Design and development of automated car parking system using microcontroller

[1]Aniket Balasaheb Bandgar, [2]Harshad NIvarutti Kumbhar, [3]Vaishnav Tanaji Patil, [4]Pritam Anilkumar Bandgar, [5]Abhaysinh Shivaji Kore.

[1]Student, [2]Student, [3]Student, [4]Student, [5]Student
Mechanical Engineering,
SITCOE, Ichalkaranji, India

***Abstract*: In this fast and competitive world, problem in metro cities include lack of scarcity of area for car parking hence lot of time is wasted in searching for the parking area. There is also a security problem of cars. Now-a-days there are conventional car parking which utilizes lot of man power and time. To reduce this man power and time, conventional car parking system can be automated. The technology used to do this is typically based on automated warehousing and there are several different technologies used in automated parking today. This research paper includes the design and development of automatic car parking system by using components such as microcontroller, sensors and lifting mechanisms. This research also gives an insight about the integration of automation system, electric circuits, and development of application or website for user interface.**

***Index Terms*: Automatic Car parking, Microcontroller, Lifting mechanism, User interface**

I. INTRODUCTION

An automated car parking system (APS) is a mechanical system designed to minimize the area and volume required for parking cars. Like a multi-story parking garage, an APS provides parking for cars on multiple levels stacked vertically to maximize the number of parking spaces while minimizing land usage. The APS, however, utilizes a mechanical system to transport cars to and from parking spaces (rather than the driver) in order to eliminate much of the space wasted in a multi-story parking garage. While a multi-story parking garage is similar to multiple parking lots stacked vertically, an APS is more similar to an automated storage and retrieval system for cars.

Automated parking is the automated storage, or parking, of vehicles with no human intervention. From a driver's perspective they simplify park their vehicles in a parking area, somewhat similar to pulling into a single garage, and are guided to the correct parking position by sensors via a display sign. The drivers switch off their engines, all vehicle occupants leave the parking module, and the parking module door is closed to secure the module. Once the module is secured the vehicle is removed from the parking module and stored. When drivers return and request their vehicles, their vehicles are returned to a parking module, usually facing the correct direction, ready to be driven away.

Since there is no requirement for ramps, driveways and personnel access to the parking areas, automated parking can typically park twice the number of vehicles in the same volume as conventional parking. Or, conversely, park the same number of vehicles in half the volume.

Problem with current parking system

Problems with automated parking garages have three reasons:
1) