E3S Web of Conferences **688,** 05004 (2026) https://doi.org/10.1051/e3sconf/202668805004
*CONSER 2025*

# Prototype of car body assembly robot based on outseal PLC and haiwell SCADA

*Tugino*[*], *Yahya Harishta* Ghani*, Suyanta, Joko* Prasojo

Department of Electrical Engineering, Institut Teknologi Nasional Yogyakarta, Yogyakarta, Indonesian

**Abstract.** As technology advances and industrial demands for efficiency grow, automation systems based on Supervisory Control and Data Acquisition (SCADA) have become essential. SCADA is particularly suitable for large-scale operations with high safety risks, such as the Car Body Assembly Process at the welding line. This study develops a prototype of an automated car body assembly system integrating an Outseal PLC and Dobot Robot with Haiwell SCADA via the Modbus RTU protocol using RS-485 and internet communication. The developed programs enable the PLC and robot to operate automatically and execute assembly tasks in real time. The SCADA system was configured by inserting binary and relay bits into the PLC program and linking input-output variables in Haiwell SCADA. Experimental testing confirmed the system operated successfully as designed. The prototype achieved a fastest cycle time of 1 minute and 19 seconds for producing one car body unit. However, minor inconsistencies occurred during roof installation, welding, and miniature car body pickup due to conveyor response delays affecting the Dobot Robot. Overall, the integration of PLC, robot, and SCADA demonstrated effective automation and monitoring suitable for industrial-scale car body assembly.

## 1 Introduction

The automotive manufacturing industry involves multiple complex production stages, one of which is the Car Body Assembly stage on the welding line. This stage plays a critical role in forming the main structure of a vehicle through welding processes, directly affecting product quality, production efficiency, and subsequent manufacturing stages [1], [2]. To improve productivity, consistency, and operator safety, modern car body assembly increasingly relies on automation systems and industrial robots [3].

Alongside automation, Supervisory Control and Data Acquisition (SCADA) systems have become essential in industrial environments due to their ability to provide real-time monitoring, control, and data acquisition over wide and potentially hazardous production areas [4], [5]. SCADA enables centralized supervision, reduces human error, and improves

[*]Corresponding author: tugino@itny.ac.id

fault detection and response time, particularly in automated production lines such as welding and assembly systems.

However, most existing studies and industrial implementations focus on high-end commercial PLCs and SCADA platforms, which often involve high costs and limited accessibility for educational laboratories, small-scale industries, or prototype development. The integration of low-cost PLCs, robots, and SCADA systems remains relatively underexplored, especially in terms of system architecture, communication reliability, and real-time performance evaluation. This gap limits the adoption of scalable and cost-effective automation solutions that can serve both industrial training and early-stage system development.

In response to this gap, this research proposes the integration of an Outseal PLC and Haiwell SCADA in a car body assembly robot prototype. Outseal PLC, a locally developed Indonesian controller, offers affordability, open accessibility, and sufficient reliability for automation applications [7], yet its implementation in SCADA-integrated robotic systems has not been widely reported. Haiwell SCADA is selected due to its flexibility, support for standard industrial communication protocols such as Modbus RTU, and capability for cloud-based monitoring [6]. The Dobot Magician robotic arm is employed as a representative robotic platform that enables realistic simulation of industrial handling and welding operations [8].

The novelty of this study lies in demonstrating a low-cost, modular PLC–robot–SCADA integration framework that enables real-time supervision, control, and data acquisition for a car body assembly process. By experimentally evaluating system functionality, communication reliability, and production cycle time, this research provides practical insights into the feasibility and limitations of using Outseal PLC and Haiwell SCADA as an alternative automation solution. The proposed system is expected to contribute not only to industrial prototyping but also to education and training in automation and robotic manufacturing systems.

## 2 Method

### 2.1 System Scheme

The prototype system consists of several components that are integrated and communicate with each other in performing the car body assembly process. The Outseal PLC serves as the master device that controls the LED, Buzzer, Robot Dobot, and Conveyor Belt based on the information provided from the Push Button, switch, and Infrared Sensor. Figure 1 shows the scheme of the prototype system built.

