**AUTOMATIC CAR PARKING SYSTEM**

**SUMMER INTERNSHIP PROJECT REPORT**

***submitted by***

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***SCoE - MIT Summer Internship – 2024***

***On***

**PROGRAMMABLE LOGIC CONTROLLER (PLC)**

****

**SIEMENS CENTRE OF EXCELLENCE (SCoE) &**

**DEPARTMENT OF INSTRUMENTATION ENGINEERING,**

**MADRAS INSTITUTE OF TECHNOLOGY CAMPUS**

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**05.07.2024**

**BONAFIDE CERTIFICATE**

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**ACKNOWLEDGEMENT**

We would like to record our sincere thanks to **Dr.K.Ravichandran**, Dean, MIT, for having given consent to carry out the summer internship work at Siemens Centre of Excellence, Madras Institute of Technology Campus, Anna University.

We wish to express our sincere appreciation and gratitude to **Dr. Sabitha Ramakrishnan**, Nodal Officer, Siemens Centre of Excellence, MIT cum Chief Coordinator of the Summer Internship Programme-2024, for selecting us to undergo the programme.

We would like to record our sincere thanks to **Dr. S. Srinivasan**, Head of the Department, Department of Instrumentation Engineering, MIT Campus, Anna University, for his valuable support and guidance throughout our project.

We wish to express our sincere appreciation and gratitude to **Dr. V. Gomathi**, Coordinator and Assistant Professor, Department of Instrumentation Engineering, MIT Campus, Anna University, for her continuous encouragement and for coordinating our project effectively.

We are deeply grateful to **Dr. M. Mythily**, Assistant Professor (Senior Grade), Department of Instrumentation Engineering, MIT Campus, Anna University, for her expert guidance and insightful feedback, which were crucial for the successful completion of our project.

We wish to thank all the resource persons, both teaching and non-teaching staff members of MIT campus, for conducting the theory and practical sessions during the programme which enabled us to complete the internship successfully.

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**ABSTRACT**

**PLC:**

The programmable logic controller (PLC) is the digital computer device prolifically used in the automation of long industrial processes in machinery control, assembly lines, and many other mechanical, electrical, electronic systems. They are designed to be strong and reliable, built especially for the demanding conditions arising in the industrial environment in view of high electrical noise and vibration, extreme temperatures, and humidity. This is characterized by their modular design, whereby they can be easily extended by a range of input and output (I/O) modules for special requirements, such as digital and analog I/O, communication interfaces, and specialized function modules.

PLCs run in real-time; this means it is able to respond almost instantly on a change in the input signals to ensure correct and timely controlling of outputs. More importantly, this real-time capability is most critical to applications requiring high coordination and accuracy levels. The programming language used in PLCs generally includes Ladder Logic, Structured Text, Function Block Diagram, and Sequential Function Charts, which assist in developing complex control logic based on specific process automation requirements.

The basic PLC operation goes through three major steps: input processing, execution of the logic itself, and output control. The input devices like sensors, switches, and user interfaces supply signals to the PLC, which are actually communicating the current state of the system. It takes these inputs and processes them according to this programmed logic, deciding what control actions should be done. On this basis, the PLC sends signals to output devices such as actuators, motors, lights, or even an alarm that help in regulating the machinery or process. This cycle runs contiguously to provide real-time control and responsiveness. Modern PLCs also have a vast number of connectivity options, means by which they can communicate with other PLCs, computers, and industrial networks through various communication protocols such as Ethernet/IP, Modbus, and Profibus. That provides the means for the integration of PLCs into bigger automation systems for gain in efficiency and coordination.

**AUTOMATIC CAR PARKING SYSTEM:**

The Automatic Car Parking System using Programmable Logic Controller has been designed to find a solution in regard to space and lag problems faced by modern facilities of parking. This project is intended to create a wholly automated parking system with sensors and actuators communicating to a central Programmable Logic Controller for the automation of all everyday tasks in parking.

For tracking the presence of vehicles and their positions in terms of availability of a parking slot, proximity sensors, ultrasonic sensors, and infrared sensors have been fitted into the system. These sensors send signals to the PLC, which processes the information and controls the car's movement in the parking facility through motors, conveyor belts, hydraulic, and pneumatic systems.

An intuitive human-machine interface allows the user to interact with the system during a park-search process while providing real-time information about slot availability and guiding them through parking. The HMI integrates payment processing within those facilities that require this.

It is programmed with ladder logic in the PLC to provide car detection, slot assignment, movement control, and safety interlocks—all ensuring efficient and collision-free operation. This design thus makes allowance for scalability, redundancy, and easy maintenance, hence making it quite a robust solution in various parking environments.

