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PLC Based Lab Automation For Fans and Computers

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Abstract: Applying ever growing technological advancements in the automation sector to the education systems and with the intent to make the laboratories smarter and perform experiments in favorable conditions, an idea of PLC based Lab Automation was proposed. This paper represents the implementation of different modes as per the user's convenience. Special features of this design ensure the control of the presentation environment when the projector is in use and monitoring the availability of computers while entering the room. In this project, the aim is to have control over the electronic and electrical appliances as per the user's convenience either automatically by interfacing sensors with PLC or manually by human inputs. This is achieved with the help of an emerging communication protocol OPC Unified Architecture (OPC UA) in different ways mainly focusing on Client-Server application UaExpert and Android app Prosys. The main motive behind implementing this plan is to foster a better teachinglearning environment, save time and reduce human effort.

Keywords*:* *PLC*(Programmable logic controller), Smart Lab Automation, Energy Management, Lab Security, Connectivity, Automation, Smart Devices

I.INTRODUCTION

Automation has seen rapid growth over recent years, with its increasing necessity in the industrial sector considering it not only reduces errors by minimizing manual interventions but also improves the safety, productivity and ensures optimum use of resources. Today, Programmable Logic Controller (PLC) is identified as one of the major revolutions in the automation sector contributing to the upgradation of conventional industrial processes. PLC is a versatile control unit due to its ability to be reprogrammed with user friendly programmable languages such as Ladder logic, structured text and many more to meet the changing needs of production and its diversity in the different sectors. Due to its robust nature, it is specifically designed to meet the needs of harsh environmental conditions in industries. Over the decades PLCs have expanded their networks by adapting to a variety of communication protocols and increased compatibility with peripherals. Contributing to the already existing applications and making the most out of the advancements for the education sector, the project of lab automation was proposed. This design mainly focuses on troubleshooting the problem of unnecessary energy consumption when it is not demanded and by dedicating our time solely for the lab activities. PLC and HMI along with other interfaced peripherals ensure the necessary control action for the system. The proposed project is centered around a B&R X20-PLC module integrated with HMI that will control the electrical and electronic appliances. The tasks were to control the lamps and fans in the room, indicate the availability of computers and create a suitable environment for presentation when the projector is turned on. The complete system was categorized into 2 main modes of operation namely Automatic and Manual mode.

II.LITERATURE SURVEY

Smart Lighting in Labs: A study by Kiziroglou and Venetsanos (2020) discusses the integration of PLC systems with smart lighting systems in labs. They found that PLC-based control could reduce energy consumption by adjusting light intensity according to the experimental needs of the lab environment (Kiziroglou & Venetsanos, 2020).

Control of Environmental Conditions: A paper by Gupta et al. (2019) details the use of PLCs to monitor and control environmental parameters such as temperature, humidity, and lighting in scientific laboratories. Their work highlighted the efficiency of PLCs in maintaining optimal conditions for various experiments (Gupta et al., 2019).

PLC-Computer Integration: The research by Zhang and Li (2018) explores the integration of PLCs with laboratory data acquisition systems. They propose a model in which the PLCs are linked to a central computer for real-time data acquisition, analysis, and remote control. The system was successfully implemented in chemical laboratories for monitoring experimental conditions (Zhang & Li, 2018).

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Communication Protocols in Lab Automation: A study by Wang et al. (2021) reviewed different communication protocols in PLC-based lab automation systems. They emphasized that Ethernet/IP and OPC protocols are ideal for high-speed data transfer and integration with computer systems in laboratory environments (Wang et al., 2021).

PLC and IoT in Labs: A recent study by Lee and Choi (2022) discusses how IoT devices can be connected to PLCs to monitor real-time data such as temperature, pressure, and light intensity in laboratories. Their research highlights the potential of IoT-enabled PLCs to enhance lab automation and remote control (Lee & Choi, 2022).

III.WORKING

The working of PLC-based lab automation for light and computer systems involves using Programmable Logic Controllers (PLCs) to automate and control various aspects of laboratory environments, such as lighting systems and computer-based tasks. Below is a breakdown of how this works, focusing on automation of lighting and integration with computer systems.

