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Car Park System Controlled By PLC

by

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A project submitted in partial fulfilment for the
Degree of BEng. (Hons) Electrical and Electronic Eng.

In the
School Of Applied Computing Faculty of Architecture
Computing & Engineering

April 2021



Declaration:

I, Nour Srihini declare that I am the sole author of this Project; that all references cited have been consulted; that I have conducted all work of which this is a record, and that the finished work lies within the prescribed word limits.

This work has not previously been accepted as part of any other degree submission.

Signed: Nour Srihini

Date: 23/04/2021

FORM OF CONSENT

I Nour Srihini hereby consent that my Project, submitted in candidature for the B.Sc. (Hons) Computing & Information Systems degree, if successful, may be made available for inter-library loan or photocopying (subject to the law of copyright), and that the title and abstract may be made available to outside organisations.

Signed: Nour Srihini

Date: 23/04/2021

Acknowledgments:

Studying in a different country with a different language with people from all around the world was not the easiest thing, and the outbreak of the pandemic made it even harder. However, I am pleased to be a student in the University of Wales Trinity Saint David, enabling me to prove that females can be successful at any field.

I wouldn't have been able to complete this project without the support of my supervisor Dr. Gary Jones. I really appreciate his assistance as he offered help and support whenever I required it, a huge thanks to him.

I would also like to thank my family, friends and my boyfriend who believed in me, helped, and supported me through my difficult times and motivated me to finish this project within the limited time.

Abstract:

The main steps to complete this project are firstly to research then design and lastly to write the PLC program to run the car park. The author will be creating a system that can count the cars number entering the car park and the ones going out, as it has a number limited for the cars to be parked in. so when its full it cannot allow more cars to entre.

Adding the lighting technology to the drivers to follow therefore to show the directions and where to park.

The content of this report includes:

- Research on the car park types and systems.
- Research into the market to establish other systems related to the proposed idea.
- Research into different parts that needed to build the project finding the most appropriate for the application.
- Design car park using Factory I/O.
- Design PLC system to control the car park.
- A prototype builds and a cost list research.
- Evaluation of the project.
- Overall conclusion.
- Personal Reflection.

The softwares used to build and design this project are:

- PLC
- Factory I/O
- Microsoft Word.
- Microsoft Excel.
- yEd Graph Editor

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Chapter 1 (Introduction):

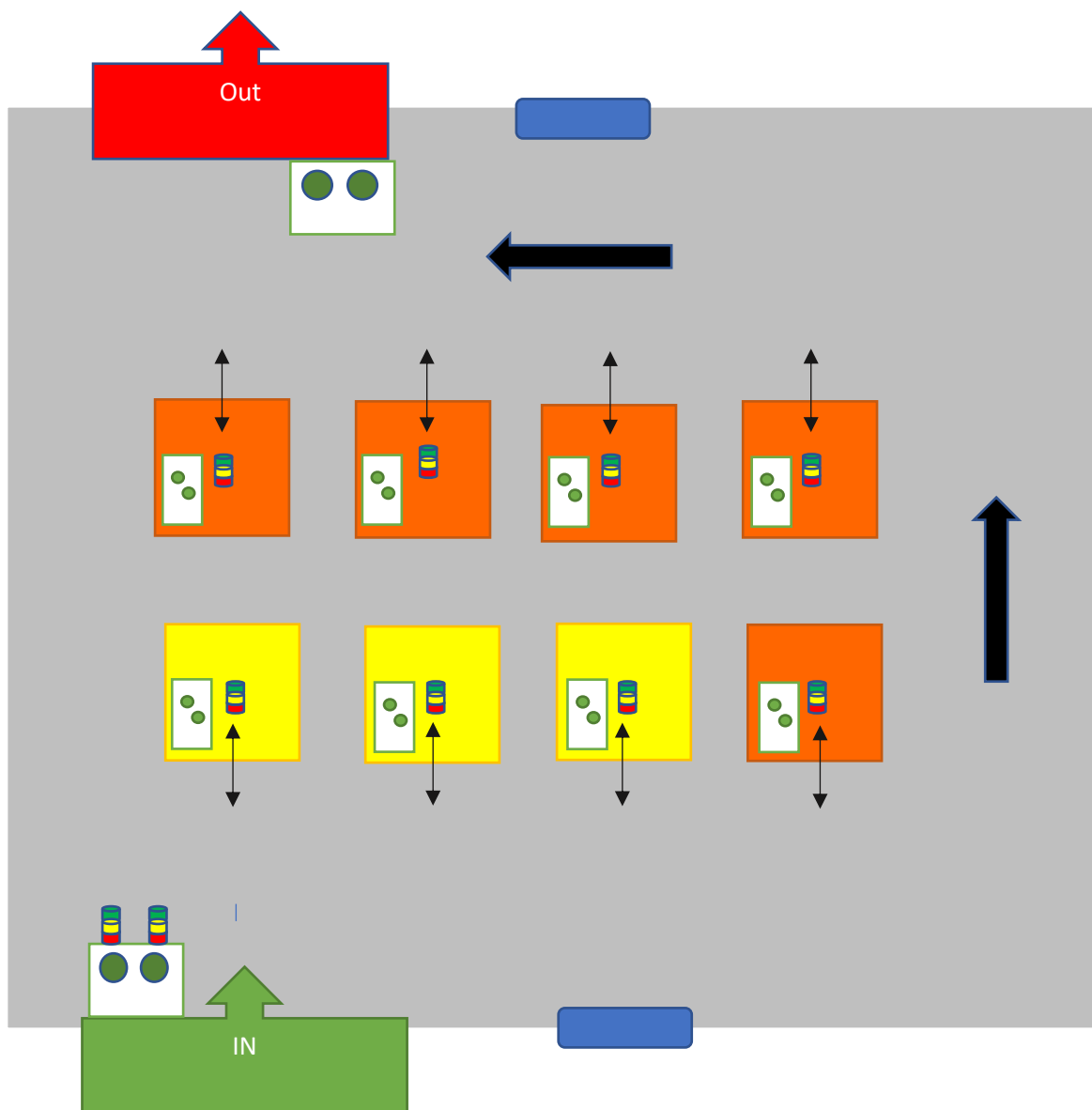
Introduction:

As part of the level 6 in the UWTSD, I have been asked to complete an individual project. In my previous year, I did a group project where I had to individually complete a portion of that project. However, in this year's module, a complete project including individual research is expected of me.

After prolonged research, I came up with various possible project ideas, however I ended up choosing 'the car park system with counters' as my individual project idea.

'Car park systems controlled by plc' is the title of this project. Using the Factory I/O, the author will be able to design a car park, connect this design and connect it with a plc program to control it.

Car park structure: The design below represents my expectations of the design model in the factory I/O, including all the components needed.



starting with the entrance:

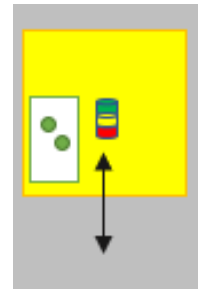
- 2x switches
- 2xStack light (green and red)
- Car's gate
- Customer's gate



9

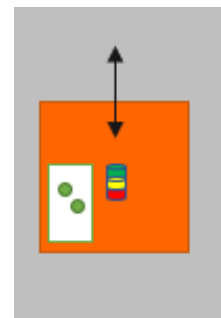
disabled parking space:

- stack light (green and red)
- switch



parking space:

- stack light (green and red)
- switch



Exit:

- two switches
- Car's gate
- Gate for pedestrians



Aims:

- PLC Program System to control the car park which is going to be on the Factory I/o.
- Aiming to get the system working perfectly with the factory car park design.
- Test the design before the submission day, ideally one week prior.
- Finishing this report on time.

Objectives:

Starting to build the factory I/O as a car park structure with the number of car slots needed, placing all the stack lights and the parts. Once finishing the factory design, a suitable PLC programme will be written to control it.

The Gantt chart will assist me in time management, where the aim is to accomplish my project on time and on the dates provided, to increase time efficiency.

plan:

Gantt chart			
Task to be done	start date	ending date	Duration
Project ideas research	10/10/2020	13/11/2020	34
Search about each project idea	14/11/2020	02/12/2020	18
research on the selected project	03/12/2020	21/01/2021	49
Major project proposal	01/12/2020	04/12/2020	3
setting plan	20/01/2021	22/01/2021	2
prepare my first presentation for viva 1	15/01/2021	21/01/2021	6
Interim Viva 1 presentation	21/01/2021	22/01/2021	1
find all components needed	23/01/2021	30/02/2021	6
Building on factory a/o	01/02/2021	09/02/2021	8
write my program on plc	10/03/2021	30/03/2021	20
make the circuit on proteus	30/03/2021	07/04/2021	8
testing all the system	08/04/2021	10/04/2021	2
Final Report	11/04/2021	23/04/2021	12
2nd presentation viva 1 (preparing)	24/04/2021	29/04/2021	5
Final Viva	29/04/2021	30/04/2021	1
exhibition of materials	30/04/2021	04/05/2021	4

Table 1 Gantt chart

Gantt chart:

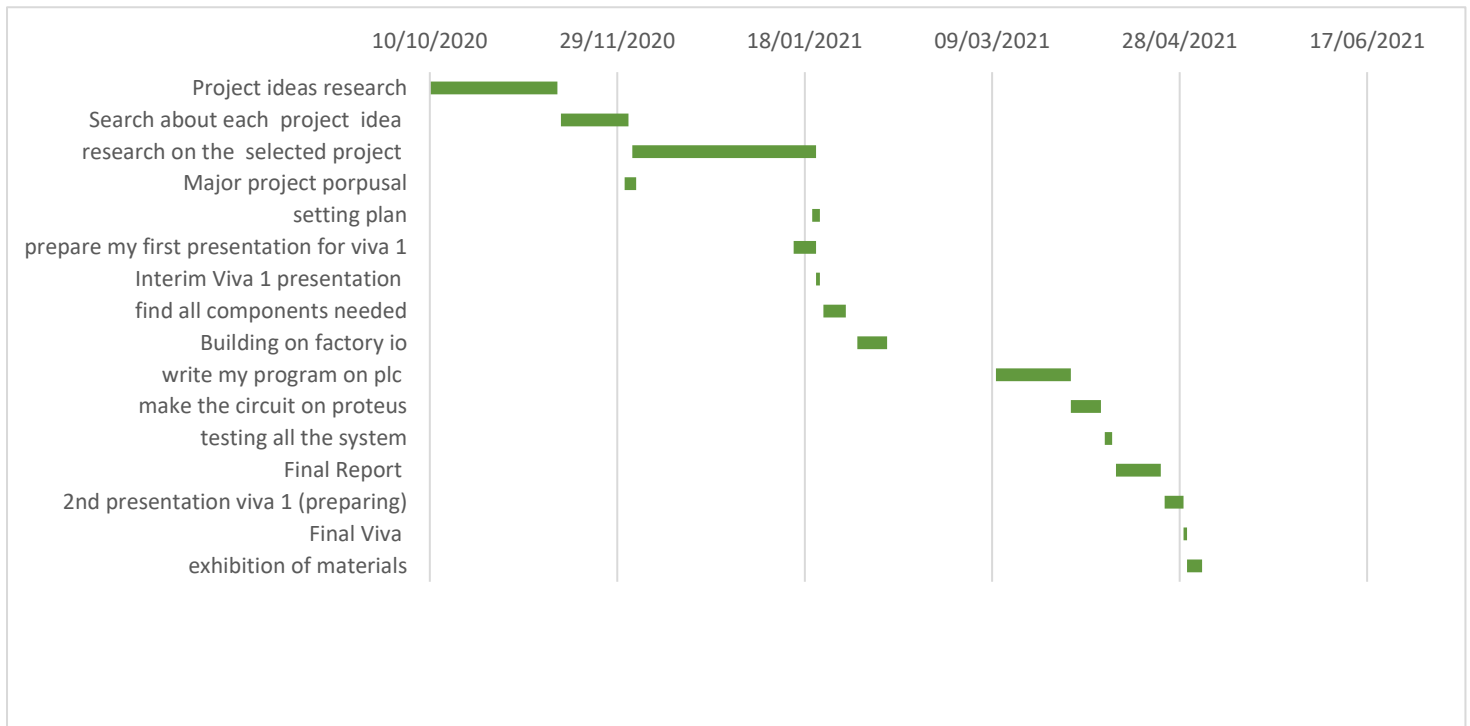


Figure 1 plan

Chapter 2 (Methodology):

The research methodology is all about how the researcher designs a project to maintain valid and consistent outcomes that meet the research goals and objectives. These methods also help to provide a better picture, ensuring researchers are on track with the projects and giving a clear view on tasks that need to be completed.

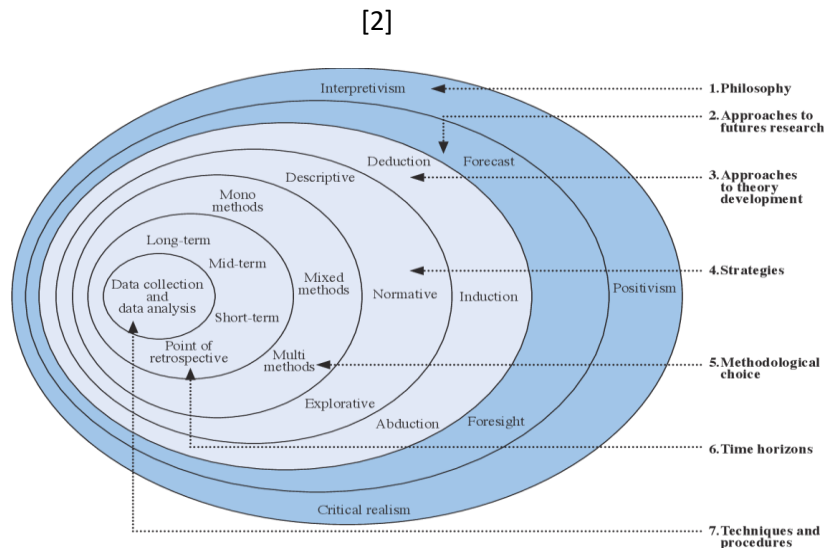


Figure 2: onion research

Research Onion:

The research onion model has been introduced by Saunders, Lewis and Thornhill explaining the relevant stages concerned with the methodology, that will be applied to the research project (Melnikovas, 2018). [3]

Research onion model's application is given under the following stages:

Research Philosophy:

The philosophy involves perceptions and beliefs used in the research to assist the core objectives. In this study, the application of pragmatism is found to be suitable as this philosophy has the rationale of identifying data patterns based on real experiences of individuals and their interaction of them with the external environment (Paiva-Silva, 2020). [4]

Pragmatism also confirms the validity of the retrieved experience-based data by ensuring its existence also in the external or outside environment. Similarly, with the application of pragmatism philosophy, the data about innovative car parking system design gathered from experience and knowledge of specialist car parking system manufacturers has been made aligned with data about external market demand about this system to verify the generation of an effective and strong idea about car parking system designing (Paiva-Silva, 2020). [4]

Research Approach:

The inductive approach has been found as a highly suitable one for the contemporary project because this approach focused mainly on supplying relevant evidence and attaining required flexibility to emerge facts and information regarding car parking system's demand and required features for making it highly efficient to satisfy consumers' needs (Graneheim, Lindgren and Lundman, 2017). [5]

The inductive approach has also been noted as relevant in understanding the overall meaning of how human needs can be fulfilled by appropriately and innovatively designed and tested car parking system through emerging facts and deriving appropriate data and theories relevant to market needs and advanced car parking system's designing (Graneheim, Lindgren and Lundman, 2017). [5]

Research Strategy:

The research used a strategy wherein both survey and literature review have got adopted to assist the research query and agenda. For example, with help of a literature review, relevant information about market needs and demand about the type of car parking system has been effectively retrieved from secondary data sources like market reports, news articles, journals, and credible magazine sources. [6]

On the different side, the survey with purposively selected specialist car parking system manufacturer (with purposive sampling to obtain expert knowledge) has been considered as an effective strategy that was adopted to obtain relevant suggestions, opinions, and specialist knowledge of these experts about the features, design, and mechanism essential for developing innovative car parking system (Ponto, 2015; Etikan, Musa and Alkassim, 2016). [7]

In this way, comprehensive and authentic data have been gathered by using survey and literature review strategy to assist the derivation of effective concepts and idea about innovative and useful car parking system.

Data Collection Method:

Mixed methods have been utilised for data collection purpose in the undertaken project. Mixed-methods involve quantitative and qualitative data accumulation to emerge accurate statistical evidence by gathering survey data of expert opinions regarding car parking system and market-based information regarding anticipated needs of customers oriented to car parking system (Techataweewan and Prasertsin, 2018). [8]

In this manner, in-depth and evidence-based data could be collected with the mixed-method approach to confirm the alignment of market needs with the advanced design features suggested by experts in regard to car parking system to reach up to innovative ideas regarding car parking system to meet the current project's agenda (Techataweewan and Prasertsin, 2018). [8]

Time-Horizon:

The time-horizon used in this study is cross-sectional wherein the survey has been organised at a particular instance in the current time with specialist manufacturers of car parking system to obtain the latest information and knowledge regarding advanced features of this system to add values for the customers (Setia, 2016). [9]

Moreover, recent market data has been collected to analyse the demand and position of car parking system products in the market. A cross-sectional study is proved to be beneficial for identifying the latest information about car parking system, latest innovative features, and consumers' current demand to reach up to the most significant idea and concept regarding car parking system to be developed within the project (Setia, 2016). [9]

Data Analysis:

For survey data analysis, the graphical representation method has been noted as highly significant for presenting and emerging participants' opinions in a numeric and accurate manner. The graphical representation process helps in clearly visualising participants' response majority to identify their opinions in a highly accurate manner. With graphical representation, the expert advice and knowledge of participants regarding car parking system, concerning latest features, and designing have been effectively evaluated and presented to gain a clear idea regarding the making of advanced car parking system (Asnicar *et al.*, 2015). [10]

Moreover, literature data analysis, the thematic method has been shortlisted as a highly beneficial one in terms of finding out relevant themes and patterns under which the qualitative data findings got evaluated in a dynamic or flexible manner to reach effective results about market demand and needs about car parking system (Nowell *et al.*, 2017). [11]

In this way, both these methods including survey and thematic analysis have been used in regard to performing data analysis effectively to reach desired outcomes about market data and car parking system's features to create an innovative solution for high-quality parking facilities.

Conclusion:

Based on the research onion model, the methodology selected for the undertaken project has been divided into distinct categories. For instance, pragmatism philosophy for accumulating real-time information and evidence, inductive approach for flexibility evaluating information, survey and literature review for comprehensive data collection and thematic along with graphical representation for data analysis were used as appropriate methods for assist query concerned with the undertaken project. It is also derived that the undertaken study is cross-sectional wherein a single instance of time in the latest year has been selected for acquiring current knowledge about car parking system related market needs and technological innovation and features to support designing of this system to assist the contemporary project.

Chapter 3 (Research):

History of Car parks:

The first vehicles created were not as weather resistant as the vehicles we have today. Their tops were open, and the seats were made of leather, so it was necessary to park them in doors, to keep them safe from rain, cold, high temperature and weather conditions.