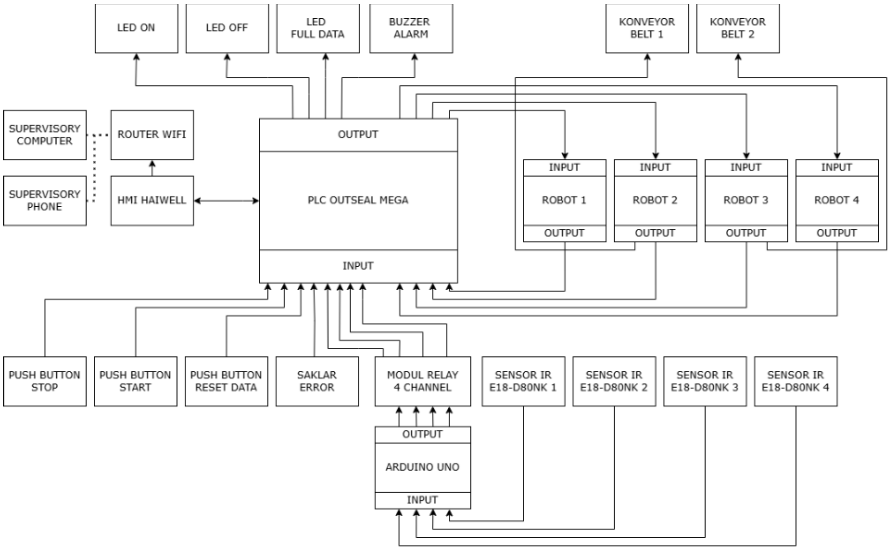


**Fig. 1.** Prototype system scheme.

## 2.2 System layout

The system layout shows the physical placement of all system components used in building the prototype. The system area is divided into 3 parts, namely the Car Body Assembly Process Area, control panel, and SCADA. While the work of the Dobot Robot is divided into 3 stations, namely Robot 1 (Handling) which carries out the process of taking and placing the roof onto the miniature car body at Station 1, Robots 2 and 3 (Welding) which carry out the process of welding the roof with the miniature car body at Station 2, and Robot 4 (Handling) which carries out the process of lifting the miniature car body produced to the car storage at Station 3. Figures 2 show the prototype system layout of car body assembly process area design.

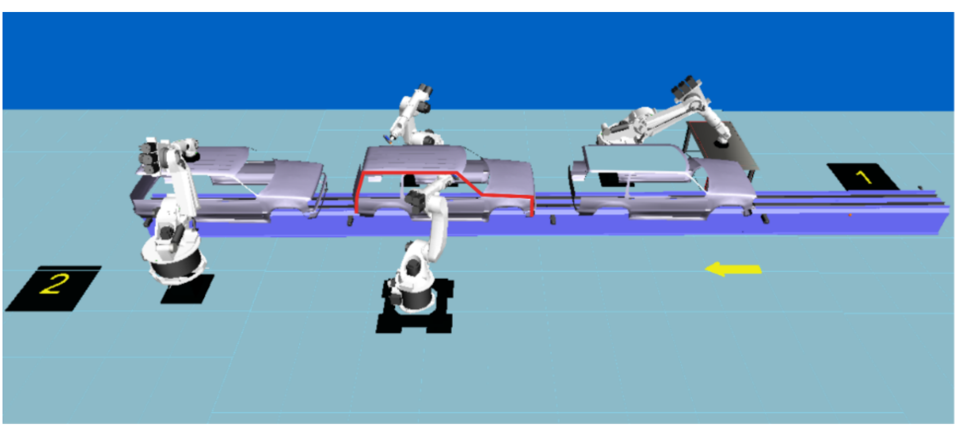


**Fig. 2.** The system layout of car body assembly process area design.

## 2.3 HMI and SCADA display

The HMI and SCADA interface was developed using Haiwell Cloud SCADA Develop software with clear and intuitive visualization of the overall system operation. The interface consists of several menus, including Main, Control Panel, Station, Unit Data, History, and Emergency. The Main menu visualizes the complete car body assembly process, while the Control Panel enables system control and status monitoring with indicators and alarms. Station menus provide detailed operational status for each station, Unit Data displays real-time production counts, and the History menu allows data export via external storage. Figures 3 show the HMI and SCADA displays used in the prototype.