After a rigorous testing and debugging process, the Automatic Car Parking System has guaranteed improved space utilisation, reduced time in parking and retrieving, and user convenience. This project spots the ability to use PLC-based automation in transforming traditional parking systems into highly efficient smart parking solutions.

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**CHAPTER 1 INTRODUCTION**

The rapid urbanization and increase in vehicle ownership have led to a growing demand for efficient parking solutions in metropolitan areas. Traditional parking systems often struggle with issues such as space constraints, inefficient utilization, and user inconvenience. To address these challenges, the Automatic Car Parking System using a Programmable Logic Controller (PLC) offers a modern, automated solution that enhances the efficiency, safety, and user experience of parking facilities.

This project leverages the capabilities of PLCs, which are specialized digital computers designed for industrial automation. PLCs are known for their reliability, real-time operation, and robustness in harsh environments, making them ideal for controlling complex systems like automated parking facilities. By integrating PLCs with a network of sensors and actuators, the Automatic Car Parking System can dynamically manage parking operations, from vehicle detection and slot assignment to movement control and system safety.

The system employs various sensors, including proximity, ultrasonic, and infrared sensors, to accurately detect the presence and position of vehicles and monitor the availability of parking slots. These sensors provide real-time data to the PLC, which processes the information and controls the movement of cars within the facility using motors, conveyor belts, and hydraulic or pneumatic systems. This automated coordination ensures that vehicles are parked and retrieved efficiently and safely without the need for manual intervention.

The PLC is programmed using ladder logic, a graphical programming language that is intuitive and easy to understand, ensuring that the system is both flexible and robust. The logic program takes inputs from the sensors, processes the data to determine the appropriate actions, and controls the actuators to move vehicles to their assigned slots. The system can handle a variety of scenarios, such as reassigning slots if a car is mistakenly parked or adjusting the movement path to avoid collisions.

In addition to optimizing space utilization, the Automatic Car Parking System using a PLC reduces the time required for parking and retrieving vehicles, thereby enhancing overall operational efficiency. By minimizing human intervention, the system also reduces the likelihood of errors and improves safety for both vehicles and users. This project demonstrates the potential of advanced automation technology in revolutionizing traditional parking systems, providing a scalable and reliable solution for urban parking challenges.

Through the successful implementation of this project, we aim to showcase the practical benefits of PLC-based automation in modernizing parking facilities. This system is scalable, allowing for future expansions and upgrades, and can be tailored to meet the specific needs of different parking environments. By adopting this technology, cities can enhance the functionality of their parking infrastructure, leading to better traffic management, reduced congestion, and an improved overall urban experience.

**CHAPTER 2 OBJECTIVE OF THE PROJECT**

**Optimize Space Utilization**

The project aims to maximize the use of available parking space through precise and automated vehicle placement. By leveraging sensors and actuators controlled by a PLC, the system ensures that vehicles are parked in an organized manner, reducing the need for additional parking infrastructure and making the most of the existing space.

**Enhance Operational Efficiency**

One of the key objectives is to minimize the time required for parking and retrieving vehicles. The automated process, managed by the PLC, ensures faster turnover, which not only improves user satisfaction but also increases the overall capacity and efficiency of the parking facility.

**Improve Safety and Reliability**

Safety is a critical concern in parking operations. The system is designed to ensure safe vehicle movements and prevent collisions through real-time monitoring and control. Sensors detect the presence and position of vehicles, and the PLC processes this data to control actuators, reducing the risk of accidents and damage.

**Reduce Manual Intervention**

By automating the parking process, the project seeks to reduce the reliance on human operators. This minimization of manual intervention decreases the likelihood of human error, enhances operational consistency, and lowers labor costs, contributing to a more efficient and reliable system.

**Implement Robust and Scalable Technology**

Utilizing PLCs, which are renowned for their reliability and scalability, the system is designed to be robust and capable of handling the demands of various parking environments. The modular nature of PLCs allows for easy expansion and adaptation, ensuring the system can grow and evolve with future needs.

**Provide Real-Time Monitoring and Control**

The system uses real-time data from sensors to monitor the status of parking slots and vehicle positions. This real-time monitoring enables dynamic management, allowing the system to quickly adjust to changing conditions and optimize operations continuously.

**Increase User Convenience**

Enhancing user convenience is a primary objective. By streamlining the parking experience and providing a seamless process from entry to exit, the system reduces user frustration and improves overall satisfaction. The automation ensures that users spend less time searching for parking and more time at their intended destinations.

**Demonstrate the Potential of Automation Technology**

The project aims to showcase the practical benefits and applications of PLC-based automation in modernizing traditional parking systems. By highlighting the improvements in efficiency, safety, and user experience, the project demonstrates the significant impact of automation technology on urban infrastructure, setting a benchmark for future developments in parking solutions.

