AUTOMATED PARKING SYSTEM

LINA LO

This Report Is Submitted In Partial Fulfillment Of Requirements For The Degree Of Bachelor In Electrical Engineering (Industrial Power)

Fakulti Kejuruteraan Elektrik
Universiti Teknikal Malaysia Melaka

May 2008

"I hereby declared that this report is a result of my own work except for the excerpts that have been cited clearly in the references."

Signature :……

Name :……

Date :……

"I hereby declared that I have read through this report and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering (Industrial Power)"

Signature :……

Supervisor's Name :……

Date :……

ABSTRACT

The aim of this project is to design and build a prototype of an automated parking system which will automatically park and retrieve the vehicle without the driver. The driver will park his vehicle on a pallet at the platform of the car park. Then the sensor will detect the available empty parking spaces and display them on the control panel. After the driver selects the desired parking space on the control panel, the vehicle will be transported to that parking space. In order to retrieve the vehicle, the driver will select the location of his vehicle on the control panel. The system will retrieve the vehicle from the parking space and send it back to the original position where the driver is waiting. Programmable Logic Controller (PLC) will be used in the design of the prototype of the automated parking system. The PLC is used to control the movement needed to transport and retrieve the vehicle to and from the available parking space based on the signal from the driver. A program needs to be created for the PLC using CX-Programmer by drawing ladder diagram. Power window motor and direct current (DC) motor would be used to provide movements to transport the vehicle in the parking system. Besides that, limit switch will act as sensor to detect the available parking space and also the location of the carrier.

ABSTRAK

Matlamat projek ini adalah untuk mereka dan membina sebuah prototaip sistem letak kenderaan automatik yang akan memasukkan dan mengeluarkan kenderaan tanpa pemandu. Pemandu akan meletakkan kenderaannya di atas pelantar tempat letak kenderaan. Kemudian, pengesan akan mengesan tempat letak kenderaan yang kosong dan menunjukkannya pada panel pengawal. Selepas pemandu memilih tempat kenderaan yang dikehendaki pada panel pengawal, kenderaan akan dihantar kepada tempat letak kenderaan tersebut. Bagi mengeluarkan kenderaan, pemandu akan memilih lokasi kenderaannya pada panel pengawal. Sistem akan mengeluarkan kenderaan daripada tempat letak kenderaan dan menghantarnya kembali kepada lokasi asal di mana pemandu tersebut sedang menunggu. *"Programmable Logic Controller"* (PLC) akan digunakan dalam rekaan prototaip sistem letak kenderaan automatik. PLC digunakan untuk mengawal pergerakan yang diperlukan untuk memasukkan dan mengeluarkan kenderaan ke dan dari tempat letak kenderaan berdasarkan isyarat daripada pemandu. Satu program perlu dibuat untuk PLC dengan menggunakan *"CX-Programmer"* dengan melukis gambarajah tetangga. Motor tetingkap kuasa dan motor arus terus akan digunakan bagi menghasilkan pergerakan untuk menghantar kenderaan dalam sistem letak kenderaan. Selain itu, suis pengehad akan digunakan sebagai pengesan untuk mengesan tempat letak kenderaan yang ada dan juga lokasi pengangkat.

TABLE OF CONTENTS

LIST OF TABLE

LIST OF FIGURES

LIST OF ABBREVIATIONS

PLC	- Programmable Logic Controller
MAPS	- Modular Automated Parking System
HMI	- Human machine interface
ft	- feet
PC	- Programmable Controller
LED	- Light Emitting Diode
V	- Volt
DC	- Direct current
K	- kilo
M	- mili
A	- Ampere

CHAPTER 1

INTRODUCTION

According to An English-Reader's Dictionary by Oxford University Press [1],

- *automatic means self acting or self moving machine that is able to work without attention*
- *park is a place where vehicles are left for a certain time*
- *system is a group of things or parts working together in a relation*

Therefore, from what that is understood, automated parking system is a group of self acting or self moving machine, things or parts that work together in a relation without attention to build up a place where vehicles can be left for a certain period of time.