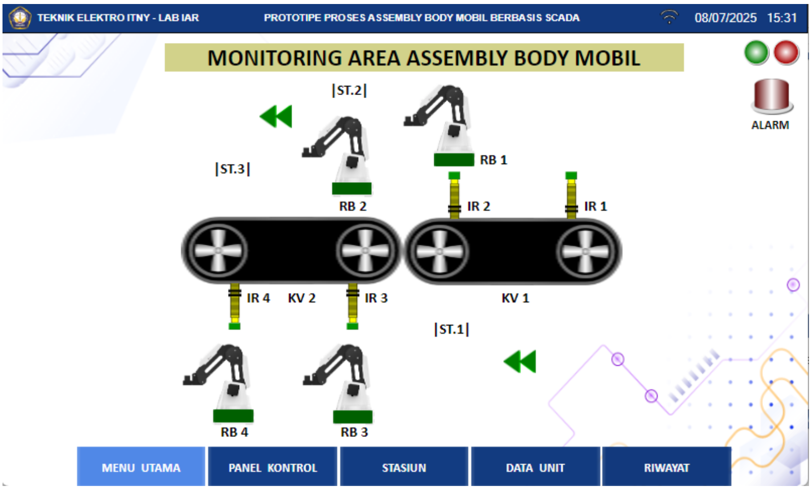


**Fig. 3.** HMI and SCADA main menu display design.

## 2.4 Overall Component

The prototype is designed and built by connecting the electrical and control and communication systems of all components, starting from the Outseal PLC, Robot Dobot, input devices, output devices, and SCADA Devices correctly and structured. Figure 4 shows the connection design of all prototype system components.

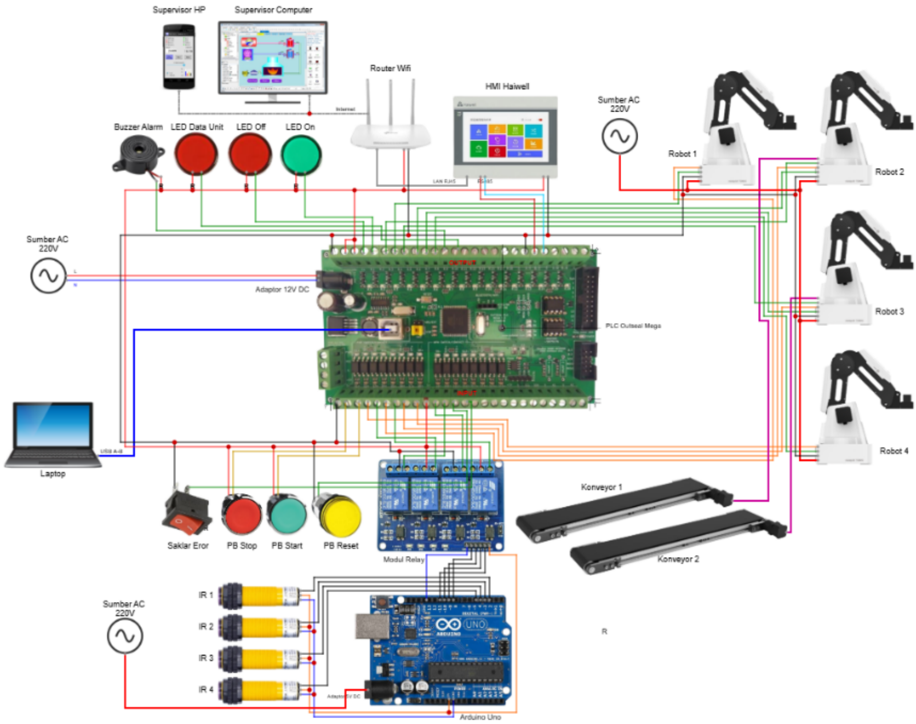


**Fig. 4.** Connection design of all system components.

## 3 Result and discussions

In this section, the research results of all system tests are shown, which are then discussed and analyzed in depth. Figure 5. shows the results of the implementation of the Car Body Assembly Robot Prototype Based on Outseal PLC and Haiwell SCADA.