1. Overview of PLC-based Lab Automation:

A PLC is a rugged digital computer used for industrial automation that controls processes, machines, and systems. In the case of lab automation, the PLC acts as the central controller that receives input from sensors, processes the data, and sends outputs to actuators (such as lights or computer systems).

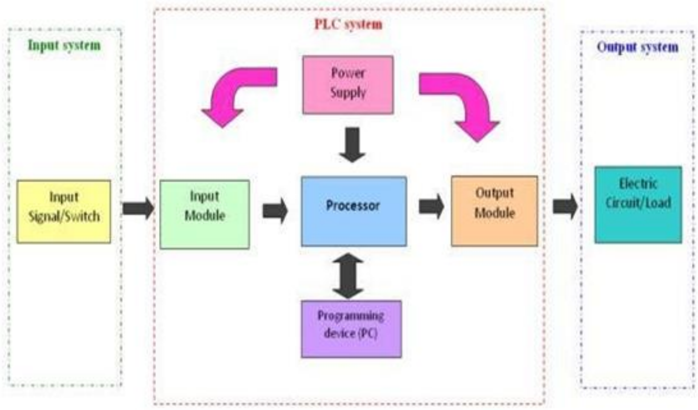

Fig A)Block diagram of PLC

2. Components of a PLC-Based Lab Automation System:

The key components involved in a PLC-based lab automation system for light and computer control include:

- **PLC (Controller):** The central unit that processes inputs and outputs based on programmed logic.
- **Sensors**: Devices that measure environmental factors, such as light intensity, temperature, or occupancy in the lab.
- **Actuators:** Devices that carry out actions, such as turning lights on/off or adjusting light intensity.
- Communication Interface: Facilitates communication between the PLC, computers, and other devices using protocols like Modbus, Ethernet/IP, or OPC.
- **Computers:** Used for monitoring, data acquisition, and analysis, often in conjunction with SCADA (Supervisory Control and Data Acquisition) systems.
- **User Interface (HMI):** Allows operators to interact with the system, monitor conditions, and make adjustments to the automated processes.

3. Working Principle of PLC-based Lab Automation for Lighting Control:

The lighting control aspect of lab automation involves regulating lighting conditions in response to specific needs, such as adjusting light levels based on occupancy, time of day, or environmental conditions

Lighting Control Process:

1. **Sensor Input:** The system uses sensors (e.g., light sensors, motion detectors) to gather data about the environment in the lab. For example, light sensors can measure the ambient light levels, and motion detectors can detect if someone is present in the lab.

2. **PLC Programming:** The PLC is programmed with logic to process sensor inputs and determine appropriate actions. For example:
   - If light intensity is below a set threshold, the PLC will send a signal to increase the light intensity.
   - If the motion sensor detects no presence in the lab, the PLC may turn off the lights to save energy.
   - The PLC can also adjust light intensity based on the time of day or experimental needs (e.g., dimming lights for a particular experiment).

3. **Actuation:** The PLC sends signals to actuators that control the lighting systems. The actuators can be dimmers, relays, or light switches that adjust the light levels or switch the lights on/off.

4. **Feedback and Adjustment:** The PLC constantly monitors the sensor data to make real-time adjustments, ensuring that lighting is always at the correct level for the task at hand.

4. Working Principle of PLC-Based Lab Automation for Computer Integration:

In modern laboratories, computer integration is key to collecting, analyzing, and storing experimental data. PLCs can communicate with computers to provide real-time monitoring, data logging, and remote control of the lab systems.
Computer Integration Process:

1. **Data Acquisition**: Sensors (such as temperature, humidity, and light sensors) send signals to the PLC. The PLC reads this data and processes it based on the logic programmed into it.

