Design and Fabrication of an Automated Multi-level Car Parking System

A. ALBAGUL, K. ALSHAREF, M. SAAD, Y. ABUJEELA
Department of Control Engineering
Faculty of Electronic Technology
P. O. Box 38645, Baniwalid
LIBYA
albagoul@yahoo.com

Abstract: - In this paper, the basic multi-level car parking system with three floors is considered to show the use of control systems in parking systems. The control system will play a major role in organizing the entry to and exit from the parking lots. It also presents the design of multi-level parking lots which occupies less need on the ground and contains the large number of cars. In the modern world, where parking-space has become a very big problem, it has become very important to avoid the wastage of space in modern big Automatic multi-level car parking system helps to minimize the car parking area companies and apartments. The parking lots have an elevator to carry cars to different floors according to the vacancies. The elevator is controlled by a programmable logic controller (PLC) along with the help of some sensors.

Key-Words: - PLCs, Car park system, sensors, DC motors

1 Introduction

The advancement and progress of nations is measured by the possibility of their use and application of latest invented technologies in all aspects of life. Control engineering is one of the aspects which have been given a great deal by many researchers. It became to a great concerns in many areas such as industry, agriculture, medicine, education and infrastructure. Automatic control systems have emerged as an integrated part in telecommunications, electricity, fuel and other applications [1, 2]. This paper is devoted to the use of control systems in parking systems. The control system will play a major role in organizing the entry to and exit from the parking lots. It also presents the design of multi-level parking lots which occupies less need on the ground and contains the large number of cars [3]. Therefore, the need of using technologies became inevitable. In the modern world, where parking-space has become a very big problem, it has become very important to avoid the wastage of space in modern big Automatic multi-level car parking system helps to minimize the car parking area companies and apartments etc [4]. There are two types of car parking systems: traditional and automated. In the long term, automated car parking systems are likely to be more cost effective when compared to traditional parking garages. Automatic multi-storey automated car park systems are less expensive per parking slot, since they tend to require less building volume and less ground area than a conventional facility with the same capacity. Both automated car parking systems and automated parking garage systems reduce pollution. This research is devoted to the automated multilevel car parking system. A multi-level car parking is essentially a building with number of floors or layers for the cars to be parked. The different levels are accessed through interior or exterior ramps. An automated car parking has mechanized lifts which transport the car to the different levels at a certain position. Therefore, these car parks need less building volume and less ground space and thus save on the cost of the building. This system proves to be useful in reducing wastage of space where more than 100 cars need to be parked. This system enables the parking of vehicles, floor after floor and thus reducing the space used. Here any number of cars can be parked according to the requirement. These makes the systems modernized and even a space-saving one. Multi–level car parking system is essential especially in regions facing space shortages, also in areas which cater huge crowds. Failing to accommodate the growing number of cars, it has become imperative to come up with more efficient parking solutions. In this regard, multi-level automated car parking is considered effective in tackling the issue of parking. Multi- level car parks offer greatest possible flexibility for the realization

ISBN: 978-960-474-371-1

of optimum parking solution. Multi-level car parks offer provide a fast parking process in which the driver does not have to manoeuvre his car on each level. If there is no vacant space on the first floor, the lift automatically will go to the second floor and so on. A multi-level car parking is in fact a building with number of floors or layers for the cars to be parked. The different levels are accessed through interior or exterior ramps. An automated car parking has mechanized lifts which transport the car to the different levels. Therefore, such car parks need less building volume and less ground space and thus save the cost of parking. It also does away with the need for employing too many personal to monitor the place. In this project, the multi-level car parking system haves been accomplished dealt with three floors equipped with Two sensors for each floor and two sensor on the elevator. The elevator carries the car to each floor under control of programmable logic controller (PLC) after reach the signal from sensors, and stops automatically. The elevator comes in front of the floors to allow the car get in or get out at First of all the cars will be parked on ground floor as long as the green light appears when the ground floor filled up, the red light will be on to signal that refer the ground floor is full. When the car approaches the elevator will work automatically because there is no vacant space on the ground floor and it will proceed to the first floor, if the first floor has empty space to park the car will go to the second floor if the first floor is full. If there is no vacant space on all floors the red light will be on in front of the parking to indicate the driver that there is no empty space to park. In the case, the car is inside floor and wants car want to go out, the elevator will rise automatically to the floor that contain the car, then go down to the ground to allow the car to go out. The main objectives of the car parking system are- to design and fabricate a multi-level car parking system and to design and fabricate a cost-effective model, to develop a fully automated control system and to prevent illegally parked vehicles.