The first car park created had a simple design and looked like any other average building.

Nowadays, cars are of pivotal importance, whereas in the past people were not aware of its essence and thought it was an average machine. Hence, the availability of car parking's was rare. Even drivers were using horse stables as garages, and owners were charging them same prices as stalling horses.

[12]

When it came to parking garages, a construction boom was put in place in the 1950s. There have been many developments in the building and design of the parking ramps. This construction boom was attributed to the fact that car parking's encouraged the residents and workers to invest time and money in the area. Therefore, self-parking has also become more common.

The urge for parking places was growing larger and larger as more people got cars. Parking became a concern and towns began working on new ways that would enable as many vehicles to park without taking up big spaces.

Old car park types:

Multi-storey parking:

This is an indoor parking which resembles an average building from the outside, however it is exclusively designed for car parkings, with several number of floors and cars spaces.

The first multi storey parking was built back in 1918. It was designed by Roche and Holabird for a hotel called La Salle. The garage was built only a few blocks away from the hotel. The parking remained until the hotel was demolished in 1976. Then the parking destroyed in 2005.

Mechanised parking:

In this type of parking, drivers were not able to chose their parking space, they could not park the car themselves and they had to hand over their vehicle in the entrance to the parking attendant. In this model drivers had no freedom and exit/entrance times were restricted.

The cars were set on a board and automatically moved to the parking place by using car lifts and turntables. There were several models and designs built for car park lifts in the 90's to transport cars between car parks. One of these models was known as (the double helix) because its structure had two spiral ramps to move the vehicles.

The mechanised parking is simply the first version of the automated parking system of today.

Garage with ramps:

This model of car parking's gave drivers the ability to individually park their cars. Handing over the car to an attendant was not necessary, and no waiting was required.

The ramps have been used to move the cars between the floors. Building a ramp was a challenge as they could not have a long designed to avoid losing parking space, at the same time it could not be too short, so the cars would not have the ability to drive up. This means that the parking's were becoming wider and bigger in order to provide more space and enough capacity to fit the cars with the ramps.

[12]

Car park types

There are many different car park types, with various ways to control it.

Old car parks had no electric systems, it functioned manually. For the non-free car parks, humans were used on the entrances and the exits. Alternatively, a manual barrier driven by humans was put in place.

Free car parks didn't require a human on the entrance, so car drivers had to look for spaces themselves.



Figure 3 old car park

[13]

Different car park systems

Car park system definition:

Car parking system is used to help control vehicles in certain parking areas in order to reduce congestion and to place cars in the designated location. These systems help monitor how many vehicles come through the gate as well as how long each car takes, and then measures the sum of money that the car can pay before leaving if it was not a free car park.

Every car park needs a system to control it, and nowadays every place and building such as universities, colleges, shopping malls, cinemas, schools. etc. has got a car parking in each car park there are so many different types of systems been using. [14]

Car park systems technology:

Wired sensor:

The wired sensor-based type is a device that uses a detector sensor, like the ultrasonic sensors, which is mounted on every parking lot. So, the sensors are connected to the central control device, where it stores and controls the information on the car park occupancy. The details and information will be forwarded to the show panels at specific positions in the car park. The show panels contain all the data and the information's for the drivers to direct and guide them to the free parking space so they can park in there. [15]

Wireless based:

The wireless method is a new way to control a car park system, this technology costs more than other technologies, as the transceiver and the processing unit must be connected to every sensing unit.

A single node must be fitted on each parking space and each sensor board has to be provided with a temperature, light, acoustic and a sounder sensor.

Image based:

It is known as the image technique or the video sensor technique. There are many concerns on its ability to work successfully. This technology is extremely expensive and the downside of it that its video sensor can generate very large size of data, so this makes it very difficult to transfer in wireless networks.

Counter based:

This technology uses sensors to count the sum of the cars going in and out of the car park. Once the maximum number is reached, it will prevent any cars from entering the car park. The counter-based system can be installed in many ways such as; the gate arm counters and barriers, where the sensor is placed.

A disadvantage was that drivers were not guided on specific parking spaces and hence had to find their own free places. [16]

PLC

PLC stands for Programmable Logic controller; the first model of the plc was found by Dick Morley. It's called the 084 model and it was found in 1969. This system is an industrial computer control system which can regularly track the state input of the devices and make decisions. Followed by managing the state of the output devices based on a custom program.

By using the plc control system, all production lines, computer operations and machine's function have a higher change of improvement. The main advantage of the plc is that it has the ability to repeat and adjust the operation of procedures, while gathering and transmitting critical information. Also, since the plc is a modular, it can mix and match the inputs and the outputs forms of the system to best fit an application.

It was created with the aim of providing reliable service in harsh manufacturing environments such as high temperatures, dusty and dry conditions.

A typical PLC block has five parts which are the following:

- power supply module
- input and output module
- (CPU) central processing unit
- rack or chassis
- communication interface module.

[17]

In order to operate a PLC, four simple steps are required: an input scan to detect all input devices connected to the PLC, a programme scan to protect the logic program that produced by the user, an output scan where the output devices -those attached to the PLC are energised or de-energized, and the house keeping phase involves all communications with the programming terminals as well as the diagnostic internal.

[18]

PLC pros & cons in general:

pros	cons
Incredibly quick scan time	Slow when problem occurs
Capable to communication with computer in plant	Not able to work in all weather conditions such as the high temperature
Quite computational capabilities	Not able to work in such vibration condition
Easy to learn- no need for long training	Accidents can occur if the plc turned-on as some of it works when the power restored.
Large variety of control applications	
Costs can be calculated accurately	
Tiny size	
Very flexible to program and reprogram	
Reliability to operation	
Its counters are fast and useful	
It provides the flexibility in reprogramming and programming	
Reference: [19]	

Table 2plc pros & cons

As shown in this table of the 'PLC pros and cons', there are more advantages than downsides when it comes to using the programmable logic controllers (PLCs). However, it is a great process to use for making an easier and quicker system to handle.

Chapter 4 (Designs):

First design draft:

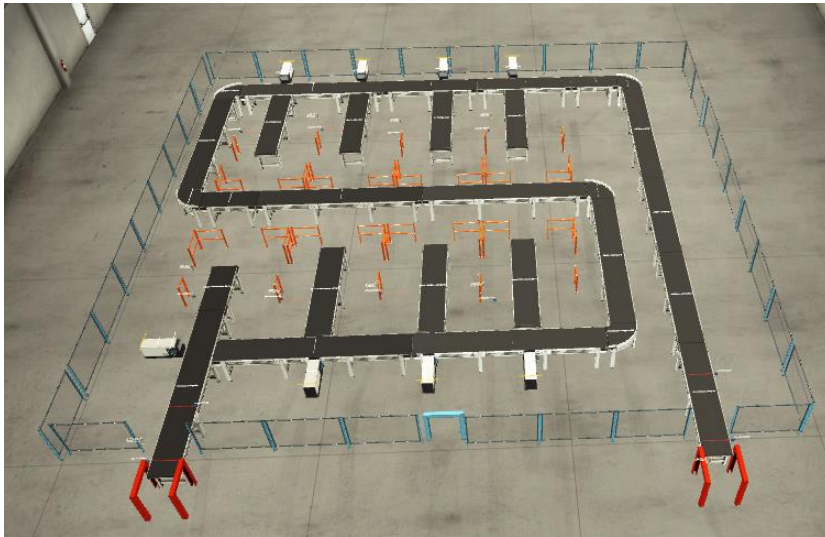


Figure 4factory first design draft

First Design explanation:

In the first design; conveyers, pushers and sensors were placed to make the car park look complex.

Two sensors were placed on each car gate. The aim of the first sensor is to detect the car and the other sensor acts as a counter when a car goes through.

Conveyors were placed as roads and pushers which is not ideal. When conveyors run, the pushers will extend to push the car to the free space.

In each parking space, a sensor is present and one stack light was placed. A sensor was used to detect the car when entering and to recognise available car park spaces. If spaces are unavailable, a red light will be displayed.

The design did not meet the expectations and hence a new design should be built including new components, to fit the idea of the project.

Second design:



Figure 5: second design

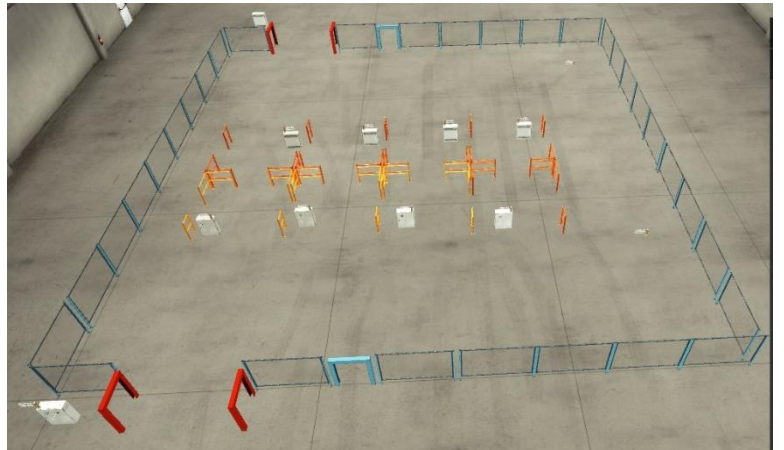
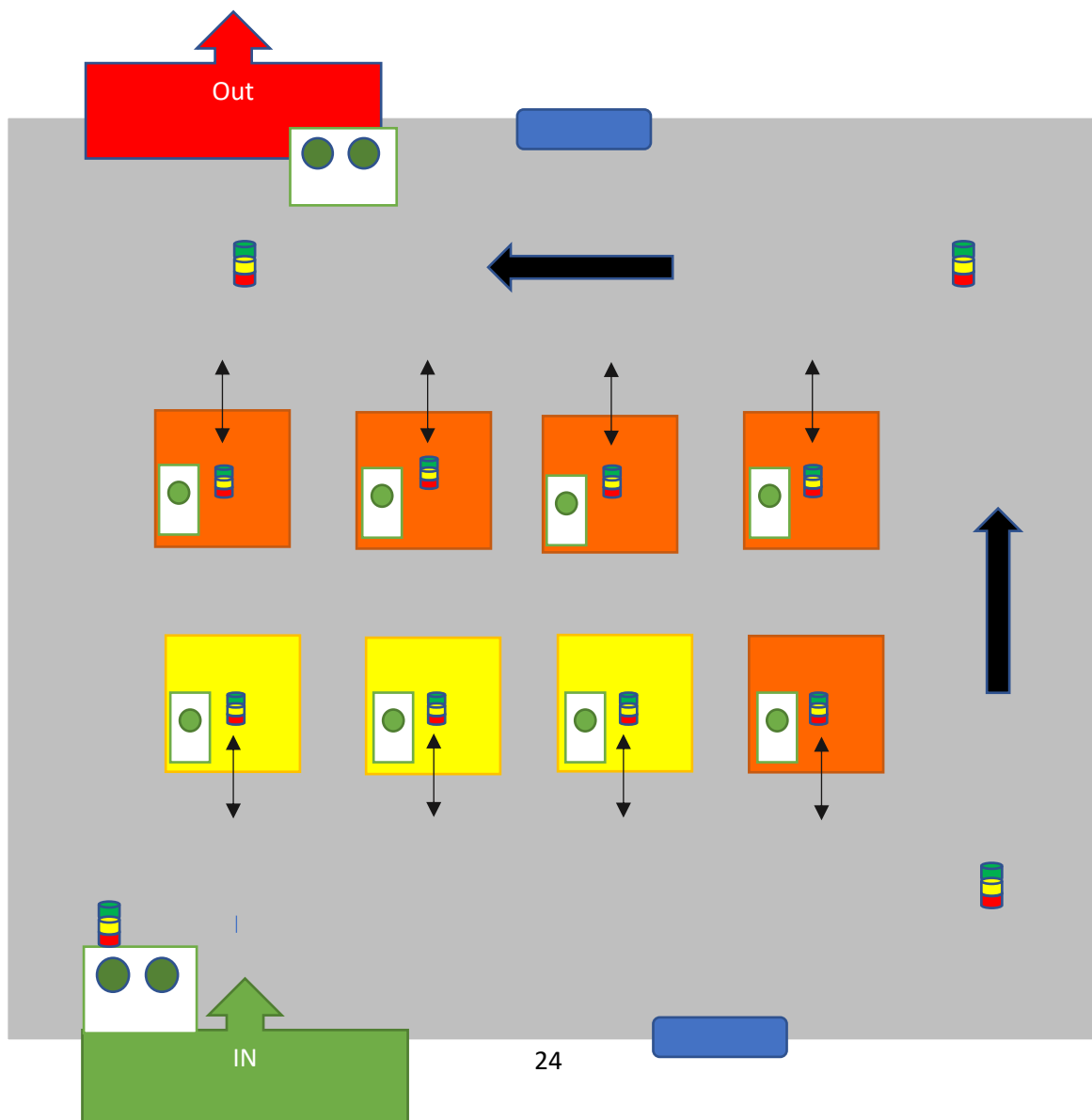


Figure 6: second design

Second design structure:



Second Design explanation:

In this design, all the conveyors were removed to introduce a lighting system. In this system, a light has been placed on the entrance with two switches. If there are available parking slots, the light will turn green. If no spaces are available, the red light will be activated. A switch will be pressed once a car is preset and waiting for the lights indicators. The switch will then be used as a counter if the green light went on.

In each parking space there is one stack light and switch available. A green light will indicate the presence of a free parking space, hence would be a sign for the drivers to follow. Whenever the driver presses the switch, a red light will be activated and the green goes off.

Three stack lights were placed in each corner for drivers to follow. If the front parking spaces were full, these stack lights will be activated, so the driver will follow them to reach the other side of the parking spaces, where one of them has a green indicator.

Lastly, on the exit there are another two switches as down counters. When a car leaves, the drivers must press the switch to indicate the availability of one more free place from the total number of free parking spaces. Hence, one more space is added to the counter.

Two switches are inserted in the design by the entrance and exit, one symbolising the normal spaces and the other indicates the disabled ones.

Final design:

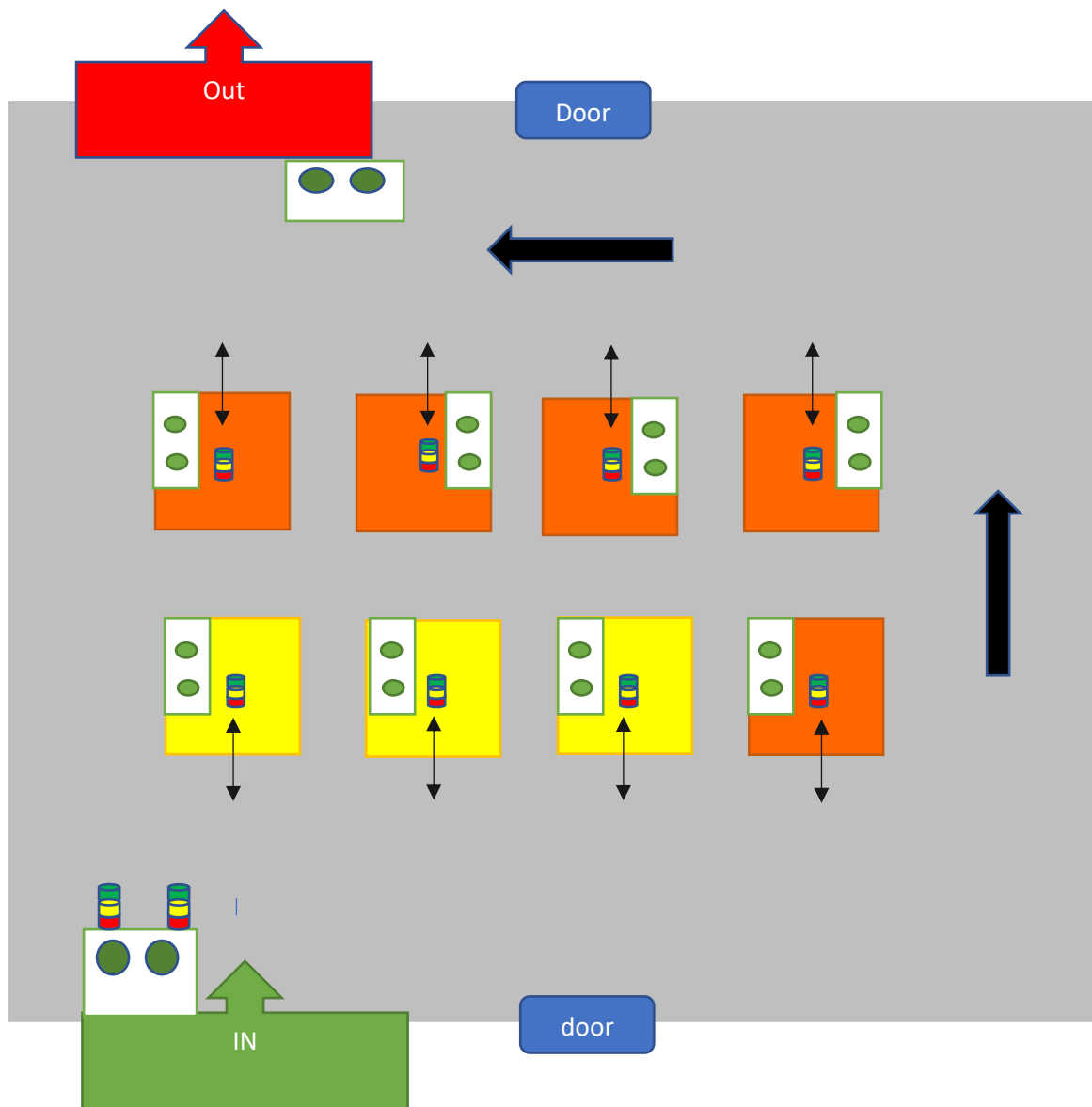




Figure 7: last design

Final Design explanation:

Not many changes have been applied to this design. The aim was to establish a PLC program that is useable, reliable and effective in our lives.

In this design, the stack lights present on the entrance will be activated without the need to press switches; for example the green light will remain on as long as there are free spaces inside the car park. This way, it would be more practical and easier for drivers wishing to park to see the light, without the need to change direction. It's also a more time efficient solution, as drivers do not need to wait on the entrance or press the switch, compared to the second design. Once the red light switches on, drivers will recognise that there are no parking spaces available.

In this design, two different stack lights have been placed, to show the availability for normal spaces and disabled ones.

All the stack lights will be on continuously, hence there is no need for the three stack lights in the corners, unlike the previous model. This enables the drivers to park in any of the places containing a green indicator.

In the previous design, drivers were expected to press the switch in order to turn the red light, indicating the unavailability of the parking space. However, in this design another switch has been added. The driver is expected to press it once he wishes to leave the parking space, hence the red light will be turned off and the green light will be activated, symbolising the availability of a new place.

