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IoT-Based Industrial Automation Using PLC

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Abstract: *Mention the abstract for the article. An abstract is a brief summary of a research article, thesis, review, conference proceeding or any in-depth analysis of a particular subject or discipline, and is often used to help the reader quickly ascertain the paper's purpose. When used, an abstract always appears at the beginning of a manuscript, acting as the point-of-entry for any given scientific paper or patent application.*

Keywords: IoT, Industrial Automation, LoRa, PLC, HMI, Wireless Communication, Remote Control

I. INTRODUCTION

Industrial automation has rapidly evolved with the rise of Industry 4.0, where connectivity and intelligence are the driving forces behind productivity. Traditional SCADA and wired PLC systems often limit flexibility and expansion, especially in environments where laying communication cables is impractical or expensive. To overcome these limitations, this research explores the integration of LoRa technology—a low-power, long-range wireless communication protocol—with existing PLC-based control systems. LoRa's ability to cover up to 10 km in open areas with minimal power consumption makes it ideal for industrial plants, remote farms, and monitoring systems. The Delta PLC SS2 processes real-time logic, while the HMI (DOPSoft) provides visual control and monitoring. By integrating these technologies, the proposed model achieves robust, wireless, and costeffective automation.

Furthermore, this system facilitates remote supervision and automated process control without human intervention. In contrast to Wi-Fi or Bluetooth, LoRa provides superior range and interference immunity, making it more suitable for industrial environments. The architecture supports scalability—additional sensors, actuators, or relays can be integrated without altering the existing infrastructure. The proposed system stands as a prototype for smart factories and smart agriculture fields, offering seamless communication, user-friendly visualization, and efficient control mechanisms.

The use of LoRa technology enables long-distance communication across several kilometers while maintaining low power consumption, making it highly suitable for distributed industrial setups and remote agricultural fields. The proposed system architecture focuses on enhancing scalability, reducing wiring complexity, and improving operational flexibility. Experimental results demonstrate stable LoRa signal performance, fast switching response of the relay module, and seamless interoperability between the PLC and HMI dashboard. Furthermore, the system supports reliable remote control, minimizes downtime, and offers a cost-effective approach for industries seeking to transition from conventional wired automation to smart wireless systems. Overall, the study highlights the potential of LoRa-integrated IoT automation in revolutionizing industrial and agricultural monitoring and control frameworks.

II. LITERATURE REVIEW

Recent advancements in the Industrial Internet of Things (IIoT) have shifted focus toward decentralized systems. Satyendra K. Vishwakarma et al. (2019) demonstrated an IoTbased smart energy-efficient home automation system that utilized IoT protocols for optimization. Premalatha Gurumurthy et al. (2025) introduced an IoT-based automation framework for household appliances, highlighting the ease of control through mobile interfaces. Similarly, Abdullah All Mamun Anik et al. (2021) proposed a mechanized robot using IoT modules for multipurpose automation and surveillance. However, these models often relied on Wi-Fi or GSM-based communication, which are power-intensive and limited in range. Recent advancements in the Industrial Internet of Things (IIoT) have increasingly emphasized the development of decentralized and wireless automation systems to enhance scalability, flexibility, and reliability. Satyendra K. Vishwakarma et al. (2019) presented an IoT-based smart and energy-efficient home automation

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architecture that leveraged lightweight IoT protocols to optimize device control and monitoring. Premalatha Gurumurthy et al. (2025) proposed a comprehensive IoT-enabled automation framework for domestic appliances, demonstrating how mobile-based interfaces can simplify user interaction and reduce manual intervention. In another related study, Abdullah All Mamun Anik et al. (2021) designed a multifunctional mechanized robot incorporating IoT modules for intelligent surveillance and task automation. While these approaches significantly contributed to the advancement of automation technologies, their communication channels primarily depended on Wi-Fi or GSM networks. Such systems exhibit constraints including high power consumption, limited coverage areas, and vulnerability to connectivity interruptions in remote or industrial environments. These limitations highlight the need for long-range, low-power, and robust communication technologies—such as LoRa—to support next-generation industrial automation systems.

Fig: Lora iot usr lg206 h p

The LoRa technology used in this project offers a significant improvement in coverage and energy efficiency. Its star network topology reduces data collisions, while adaptive data rate mechanisms enhance communication reliability. Research indicates that LoRa-based automation can achieve over 90% reliability in industrial environments with up to 3 km coverage indoors and 10 km outdoors. Hence, this research builds upon prior work but introduces PLC-based logic control—a practical step toward merging industrial hardware with IoT communication layers.