1.1 History of multilevel car park system

The earliest known multi-level car park was built in 1918. It was built for the Hotel La Salle in Chicago, IL at 215 West Washington Street in the West Loop area of downtown. It was designed by Holabird and Roche. The Hotel La Salle was demolished in 1976, but the parking structure remained because it had been designated as preliminary landmark status and the structure was located several blocks from the hotel it was built to service. The Hotel LaSalle multi-level was demolished in 2005 after failing to receive landmark status from the city of Chicago [3]. Jupiter Realty Corp. of Chicago is constructing a 49-level apartment tower in its place with construction underway as of March 2008. During the 1920's and 1930's a series of other patents were granted but it was not until the late 1940's that the Bowser, Pigeon Hole and Roto Park systems became operational and installed in numerous locations. Some of these early systems were vertical elevator lift modules that placed cars on upper levels of a structure to be moved by attendant and others mechanical devices that could move vehicles into "slots" in a framework built around a central corridor. Capacities ranged typically from less than 100 spaces to more than 600. Automated car parks rely on similar technology that is used for mechanical handling and document retrieval. The driver leaves the car in an entrance module. It is then transported to a parking slot by a robot trolley. For the driver, the process of parking is reduced to leaving the car inside an entrance module. At peak periods a wait may be involved before entering or leaving. The wait is due to the fact that loading passengers and luggage occurs at the entrance and exit location rather than at the parked stall. This loading blocks the entrance or exit from being available to others. Whether the retrieval of vehicles is faster in an automatic car park or a self park car park depends on the layout and number.

1.2 Advantages of multilevel car park system

This system is more versatile and fast automatic parking system. The advantages of multilevel parking system are:

- Maximum utilization of ground space.
- Quick entry and exit due to the independent operation of lifts.
- designed for driver convenience.
- Partial breakdown doesn't affect the other parts.
- Governed by computers.
- Multiple safety guarantee of the drivers and the cars too.
- Average vehicle retrieve time is less than 2 minutes.
- require less building volume and less ground area.

1.3 Disadvantages of multilevel car park system

The disadvantages of multi-level car parking system are:

- Expensive as the whole parking and retrieval operation is multi-level.
- Any fault in the multi-level car parking system will lead to the great haphazard and inconvenience to the people.

ISBN: 978-960-474-371-1

- The power consumption is high to run such system.
- This system is more complex to build.
- Customers have to pay large fares to park their vehicles in multi-level car parking system.
- Construction cost is very high.

2 Experimental Setup

In this paper, a symbolic parking system has been designed for car parking comprising three floors, executing the entry and exit of vehicles through elevator which is controlled by (PLC). In order to implement the multi-level car parking system, one needs to setup and assemble the hardware components and write a program to control the multi-level car parking system. The layout of the multi-level car parking system is displayed in Figure 1.

Fig.1 Multi-level car parking system layout

2.1 Construction of the system

In this project I discussed some elements that help in shaping a compact system for the car parking comprising three floors. Keeping in view the cost of elements, easily available ones in the market were selected which contributed to the cheep execution of the project. The elements chosen were as follows;

- Relay
- DC motor
- Limit switch
- Sensor
- Lamps

2.2 Relay

We know that most of the high end industrial application devices have relay for their effective working. Relay are simple switches which are operated both electrically and mechanically. Relays consist of an electromagnet and also a set of contacts. The switching mechanism is carried out with the help of the electromagnet. There are also other operating principles for its Working. But they differ according to their application. Figure 2 depict the typical relay.

Fig.2 Typical relays

2.3 DC motor

DC motors have been used in industrial applications for years. Coupled with a DC drive, DC motors provide very precise control. DC motors can be used with conveyors, elevators, extruders, marine applications, material handling, paper, plastics, rubber, steel, and textile applications. Figure 3 shows and explains the major components of DC motor which consists of frame, shaft, bearings, stator, rotor and brush assembly.