Factory I/O driver and Configuration:

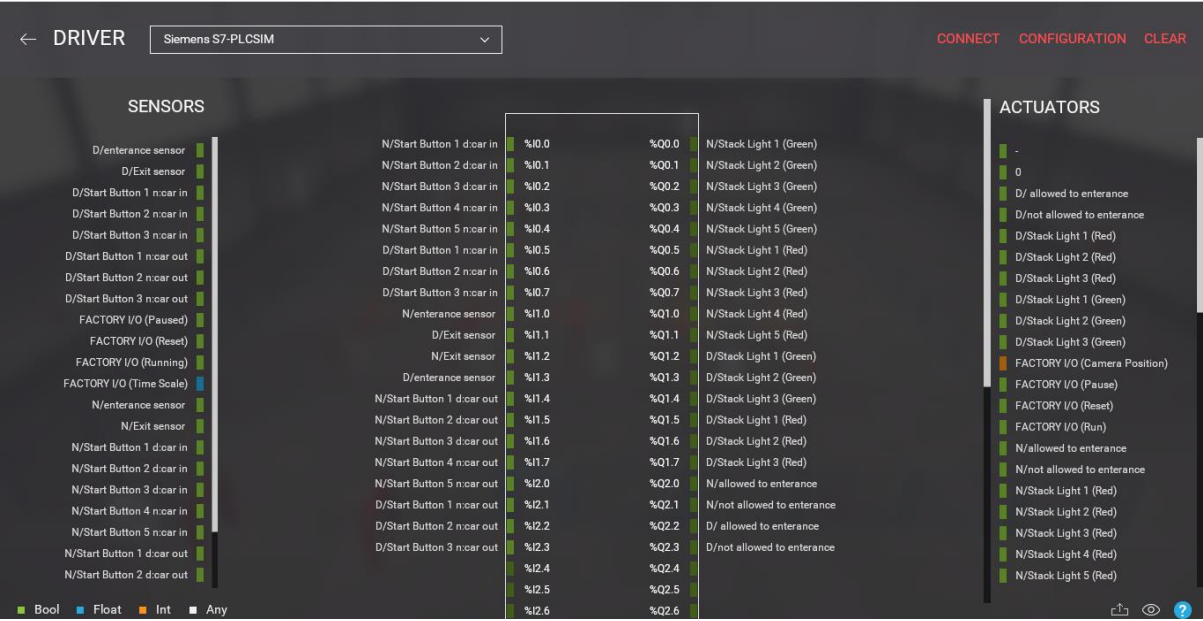


Figure 8: driver

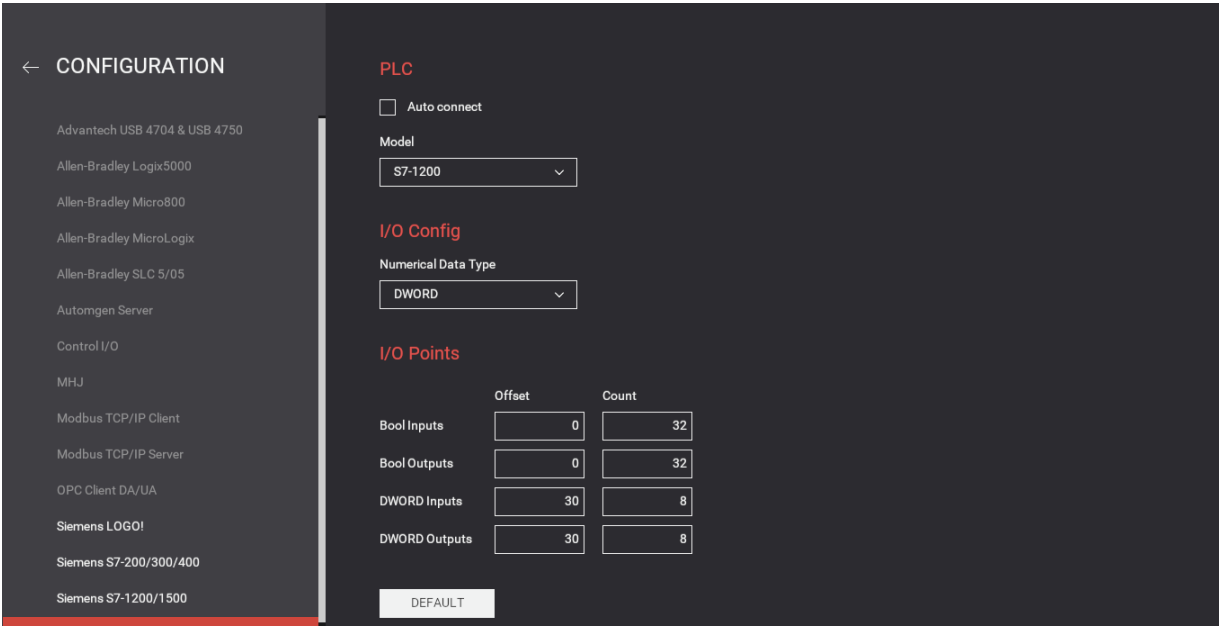


Figure 9: configuration

Factory design conclusion:

The last design did meet the expected standards, and is believed to be the most useful and efficient design, suitable for nowadays use.

Advantages:

- Time efficient
- Tidy
- Practical
- Easy for drivers (straight forward)

Parking system parts:

- Counters
- Push buttons/sensors (Push buttons have been placed instead of sensors)
- Stack lights
- Plc

Parts list:

Factory I/o parts:

Car Entrance/ Exit			
Image	Part name	colour	How to use it
	Small handrail	Yellow	By grouping two of the small handrail, I can create a barrier for the entrance and the exit.
	Bracket	Red	By grouping two brackets I will be able to use it as a barrier to my entrance and exit

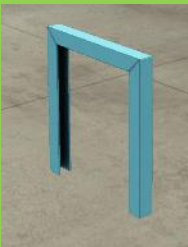
The red brackets have been chosen due to the size and shape of the brackets, which are more suitable than the yellow handrail.

walls			
Image	Part name	colour	How to use it
	Small handrail	Yellow	Grouping the small handrail next to each other can build a wall for the car park.
	Small safeguard	Blue	By grouping small safeguards together, I can create a car park wall in the size I need.

The Blue Small Safeguard has been chosen to build the walls, as it is higher than the handrail and meets my structure requirements.

Parking lots			
Image	Part name	colour	How to use it
	Small handrail	Orange	
	Corner handrail	Orange	

Disabled Parking lots			
Image	Part name	colour	How to use it
	Small handrail x16	yellow	
	Corner handrail x10	yellow	

Entrance and exit door			
Image	Name	Colour	How to use it
	Bracket	Blue	Placed two brackets as a door for both exit and entrance.

Electric switchboard		
Image	Colour	How to use it
	White	To place the switches and counters

Switch button		
Image	Colour	How to use it
	green	• when car leave. • When car in • When car enter or exit the parking • counter

Stack lights		
Image	Colour	How to use it
	Green/Red	• shows the free/busy spaces. • On the entrance and exit

Real Design Parts:

Stack light				
Image	Description	Reason to use/ not to use	Price	reference
	DC 12 v red, green signal tower lamp warning stack light with buzzer alarm apparatus.	Just two light colours needed for the design which are the red and green. Good price	£8.80	[20]
	Warning Stack Light, Unique bargains DC 24V Industrial. Red, Green Yellow Signal Tower Lamp	It does not meet the requirements, no need for the yellow light. Expensive	£18.97	[21]

Switch button				
Image	Description	Reason to use/ not to use + features	Price	reference
	BACO L2AA01 Red non-illuminated push button switch	Protected to IP66. Diameter 29.9mm Height 11mm Screw terminal connection Max current 10A Max voltage 600V Expensive	£14.79	[22]
	Self-reset Push Button Switch 22 mm LA 38 11. small Start switch button	Green colour 10 A High temperature flame retardant (original plastic) Very thick silver layers on the silver point Long life Meet all the requirements	£6.95	[23]

Electric switchboard				
Image	Description	Reason to use/ not to use	Price	reference
	Waterproof wall mount aluminium metal electrical enclosure distribution box	Size:300x300x200 Protection level: IP65	/	[24]
	Top quality Oem service water-proof outdoor metal electric switchboard distribution box for electrical power	Can be used outdoor. Material: sheet steel/ stainless steel IP66 protection thickness: 1.5x2x2mm size:250x300x150	£40.67	[25]

Sensors				
Image	Description	Reason to use/ not to use	Price	reference
	24vdc PR08-2-DP DC 12-24V PNP NO Inductive Proximity Sensor Switch Detector 2mm	To be placed in each space to detect the cars when park in and go out. DC voltage supply. The cable size is suitable to be connected to the PLC.	£9.53	[26]
	M12 24VDC stainless steel inductive proximity sensor	-	£17	[27]

Parking spaces				
Image	Description	Reason to use/ not to use	Price	reference
	Vestal vdkr-4 yellow powder coated steel safety railing 48'' L	Quantity: 10 Available in factory I/o	£58.03	[28]
	Yellow steel corner guard floor mounted guard rail mounting style.	Available in factory I/o Features: - Length: 2ft4 - Material: steel - Quantity: 6	£280.38	[29]
	Parking space separator lane dividers- electricity	Features: Strong recycled rubber material Easy to park without cause any damage to the vehicles. Has got a reflector	£28.63	[30]
 	CR27 Road line paint yellow 5L BRADITE (British paint makers since 1938)	Features: Quick drying Size: 5 L Colour: Yellow	£81.58	[31]

Car gate				
Image	Description	Reason to use/ not to use	Price	reference
	Red ak-941 pu sprong post	Colour: red Dimension 80x750mm Similar to the ones in the factory I/o	£12.78	[32]
	Arm barrier manual	Barrier not needed. Very expensive	£661.82	[33]

Gate				
Image	Description	Reason to use/ not to use	Price	reference
	Steel door frames Three-piece steel	Can be used interior and exterior applications. Similar shape to the selected on in the factory I/o	/	[34]

PLC Design:

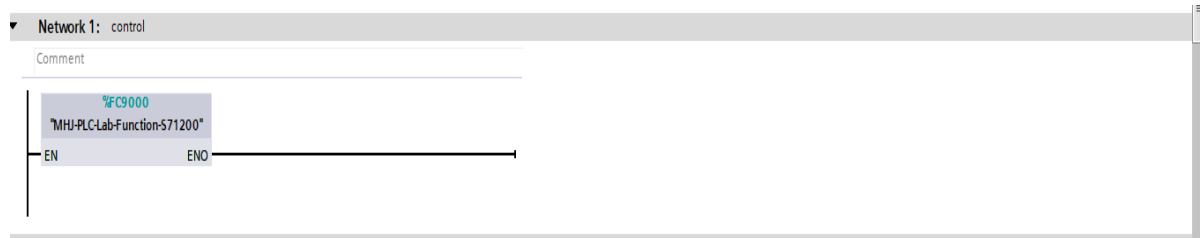


Figure 10: plc

start the program.

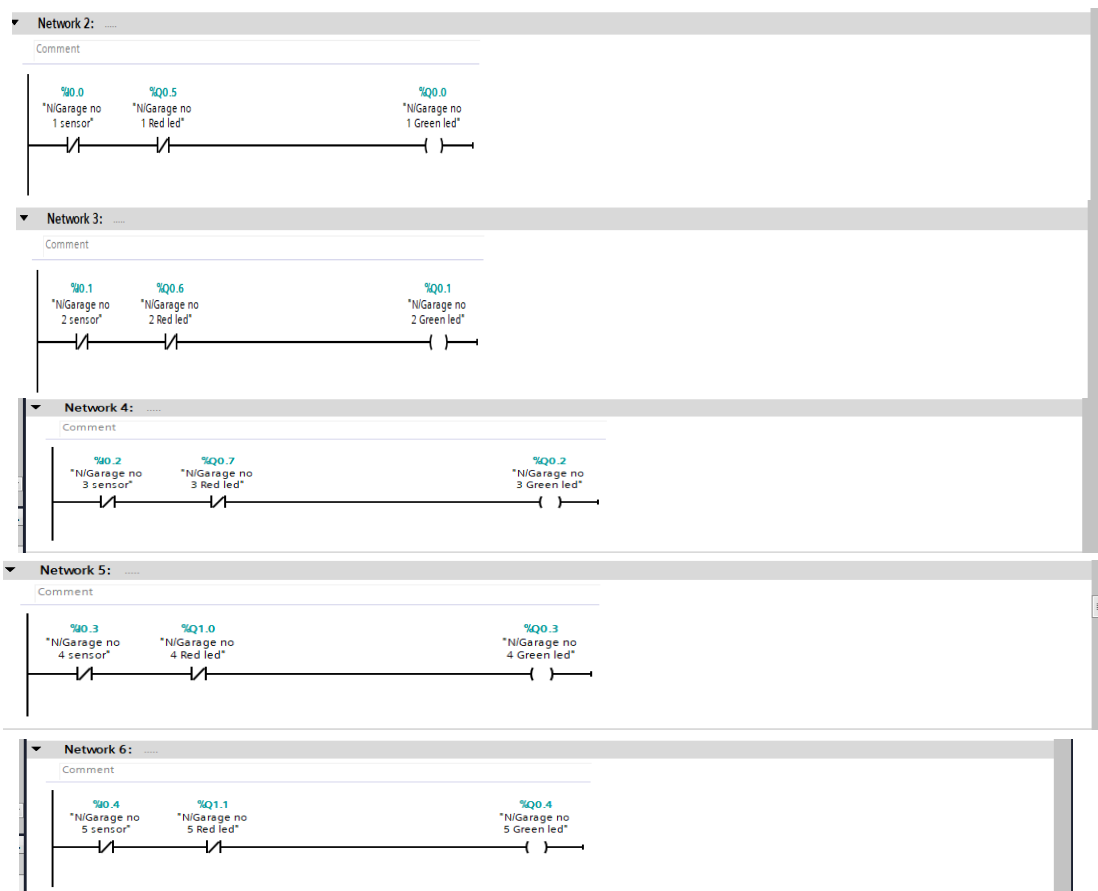


Figure 11: plc

From network two to network six : Normal parking spaces (green led)

These networks demonstrate the stack lights for normal parking spaces. When the program is started, all the lights will indicate a green colour in the parking spaces, unless a driver presses the red switch. In this case, the red light will be activated and the green light switches off.

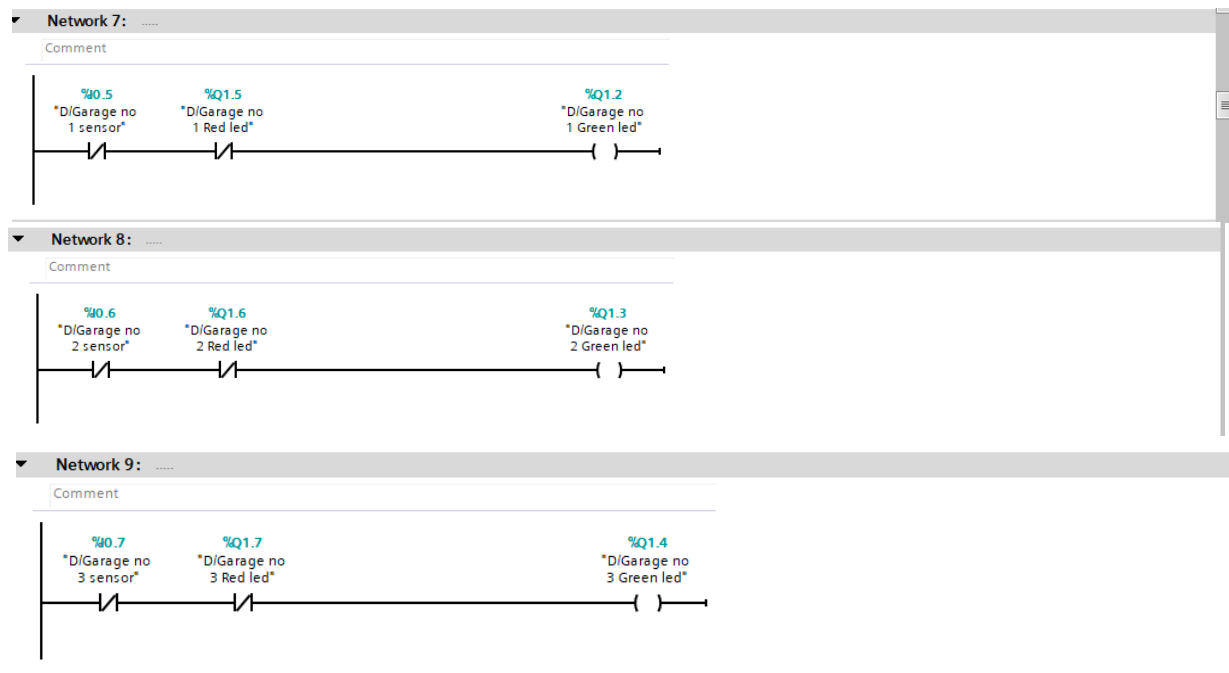


Figure 12: plc

Network 7 to network 9: Disabled parking spaces (green led)

Similar to network 2 to 6, but it is specifically designed for disabled spaces. When the program is started, the green lights in each parking space will be switched on, as they are all free.

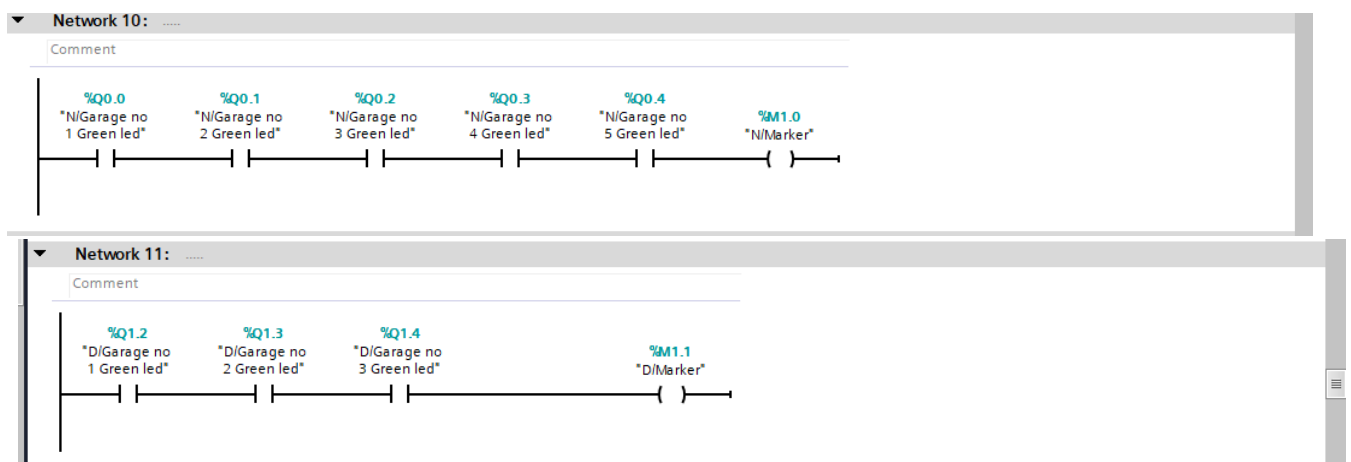


Figure 13: plc

Network 10 and 11:

N/Marker is for the green led in each normal space, and the D/Marker is for the green led in the disabled spaces.