2. **Communication Protocol:** The PLC communicates the processed data to a computer system using a suitable communication protocol. Common protocols include:

3. **Data Monitoring & Control:** The computer system, often running PLC software or HMI (Human-Machine Interface), displays the data from the PLC on a graphical user interface (GUI). Lab operators can monitor live data from various sensors (e.g., light intensity, temperature, equipment status) and adjust PLC settings in real-time through the computer.

4. **Data Logging & Analysis:** The computer system records data from the PLC, enabling long-term storage for analysis and reporting. The data can be used for:
   - Trend analysis (e.g., tracking changes in light levels over time).
   - Predictive maintenance by analyzing equipment behavior and sensor data.
   - Reporting for compliance, research documentation, or further analysis.

5. **Remote Monitoring and Control:** The integration allows remote access to the system through the computer. Lab managers can control or monitor laboratory conditions from anywhere, enhancing the flexibility and efficiency of lab operations.

5. Benefits of PLC-Based Lab Automation for Light and Computer Control:

- **Energy Efficiency:** Automating lighting and environmental control ensures that resources like energy are used optimally.

- **Consistency and Accuracy:** PLCs ensure precise control over lab conditions, improving the reliability and repeatability of experiments.

- **Real-Time Monitoring:** The integration with computer systems allows continuous monitoring and instant adjustments, helping ensure that experiments are conducted under the best possible conditions.

- **Remote Control and Data Access:** Computers can store and analyze data from PLCs, providing remote access to lab conditions and automating data logging for research purposes.

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- **Safety:** Automating certain processes (e.g., turning off lights or controlling hazardous equipment) enhances safety by reducing human error.

6. Example of PLC-Based Lab Automation System Workflow:

1. **Sensors:** Light and motion sensors are installed in the lab.

2. **PLC Logic:** The PLC is programmed to adjust the lighting based on time of day and sensor inputs. If the motion sensor detects activity, the lights are automatically switched on.

3. **Actuators:** The PLC sends signals to the lighting control systems to adjust the brightness based on the programmed logic.

4. **User Interaction**: Lab managers can adjust light settings from a computer interface, making real-time adjustments if needed.

7.Advantages of Computer Integration for Fan Control

1. Remote Monitoring and Control:

- SCADA (Supervisory Control and Data Acquisition) systems can be connected to PLCs, enabling remote monitoring and control of fans from a computer. Lab managers or operators can check fan status (on/off, speed, temperature) from any location, even off-site.
- This integration is particularly useful in large facilities or when lab staff need to manage multiple rooms or areas remotely.

2. Data Logging and Analytics:

- Computer systems can continuously log data on fan operation, such as speed, runtime, power consumption, and maintenance records. This data can be stored for future analysis, enabling lab managers to track performance and make informed decisions.
- Data logging also helps in generating reports for compliance, maintenance, and performance optimization.

3. Trend Monitoring:

- Computers can analyze historical data from PLCs to identify patterns or trends in fan operation. For instance, if fans tend to run at high speeds during certain times of day or in specific weather conditions, predictive algorithms can help adjust fan control to optimize energy usage.
- This trend analysis can also help predict future maintenance needs by detecting deviations from ormal operating patterns.

4. Enhanced User Interface (HMI):

- The computer-based Human-Machine Interface (HMI) provides an intuitive interface for lab operators to interact with the PLC system. The HMI displays the fan status, control settings, and real-time sensor data, allowing users to make quick adjustments or troubleshoot any issues.
- The HMI may also provide graphical visualizations of airflow and fan performance, aiding in better decision-making.

5. Safety and Alerts:

- Integrated computer systems can trigger safety alerts when conditions deviate from acceptable levels. For example, if a fan fails or a sensor detects dangerous air quality levels, the system can automatically send notifications or alarms to the operators.
- This integration ensures rapid responses to any emergencies, enhancing the overall safety of the laboratory environment.

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CONCLUSION

PLC-based automation for lighting and computer systems in laboratories offers efficiency, accuracy, and ease of management. By combining sensors, PLCs, and computer systems, labs can automate lighting control, monitor environmental conditions, and streamline data collection. This integration significantly improves the overall productivity, safety, and energy efficiency of laboratory operations.

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