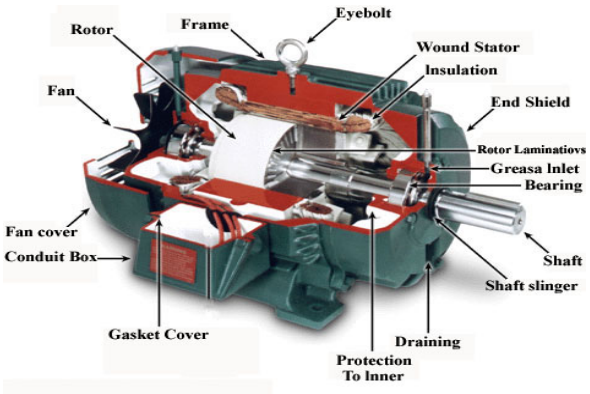

Fig.3 DC motor

It is important to understand the electrical characteristics of the main field windings known as the stator and the rotating windings known as the armature. Understandings of these two components will help with the understanding of various functions of a DC Drive. The relationship of the electrical components of a DC motor is shown in the following illustration. Field windings are mounted on pole pieces to form electromagnets. In smaller DC motors the field may be a permanent magnet.

ISBN: 978-960-474-371-1

However, in larger DC fields the field is typically an electromagnet. Field windings and pole pieces are bolted to frame. The armature is inserted between the field windings.

2.4 Limit switch

A typical limit switch consists of a switch body and an operating head. The switch body includes electrical contacts to energize and de-energize a circuit. The operating head incorporates some type of lever arm or plunger, referred to as an actuator. The standard limit switch is a mechanical device that uses physical contact to detect the presence of an object (target). When the target comes in contact with the actuator, the actuator is rotated from its normal position to the operating position. This mechanical operation activates contacts within the switch body. Figure 4 shows the limit switch.

Fig.4 Typical limit switch

2.5 Inductive Proximity Switch

Inductive Proximity Switches are precision, solid-state sensing devices that provide an attractive alternative to physically activated limit and control switches with their mechanical contacts, moving parts and attendant wear characteristics. Proximity Switches are fully sealed against most hostile industrial environments. Usual positioning and operational constraints are virtually eliminated, while life span remains unaffected by problems related to mechanical wear. Proximity switches will operate electromechanical devices such as relays, contactors, solenoids, counters and valves without additional interface components. Also, DC types provide an output compatible with solid state loads, including programmable controllers. Proximity switches offer reliable and long-lived operation in applications as diverse as machine tools, conveyors, automated warehouses, wood working machines, robotics, farm machinery, packaging equipment, production lines and general automation. Philips Proximity switches offer a broad range of types to meet the variety of users' needs. Figure 5 depict the inductive proximity switch.

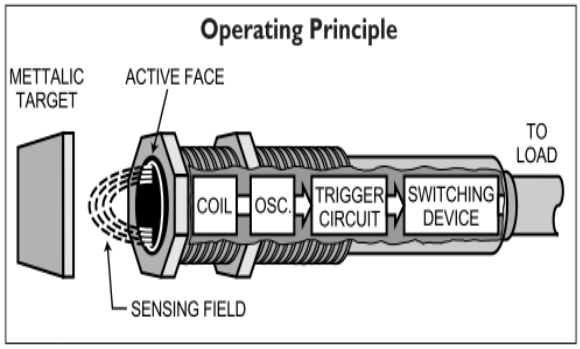

Fig.5 Typical inductive proximity switch

2.6 Design of the elevator

Elevator consists of a continuing effort engine: it is compose of DC motor operating with 36v erected on the plate (made of metal) and the two pullies which help in going up and down the elevator and to prevent any friction. The elevator possesses separator between entry and exist. Right hand side named as entry point as it contains sensor which inform about the existence or non existence of the vehicle. The left hand side named as exit door as it contains sensor about the existence or non existence of the vehicle.

2.7 Entry of the cars thought the main gate

Arrival of the car on the elevator will displayed through sensor and the signal will be sent to the control system regarding the need of the car for parking, the system will instruct the elevator regarding the availability of space on all the three floors. Figure 6 shows the car entry to the parking space.