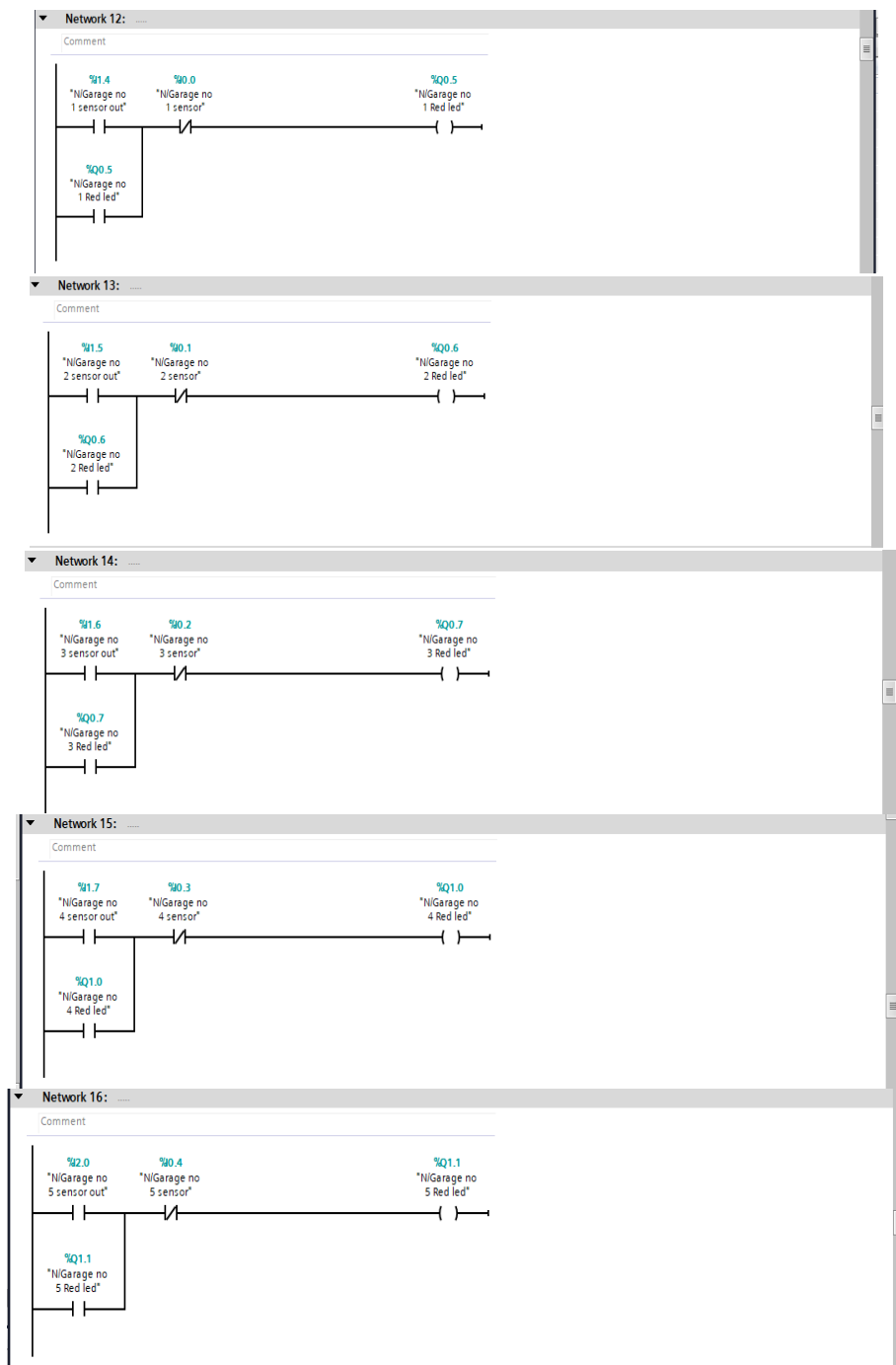


Figure 14: plc

Network 12 to 16: for normal spaces stack lights (Red led)

When a car parks, the red switch must be pressed to turn the green light off. This keeps the light on without having to keep the push button pressed.

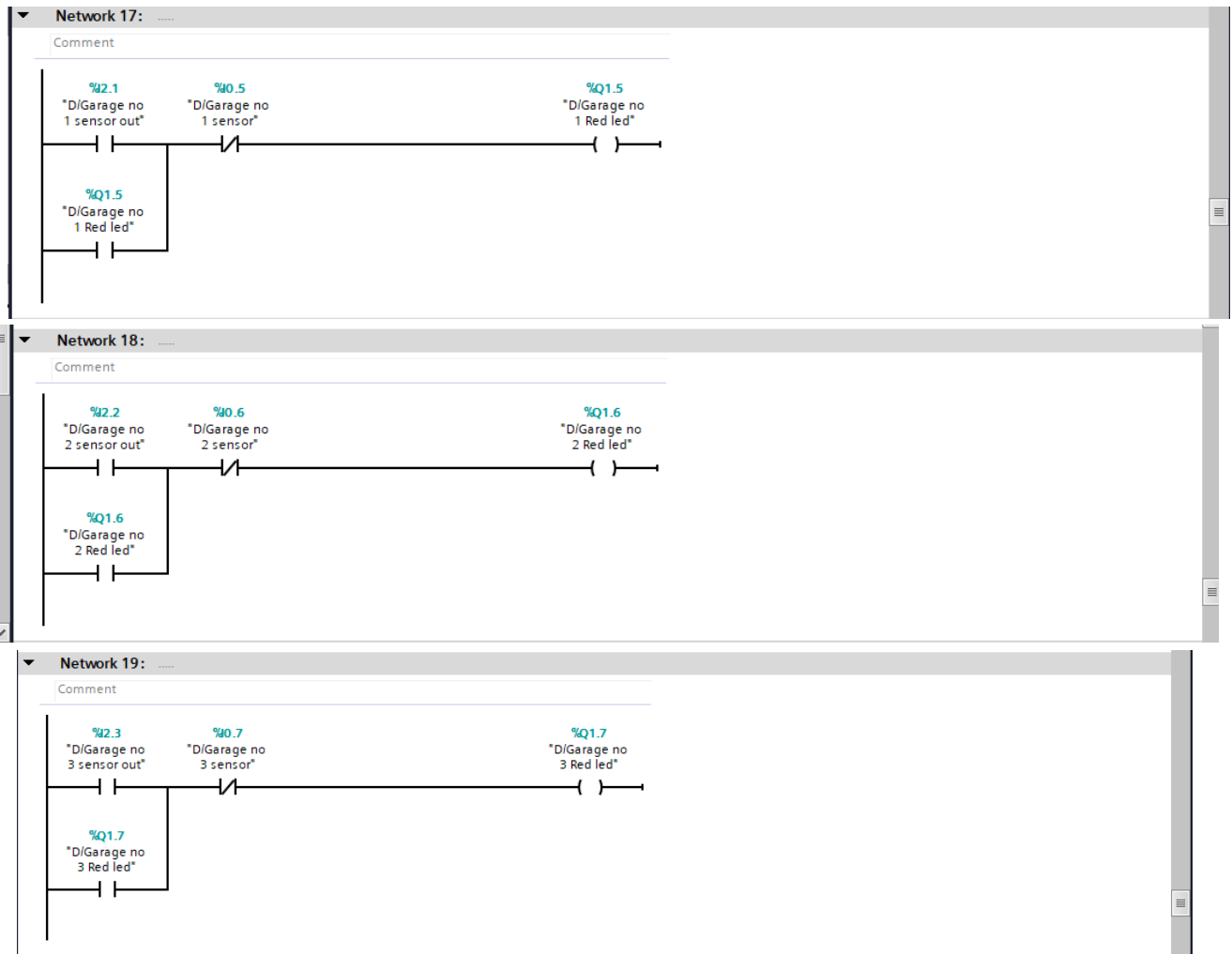


Figure 15: plc

Network 17,18 and 19: for the disabled spaces stack lights (red led)

Green lights will be on, unless the red switch has been pressed if a car parks. The red light will be activated and the green light turns off.

As mentioned, there is no need to keep the button pressed. Pressing once is sufficient.

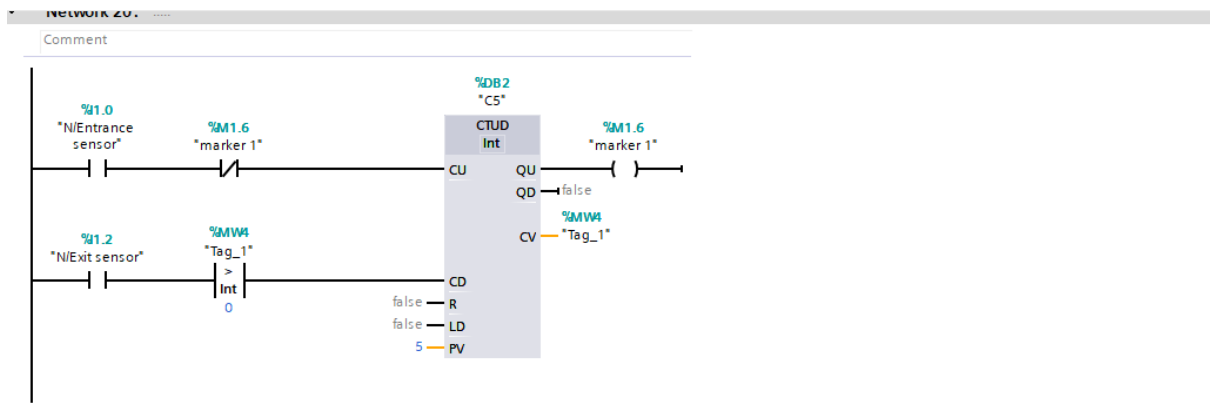


Figure 16: plc

Network 20: Normal spaces counter

Maximum number PV= 5, CV= the number of cars went in and out (number of cars).

Pressing the N button in the entrance will count +1 till number 5 is reached, which is the limit number of cars. It cannot count more than 5.

Pressing the N switch in the Exit will -1 from the counter till it reaches 0. It cannot count less than 0.

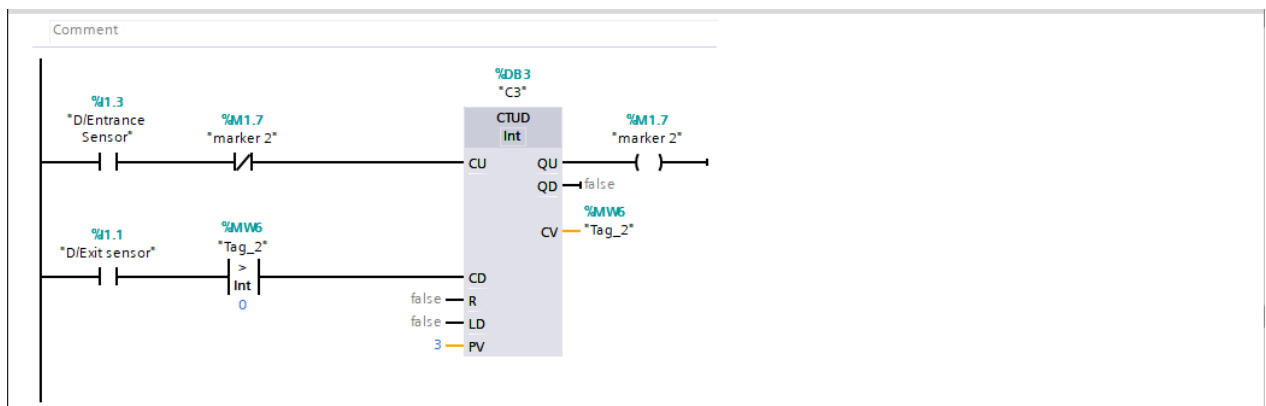


Figure 17: plc

Network 21: Disabled spaces counter

Maximum number of spaces/cars = 3, CV is to show the number of spaces that has been taken or number of cars present inside the car parking.

By pressing D switch in the entrance, the counter will add one till it reaches 3. Then it will stop as it is not able to count-up anymore.

Pressing D Switch in the exit, will count down (-1) from the cars number till it reach 0. The down counter cannot go less than 0.

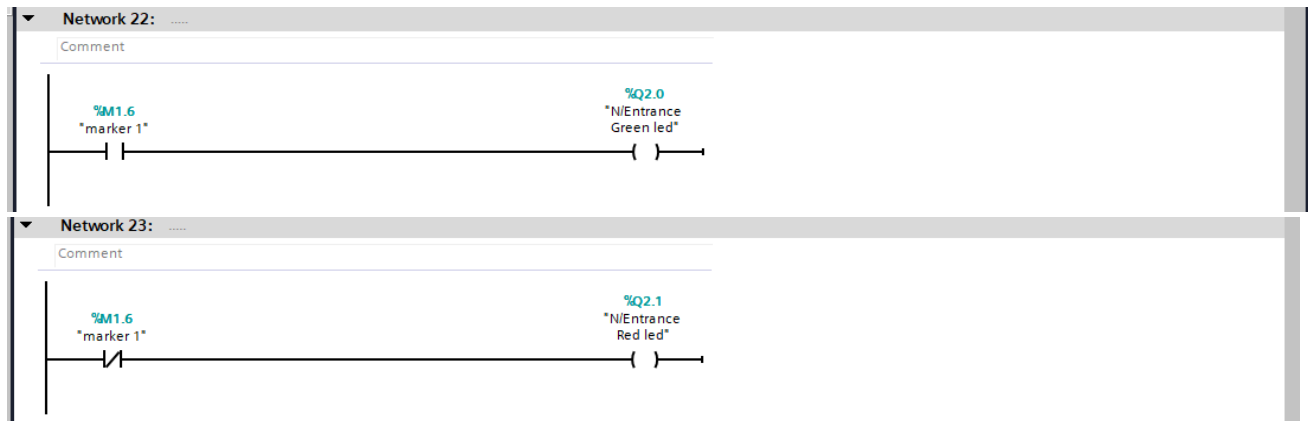


Figure 18: plc

When the marker 1 is open, this means that the N counter is still less than the maximum number (less than 5). The stack light on the entrance will keep the green led on.

When D counter reaches 3, the disabled spaces are full and cannot let any more cars enter. The D stack lights will turn the red led on (the one in the entrance).

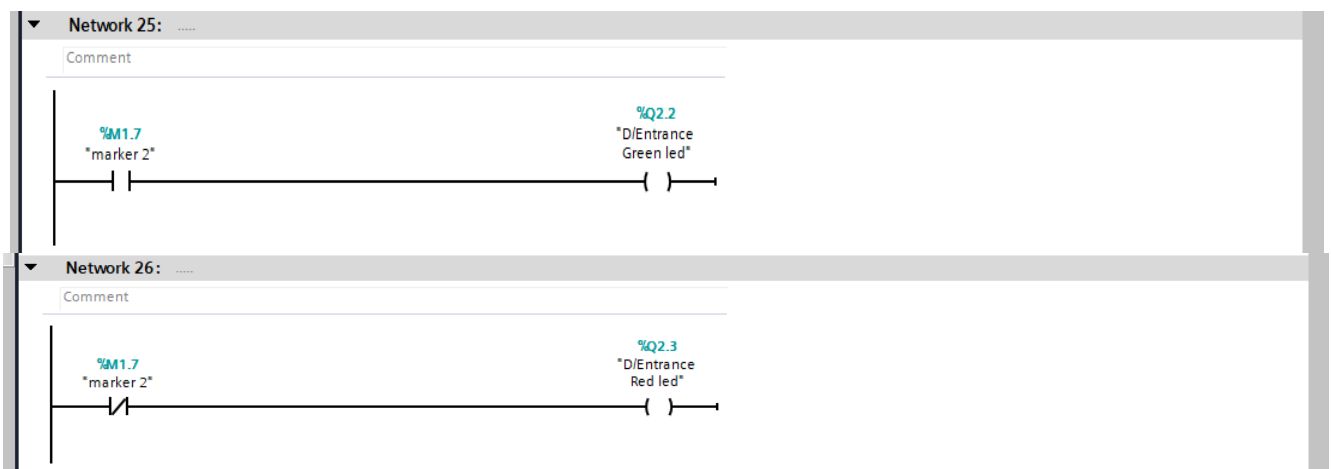


Figure 19: plc

When the marker 2 is open, the D counter has less than (3) the maximum number, the D green led will stay on in the entrance.

When D counter reaches 3, the disabled spaces are full and does not allow any more cars in. The D stack lights will turn the red led on (the one in the entrance).

PLC tags:

PLC programming

Figure 20: plc tags

PLC introduction:

After the completion of the car park design, a plc program needs to be done to control it.

When counting the inputs and the outputs in the parking design; there are 10 stack lights. Each one has two outputs (green and red), in total there are 20 outputs.

When having the switches as inputs; in each parking space there are two switches. One to be pressed when drivers go in to turn the red light on and the other one to turn the green light back on when the driver leaves.

Four switches as counters; two on the entrance and two on the exit. One is for the disabled drivers and the other one for the normal ones. These counters count down when pressed from the entrance. It is going to count up, when space has been taken up and it will count down from the exit, as one more space is empty.

PLC program:

Once the program has started, all the stack lights are going to turn green; the ones in each free space and the two stack lights in the entrance.

The drivers who wish to park will recognise the free places by looking to the stack light. Green light indicates available spaces. Red however, indicates the opposite.

When a car approaches the entrance, the driver has a choice to press the D switch or the N switch one. By pressing one of these switches; the counter is going to increase the number by adding '+1 car' to the counter. The maximum number of the normal cars is five and three for the disabled places. For example, if the N switch has been pressed, the number is going to be 1, as the counter will count up. This means that four more available spaces are free for normal cars in the parking. Same applies for the disabled cars, with a reduced limit of three spaces.

When a car enters the car park, there is a stack light on each parking space. When the stack light is green, the car can park as the space is free and available. Once the car is parked, the driver has to press a switch to turn the red led on, indicating this place is no longer available. #

When a car wishes to leave the parking space, the driver has to press the other switch to turn the green light on, indicating a free parking place.

When the counter on the entrance reaches the maximum number (5 for normal and 3 for disabled), the red led will switch on, so no more cars are allowed to go in. Both counters function in the same way, but have different limit numbers.

At the exit, there are two more switches as the down counters. When a car leaves the parking space, the driver has to press the button, so the counter decreases one digit from the total number of the cars, meaning one more free space is available in the car parking.

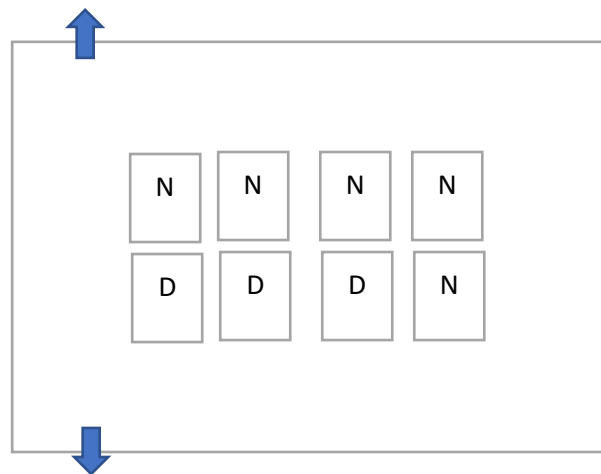
Chapter 5 (Tests and Analysis):

Factory io test:

As shown above in the Factory io chapters; many structures have been tried out before coming to the final conclusion.