1.1 Project Objectives

The automated parking system has a few objectives to be achieved. These objectives are:

1. To design and build up a prototype of an automated car park system
2. To learn how to control the operation of the prototype of automated parking system using Programmable Logic Controller (PLC).
3. To learn how to program Programmable Logic Controller (PLC) using CX-Programmer software.

1.2 Scope of Project

The scope of this project is to develop a prototype of an automated parking system which is able to park and retrieve the vehicle by itself even without the driver. All the movements needed to transport a vehicle in the automated parking system are controlled using Programmable Logic Controller (PLC) as it is the controller in this system. Programming for PLC is done in a software named CX-Programmer by using ladder logic method. Besides programming, simulation can also be done in CX-Programmer to detect errors in the program created. This will allow modifications and corrections to be done to the program before connecting the prototype to a PLC trainer. OMRON CQM1H is used as the PLC trainer in this automated parking system project because it has task dedicated inner boards, specialized input and output and also high speed communication module. Therefore, it is a powerful and user friendly model of PLC.

1.3 Problem Statement

As it is known, the land is becoming less but the population of human is growing day by day. This scenario is very obvious in modern developed cities. Therefore, land is very limited and spaces need to be saved in every aspect of life. By building an automated parking system which allows high space utilisation, less space is needed compared to the conventional car park. This is because in the automated car park, the parking space can be more compact by having vehicles parked nearer to each other and also less space is required for runways or paths in the parking space as vehicles are transferred to parking spaces using elevators and conveyers. Thus, optimized usage of spaces can be achieved.

Other than that, once the vehicles are in the car park, they will slow down to search for an empty parking space. This slow moving traffic will cause the queue of cars to be longer. Eventually, traffic jam will occur when the car park is crowded. In the automated parking system, the problem of traffic jam can be avoided because the parking spaces are located using sensors. So, drivers do not need to search for the space one by one as they are notified by the system regarding where the empty

parking space are located before the vehicle is transported to the desired parking space. In this way, a lot of time can be saved in the car park and vehicles are parked efficiently by the system. The automated parking system is simple and convenient for storing vehicles in the shortest time.

While the development of the country and nation is growing in a quick pace, crime rates are also increasing daily. Therefore, security has become one of the main concerns in everyday life of the society. Car park is also one of the places where individuals are attacked frequently. Theft and robbery happen in car park because it is considered a quiet place where not many people would be in the car park all the time. By having an automated car park, safety for both the driver and vehicle is less at risk because the public is not allowed into the car park. The automated car park can help in parking the vehicles without the driver going into the car park. In that way, security for individuals and vehicles are more guaranteed.

CHAPTER 2

LITERATURE REVIEW

2.1 Automated Parking

Automated parking is a method of automatically parking and retrieving cars or vehicles to solve the problem of increasing demand for safe and convenient parking as the number of vehicles are increasing day by day. The driver parks his car at the entrance of the car park structure and from there, the car is automatically moved through the garage and stored in an open parking space. All these are done by utilizing computer controlled system of pallets, conveyors, shuttles, carriers and lifts in transporting cars from the arrival level to a parking space and vice versa without human assistance. Later the car will be returned to the driver using a signaling device outside the building [2].

2.2 Modular Automated Parking System (MAPS)

The Modular Automated Parking System (MAPS) integrates computerization with mechanical lifts, pallets, carriers and conveyors to park and retrieve vehicles in multilevel modular garages. These garages have units that are standard in size and design and they can be arranged or fitted together in a variety of ways. They can also be fully customized system to achieve specific requirements besides ensuring optimum occupancy of spaces by vehicles. There are four models of MAPS, which are

1. Model RPS 1000
2. Model RPS 100
3. Model RPS 20W
4. Model RPS 20L

Operation of MAPS is made possible by flexibility transfer technology. This is a type of transport technology that is also being used in automobile assembly lines. Improvement that has been done in MAPS is that a new fuzzy logic based technology has been developed and integrated with the flexible transfer application in order to optimize the movement of the carriers and lifts. Other than that, it also allows several cars to be moved independently through the garage. This will help in making the vehicle storage and retrieval in a shorter time.