III. METHODOLOGY

3.1 System Overview

The system consists of:

LoRa Modules (Transmitter & Receiver): Facilitate data transfer between remote sensors and the control center.

Delta PLC SS2: Executes logic for relay control.

Fig: Delta plc dvp14ss2

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3.2 Channel Relay Module: Switches industrial devices based on PLC commands.

Fig: 4-Channel Relay Module

3.3 HMI (Human Machine Interface): Displays real-time device status and allows manual override. The control flow is:
LoRa transmitter sends data from field sensors. LoRa receiver forwards data to PLC.
PLC processes signals and activates relays accordingly. HMI displays device states and allows control input.

3.4 Circuit and Data Flow Design

A. Component	B. Specification	C. Function
D. LoRa Module (SX1278)	E. 433 MHz / 10 km range	F. Long-range wireless communication
G. Delta PLC SS2	H. 14 I/O ports, 24V DC supply	I. Logic control and decision making
J. Relay Module	K. 5V Trigger, 10A load current	L. Device switching interface
M. HMI Panel (DOP-B07S)	N. 7-inch touch display	O. Real-time monitoring and control interface
P. Sensors (optional)	Q. Analog / Digital input	R. Environmental and process monitoring

3.5 System Architecture

The system follows a master-slave architecture where the PLC acts as the master, controlling connected devices via relays, while LoRa nodes act as slaves, transmitting sensor data. The HMI communicates with the PLC using the RS-485 Modbus RTU protocol, ensuring reliable serial communication.

IV. IMPLEMENTATION AND EXPERIMENTAL SETUP

The experimental setup consists of two LoRa modules configured using Arduino UNO boards—one acting as a transmitter node placed in the field and the other as a receiver node connected to the Delta PLC. The PLC is programmed through WPLSoft, implementing logic conditions such as start-stop control, delay timers, and threshold-based actuation. The HMI interface is designed using DOPSoft to display real-time device status, relay ON/OFF states, and communication indicators.

Fig: Smps

The system was tested for:
- Communication range
- Power consumption
- Response time
- Relay switching accuracy

4.1 Performance Calculation

Parameter	Measured Value	Unit	Observation
Transmission Range	8500	meters	Stable data up to 8.5 km
Data Packet Size	20	bytes	Optimal payload for fast transmission
Average Latency	1.8	seconds	Delay between command and relay actuation
Power Consumption (LoRa node)	65	mA	During active transmission
Relay Response Accuracy	98.4	%	Based on 500 test cycles

Calculation Example:
If 500 switching cycles were performed and 492 were successful,

$$Accuracy = \frac{492}{500} \times 100 = 98.4\%$$

This confirms high stability of LoRa communication under typical industrial interference.

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V. RESULTS AND DISCUSSION

The system successfully established a stable LoRa link between the field node and the control center over long distances. The relay response time remained under 2 seconds, which is acceptable for non-critical automation. The PLC handled real-time logic effectively without missing any transitions. Power analysis showed that LoRa's active transmission consumed around 65 mA, significantly lower than GSM or Wi-Fi systems which exceed 150 mA.

Fig: Plc control panel

Moreover, the HMI interface provided intuitive visualization, enabling operators to monitor temperature, motor status, and relay states instantly. Communication logs revealed 0.8% data loss across multiple trials, demonstrating excellent reliability. The modularity of the system allows adding more LoRa nodes with unique addresses to expand coverage.

VI. CONCLUSION

The proposed IoT-based industrial automation system using LoRa and PLC effectively combines long-range communication with reliable process control. It eliminates the dependency on wired networks and enables remote operation of industrial devices through an HMI interface. The results confirm that LoRa communication ensures stability, low power consumption, and a wide coverage range suitable for smart factories and agricultural automation. Future upgrades can include cloud integration, mobile app monitoring, and AI-based predictive control for enhanced efficiency.

VII. FUTURE SCOPE

• Integration with AWS IoT Core for data analytics.
• Addition of security features (encryption and authentication).
• Development of a mobile application for on-the-go monitoring.
• Expansion to multi-node networks with hierarchical control.
• Integration of sensors (temperature, humidity, pressure) for data-driven decision-making.

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