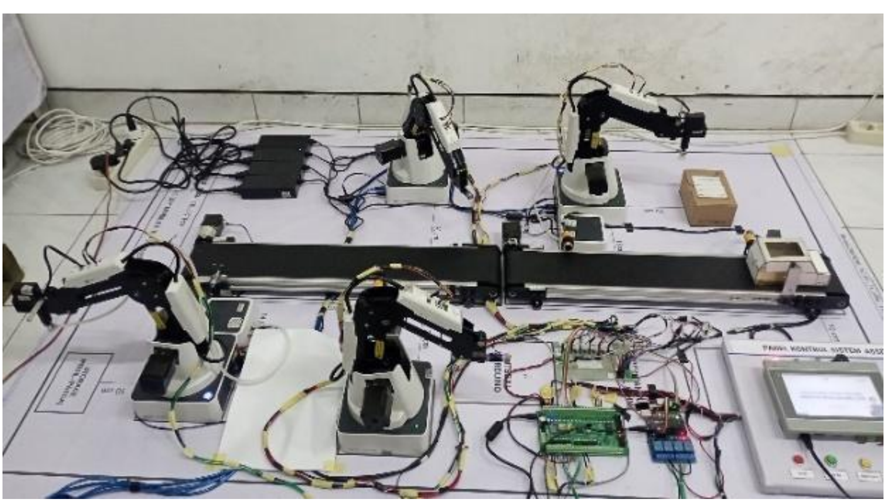

**Fig. 5.** System prototype implementation results.

### 3.1 Infrared Proximity Sensor Test Results

The test results of the Infrared Proximity Sensor function in detecting the presence of a miniature car body are shown in Table 1 below.

**Table 1.** Infrared proximity sensor test results.

| Experiment (Cycle) | Sensor IR (1) | Sensor IR (2) | Sensor IR (3) | Sensor IR (4) |
|---|---|---|---|---|
| 1 | Detect | Detect | Detect | Detect |
| 2 | Detect | Detect | Detect | Detect |
| 3 | Detect | Detect | Detect | Detect |
| 4 | Detect | Detect | Detect | Detect |
| 5 | Detect | Detect | Detect | Detect |

During the five cycles of car unit production experiments, it showed that the four Infrared Proximity Sensors were able to detect miniature car bodies made of paper consistently without any failures and errors. This indicates that the Infrared Proximity Sensor functions properly and has a high level of reliability to support the automatic detection system during the miniature car body unit production process.

### 3.2 Dobot Robot Program Test Results

There are four Dobot Robots that work on the prototype system. Robot Programs 1 and 4 as handling robots have the same program similarity while Robot Programs 2 and 3 as welding robots as well as conveyor drivers also have the same program similarity. The results of testing the Robot Dobot 1 and 2 programs are shown in Tables 2 and 3 below.

**Table 2.** Dobot robot 1 program test results.

| Experiment (Cycle) | Testing Result | | |
|---|---|---|---|
| | Input EIO05 | Robot 1 | Output Signal |
| 1 | 0 | Move | Sent |
| 2 | 0 | Move | Sent |
| 3 | 0 | Move | Sent |
| 4 | 0 | Move | Sent |
| 5 | 0 | Move | Sent |

**Table 3.** Dobot robot 2 program test results.

| Experiment (Cycle) | Testing Result | | | | | | |
|---|---|---|---|---|---|---|---|
| | Input EIO07 | Conveyor 1 | Input EIO07 | Conveyor 1 | Input EIO05 | Robot 2 | Output Signal |
| 1 | 0 | Run | 1 | Stop | 0 | Move | Sent |
| 2 | 0 | Run | 1 | Stop | 0 | Move | Sent |
| 3 | 0 | Run | 1 | Stop | 0 | Move | Sent |
| 4 | 0 | Run | 1 | Stop | 0 | Move | Sent |
| 5 | 0 | Run | 1 | Stop | 0 | Move | Sent |