MAPS is monitored by computer and human machine interface (HMI) will show real time car movements. Besides that, the HMI facilitates the maintenance and diagnostics of the car park system. The computer which is installed at the garage is accessible from any remote location. Additionally, all systems are equipped with back up system and are based on the safety philosophy of one out of two failures. This means that at least two of every major component is installed on site. At all times, every parking space can be monitored simultaneously by at least two independent units [3].

2.2.1 Model RPS 1000

Model RPS 1000 is a large parking garage which is able to accommodate from 200 to 5000 cars. It is a very flexible and modular design suitable for applications above ground, underground, inside a building, on top of a building or under a building. This model offers one of the highest level of redundancy in the industry and a greater level of reliability. This is because all major components have at least one back up system. Thus, the chances of inoperable of the system due to failures are very low. Other than that, the HMI offers a very sophisticated system of diagnostics which provides high level of detection in advance of any failures. It is

understood that any mechanical or electronic devices can fail but this failure can be overcome by early warning signals and repair.

Figure 2.1 : Model RPS 1000

2.2.2 Model RPS 100

Model RPS 100 is an intermediate sized automated parking garage with a capacity of 30 to 200 cars. It is an ideal solution for small sites with a high demand for parking. This model also provides redundancy and the HMI diagnostic tool helps in ensuring the operation of the garage is not interrupted. It is an intermediate sized garage with true redundancy which means it has the actual back up of the complete unit. Therefore the capability of the system to operate with minimal failures is guaranteed.

Figure 2.2 : Model RPS 100

2.2.3 Model RPS 20W And Model RPS 20L

Model RPS 20W and Model RPS 20L are the ultimate space efficient solution. They are automated parking systems for small applications with a need of 10 to 30 cars per model. However, the capability of occupying more cars can be achieved by building the model adjacently. These models are ideally suited for condominium, apartment, hotel and small office building development projects where land is limited and expensive. In the function wise, there is no difference between Model RPS 20W and Model RPS 20L. But they do have difference physically in design where the way of entering, leaving and also the arrangement of car park spaces are not the same [4].

Figure 2.3 : Model RPS 20W

Figure 2.4 : Model RPS 20L

2.3 Hoboken Garage

Hoboken Garage is an automated parking system operating in New Jersey, United States of America since May 2002. However it was officially opened only in October 2002. A total of $6.2 million has been spent on this facility. The Hoboken Garage automated parking system offers a patented Modular Automated Parking System (MAPS) which uses the latest electronic and automation technology.

The Hoboken parking garage is capable to accommodate 312 cars in its seven storey residential parking garage which in comparison, a conventional ramp style garage can only accommodates 90 cars. It is developed on a 1000ft^2 lot, standing 56ft high and with about 7.5ft from level to level. The garage also allocates parking spaces for the incoming cars, retrieves parked cars as requested and monitors the whole system to prevent failures and also for maintenance.