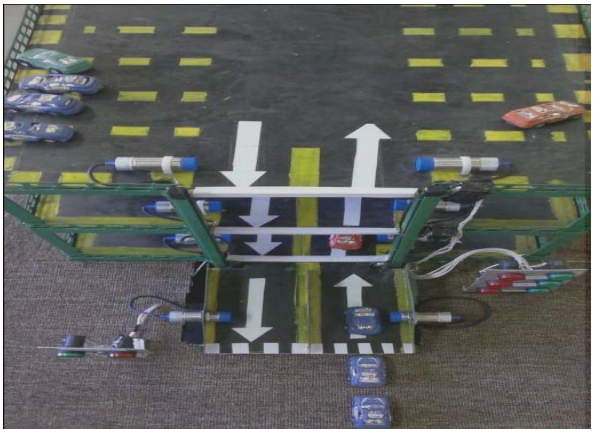

Fig.6 Car entry to the parking space

2.8 Entry of the cars thought the main gate

On finding exiting car arriving in front of the sensor (present on every floor) the signal will be sent to the

ISBN: 978-960-474-371-1

control system about the need of the car for exist and the system will instruct the elevator to approach the required floor. After arrival of the car on the elevator, the sensor will indicate its existence and send a signal to the control system. The control system will instruct the elevator to approach the main gate. Figure 7 shows the car exit from the parking space.

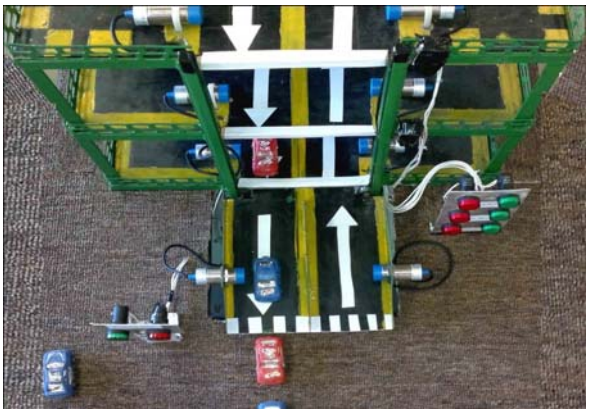

Fig.7 Car exit from the parking space

3 Implementation

Process of lining up the cars on all the three floors begins as soon as the first car arrives at the main gate. There is a pair of indicating lights; the green one indicate the availability of the vacant place in general, whereas, the red one indicates the non availability of the any vacant place anywhere all the three floors and will prohibit the entry of any car to the park. At the first state the system adopts the following sequence of the instructions on the entry of a car:

1- On the arrival of a car at a particular entry point, the sensor on the elevator sends signal to the system informing about the existence of the car whereupon the control system instructs the elevator about the suitable floor according the availability of any vacant place.

2- After the arrival of the elevator at the proper floor, the car directly enters and the sensor at the gate sends the signal to the control system to on firm the entry and the system will determine the number of entered cars. In case of the stoppage of the elevator in front of the first or second floor, the control system will guide the car about the exit of cars from the previous two floors.

3- In case of exit, the car stands before the sensor, which on turn gives signal to the control system about the existence of the car waiting for exit, and the exit process depends upon the priority of the availability of the elevator. For example; on the stoppage of the elevator in front of the ground floor the priority would be for the leaving cars. On the other two floors, priority for the exiting cars will depend upon firstly on space available on the elevator, and secondly on time required for exist.

4- The system will establish the number of cars on all the three requiring entry and exist depending on the signals of the sensor on each floor.

5- Depending upon the difference between the car in and cars out the control system will instruct the elevator about the suitable floor.

6- Each floor has the warning lights indicating the state of the parking. For example the green light indicated the availability and the red light indicates the non-availability of the parking place.

Figure 8 shows the complete block diagram of the auto-parking control system as described above.

