TITLE: Case Study Car Park

Industrial Control Systems - Assignment 1 – Car park case study project

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# Executive summary

## Car parking is the act of parking a car in a designated parking space. This can be done in a private garage, in a public parking lot, or in a parking garage. Car parking is a necessary part of driving, as it allows drivers to store their vehicles safely and legally when they are not in use. The challenge of car parking is finding a safe and legal spot to park in. This can be difficult in crowded areas, or in areas where parking rules are not strictly enforced. It can also be difficult to find a spot when parking spaces are limited. Additionally, drivers must be careful to obey all parking laws, or else they may face fines or other penalties. (Openai.com, 2022)

Automated public car parking technology is a type of automated parking system designed to increase the efficiency of public car parking. It typically consists of automation system that use programmable logic controllers (PLC), sensors, artificial intelligence, and other technologies to identify, locate, and guide vehicles to vacant parking spaces. This technology helps to reduce the time spent searching for a parking spot and improve the overall efficiency of public car parking. In addition, automated public car parking technology may also include features such as automated payment systems, automatic ticketing systems, and automated access control. These features can help to reduce the costs associated with running a public car park, while also providing a more convenient and secure experience for drivers. (Openai.com, 2022)

This study will discuss the requirements for designing a automatic car park control system. The parking system under consideration in this case study will focus on a more basic design concept and leave out more complex components like cutting-edge payment systems and number plate recognition, which will be covered in this report. The control system created will show off the programming and project management abilities acquired in Siemens.

Keywords: Automated public car parking technology, Programmable logic controllers, Artificial intelligence.

# Declaration of originality

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Pankaj Singh Rawat 30 Nov 2022

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# Introduction

## One of the biggest issues in the 21st century is finding a spot to park your automobile for free. Due to the high amount of uncertainty, this sort of problem impacts everyone daily, and there aren't many workable solutions that help users by saving time, fuel, and keeping a pleasant mental state. Without parking, the transit system is insufficient. Nearly 40% of metropolitan highways are used exclusively for parking cars on any given working day. Cities throughout the world are already crowded, and automobile parking takes a lot of time on top of that. It could take a while and use up a lot of petrol to find parking. As a result, it could irritate drivers and cause collisions.

## This report will examine the present situation of the parking sector, which has had to adjust to alterations in our way of life, alterations in the energy market, and advancements in technology. Also, The purpose of this report is to design a car park control system and outline the steps involved with the help of a flow -chart diagram.

## Problem statement

## This report's goal is to build a parking lot control system and lay out the associated stages. The automobile parking system being examined in this case study will focus on a simpler design concept and leave out more complex components. The following is a list of the criteria for the control function.

* On entry
  + If there are less than 10 cars in the car park only a green light will illuminate, and entry can be permitted.
  + If there are between 9 and 13 cars (not inclusive) only an orange light will illuminate, and entry can be permitted.
  + Otherwise, no entry is permitted.
  + Entry will only be permitted in the event of the detection of the presence of a car and a ticket request, usually via a push button.
* On exit
  + Exit will be permitted if both the ticket is shown to be valid and the presence of a car is detected.
  + To simplify the problem, you can treat ticket validity as a single bit.

## Objective

## The initial steps in the methodology for this case study was to do broad industry research to better understand the issues the sector is now facing. The case study was then finished up with its practical component. This involves doing research on the relevant parts needed to finish the project's scope. The control function was designed on a flowchart and PLC Logic was implemented during the programming stage. System testing needed to be done as a last step.

## Scope

• Only a green light will illuminate upon entry if there are fewer than 10 vehicles in the parking lot, and access will be allowed.

• Only an orange light will glow, and access may be allowed if there are between 9 and 13 automobiles (not including the lead vehicle).

• No admission is allowed in any other case.

• Only when an automobile is detected and a ticket is requested, often using a push button, will entry be allowed.

• Upon exiting, if both the ticket's validity and the existence of a car are confirmed, departure will be allowed.

• You may regard ticket validity as a single bit to make the issue simpler.

# Literature review

Since the creation of the first automobiles, parking systems have been a thing. There are automobile parking systems in place in each location where there is a lot of traffic. The requirement for vehicle storage led to the creation of car parking facilities from the beginning of the 20th century. Finding a free parking spot has grown increasingly challenging because of the fast growth of vehicles available and in use in recent years, leading to a variety of practical issues. In every big city, parking issues are spreading like wildfire and becoming worse at an alarming rate. The widespread adoption of wireless technology and recent developments in wireless parking applications suggest that the sharing of digital data may hold the key to resolving current parking issues [1].