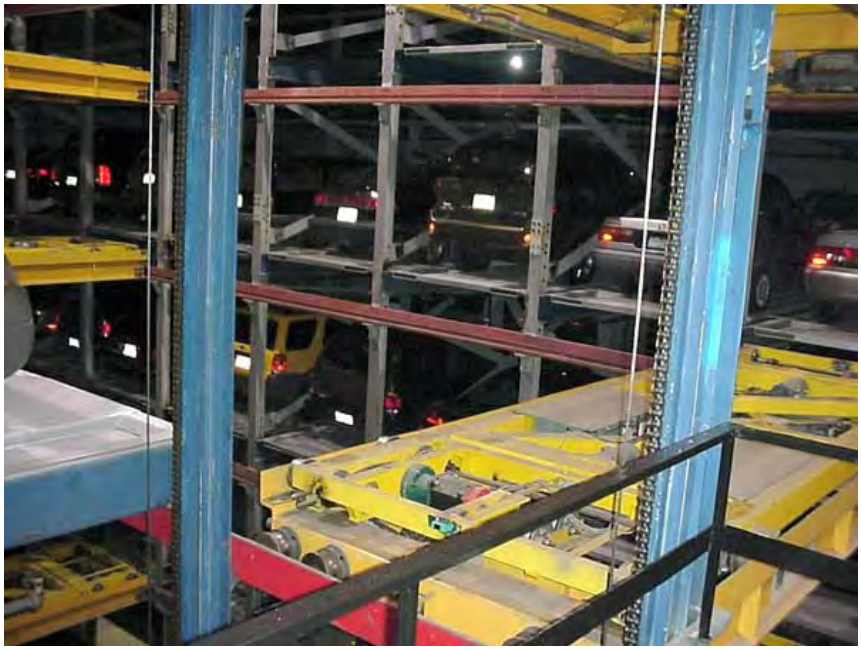

Figure 2.5 : Hoboken Garage uses electronic and automation technology

2.3.1 Motion Control System And Robot

A GE Fanuc integrated motion control system manages 35 independently operating robots. These robots will transport vehicles from the entrance bay into an

open parking space utilizing the automated system to move pallets, lifts and carriers. As it is noticed, each axis of motion employs a pair of servo systems in sharing the load. Either motor can independently supply adequate power to move vehicles during maintenance as the servos are sized to accommodate such load.

2.3.2 CIMPLICITY Software

The GE Fanuc hardware is linked to a software named CIMPLICITY. It is an open system framework that provides a graphical environment to monitor and control the automation system. It also provides a graphical interface with real time displays. Additionally, CIMPLICITY collects and compiles data from the parking system. CIMPLICITY will generate maintenance and diagnostics reports to increase troubleshooting, efficiency and to enable a quick response when system problems occur.

2.3.3 Parking And Retrieval Process

The Hoboken Garage is a monthly garage only for local residents. Therefore each patron has a card similar to a pass. As the patron drives to the garage, the card that is positioned in their windshield is detected by a sensor and sends signal to the computer that a patron is approaching. A green light at an available bay indicates entrance for the patron. Then they will proceed into the open bay, position their car, get out of the car and push a button to initiate the parking process.

The central computer system guides a carrier on steel rails along an open aisle way to a position adjacent to the arrival station and the pallet at the arrival station. An additional rack entry module moves above the upper surface of the carrier and is inserted beneath the pallet. Then the pallet and the vehicle are transferred to the carrier. Under the direction of the computer, the carrier with the pallet and vehicle is moved from the arrival station to a multilevel lifting device. Then the pallet and the vehicle are transferred to the lift. When the lift reaches the designated parking level, the pallet and the vehicle are transferred to another carrier. As shown in Figure 2.6,

this carrier will transport the pallet and the vehicle to the designated parking slot. Lastly, the pallet and the vehicle are transferred into the parking slot by the rack entry module.

When the patron's car needs to be retrieved, the patron will go to the lobby and enters a pin number into a keypad. Then their car is automatically located and retrieved in a forward drive position to an available bay. The patron's name is displayed on a marquee indicating which bay their car will be brought to. The vehicle is retrieved and is placed in the bay in about one and a half or two minutes. Once the car arrives, the patron can simply just drive away [5].