The main structures that I had in my mind are as below:

- Exit
- Entrance
- Parking spaces (Normal and Disabled)
- Counters
- Switches/sensors
- lights



Ideally, the sensors needed to be used to detect the cars, however the counters could not be done using the factory io, so switches were used instead. Hence, the design has not changed. Removing all the sensors and conveyors from the first design and replacing them with switches as well as, moving the exit to the opposite side added to the efficiency of the model and made the design more realistic.

PLC system test:

The plc system worked perfectly as required.

Open the TIA V16 then download the program and connect it to the factory I/O (car park) using the S7-PLCSIM V16.

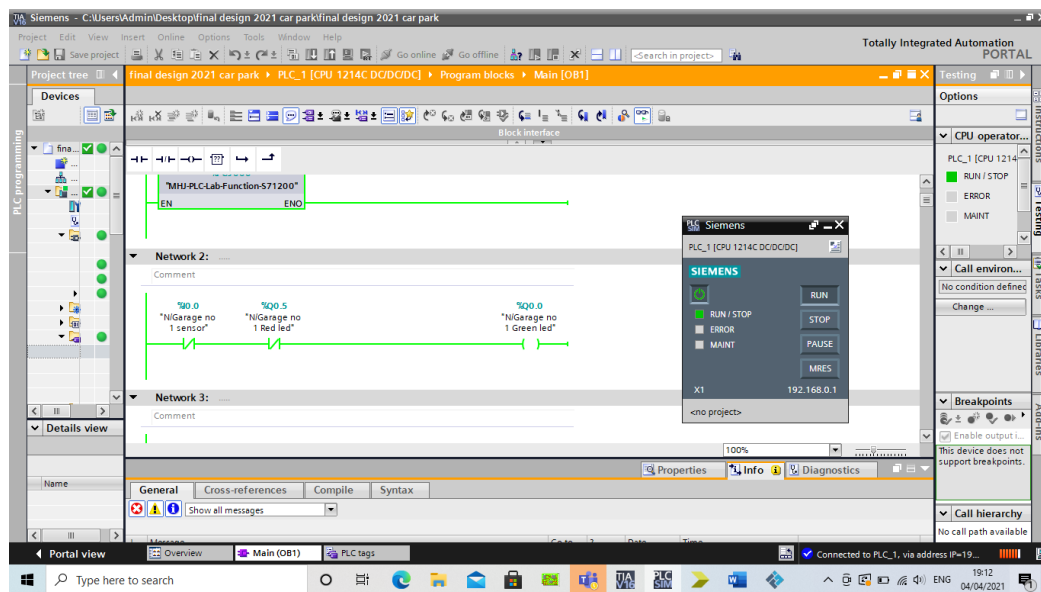


Figure 21: test

All green lights are turned on in each space as well as, on the entrance.

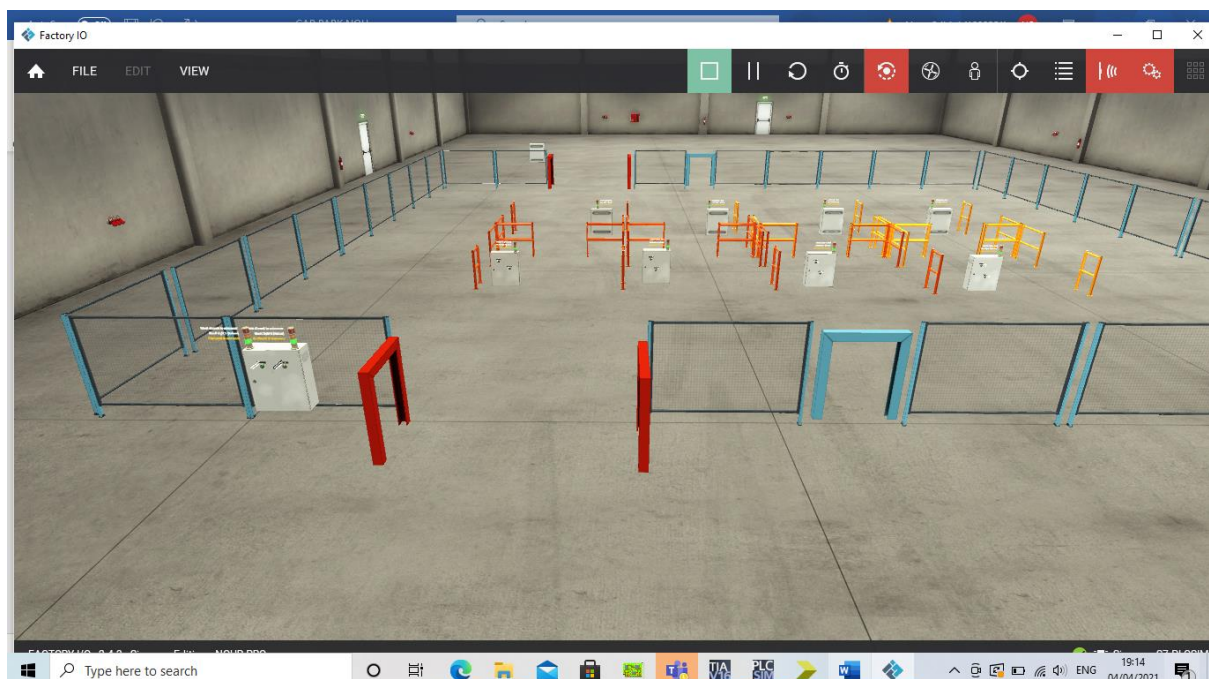


Figure 22: test

The D switch (counter) has been pressed and as shown below; the counter counted one up as a disabled car entered the parking.

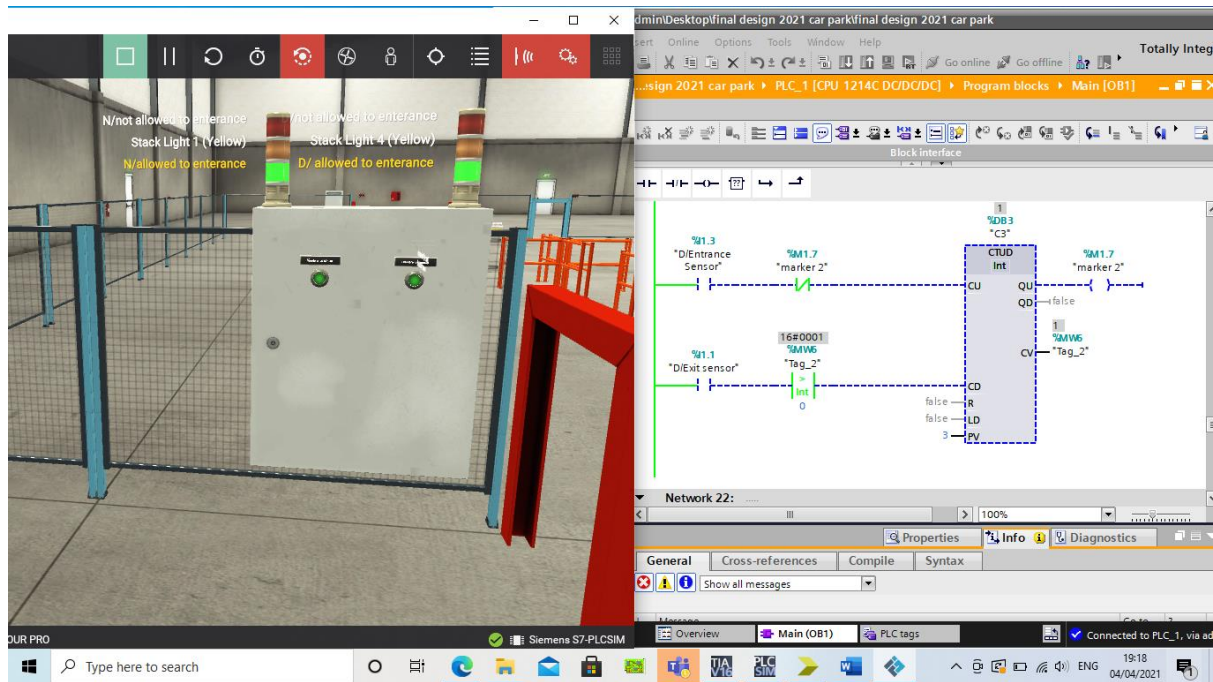


Figure 23: test

After pressing the switch twice, the green stack light stayed On and counter on number 2

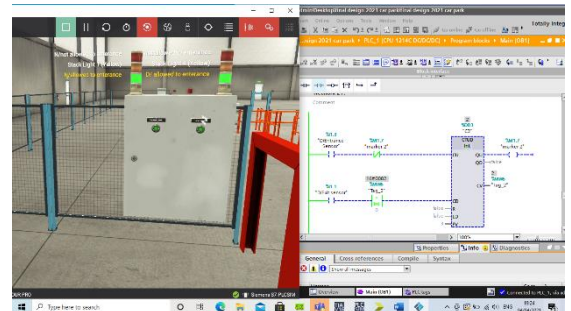


Figure 24: test

After the third press, the counter went up to number 3 and the stack light changed from green to red led.

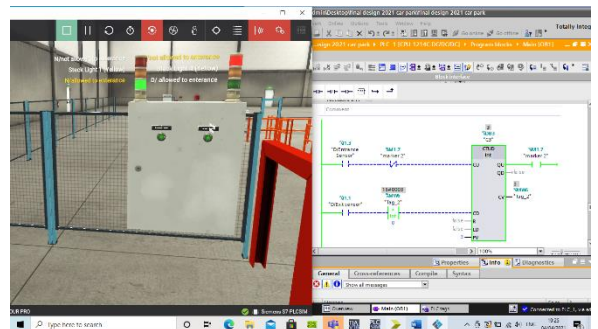


Figure 25: test

If the counter has been pressed more than three times, it won't count any higher than the limited number (max. 3 number).

When the space is free, the green led will be on. By pressing the red switch, the red led is activated to show that the place has been taken.

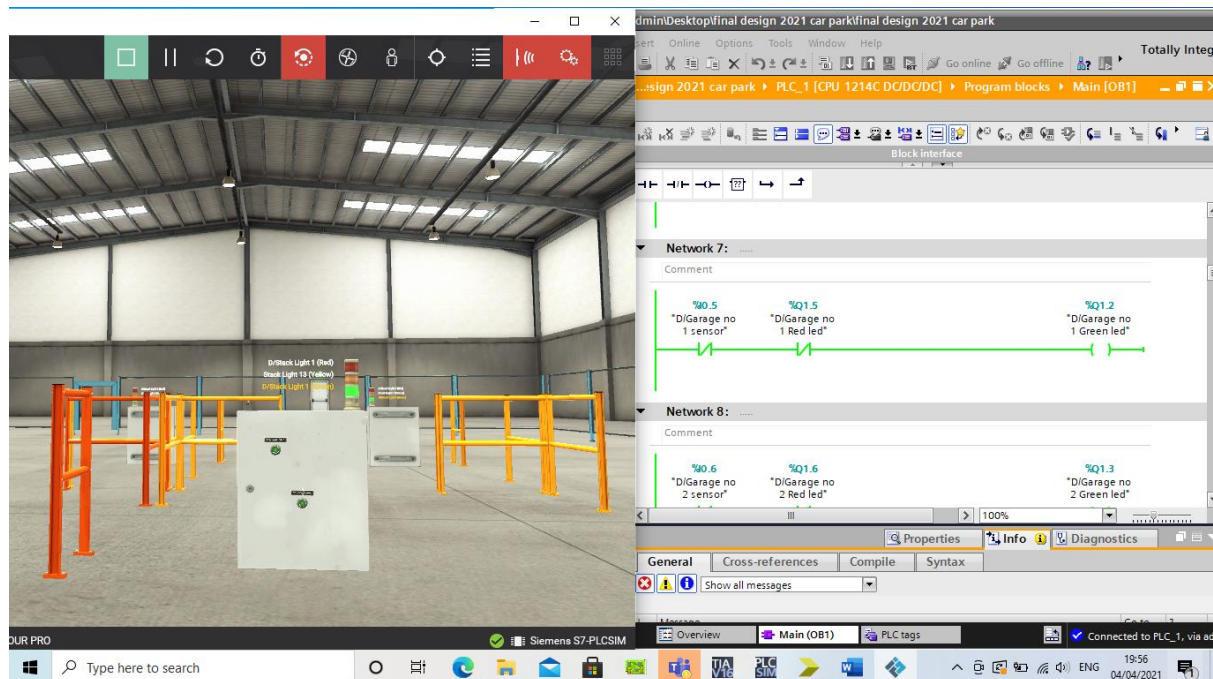


Figure 26: test

By pressing the green switch, the car is leaving the parking space. Hence, the green indicator is switched on and the red switches off.

The same test has been carried out for all three disabled spaces.

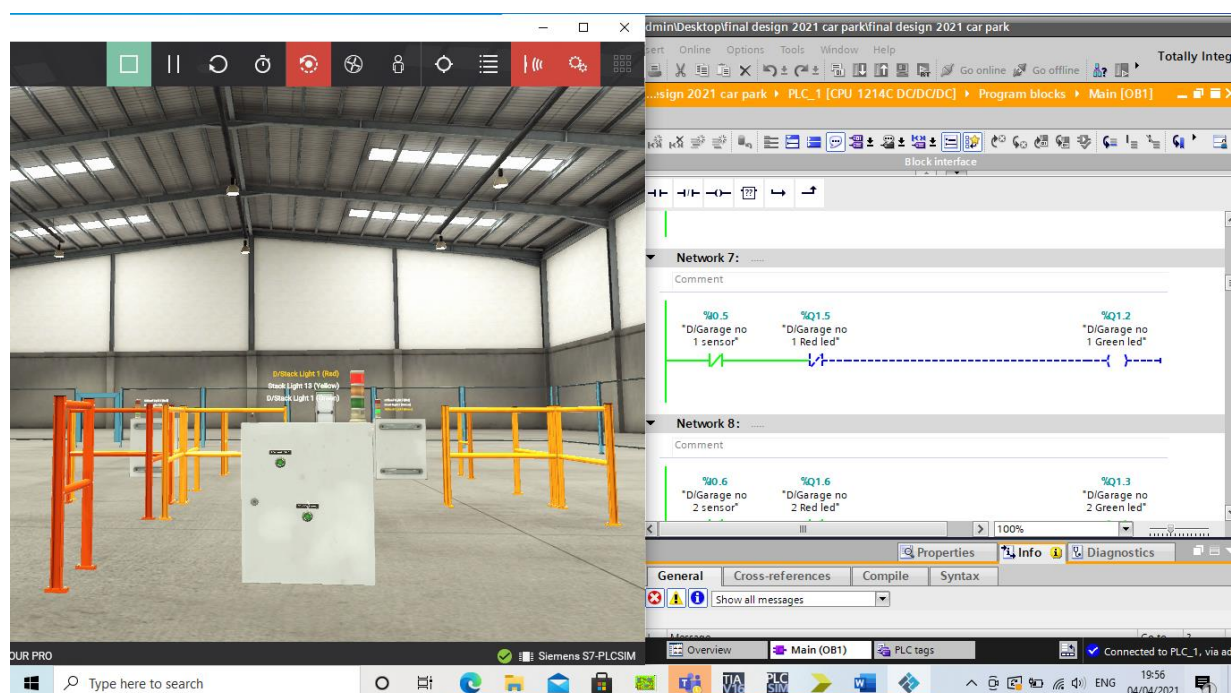


Figure 27: test

The red switch has been pressed indicating the space is busy. The green switch will be pressed once car leaves place. The same test has been carried out for all normal places.

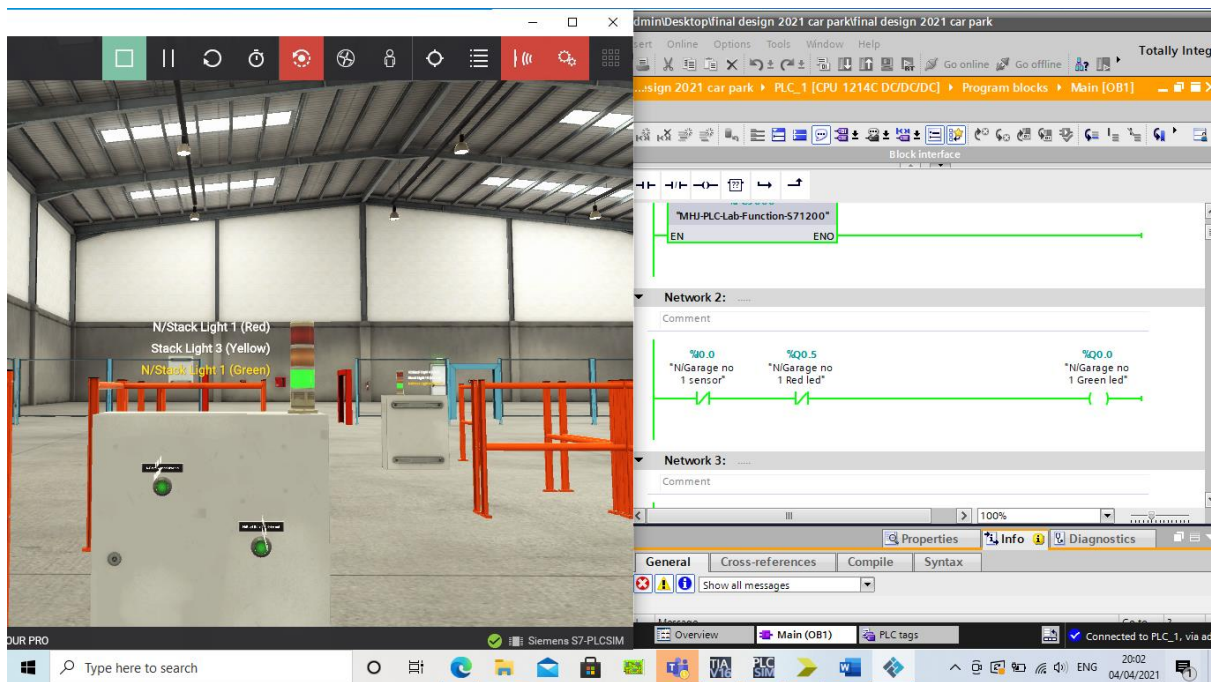


Figure 28: test

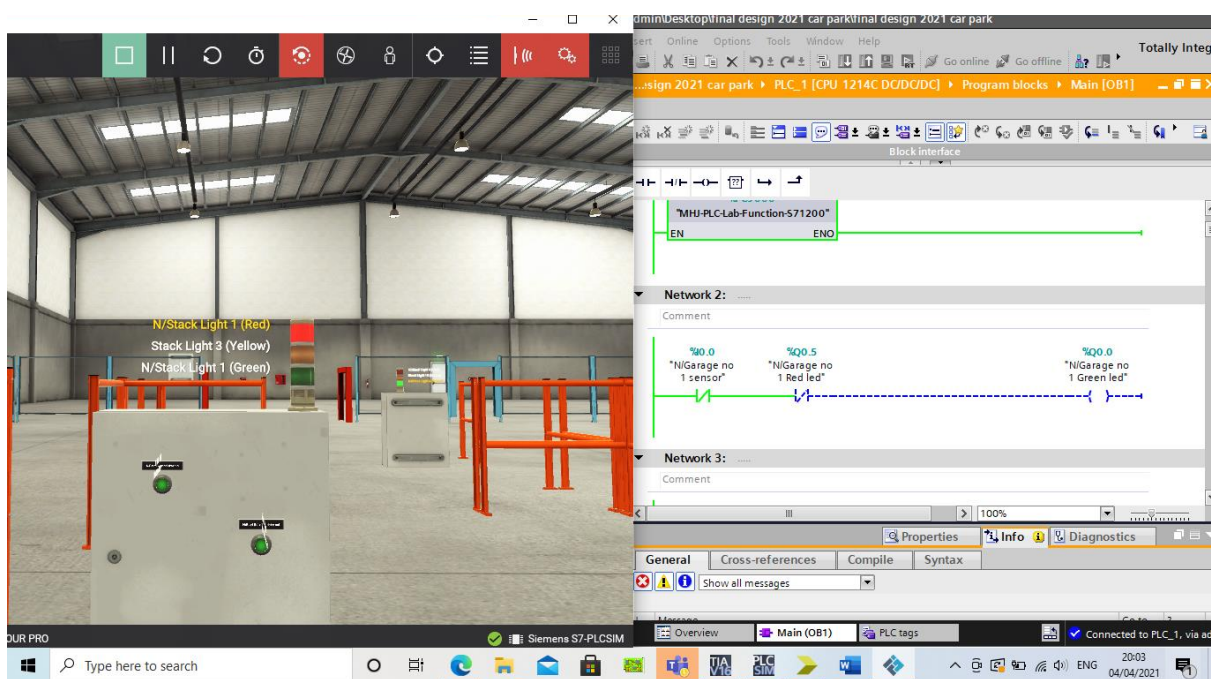


Figure 29: test

The D/exit counter has been pressed, so the number of cars decreased to 2 as it was full (3). And the stack light went back to the green led after it was red.