Employing a parking management system has several benefits for city planners, business owners, and motorists. They provide convenience for drivers and optimal space use for businesses headquartered in cities. Automated parking systems make parking easier while saving time, money, and space. Traditional and automatic parking systems are the two different varieties. In the long run, automated automobile parking systems are probably less expensive than conventional parking garages. Since they often need less ground area and building volume than a traditional facility with the same capacity, automatic multi-storey automated car park systems are less expensive per parking space. As fewer automobiles are running or turning in circles while looking for parking spots, automated parking garage systems and automated car parking systems both minimize pollution. It can be challenging, if not impossible, to locate an open spot quickly in a multi-level parking lot, particularly on the weekends or on holidays. About 66% of visitors report that it takes longer than 10 minutes to find parking on weekends or holidays. Peak times are busy at stadiums or shopping centers, and people frequently have trouble finding open seats there. There are not enough parking places, which causes traffic jams and aggravates drivers. Improper parking is when a car is parked such that it takes up two parking spaces as opposed to one. When a motorist acts careless with respect to another driver's rights, improper parking may result [2]. Fig. 1 illustrates the issue that individuals experience because of poor parking management.

A picture containing car, outdoor, person, people

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Fig. 1. Improper parking system

We need an automated intelligent parking system that protects the driver's safety while also saving time and parking places to tackle all these issues.

The automatic intelligent car parking system has several advantages, including the ability to fit the most cars into the smallest amount of space, customized parking options, low maintenance and operation costs, safety for the car and the driver, quicker parking and retrieval, and eco-friendliness.

A PLC-based Automatic Intelligent Car Parking System will be created using IR sensors, Light Dependant Resistors (LDR), and solar panels for electricity.

The Automatic Intelligent Car Parking System just requires the input module from IR Sensors and LDRs to transport it to the Programmable Logic Controller to ensure easy, dependable, and effective vehicle parking management (PLC).

PLC (Programmable Logic Controller) (Programmable Logic Controller) PLC, or programmable logic controller, is the technical term. It is an industrial computer that has been toughened up and modified for use in operating manufacturing processes like assembly lines, equipment, robots, or any other task needing high dependability, simple programming, and process fault detection. PLCs are simpler to program and contain more input and output pins in addition to memory. The programming languages are ladder diagram, functional block diagram, instruction list, structured text language, and sequential function chart. The ladder diagram is an illustration of vocabulary that is clear and approachable. There are standard and failsafe Siemens SIMATIC S7-1200 PLC models available.

By monitoring inputs and other variable values, making decisions based on a stored program, and controlling outputs, PLCs automate processes.

Graphical user interface, diagram

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Fig. 2. SIMATIC S7-1200: The Modular Mini-PLC

Diagram

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Fig. 3. Communication of Programmable logic controller (PLC) and Human machine interface (HMI)

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Fig. 4. Typical PLC scan cycle

Diagram

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Fig. 5. Standard IEC 61131 languages associated with PLC programming.

**PLC Based Automatic Intelligent Car Parking System**

Using IR sensors, Light Dependant Resistors (LDR), and solar panels for power consumption, a PLC-based Automatic Intelligent Car Parking System will be developed.

To assure simple, dependable, and efficient automobile parking management, the Automatic Intelligent Car Parking System only takes the input module from IR Sensors and LDRs to deliver it to the Programmable Logic Controller (PLC).

A collection of LDRs and IR sensors are used by the automated intelligent vehicle parking system, a smart system, to provide efficient and secure automobile parking management. There are three operating modes for the intelligent auto parking system: ON, OFF, and EMERGENCY.

When auto parking system usage is at its height throughout the day, the ON mode is turned on. When there is little use of the automobile parking system at night, the OFF mode is employed. When an illegal event occurs, parking authority staff members press the emergency push button to activate the EMERGENCY system. In an emergency, the PLC orders that all gates be closed and that no vehicles be allowed to enter or exit the parking lot.

There are ten car spaces available at the parking lot, and ten LDRs are positioned on each one to detect the presence of a car parked there. The LDR provides this output to the PLC if there are ten cars parked in the lot.

