrapping machine.
- Displays the machine indicator whether it is operating or not.
- Displays the machine indicator whether it is in auto or manual condition.

To support interface design according to the criteria, we created several windows on InTouch Wonderware. Table 1 shows the appearance of the interface design. While Table 2 shows the data that will be displayed in the window.

Table 1. Interface design display

| Window's Name | Information |
|---|---|
| Log in | Users are required to enter a username and password for security purposes. |
| Main Menu | The window that contains all the buttons for opening window wrapping and counter graphs. |
| Wrapping 1 | Displays the data required by the foreman in monitoring wrapping machine number 1. There is a record database button, which is a button to activate the connection between Wonderware Intouch and the database on Microsoft SQL Server. |
| Wrapping 2 | Displays the data required by the foreman in monitoring wrapping machine number 2. There is a record database button, which is a button to activate the connection between Wonderware Intouch and the database on Microsoft SQL Server. |
| Wrapping 3 | Displays the data required by the foreman in monitoring wrapping machine number 3. There is a record database button, which is a button to activate the connection between Wonderware Intouch and the database on Microsoft SQL Server. |
| Wrapping 4 | Displays the data required by the foreman in monitoring wrapping machine number 4. There is a record database button, which is a button to activate the connection between Wonderware Intouch and the database on Microsoft SQL Server. |

| | |
|---|---|
| Wrapping 5 | Displays the data required by the foreman in monitoring wrapping machine number 5. There is a record database button, which is a button to activate the connection between Wonderware Intouch and the database on Microsoft SQL Server. |
| Counter Graphic | Displays a graph of the production output of each machine. |

Table 2. The data will be displayed in the window.

| Name | Function |
|---|---|
| Counter Ban | The amount of production from each wrapping machine |
| Indicator man/auto | Machine indicator is running manually or automatically |
| Indicator wrapping on/off | Indicator indicating whether the wrapping machine is in production or not. |

When the user runs the system, the first window that will appear is the login window. After the user logs in, the next window to open is the main menu. Two types of users can access this page: foreman and admin. The difference lies in the access rights; the admin can add users, while the foreman cannot. When the user selects the counter graph button, a graphical screen will display the production results from each wrapping machine. When the user selects the button for the database record, the counter data will automatically be saved in Microsoft SQL Server. Figure 3 shows the login window display, allowing users to access their accounts.


Figure 3. Login window display

After completing the login, the main menu window will appear. The main menu is a window that contains all the buttons to open the wrapping machine window and counter graph. In this main menu window, there are also 6 types of window buttons that can be accessed by all users. Figure 4 shows the button display from the main menu window.

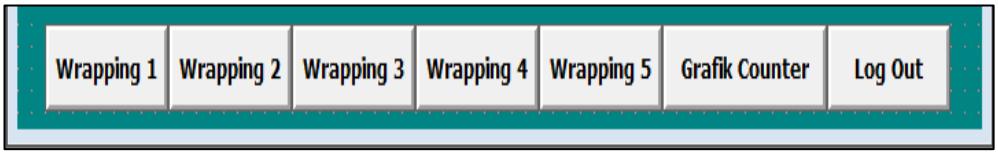



Figure 4. The button displays from the main menu window.

When the wrapping button is pressed, the wrapping machine window will appear, displaying the wrapping machine information according to the machine number. For example, if the user selects the first wrapping button, the first wrapping window will appear. The foreman cannot operate the machine remotely but can only monitor production results and record data. To make the simulation easier, the author added a selector switch, a start button, a reset button, a flyer inching button, a moving inching button, and a guide roll button on the wrapping machine window. Figure 5(a) shows the appearance of the first wrapping window. When the user selects the counter graph button, the counter graph window will appear. Figure 5(b) shows the display of the counter graph window.