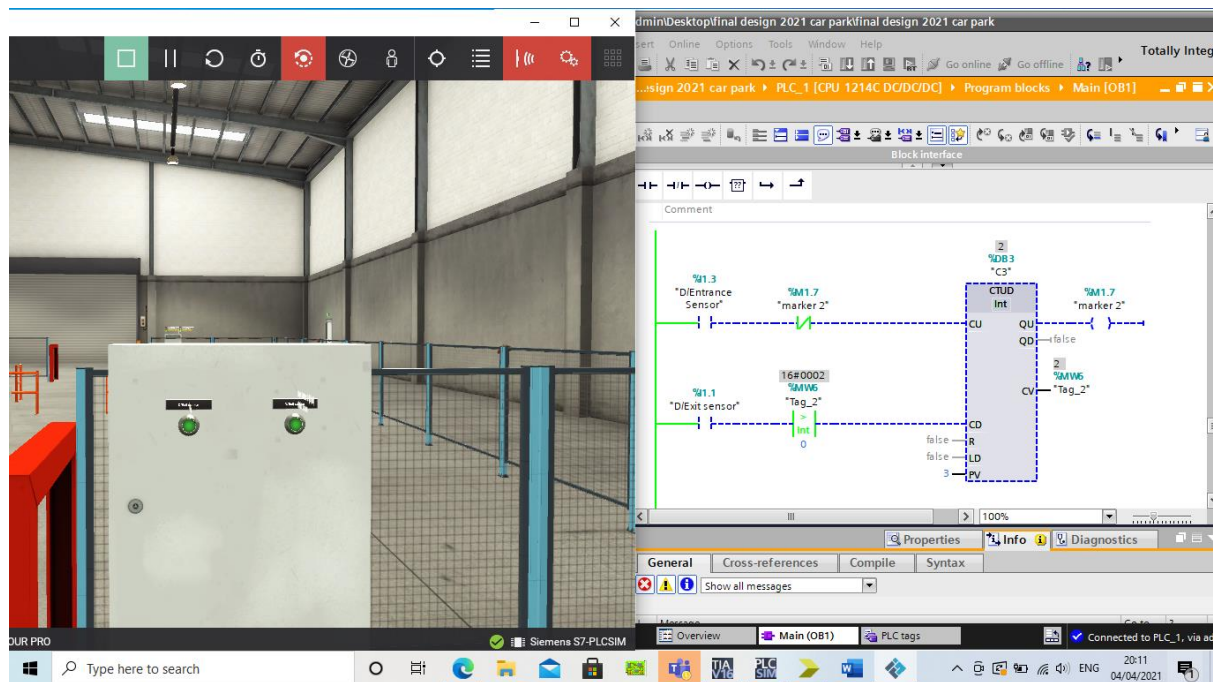


Figure 30: test

These are the three disabled parking spaces (yellow). It shows that two of the spaces are busy (red light is on). In network 11, the blue inputs present the other two busy spaces. The middle space, represented in green, is the free space. It has the green stack light on.

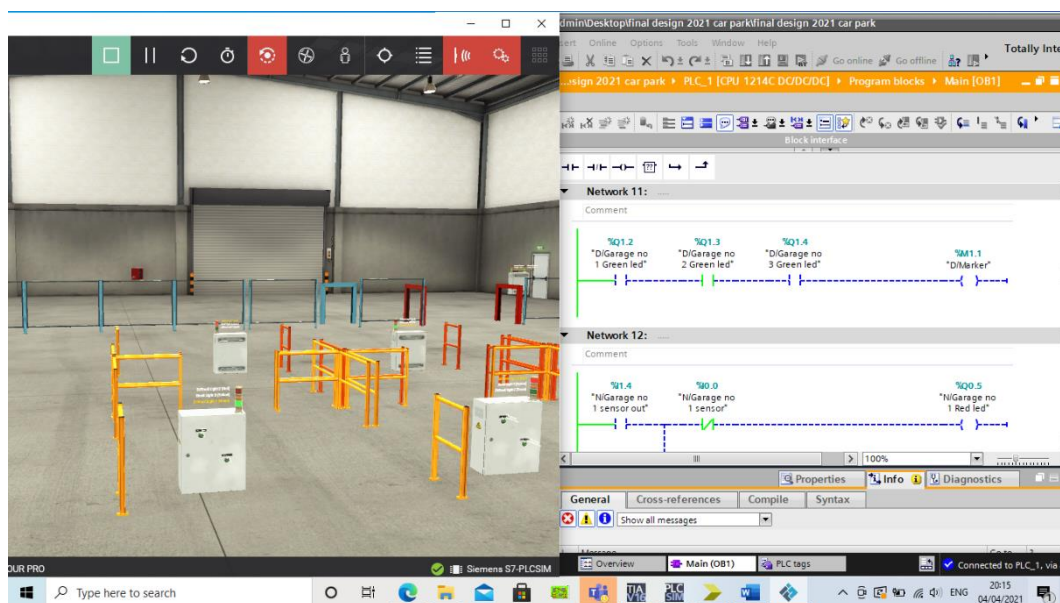


Figure 31: test

The normal spaces that has been taken in network 10 are represented below:

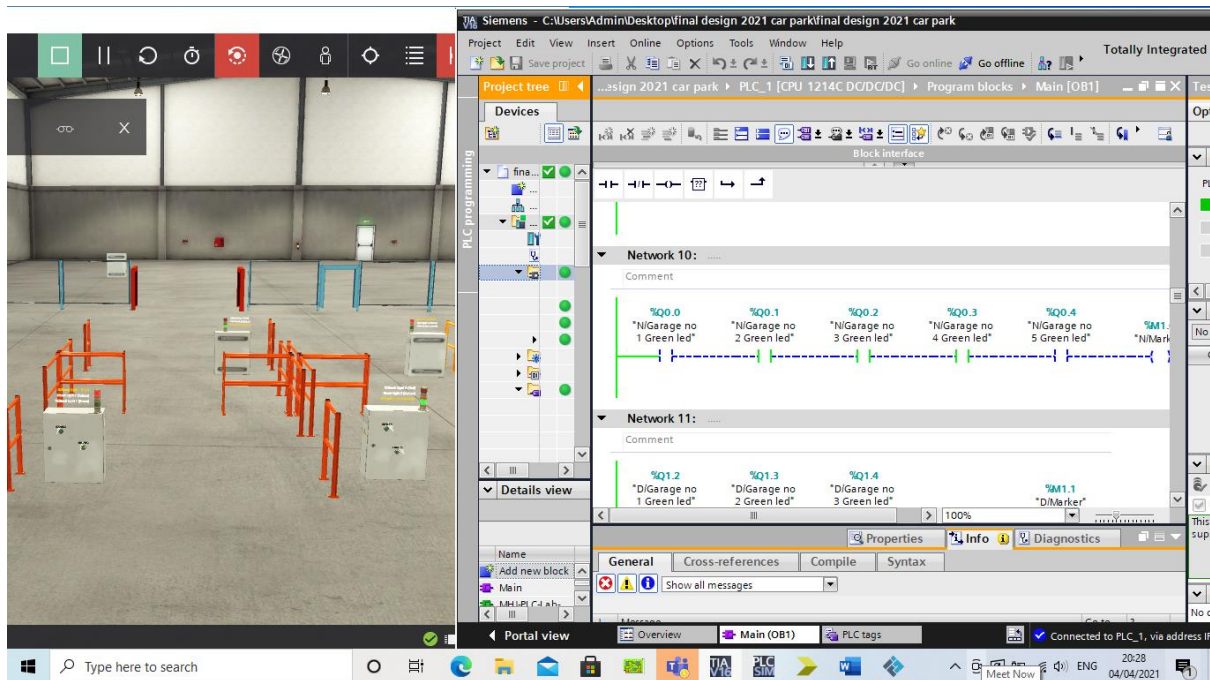


Figure 32: test

The red switch is on, and it will remain activated.

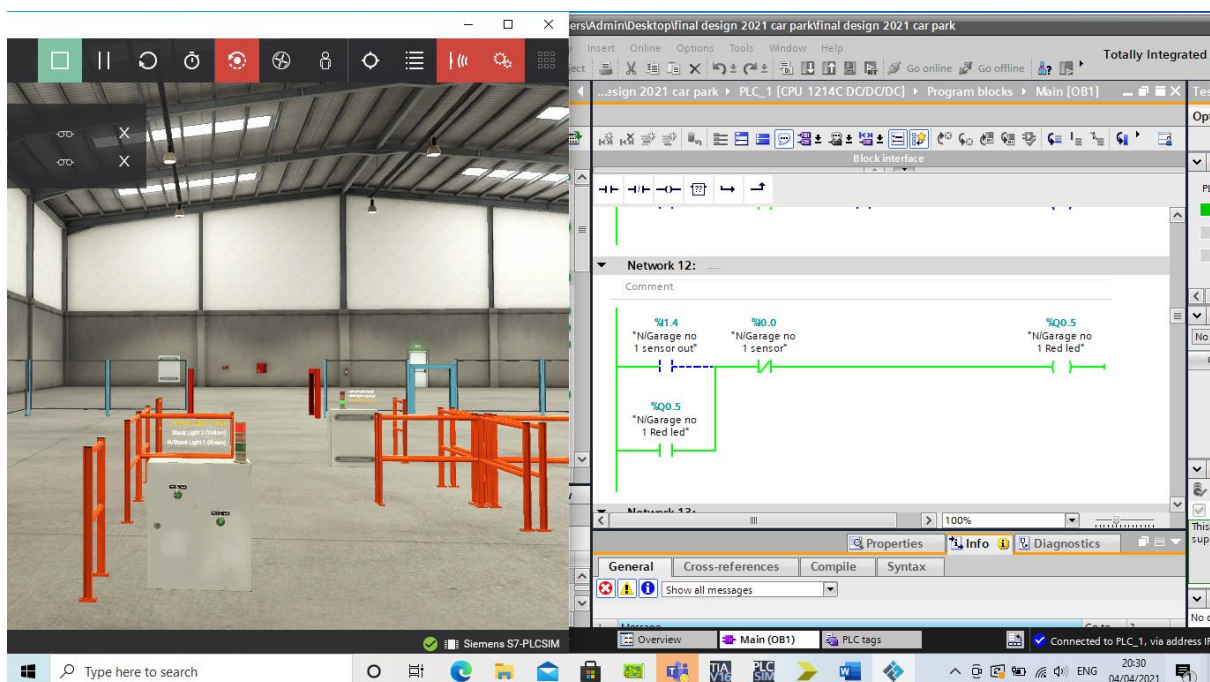


Figure 33: test

The green switch has been pressed, meaning the car is no longer parking.

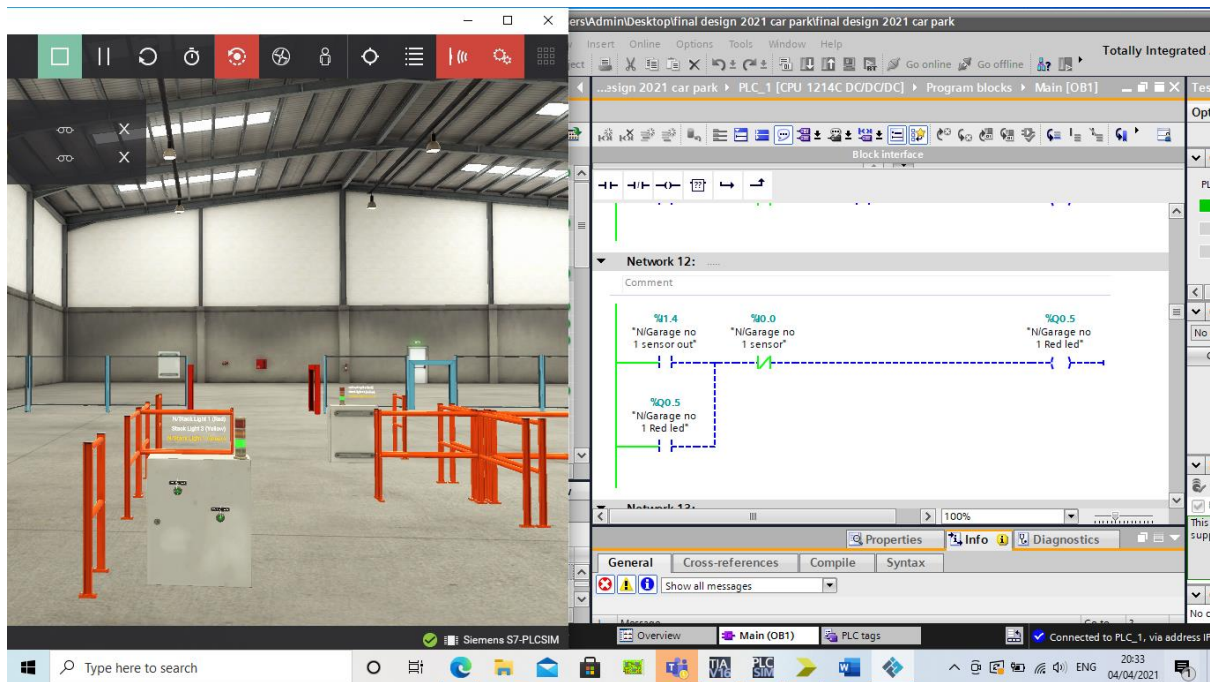
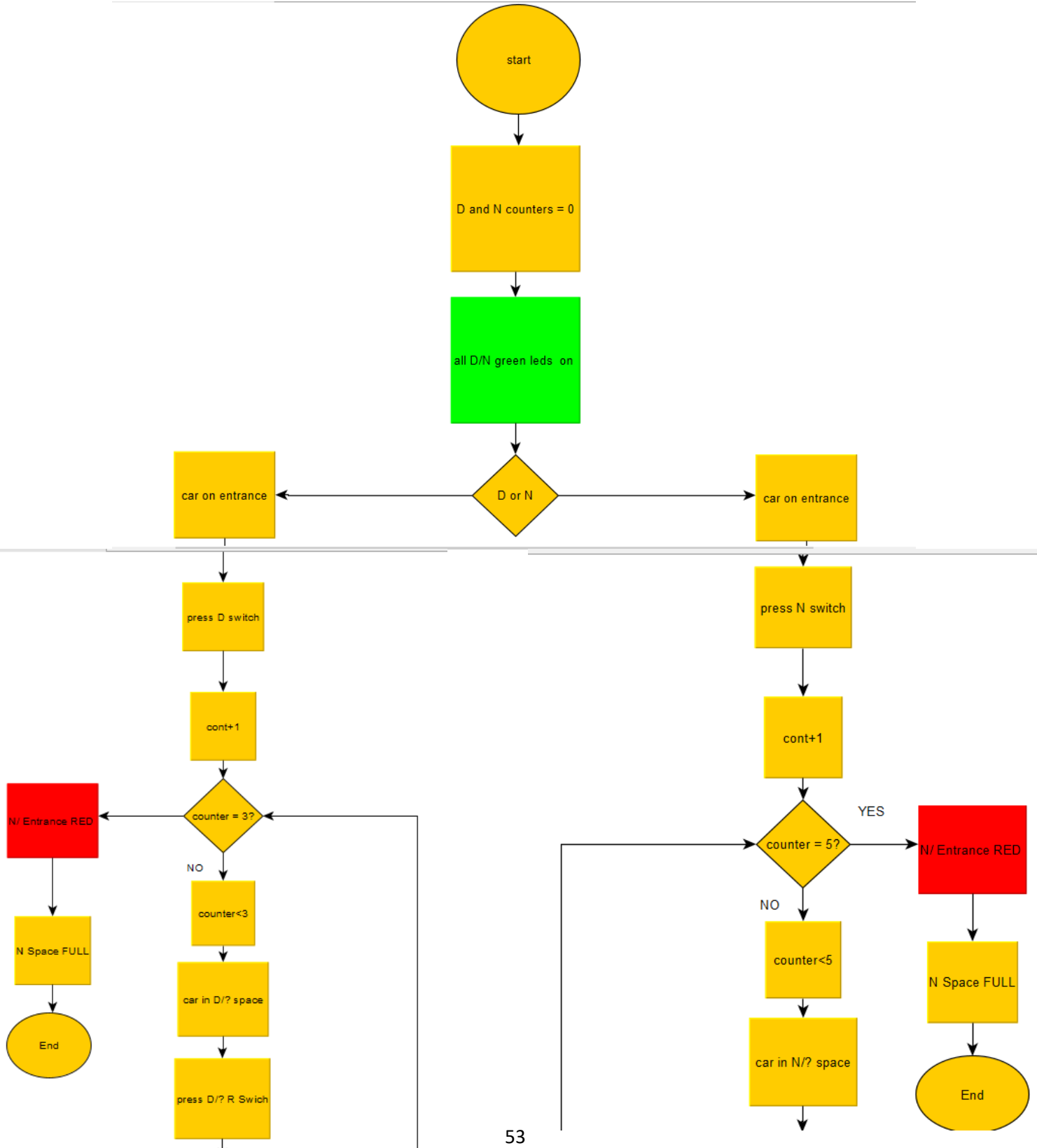