A single set of IR sensors is positioned at the car parking's main gate to identify the presence of a vehicle waiting to enter. The output is sent to the PLC if the IR sensor detects the presence of a car. To determine whether a car may be parked or not, the PLC modifies the data that the LDR and the IR sensor have supplied. The PLC instructs the main parking gate to open and let the automobile into the parking area if the data from the LDR indicates that there may be available space for car parking and the IR sensor also identifies the presence of a car waiting to be parked. The PLC prevents the main gate from opening and guides the automobile to the next parking ground if the data supplied by the LDR indicates the probability of a completely occupied parking spot. Because the parking system employs solar panels to generate its own electricity, it is both highly affordable and practical. A solar panel harnesses solar energy from the sun to charge a number of batteries in an intelligent auto parking system. The solar panel system is installed in an empty, underused area of the parking garage, where it transforms solar energy into DC electricity and stores it in a large battery. Depending on how frequently a car enters the parking system, the large battery may be able to supply power backup for a longer amount of time [3].

Fig. 6 illustrates how the automated intelligent automobile parking system functions.

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Fig 6. Automatic Intelligent Car Parking System.

Fig. 7 depicts the block diagram of the automatic intelligent automobile parking system. The linked input and output components to the PLC are shown in the diagram.

Six LDR sensors, IR sensors, and a security camera make up the input component. The entrance gate and exit gate mechanisms are included in the output components. Batteries that are charged by solar panels are connected to the input, output, and PLC.

Diagram

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Fig 7. Block diagram

**Input Module**

The IR sensors, LDRs, Camera, and Push Button Switch are all part of the input module for the autonomous intelligent automobile parking system. Two IR sensor sets are present. To start, an IR sensor is positioned at the entrance gate to identify whether a vehicle is there. The exit gate has a second IR sensor, which aids in seeing vehicles there and instructs the PLC to open the gate.

The automated intelligent automobile parking system has ten LDR sensors installed on each parking space. The LDR recognizes when a car is driving over it and assists in determining the precise number of parking spots that are available in a certain parking lot. The PLC receives this output.

Switches with pushbuttons are used for security measurements. When an emergency occurs, the push button switch is activated. The security guard activates the security mode of the parking system by pushing the button switch whenever he observes something unexpected or suspicious on the surveillance cameras. The push button activates the security alert and instructs the PLC to close all of the car park system's gates.

**Output Module**

Entry gate and exit gate mechanisms make up the automatic intelligent automobile parking system's output module. The batteries that are charged by the solar panel are connected with these processes.

The output of the IR sensors determines when the gate will open and close. When a car is at the entry gate and a parking spot is available, the entry gate automatically opens. When an approaching vehicle is detected by the IR sensor at the exit gate as well as when the emergency mode is off, the exit gate automatically opens.

**Signal Processing**

The output of the IR sensors and LDR sensors cannot be provided directly to the PLC since the input voltage to the PLC should be 24 V. As a result, they are provided through signal conditioning circuits, which then provide the input signals to the PLC as inputs. The inputs are not sent to the PLC directly for safety reasons. Through relay circuits, they are distributed. The relay has three terminals: common, NO, and NC. The common terminal will have access to the 24 V that must be pushed into the PLC [5]. Therefore, based on the required signals, the circuits either close or open, connecting to the PLC [5].

# Discussion

**Concept and Standards for Design**

Fig. 8 is a schematic representation of the planned completely automated automobile parking lot. The parking spots' driveways are accessible from the road. The barricade serves as a parking lot fence. The parking space number is used to identify specific parking spots. There are ten parking spaces available for demonstration purposes. The parking lot's accessibility is managed by the barrier gate. Information is generated and sent by the retroreflective sensor to the PLC. These sensors are available at the automobile parking places, exits, and entryways.

**The proposed automated car parking lot's mode of operation**

The automated parking lot has four operational phases.

1] Car at the parking lot: Put the car in the designated space. The sensor detects the presence of a car and alerts the PLC with a signal. The PLC runs the program, and an appropriate output is then given. The computer algorithm looks for available parking spots for cars. For instance, there are three parking spots available: spots 1, 3, and 5. On an LED display, show parking spots 1, 3, and 5. Next to the driver, the LED display is attached to the wall. It takes around 5 seconds for the entrance barrier gate to open.