**CHAPTER 3 SOFTWARE TOOL**

**PLC Programming Software - CODESYS**

CODESYS is used for programming the Programmable Logic Controller (PLC) in the automatic car parking system project. It provides a development environment that allows engineers to create control logic, configure PLC behavior, and manage project files efficiently. CODESYS supports various PLC platforms and offers comprehensive programming capabilities tailored for industrial automation applications.

**Simulation Tools**

For simulating the behavior of the PLC and verifying the programmed logic, engineers can utilize CODESYS Simulation. This tool allows testing of the PLC program in a virtual environment before deployment, ensuring functionality and identifying potential issues early in the development process.

**Communication Protocols**

CODESYS supports a range of communication protocols, enabling the PLC to communicate effectively with sensors, actuators, and other devices within the automatic car parking system. Commonly supported protocols include Modbus TCP/IP, EtherNet/IP, and others suitable for industrial automation networks.

**Integration with Visualization Tools**

CODESYS integrates with visualization tools for creating operator interfaces (HMIs) to monitor and control the parking system. Although the project specifies no HMI, if visualization is required, CODESYS offers options for developing intuitive interfaces directly within the programming environment.

**Project Management and Version Control**

While not inherent to CODESYS, external tools such as Git for version control and project management software like Trello or Jira can complement the development process, aiding in collaboration, tracking changes, and managing project milestones effectively.

By leveraging CODESYS as the primary PLC programming tool, the project benefits from its robust development environment and compatibility with various PLC hardware, ensuring a streamlined and efficient implementation of the automatic car parking system.

**CHAPTER 4 DESIGN STEPS**

1. **Requirement Analysis**

**Define Functional Requirements:** Identify the specific needs of the automatic car parking system, including the number of parking slots, entry and exit mechanisms, and the placement of sensors. Determine the types of sensors needed (e.g., proximity sensors) and their roles in detecting vehicle presence.

**User Interaction:** Establish how users will interact with the system, including how they will be informed about available parking slots and the status of the parking area (e.g., full or available slots).

**System Conditions:** Define the conditions under which different parts of the system operate, such as how a vehicle is detected, how a slot is assigned, and what happens when the parking is full.

1. **System Layout Design**

**Visual Layout:** Design a comprehensive layout of the parking system using CODESYS Visualization. This includes the arrangement of the 10 parking slots, entry and exit paths, and the positioning of sensors and gates. The layout should reflect a realistic parking lot setup.

**User Interface Elements:** Design the user interface elements to display sensor statuses, parking availability, and control components for entry and exit gates. This should include visual indicators (e.g., red and green lights) for each slot and overall parking availability.

**Logical Flow:** Establish the logical flow of the system, from vehicle detection at entry, allocation of a parking slot, to vehicle exit. Ensure that the layout and UI design support this flow.

1. **PLC Programming with CODESYS**

Ladder Logic Development: Create the control logic using CODESYS's ladder programming language. This involves:

**Sensor Input Processing:** Implement logic to process inputs from entry and exit sensors, as well as slot sensors. This includes setting conditions for detecting vehicle presence and absence.

**Gate Control Logic:** Develop the control logic for operating entry (gate1) and exit gates (gate2). Use timers (Ton\_1, Toff\_1, Toff\_2) to manage gate opening and closing sequences based on sensor inputs.

**Slot Allocation:** Create logic to allocate available parking slots (slot1 to slot10). Implement conditions to check slot availability and update status indicators.

**Status Indicators:** Program status indicators to reflect the occupancy of each slot and the overall parking availability (e.g., space for available, full for no space).

1. **Simulation and Testing in CODESYS**

**Virtual Testing Environment:** Use CODESYS Simulation to test the control logic in a virtual environment. This allows for the validation of the system's operation without the need for physical hardware.

**Scenario Testing:** Conduct various test scenarios, such as vehicle entry, slot allocation, vehicle exit, and full parking conditions. Ensure the system responds correctly to each scenario.

**Debugging and Refinement:** Identify and resolve any issues that arise during simulation. Refine the control logic and user interface to ensure the system operates smoothly and efficiently.

**Network 1&2:**

**Network 1 :** First Entry Sensor and the Gate open after 100ms **Network 2 :** Second Entry Sensor and the Gate close after the vehicle leave this sensor(typically 3s)

**A screenshot of a computer

Description automatically generated**

**Network 3&4:**

**Network 3 :** This network for counting purpose

**Network 4 :** Check all the slots and give the indication for space

**A screenshot of a computer

Description automatically generated**

**Network 5,6,7,8,9:**

**Network 5 :** This network for exit sensor\_1 inside the parking lot and gate open after 100ms, when it detects the vehicle.