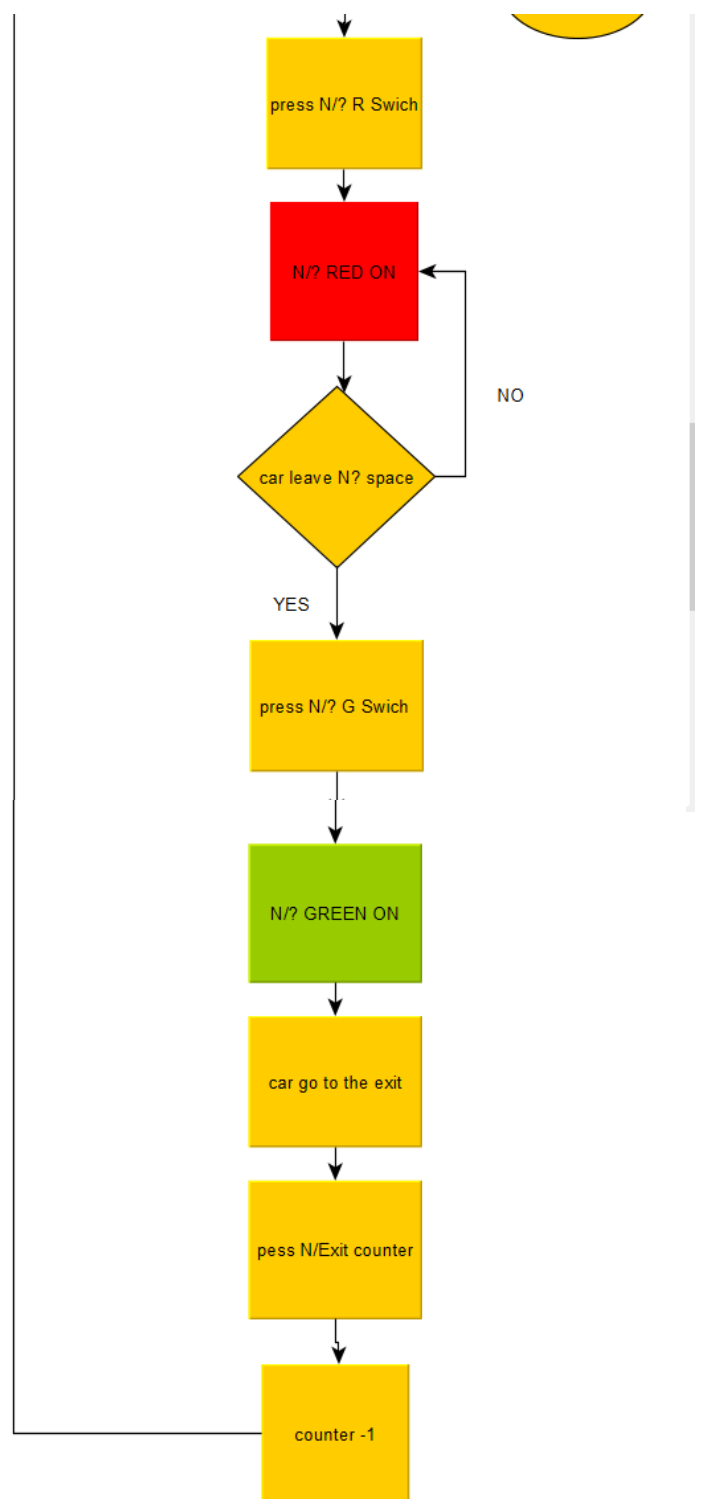
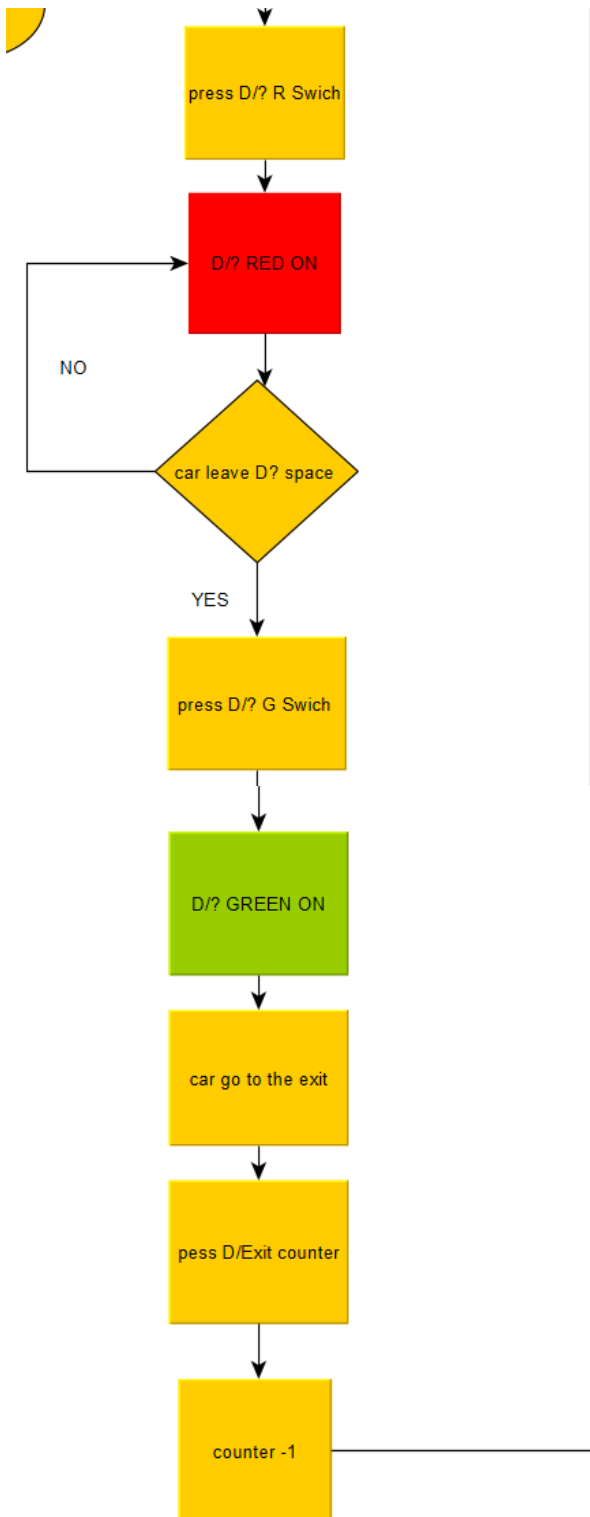
Figure 34: test

Same test has been carried out for the normal and disabled spaces.

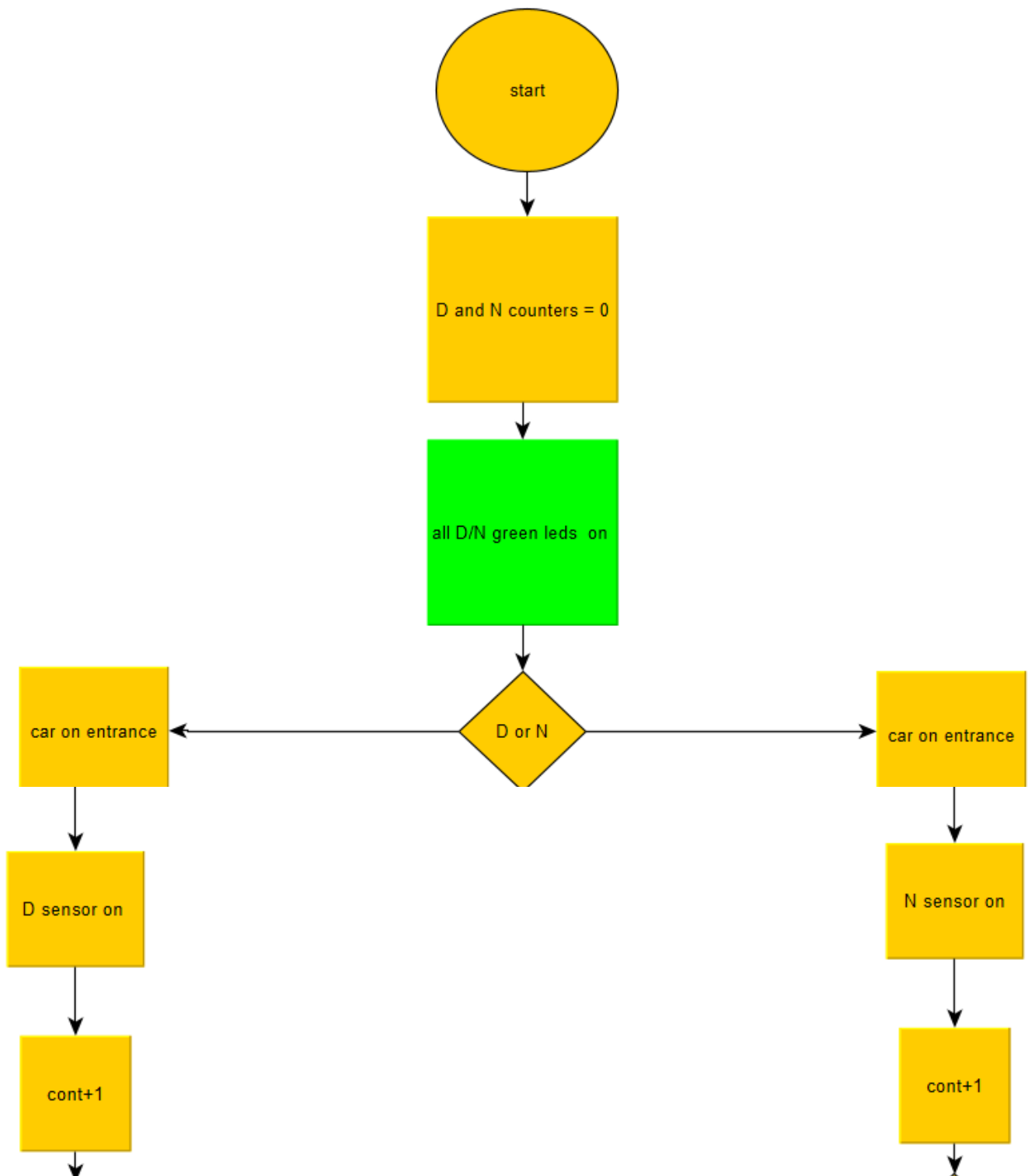
PLC Flowchart:

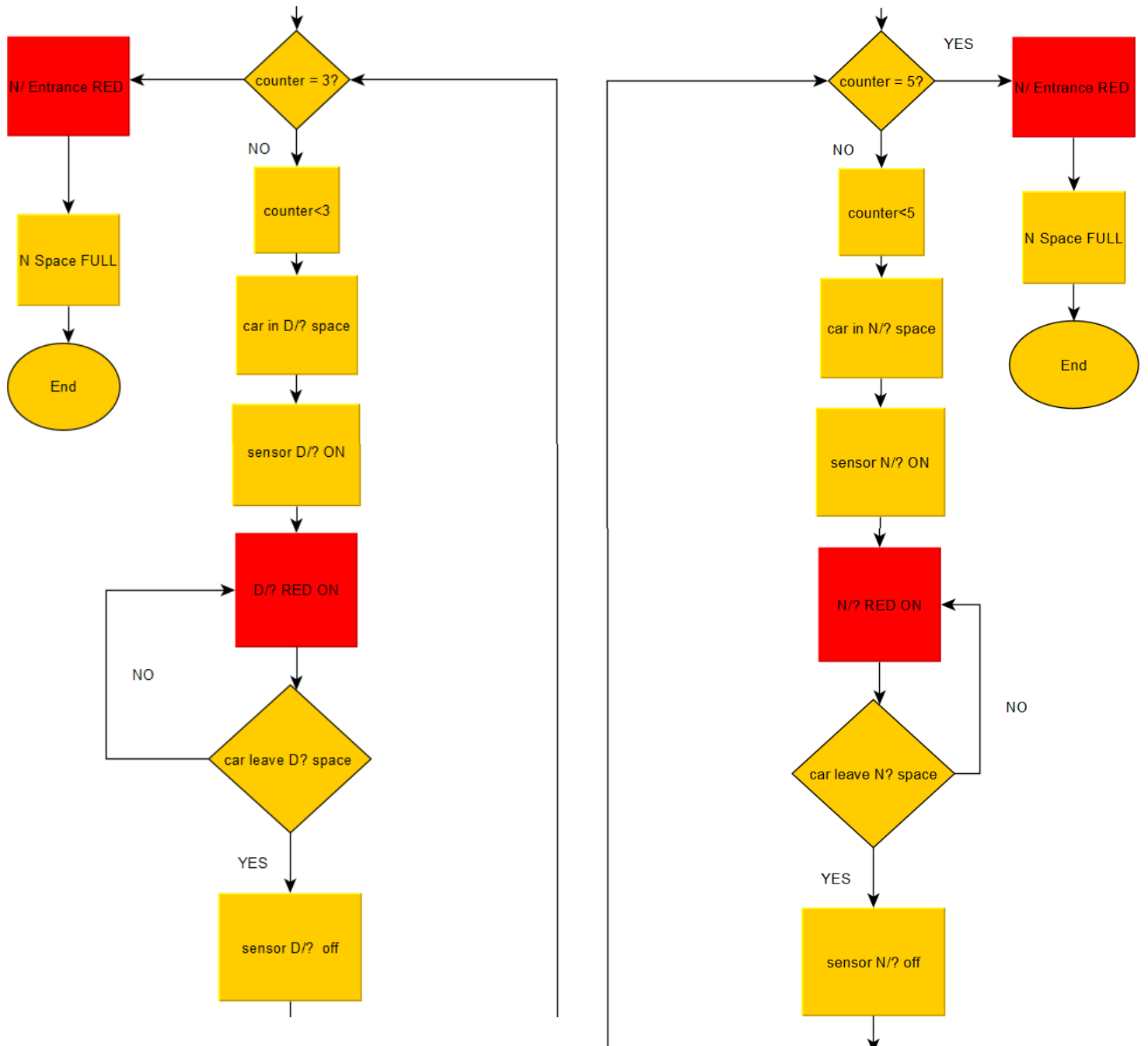
with switch buttons:

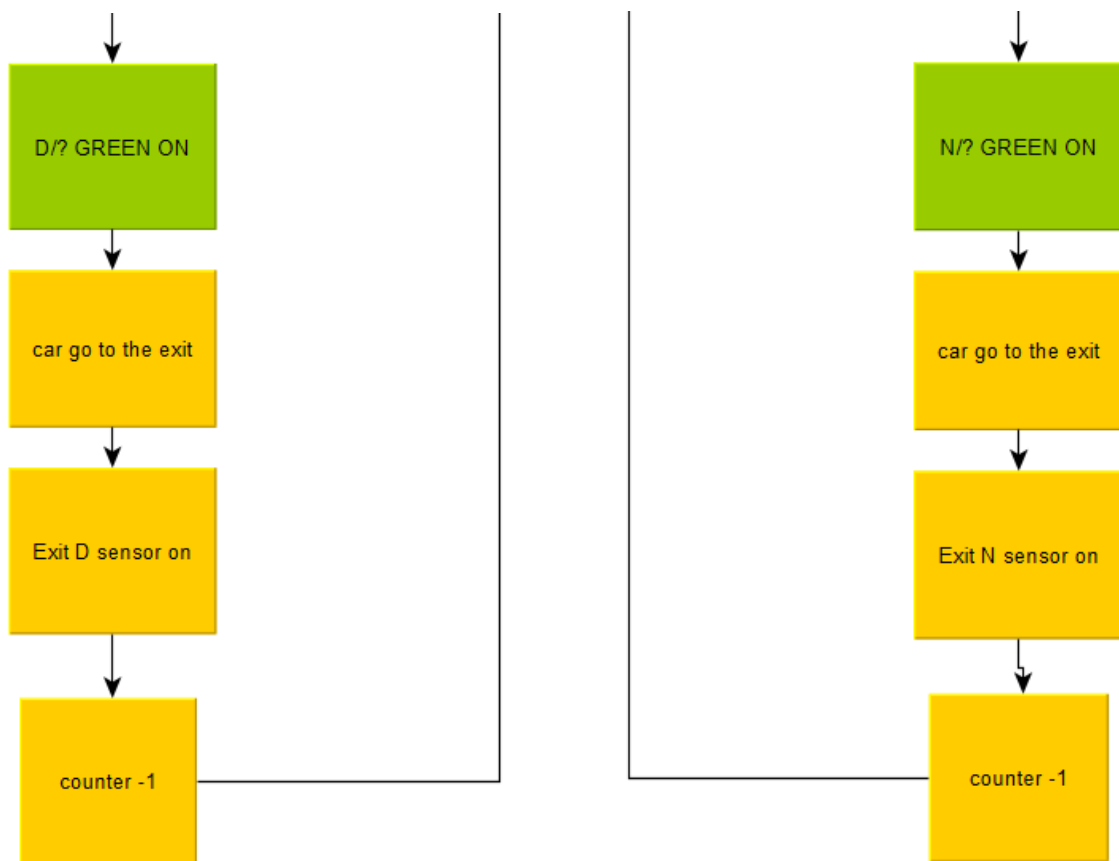




With diffuse sensors:







Flowchart explanation:

When starting the system, both counters (D- as the disabled cars counter) and (N- as Normal cars counter) = to zero, so the green stack lights in each space and in the entrance are going to be on.

Driver has to press either the normal switch or the disabled one. Once one of the switches are pressed e.g; the driver pressed the N switch, the counter will add one as its less than 5 cars inside the car park. However, if the counter equals 5 (the maximum limit), then the red led in the entrance will be activated instead of the green light. If the counter is less than 5, the car enters the parking space and driver has the option to choose between any of the free spaces with the green light on.

Once parked, the driver has to press the red switch. Once the red stack light is on, the space is busy and it will remain red as long as the car is occupying the place.

If the car wants to leave the parking space, the driver has to press the green switch, so the red stack light turns off and the green light is activated. Now, the parking space is available once again. The car is expected to drive towards Exit, once it leaves the parking space.

Once the car reaches the Exit point, the driver presses the N counter. This will decrease the number of cars and increase the number of N spaces.

The D counter and D/ spaces work in the same way as the normal counter.