Diagram

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Fig 8. Schematic Diagram of the Proposed Fully Automated Car Parking Lot [6]

Graphical user interface, application

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2] Car at the parking space: At the parking slot, there are two substages: "car packed" and "car removed." When a car is parked, the sensor detects its existence and notifies the PLC of it. The PLC looks through its software. A timer will be started by the associated output when the required criteria are met. For the car that was removed, the same sensor provides data to the PLC. The car has been removed, therefore the timer ends. Calculating the time difference and converting it to its appropriate financial equivalent. A message is delivered to the ticket machine [6].

3] Car at the exit: Car park close to the ticket machine. Put cash into the ticket machine and wait for change or a credit. To the PLC is provided feedback. The PLC opens the barrier gate after making a choice based on the program. Car leaves the parking lot.

4] Monitoring: Monitoring is done remotely where the Rockwell PLC ladder program is integrated with Allen Bradley HMI. Fig. below shows the flowchart for the first three operating stages of the automated car parking lot.

Chart

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1. Car at the parking lot (b) Car at the exit

Fig 9. Flow chart for the Automated Car Parking Lot

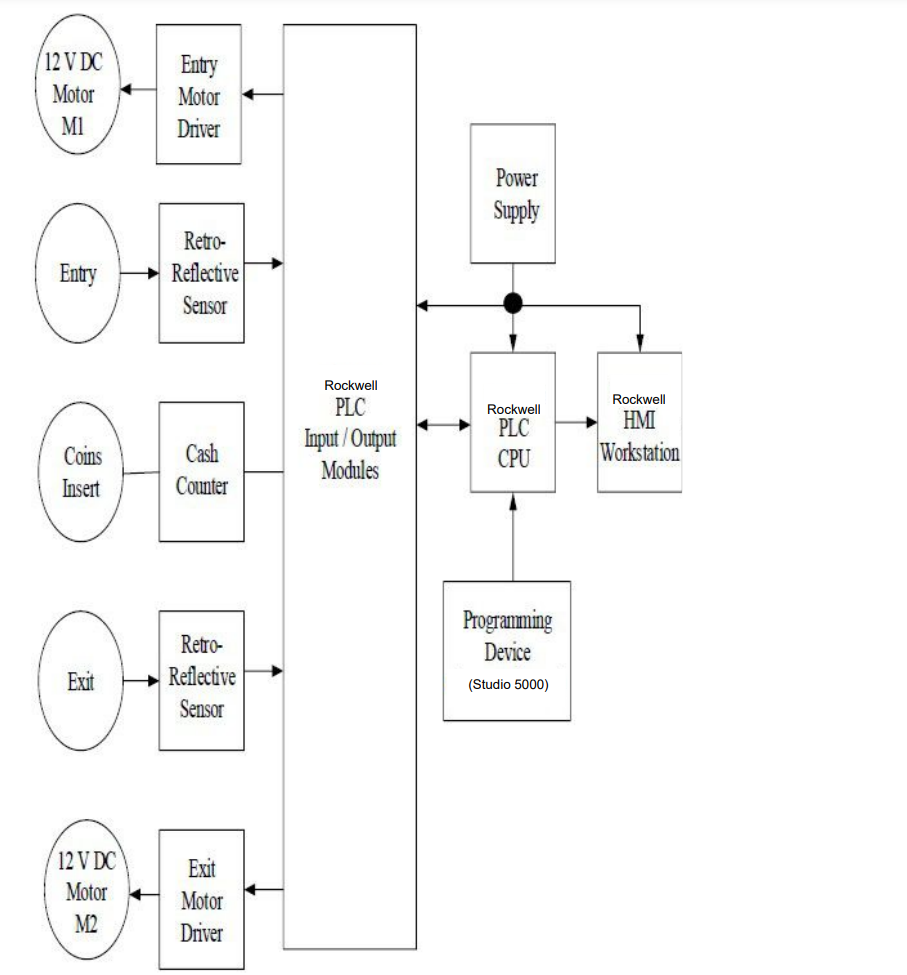
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Fig 10. Block diagram of the proposed PLC based park Car parking

The block diagram of the automated parking lot's proposed design and implementation is shown in Fig. 3. The design uses a programming device, Rockwell PLC Studio 5000 programming software, and a Rockwell-Allen Bradley PLC and HMI workstation. The following design criteria were used to create the automated parking lot:

• PLC Brand: Allen Bradley

• PLC Type: CONTROL LOGIX-L75 PROCESSOR

• Communication Port in PLC & PC: Ethernet RJ-45

• Communication Cable: Studio 5000 Emulate software

• Driver Software: Emulator ETHERNET/IP

• Communication Software: RS Linx

• Programming Software: Studio 5000

•Communication Adaptor: 1734 AENTR Common adapter

• Allen Bradley Brand

• Remote cards:

Allen Bradley 1734-1B

Allen Bradley 1734-0B

Allen Bradley 1734-1E2

Allen Bradley 1734-0E2

[7] (Manual n.d.)

**Materials**

1. **Automated car parking Lot Hardware**

Entrance and exit barrier gates: The barrier gates are made of a long, single arm of metal that prevents a vehicle from moving forward. When a sensor determines that a vehicle is waiting to pass through the gate, it is set to automatically lift. Another mechanism prevents damage to the vehicle by making the gate arm go back up if a car doesn't move quickly enough. Motor vehicles are unable to enter or leave the parking lot because of the barrier gates.

Retro-reflective sensor: There are a total of 13 retro-reflective sensors used in the parking spaces, gates, and entrances. In order to create an effective beam between the emitter, the reflector, and the receiver, each sensor has an emitter and a receiver element. When an object disrupts or breaks the effective beam, the sensor activates. The PLC receives information about parking lot activity from the sensor.



Fig 11. Working on Retro-elective sensor

12 V DC motor and driver circuit: The barrier gates at the entrance and exit gates are opened and closed by two 12 V DC reversible motors with shaft-mounted bars. A computer program that sends electrical signals to a motor driver manages the barrier gate. The barrier gate is precisely moved to a predetermined location for the vehicle to pass by using pulsed voltages that the motor driver sends to the 12 V DC motor. A four 1N5817 Schottky diode-based H-bridge driver circuit provides the necessary forward and reverse motions for the 12 V DC motors at a predetermined speed [8].

*Rockwell PLC:* The 1756-L75 ControlLogix 5570 Controller is a hardware that communicates with the field devices. It is also the PLC that does the job of the program software. 1756-L75 Controller, ControlLogix,32 MB User Memory,0.98MKB I/O Memory, USB Port,500 Controller Connections,4 Character Alpha/Numeric Display,5ma @ 1.2VDC,800ma @ 5.1VDC.

HMI workstation: A computer connected to a network serves as the HMI workstation, giving a human operator access to the entire network. The human operator can observe and oversee the automated car parking lot's operation from the HMI workstation in the remote-control room. The automated car parking lot operator can use it to visually interpret any situation.

Power supply unit - QUINT4-PS/1AC/24DC/20 A power supply drawn from AC and DC networks, as well as 1-phase and 3-phase supplies, powers the PLC and the HMI workstation

(Phoenixcontact.com, 2014).

1. **Automated car parking Lot Software**

Rockwell Studio 5000 Logix Designer Software FactoryTalk: Studio 5000 is one of the most popular software programs in the world for industrial automation. The most potent Allen-Bradley PLCs (technically PACs), including the ControlLogix and CompactLogix controllers, are programmed using Studio 5000 Logix Designer (previously known as RSlogix 5000) [10].

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## Methodology

**Flowchart for the Automated Parking Lot for Cars**

The development of a system flowchart made possible to write codes based on programming stages with the help of the input and output signals.

The suggested automated automobile parking lot's system flowchart is shown in Fig. 11.

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Fig 12. The System Flowchart of the Proposed Fully Automated Car Parking Lot.

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Fig 13. Flowchart philosophy at the entry barrier gate

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Fig 14. Flowchart philosophy at the exit barrier gate

Diagram

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Fig 15. The System Flowchart philosophy for light indication [11].

## *Programming the Automated Car Parking Lot*

Programming of the automated car parking lot starts with creating a project in Rockwell Studio 5000 logix designer software. The project created is named **AUTO\_CAR\_PARK**. It is a folder which stores the entire main programming work done in Rockwell Studio 5000 logix designer for the automated car parking lot.

-Now open ‘Studio 5000’ software and click ‘New Project’

Enter the required name for the project i.e., AUTO\_CAR\_PARK and select an appropriate ‘PLC controller’ (In my case we don’t have a PLC hardware, so in order to simulate the project we’ll be using a Rockwell Emulator (Studio 5000 Logix Emulate Controller) for simulating the I/O’s.

Click next and Click Finish.

Ladder logic programming language was used to create the codes for the creation of the programming blocks.

# Logix Designer

Logix Designer application is comprehensive programming software for sequential, process, drive, and motion control. The Logix Designer application environment offers an easy-to-use, IEC61131-3 compliant interface, symbolic programming with structures and arrays, and an instruction set that serves many types of applications. This environment is common to the Rockwell Automation® Logix platforms: ControlLogix and CompactLogix.

The Logix Designer application is designed to work with Rockwell Automation Logix Platforms and the Logix5000™ family of controllers. Logix Designer application functionality includes the following.

* Ease of configuration, including a graphical controller organizer, I/O configuration dialog boxes, a motion configuration tool, and point-and-click methods of configuration.
* Sophisticated data handling, using both arrays and user-defined structures, to provide the flexibility necessary for the application rather than forcing it to fit the particular memory structure as defined by the controller’s data table memory.
* Easy-to-use I/O addressing methods.
* A free-form ladder editor that allows you to modify multiple rungs of logic simultaneously, as well as to enter logic either from the point-and-click interface or via an ASCII entry prompt.
* Flexible, easy-to-use ladder diagram, function block diagram, sequential function chart, and structured text language editors to allow you to create application programs with ease.
* Drag-and-drop editing and navigation to quickly move instructions, rungs of logic, function blocks, routines, programs, and tasks either within a single project or between two copies of the application to create project libraries; you can even move program elements between the RSLogix™ 5 and RSLogix 500 software packages.
* Right-click access to context menus for common tools, letting you accomplish tasks within a single menu and reducing your need to memorize locations of features in the menu bar.
* A robust, specialized instruction set for ladder diagram, structured text, and function block diagram languages. These instructions include industry-specific instructions for process, drive, and motion applications, ASCII instructions to let you manipulate, store, and send string data, and message instructions to simplify sending and receiving data across many devices.
* Logical application organization and an intuitive programming environment in which the IEC61131-3 compliant multi-tasking operating system of a Logix controller is presented in an easy-to-understand graphical tree with tasks, programs, and routines grouped by their operation within your application.
* Diagnostic monitoring capability, using the TrendX component found in other Rockwell Software products to provide graphical, real-time data histograms for diagnostic and monitoring functions, allowing you to trend as many as eight separate values simultaneously; in addition, the language editors, Tag Editor, and Data Monitor all include a quick cross reference tool that lets you quickly navigate to tags, description text, edits, or instructions.
* The ability to force values to test your logic for individual bits, tags, bit and block instructions, and entire values.
* The stand-alone version of FactoryTalk® Security (from Rockwell Software®), offering multiple-user, multiple-level password protection to your controller, both online and offline; you can assign full controller access, read-only access, and code read and data read/write access, as well as using the source protection functionality to protect individual routines.
* Highly integrated motion support.
* The ability to create a Tool Window arrangement that makes the most sense to your workflow, saving space and time.

Graphical user interface, text

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Notice, this is Studio 5000 Logix Designer, and the project is set up with an Emulate controller and I have one IB16 discrete input module and one OB16E output module in the rack.

Here’s what these ladder logic symbols look like

  (XIC)

----| |-----

  (XIO)

----|/|-----

 (OTE)

----(  )-----

When the XIC is turned on (for instance, if it is addressed to a push-button input), it permits "power" to flow to any other Ladder Logic elements to the right of the input. The XIC is normally off and does not permit "power" to flow through it to any outputs.

On the other side, the XIO accomplishes the exact opposite. When the input is turned on, the XIO opens, interrupting the "power flow," which is normally allowed to pass through it to the other Ladder Logic elements and instructions to the right. Programs turn things on by using the OTE. In other words, you operate your motors, lights, valves, etc. with the OTE. You utilize the output instruction to tell your outputs what to do.

Every Ladder Logic program is built around these three commands. Many straightforward and complicated logic programs may be written using only the XIC, XIO, and OTE. The Timer and Counter instructions are also two additional highly crucial instructions.