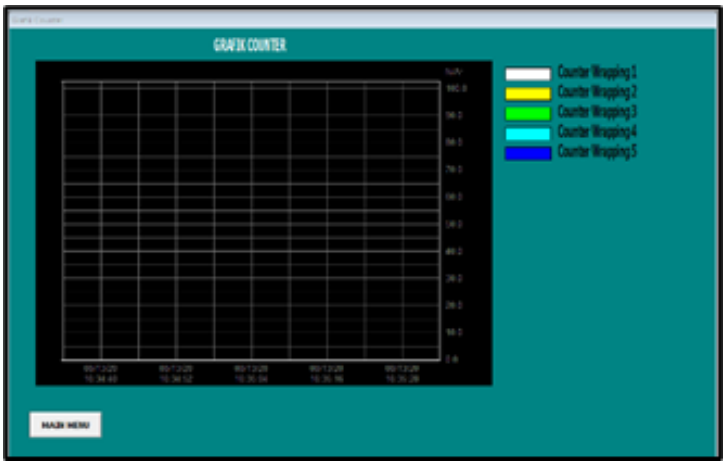
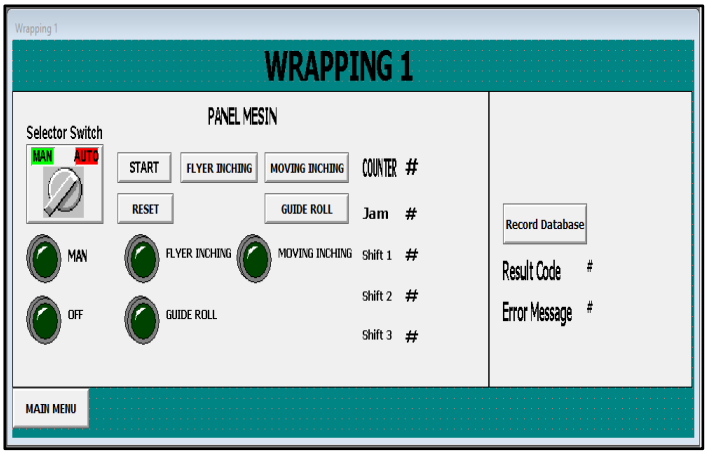



Figure 5. Display on the first Wrapping Machine Window




Fugure 6. Graphic Counter Window

In database design, we use Microsoft SQL Server in database storage. Table 3 shows the information or data that will be displayed on Microsoft SQL Server.

Table 3. Column Name Data in the Database

| Name | Function |
|---|---|
| Date | Displays the date, month and year of production data collection. |
| Time | Displays the hours, minutes and seconds of the production data collection time. |
| Counter_Wr1 | Displaying production results data on wrapping machine number 1 |
| Counter_Wr2 | Displaying production results data on wrapping machine number 2 |
| Counter_Wr3 | Displaying production results data on wrapping machine number 3 |
| Counter_Wr4 | Displaying production results data on wrapping machine number 4 |
| Counter_ Wr5 | Displaying production results data on wrapping machine number 5 |
| Shift_1 | Displays overall production data of wrapping machines on shift 1 |

Testing on this system is carried out after making connections, interfaces, programs, and databases. This process is carried out to find out whether the design has gone well and as expected. Testing on the system is divided into 4 parts, namely connection testing, interface testing, program testing, and database testing.

- Connection testing, this is done with the aim of ascertaining whether Wonderware InTouch can communicate with the PLC or not.
- Testing the program, this is done with the aim of aligning the active addresses on the PLC and the indicators on the Wonderware InTouch.
- After testing the program, next is interface testing. Interface testing is done by running the program on Wonderware InTouch, there are various objects that exist in each window that

has been made. This test is carried out with the aim of seeing whether all the components on the interface are running according to the target.

- After testing the program, the next step is testing the database. This test is carried out in order to see whether the database is in accordance with the data or if there are still deficiencies that must be added.

**Discussion**

The design evaluation we conducted is a theoretical estimate regarding the results expected from implementing the SCADA system on the wrapping machines in the company. The estimated results can be seen from several aspects. Previously, the machine operator manually collected data using a check sheet, which was then collected by the foreman at the end of each shift. The foreman would then manually input the data into the summary report for the wrapping process achievements. With the new system, machine operators will no longer need to manually collect data using check sheets, and the foreman will no longer need to input data manually into the achievement report. Instead, they will simply log into Wonderware InTouch and record the production data of the wrapping machine from Microsoft SQL Server.

## CONCLUSION

In this paper, the design of SCADA systems for a wrapping machine using Mitsubishi PLC and Wonderware InTouch in the automotive manufacturing industry is discussed. The SCADA system for the wrapping machine was developed using the Wonderware InTouch 10.6 application. The system design utilizes the Mitsubishi QJ71E71-100 Ethernet module as a communication module and the CC-Link module as a remote I/O module. However, due to hardware constraints, only a simulation program was developed. In this final project, the author uses Microsoft SQL Server as the database processor.

For the I/O configuration simulation to test the system, the authors tested the PLC Q02H program and Wonderware InTouch using the OPC MX OPC Configurator server, the OPC client System Management Console, and the Factory Suite Gateway connection driver. The machine's counter result data is stored in a Microsoft SQL Server database.

To store monitoring data from Wonderware InTouch to Microsoft SQL Server, the author created a table in the Microsoft SQL Server database, added an ODBC (Open Database Connectivity) connection corresponding to the database, and created a bind list in Wonderware InTouch. This bind list links labels in Microsoft SQL Server with tag names in Wonderware InTouch.

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this discussion and the implementation of the research will contribute to the advancement of industrial automation applications.

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