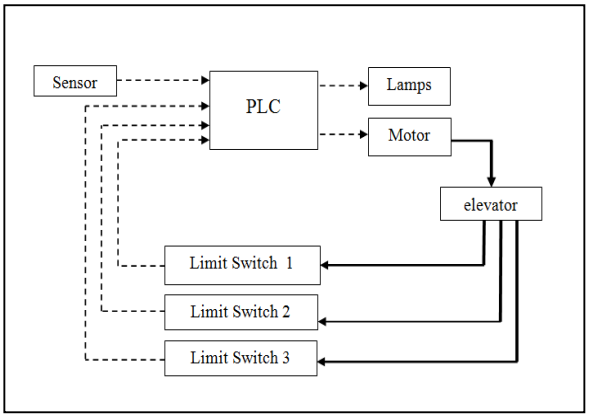

Fig.8 Car exit from the parking space

4 Conclusion

The multi-level car parking system had successfully been designed and developed. The control strategy for the traffic flow to the multi level car parking system was curried out using the PLC. The PLC with the help of some sensors checks the availability of the vacant place on each floor. It can be noticed that the control system for the multi-level car parking system has achieved the anticipated performance to regulate the entry and exit of the car to/from several floors accurately. The movement of the elevator between the floors was continuous and smooth as requested. The number of entering and existing car from all the three floors was controlled as per the signals from the sensors on each floor at the entry and exit point. The entry and exist phases of the cars depends on the availability of the elevator and the time required for exist. The preference for the entry will be for the car that is present at the stopping in front of an elevator at the

ISBN: 978-960-474-371-1

ground floor. Meanwhile, the preference for exist from other floors will depend firstly on the space and secondly on the time demanded for exist.

References:

[1] Nise, N.S., *Control Systems and Engineering*. Addison Wesley. 2nd edition, 1995

[2] John Webb and Ronald. R, " Modern Control Technology", 2nd Edition. Kalian.

[3] Papacostas, C.S. and Prevedouros, P.D., *Transportation Engineering and Planning*, 2nd Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1993.

[4] M.O. Reza, M.F. Ismail, A.A. Rokoni, M.A.R. Sarkar, Smart Parking System with Image Processing Facility, *I.J. Intelligent Systems and Applications, Vol. 3, pp.* 41-47, 2012.

[5] Sun, Wu and Kyriacos C. Mouskos, Network-Wide Traffic Responsive Signal Control in Urban Environments, *Proceedings of the 4th International Conference on Computational Intelligence & Neurosciences*, Atlantic City, New Jersey, February 27-March 3, 2000.

[6] M. Wada K.S. Yoon,H. Hashimoto, "Development of Advanced Parking Assistance System," IEEE Transactions On Industrial Electronics, vol. 50, pp. 4-17, February 2003.

[7] E. S. Kardoss, K. Baliant, I. Wahl, "Design of a Semi-Aautonomous Park Assist System," Proceedings of TheEuropean Control Conference,2009, pp. 497-516.

[8] J. Pohl1, M. Sethsson, P. Degerman, and J Larsson, "A semi-automated parallel parking system for passenger cars", Proc. IMechE Vol. 220 Part D: J. Automobile Engineering, 2006, pp. 53.

[9] Bolton, W., *Mechatronics: Electronic control systems in Mechanical engineering*, Addison Wesley Longman Limited, 1996

[10] C. W. Cheng, S. J. Chang, and T. H. Li, "Parallel-parking control of autonomous mobile robot," in Proc. Int. Conf. Industrial Electronics, and Control, and Instrumentation, Tokyo, Japan, 1997, pp. 1299–1304.

[11] M. Y. Idris, E. M. Tamil. Z. Razzak, N. M. Noor, "Smart Parking System Using Image Processing Techniques," Journal of Information Technology, 2009, pp. 114-127.

[12] Alan J. Crispin, "Programmable Logic Controllers and their Engineering Applications" , 2nd Edition, Reprinted 1997.

[13] Tzafestas et. al., *Advances in Intelligent Autonomous Systems: Microprocessor based and Intelligent Systems Engineering.* , Kulwer Academic Publishers, 1999.

[14] Solomon S, *Sensors Handbook.* McGraw-Hill, New York, 1999.

[15] Curtis D. Johnson, "Process Control Instrumentation Technology", 5th Edition, Prentice Hall Inc, 1993.

[16] Enrique Man dado, Jorge Marcos and Sera fin A. Perez., "Programmable Logic devices and Logic Controllers" Prentice Hall Inc, 1996.

[17] Ian Warnock, "Programmable Logic Controllers Operation and Application", Prentice Hall Inc., 1988.

[18] Melsec "FX series PLC programming manual", April 2003.