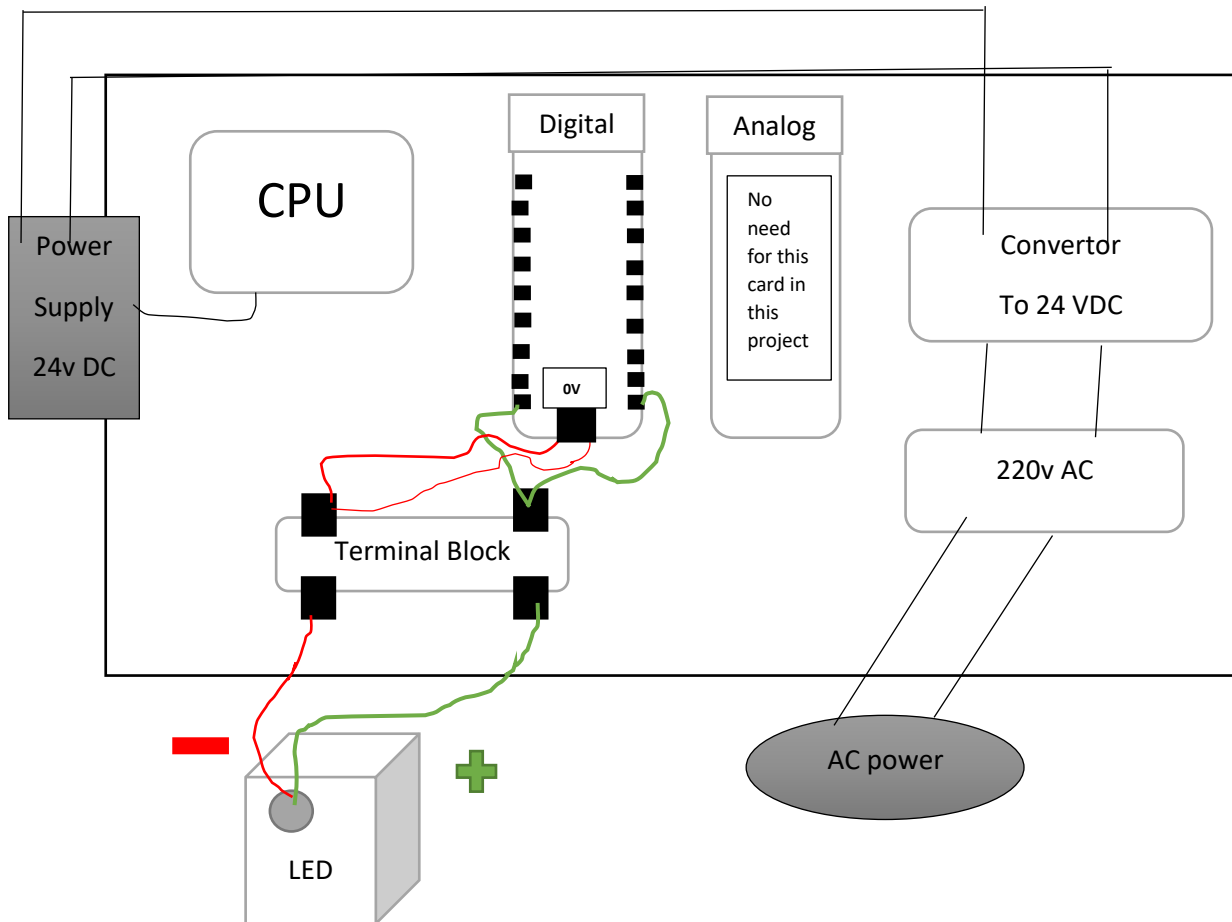
If the push buttons been replaced with sensors:

On the entrance and exit there will be two sensors instead of the push buttons. When cars enter or exit the car park, the sensors are going to detect them and send signals to the counters. The counters will either count up or down.

When a car enters the parking space, there will be no need to press any switches, as a sensor will be able to detect it. Hence, a red light will be activated. Once the car leaves the parking space, the sensor will detect the empty space, and the light will return to the green light.

Sensors must be available in each parking space, for both the normal and the disabled spaces as well as on the exit and entrance.

PLC parts and connections:



The figure above shows an example on how the connections can be in real life.

The CPU acts as the brain of the complete system. When engineers install the code, it gives orders and sends signals to each part/machine. To run the plc, it needs 24 DC volts.

The SIMATIC S7-1200 CPU and SIMATIC S7-1200:

SIMATIC S7-1200

PLC full kit:



Figure 35: plc s7-1200

[35]



Figure 36: plc kit

Siemens > Simatic S7 > S7-1200 > Starter Kits > 6AV6 651-7DA01-3AA4 Siemens S7-1200+KTP700 BASIC STARTERKIT

6AV6 651-7DA01-3AA4 Siemens S7-1200+KTP700 BASIC STARTERKIT

● Available on backorder 
Usually ships in 5 Business Days

s7-1200+ktp700 basic starterkit
consisting of: cpu 1212c ac/dc/rly, hmi
ktp700 basic, input simulator, step7
basic cd, manual cd, info material,
systainer



No reviews

Condition New
NFS - Brand New Factory
Sealed - Original 

831,98 GBP
VAT excluded

Quantity

 Buy It Now

Figure 37: PLC kit price

According to the PLC city website [36] an S7-1200+ktp 700 basic kit includes:

- CPU 1212c ac/dc/rly
- hmi ktp700
- Input simulator
- Step7 basic cd
- Manual cd
- Info material
- Systainer

The overall cost is £831,98 and comes with a 12 months warranty.

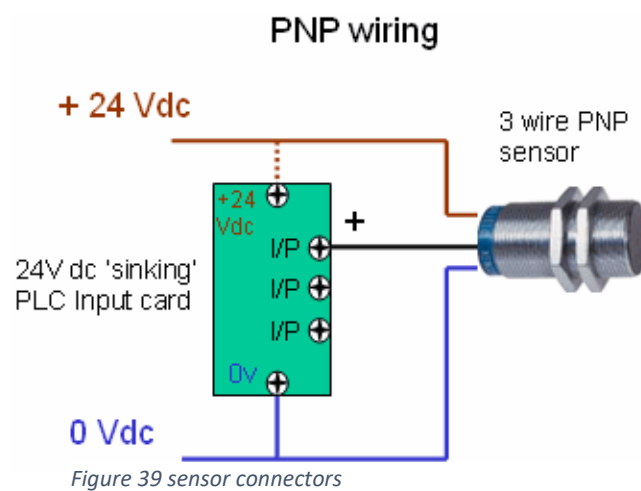
Proximity Sensors:

DC 12-24V PNP NO Inductive Proximity Sensor Switch Detector



Figure 38

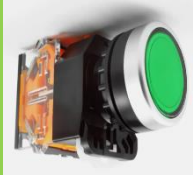
[26]



[37]

To connect a proximity sensor to the plc, three connections are needed; the voltage supply, the plc input card to one of the pins and one as ground to the 0v, as it shows in the figure above.

System Price listing:

Image	Description	Price	Quantity with sensors	Quantity with no sensors	reference
	24vdc PR08-2-DP DC 12-24V PNP NO Inductive Proximity Sensor Switch Detector 2mm	£9.53	x12 =£114.63	0	[26]
	Self-reset Push Button Switch 22 mm LA 38 11. small Start switch button	£6.95	0	x20 =£139 There is no need for switches as it will not be used for the actual project.	[23]
	DC 12 v red, green signal tower lamp warning stack light with buzzer alarm apparatus.	£8.80	x10 =£88	x10 =£88	[20]
	Top quality Oem service water-proof outdoor metal electric switchboard distribution box for electrical power	£40.67	x10 =£406.7	x10 =£406.7	[25]
	Siemens PLC kit: Siemens S7-1200 PLC CPU kit.	£495.60	1	1	[38]
Final price excluding the connectors and cables pricing.			£1,104.93	£1,129.30	

Connector's pricing:

2x2 mm connectors needed to connect the sensors to the plc.

Proximity sensor connector		
Picture		
info	3npin 22wagn3Anwaterproof connector	2.5mm² 3 core yy control flexible cable
price	£1.57	£0.92 per 1m
features	waterproof overload, overheat, open load short circuit protections.	3 cores as needed. Core can be numbered or coloured as required. 1 year guarantee cheap
Reference	[39]	[40]

Car park with diffuse sensors:

To show how the car park is going to be with the diffuse sensors, this design has been made.

All push buttons will be replaced with sensors in each parking space and on the entrance and exits. The sensors will detect all the cars movements.

Car park structure with the sensors.

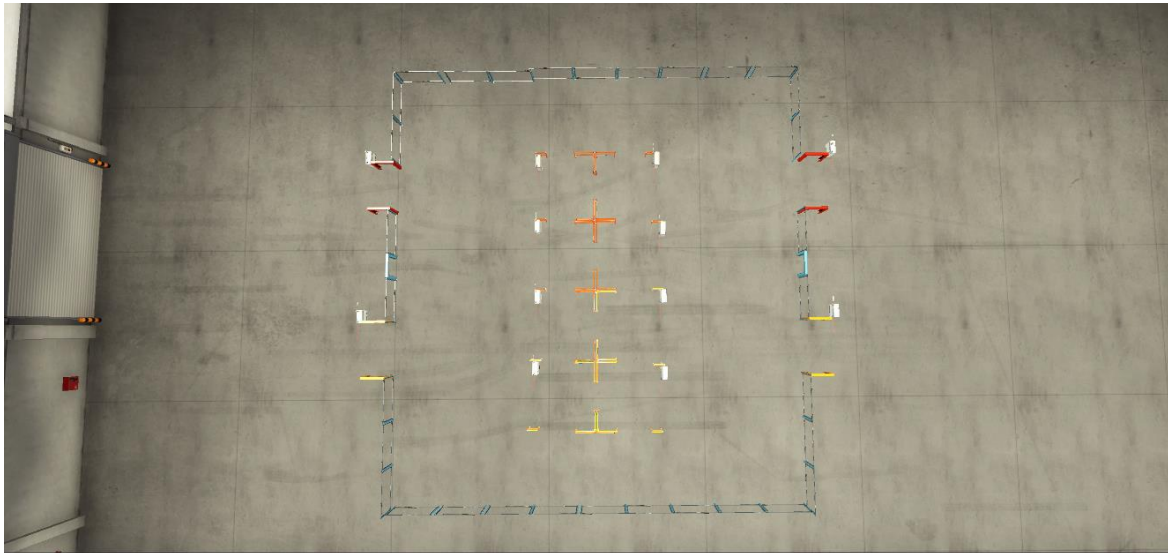


Figure 40: full car park with sensors



Figure 41: Normal cars Entrance with sensor



Figure 42: Disabled cars entrance with sensor

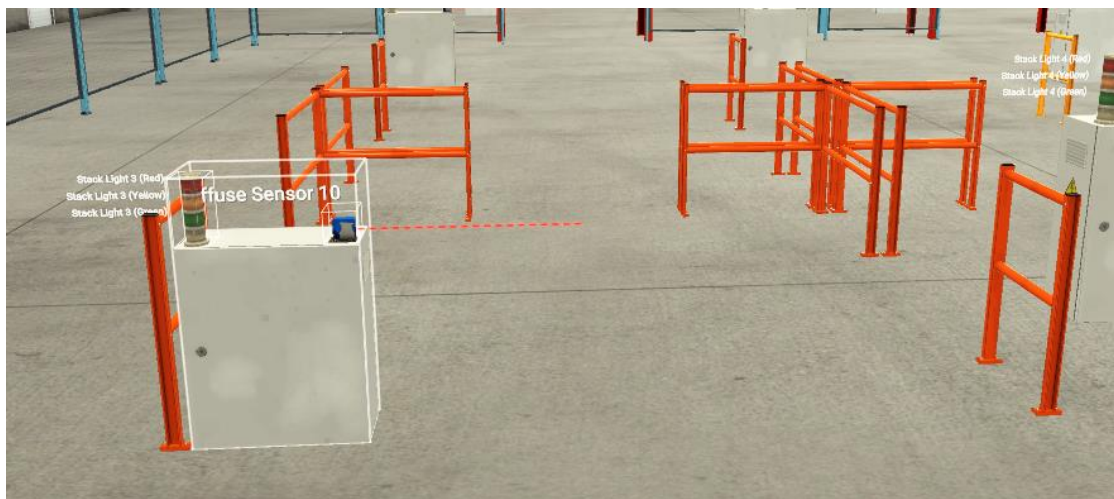


Figure 43: Normal cars space with sensor



Figure 44: Disabled cars spaces with sensor.

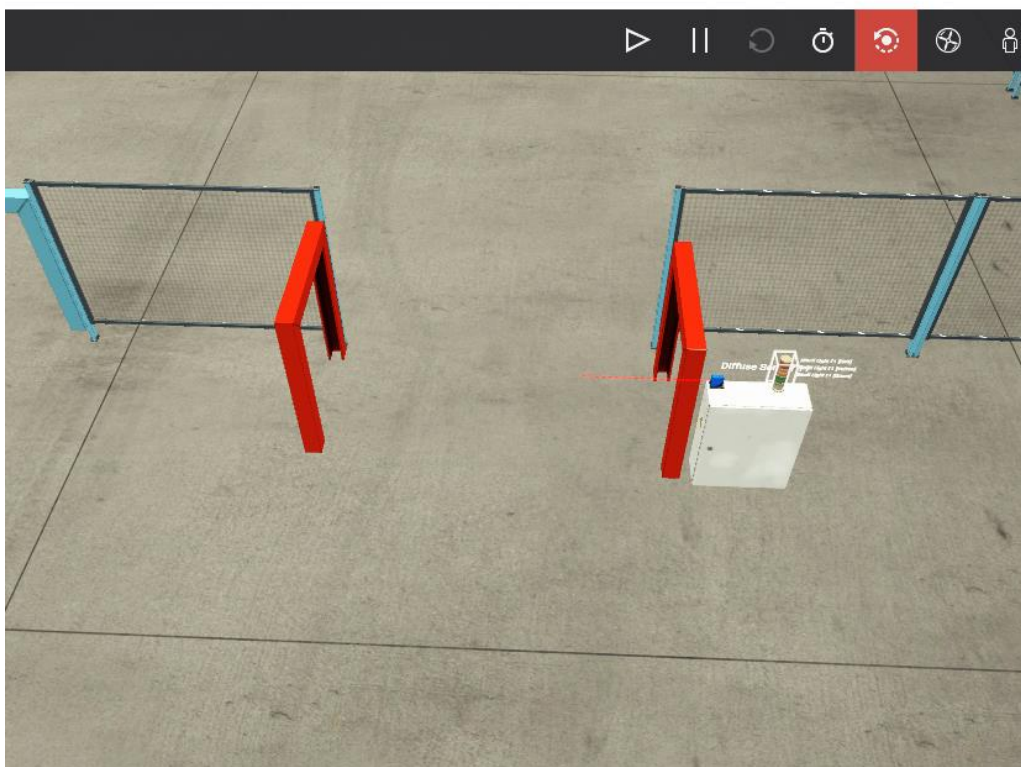


Figure 45: Normal cars exit with sensor.

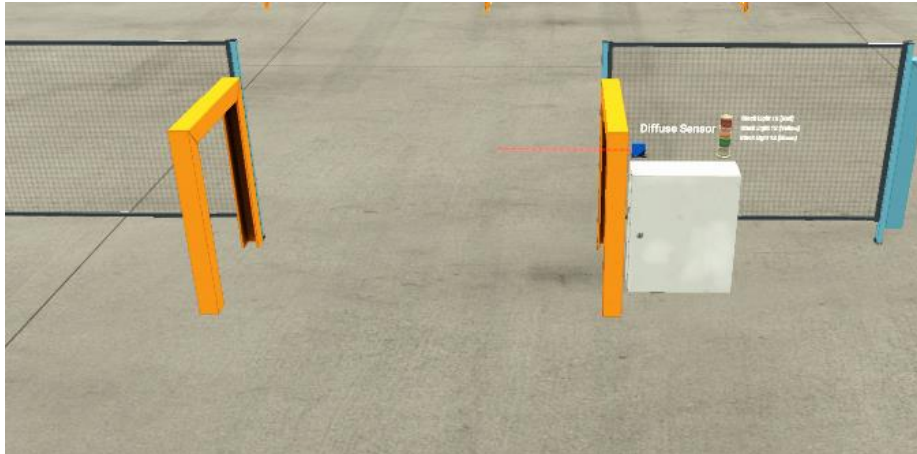


Figure 46: Disabled cars exit with sensor.

Car park system with the sensor explanation:

Using the push buttons in the car park instead of the sensors was necessary as it was not able to test the plc system with the sensors.

The diagram above shows how the car park would look like if the diffuse sensors were placed.

When a car approach any of the entrances (N or d), the counter will add one to the limit number. When a green light is on by the entrance, the sensor will detect this and send signals without having to press any buttons.

When green LEDs are on in all free spaces and a car enters in any of these spaces, the sensor will detect it and switch the red light on instead of the green one. As soon as the car leaves the space the green light will turn back on.

When a car goes through one of the exits and leaves the car park, the counters will decrease the number of the cars, so one more free space is available to use.

Chapter 6 (Evaluation):

As the aim of this project was to design a car park and control it by PLC, I have set objectives and goals to guide me throughout my project, which I believe most of them has been fulfilled.

The Plc system was connected to the car park in Factory I/o using the S7-PLCSIM V16, in order to test it. No difficulties have been experienced when testing the program. However, the downfall of the car park design was the inability to test it using the diffused sensors, so switches (push buttons) were placed instead. These need to be pressed in each step.

It would have been more satisfying to see how the system would have worked with the sensors, as this would have been my ideal visualisation of the project.

Chapter 7 (The Conclusion & Recommendations):

This project was such a great achievement of mine, as I had limited and very little experience in the software that I used. Initially, when starting to look at designs and various styles of controlling car parks, the softwares seemed to be complicated and I started doubting my ability to accomplish such thing. However, completing the design in different ways with different components was quite interesting.

The final system used can be best described as a lightning system, offering a more accessible and effective solution for drivers.

For the counters and the switches in each parking space, IR sensors could be used instead of the buttons. This enables drivers to just follow the lights.

The factory I/o has been used as the project will be presented virtually. Hence, if IR sensors are placed in the design, it would not be able to be tested. IR sensors require an actual car or an object to go through, which cannot be done by this software.

Overall, the system seemed to have worked perfectly with no issues or faults. It can be used with any number of car limits. This can be done by changing the settings of the counters and alterations need to be made to the plc program.

More knowledge and understanding of both the PLC and the Factory I/O software has been gained after accomplishing this project, with the ability to design and control similar systems in the future.

Chapter 8 (Reflection):

In order to complete a level six qualification and obtain a full degree in electrical and electronic engineering; an individual project must be done. I had a rough idea of the usage of PLC for my individual project in my mind, as I have previously done a plc assignment in the first semester. Hence, I decided to apply my intermediate knowledge in this project and control a car park system by plc and present it by the Factory io.

Working from home during the pandemic was a challenging experience, particularly for students completing their last year at university. When this academic year approached, and the new restrictions and measurements has been announced, I was hoping we could go back to university and work from the university labs, with the supervision of my lectures. Unfortunately, this has not been the case. However, I still managed to get sufficient support and feedback from my supervisors.

I really enjoyed the challenge this project has put me in, as it was my first individual project. This project has helped me improve on my time management skills and helped me organise my research ideas. This opportunity allowed me to broaden my knowledge around the topic area of research by exploring various resources

During the designing phase, I have undergone many trial and errors. This allowed me to improve on my design drafts and advance my components to reach my final desired design. This experience allowed me to identify my errors and find alternative and more effective solutions.

In the future, I could improve on my project management skills by prioritising tasks with a project schedule and make use of project management software.

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