Figure 2.6 : Vehicle is transported on pallet using carrier and lift

CHAPTER 3

PROJECT THEORY AND BACKGROUND

3.1 Programmable Logic Controller (PLC)

Programmable Logic Controller (PLC) was originally named Programmable Controller (PC) but this has caused some confusion when personal computers became more common. Thus to avoid confusion, PLC is widely used compared to PC. The original PLC was just a simple on and off device. Therefore it was very suitable to replace simple relay applications. Since the early days, manufacturers of PLC have added numerous features and enhancements to PLC. Now it has the capability to handle complex tasks such as position control, process control and other difficult applications. The speed of operation and case of programming has also improved drastically [6].

PLC is really an industrial computer as its hardware and software have been specifically adapted to the industrial environment. It is an electronic microprocessor based control system that monitors input signals to detect changes from devices such as limit switches, push buttons and sensors. Based on the status of input signals, PLC will react by producing output signals to drive output devices like motors, relays, alarm and contactors to on or off state. This is done with a control application program stored within the PLC memory. The program will execute according to pre defined sequence of operations.

PLC is widely used in the industrial sector as it has some major advantages. First of all, the wiring of PLC is much less compared to conventional relay control system. Modification can be quite difficult with all these wiring in the conventional

control panel. But in PLC, modification of control sequence or application can easily be done by programming through the console of PLC or computer software without the need to change the wiring if no additional input or output devices required. Besides that, the complicated wiring in conventional system may also cause the troubleshooting to be quite troublesome. In comparison, the PLC self diagnostic functions enable easy and fast troubleshooting of the system [7].

3.2 Ladder Diagram Programming

A ladder diagram consists of one line running down on the left side and there are lines branching off to the right just like the one in Figure 3.1. The line on the left is called the bus bar. The branching lines are called instruction lines or rungs. Along the instruction lines are placed conditions that lead to other instructions on the right side. The logical combinations of these conditions will determine when and how the instructions at the right are executed.

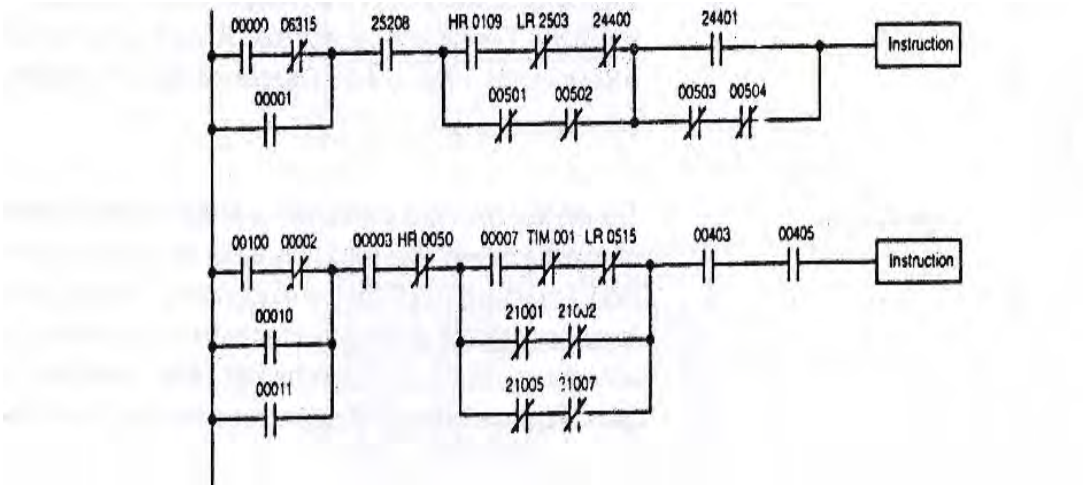

Figure 3.1 : Ladder diagram

As it is shown in Figure 3.2, instruction lines can branch apart and then join back together. The vertical pairs of lines are called conditions. The conditions without a diagonal line through them are called normally open conditions while conditions with a diagonal line through them are called normally closed conditions. The number above each condition indicates the operand bit for the instruction. The status of the bit associated with each condition determines the execution condition