## Results

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## PLC CAR PARKING Logic

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## Analysis

In conclusion, the case study was a useful exercise in showing comprehension of a fundamental control system and bringing the components together within a predetermined time frame. The usage of a barrier for access and leave would not be particularly easy for car park users, thus there are clearly some design elements that may be improved. Many automation manufacturers offer comprehensive entrance and exit system solutions that are functional and eliminate any unanticipated system failures. The project's components did come together, and the flow chart is unquestionably a useful addition to the project file, in my opinion. Planning report documentation is vital moving ahead as it might make it tough to put everything together at the end if not done properly.

Conclusion

Rockwell PLC and HMI workstations have been used to design an automated parking lot, and Rockwell PLC SIM was used to simulate the concept. Due to the design, the operator must operate and oversee the automated automobile parking lot from a distance. A fully automated car parking lot has been achieved using retroreflective sensors, a PLC, and an HMI workstation facility positioned on the driver's side for easy view. These features allow for the real-time display of events such as car arrival and departure times, time spent at the parking space, the automated payment facility, and information on parking spaces that are available.

## Future work and recommendations

An HMI workstation operator operating from a remote-control room manages the facility. Ladder logic programming were used to write the control software, which aided simplicity and use. The created method will be beneficial to both big and small businesses who need parking services. Using a PLC and HMI workstation, conventional parking systems should be transformed into fully automated systems.

# References

[1] M. Grewal, “Comparative implementation of automatic car parking system with least distance parking spaces in wireless sensor network,” International Journal of Scientific and Research Publications, vol. 2, iss. 20, November 2022.

[2] S. Sarayu, S. S. Rajendra, and V. V. Bongale, “Design and fabrication of prototype of

automated smart car parking system using programmable logical controllers (PLC)”,

International Journal of Scientific Engineering and Technology, vol. 2, iss. 9, pp. 857-860.

[3] B. H. Khan, *Non-Conventional Energy Resources*, 2nd ed. Tata

McGraw-Hill Education, 2009, pp. 159-177.

[4] *International Journal of Computer Theory and Engineering, Vol. 9, No. 1, February 2017*

[5] J. R. Hackworth and F. D. Hackworth, *Programmable Logic Controllers: Programming Methods*

*and Applications*, 1st ed.Pearson, 2006, pp. 128-138.

[6] *View of A Fully Automated Car Parking Lot* 2022, Unand.ac.id, viewed 26 November 2022, <http://jnte.ft.unand.ac.id/index.php/jnte/article/view/885/436>.

[7] Manual, U. (n.d.). *Studio 5000 View Designer User Manual*. [online] Available at: <https://literature.rockwellautomation.com/idc/groups/literature/documents/um/9324-um001_-en-d.pdf>.

[8] Unand.ac.id. (2022). *View of A Fully Automated Car Parking Lot*. [online] Available at: http://jnte.ft.unand.ac.id/index.php/jnte/article/view/885/436 [Accessed 22 Nov. 2022].

[9] Phoenixcontact.com. (2014). *Power supply unit - QUINT4-PS/1AC/24DC/20 - 2904602 | Phoenix Contact*. [online] Available at: https://www.phoenixcontact.com/en-ie/products/power-supply-quint4-ps1ac24dc20-2904602 [Accessed 28 Nov. 2022].

[10] automation.com. (2020). *A Beginner’s Tutorial to Rockwell Automation’s Studio 5000 Logix Designer*. [online] Available at: https://www.automation.com/en-us/articles/january2020/a-beginner-s-tutorial-to-rockwell-automation-s-stu [Accessed 28 Dec. 2022].

[11] free (2022). *Flowchart Maker & Online Diagram Software*. [online] Diagrams.net. Available at: https://app.diagrams.net/ [Accessed 29 Dec. 2022].

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## Appendices

## Appendix 1: Drawings and schematics

## A picture containing text, sign, screenshot Description automatically generated

## A picture containing text, sign, screenshot Description automatically generatedDiagram Description automatically generatedA picture containing text, sign Description automatically generatedDiagram Description automatically generated

## Appendix 2: Software

### Graphical user interface, application, Word Description automatically generated

Graphical user interface, text, application, email

Description automatically generatedDiagram, schematic

Description automatically generated

## Appendix 3: Hardware

Graphical user interface, application, Word

Description automatically generated

Table

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