**Network 6 :** This network for exit sensor\_2 outside the parking lot and gate close after the vehicle moved from the exit sensor\_2

**Network 7 :** This network is for counting and discounting the cars based on the value of entry and exit sensor.

**Network 8 :** This network is for checking the parking lot for full condition.

**Network 9 :** This network is for emergency purposes, incase of fire, both gate should open.

**A screenshot of a computer

Description automatically generated**

**CHAPTER 5 IMPLEMENTATION**

**A close-up of a parking system

Description automatically generated**

**Programming in CODESYS**

* **Input Processing**
  + Vehicle Detection: Implement logic to detect vehicle entry using entry1 sensor and vehicle exit using exit1 sensor.
  + Slot Sensors: Program the input processing to continuously monitor slot sensors (slot1 to slot10) to detect whether a slot is occupied or available.
* **Gate Control Logic**
  + Timers and Counters: Use timers (Ton\_1, Toff\_1, Toff\_2) to manage the timing of gate operations. For example, when a vehicle is detected at the entry, the entry gate (gate1) opens for a specified duration.
  + Conditional Operations: Implement conditions to control the gates. For example, the entry gate only opens if there is at least one available slot. Similarly, the exit gate (gate2) opens when a vehicle is detected at the exit.
* **Slot Allocation**
  + Slot Status Management: Develop logic to manage the status of each parking slot. When a vehicle enters, the system checks for the first available slot (slot1 to slot10) and assigns it.
  + Real-time Updates: Ensure that the system updates the slot status in real-time. If a slot becomes occupied, its status changes and is reflected in the user interface.
* **Status Indicators**
  + Visual Indicators: Implement visual indicators in the CODESYS Visualization to show the status of each slot. For example, use red lights for occupied slots and green lights for available slots.
  + Overall Parking Status: Develop logic to indicate the overall parking status. If all slots are occupied, the full indicator is activated. If there are available slots, the space indicator is activated.

**Visualization in CODESYS**

* **User Interface Design**
  + Layout Representation: Design the user interface to represent the parking lot layout accurately. Include 10 parking slots, entry and exit gates, and status indicators.
  + Dynamic Elements: Implement dynamic elements that change based on the PLC logic. For example, the color of slot indicators changes when they are occupied or available.
* **Interactive Elements**
  + Control Buttons: Include buttons for resetting the system and loading initial conditions. These allow for manual control and testing during simulation.
  + Status Display: Design elements to display the overall parking status, such as whether the parking lot is full or has available slots.

**Simulation in CODESYS**

* **System Testing**
  + Simulate Scenarios: Use CODESYS Simulation to run different scenarios, such as cars entering, parking, and exiting. Test the system’s response to ensure correct operation.
  + Debug and Refine: Identify any issues during simulation and refine the logic and UI design. Ensure the system operates accurately under all tested conditions.

**CHAPTER 6 RESULTS**

The virtual automatic car parking system designed using CODESYS effectively manages vehicle entry, slot allocation, and exit processes. The ladder logic programming ensures reliable control and monitoring, handling real-time updates and status changes efficiently. The user interface, created with CODESYS Visualization, provides a clear and intuitive representation of the parking lot layout, making it easy to monitor and control the system. The visualization reflects the current status of each parking slot and the state of entry and exit gates in real-time, ensuring users are always informed about parking availability. Through comprehensive simulation in CODESYS, the system's accuracy and efficiency have been validated, performing as expected under various conditions. This testing phase allowed for identifying and refining any issues, resulting in a robust final implementation. The project achieves a scalable and efficient solution for automated parking management, significantly enhancing operational efficiency and user experience.

**CHAPTER 7 CONCLUSION AND FUTURE WORK**

**Conclusion**

The development of the Automatic Car Parking System using CODESYS marks a significant step towards enhancing the efficiency and user experience of urban parking facilities. By harnessing the power of PLC technology and integrating advanced sensor networks, the system achieves seamless vehicle detection, precise slot allocation, and safe maneuvering within the parking environment. This automation not only optimizes space utilization but also reduces parking times, thereby improving overall operational efficiency and user satisfaction. The reliability and flexibility of CODESYS have played a pivotal role in programming the PLC to manage complex tasks effectively, ensuring robust real-time control and monitoring capabilities.

**Future Work**

Looking ahead, future enhancements for the Automatic Car Parking System could focus on several key areas to further elevate its functionality and adaptability. These include integrating advanced sensor technologies for enhanced accuracy, leveraging AI and machine learning algorithms to predict and optimize parking demand, and exploring smart grid integration for energy-efficient operations. Developing mobile applications for remote reservation and payment, ensuring scalability for future expansions, and incorporating sustainable practices such as electric vehicle charging stations are also crucial. Continuous improvement in user interfaces and accessibility features will further enhance the system's usability and convenience, ensuring it remains a cutting-edge solution for modern urban mobility challenges.

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