Description:
0: no signal, 1: signal present
In testing Robot Dobot 1, the results obtained show that the robot always moves in each cycle when it does not receive a signal (logic 0), and the output signal is always successfully sent after the robot finishes working. In testing Robot Dobot 2 in each production cycle, when the EIO07 input is in a logic 0 condition, conveyor 1 runs, then when it changes to logic 1, conveyor 1 stops. Then, the same as Robot Dobot 1 when the EIO05 input is logic 0, Robot Dobot 2 moves and after completion the output signal from the robot is successfully sent to the PLC system.

## 3.3 Programmable Logic Controller (PLC) program test results

The test results of the Programmable Logic Controller (PLC) program are shown in Table 4 below.

**Table 4.** Programmable Logic Controller (PLC) program test results

| No | Switch | Bit Relay | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 |
| 1 | S1 | V | X | X | X | X | X | X | X | | |
| 2 | S2 | X | V | | | | | | | | |
| 3 | S3 | | | | | | | | | | V |
| 4 | S4 | | | | V | | | | | | |
| 5 | S5 | | | | | | | | V | | |
| 6 | S6 | | | | | | V | V | | | |
| 7 | S7 | | | | | V | | | | | |
| 8 | S8 | | | | | V | | | | | |
| 9 | S9 | | | V | | V | | | | | |
| 10 | S10 | | | V | | | | | | | |
| 11 | S11 | | | | | | | | | | |
| 12 | S12 | V | X | X | X | X | X | X | X | V | |

Description:
X: Not Functioning, V: Functioning
The test results show that each switch is able to activate the relay bits in accordance with the programming logic created. The appropriate activation between relay bits and switch inputs indicates that the ladder diagram created for the Outseal PLC functions accurately. This indicates that the logic control programming used in this system has been designed and created correctly and in accordance with the needs of the Car Body Assembly Process.

## 3.4 HMI and SCADA test results

From the test results on the HMI and SCADA System for five production cycles, the system functions and displays run well and accordingly, such as start, stop, data reset commands, production plan settings, user passwords, and menu display switching. Visualization of system status is displayed accurately and in real time, both for system indicators, robot and conveyor movements, fulfilled unit data, alarms that sound, and production history that is recorded automatically. System variables such as alarms are successfully sent to the Haiwell Cloud service and registered email. This shows the successful integration of the SCADA-based Car Body Assembly Process system in supervision, control, and data acquisition in the car unit production system.

### 3.5 Car Unit Production Test Results

The production results of car units in the SCADA-based Car Body Assembly Process system are shown in Figure 6 below.


**Fig. 6.** Car unit production yield with one cycle time.

Overall, the Car Body Assembly Robot Prototype system based on Outseal PLC and Haiwell SCADA is able to work consistently and accordingly by showing good and precise production results of miniature car units with a relatively stable one cycle time of 1 minute 19 seconds.

## 4 Conclusion

This study demonstrates that the proposed car body assembly robot prototype based on an Outseal PLC, Dobot Robot, and Haiwell SCADA can operate automatically according to the defined system workflow. The integration of binary and relay-based PLC programming with SCADA variable mapping successfully enables real-time supervision, control, and data acquisition through Modbus RTU communication. Experimental results confirm that the system performs reliably, achieving a minimum production cycle time of 1 minute and 19 seconds per unit.

Despite these positive results, several limitations were identified. The system experienced response delays in conveyor–robot coordination, indicating constraints in signal handling and mechanical synchronization. In addition, the use of RS-485 communication with a fixed baud rate limits scalability and data throughput for more complex or larger industrial systems. The prototype was also evaluated in a controlled environment, which may not fully represent real industrial operating conditions.

Future development should focus on improving communication performance through higher-speed industrial protocols, optimizing control logic for better synchronization, and integrating additional sensors for enhanced feedback and fault detection. Further studies may also explore the application of this low-cost PLC–SCADA architecture in full-scale industrial environments to evaluate long-term reliability and system robustness.

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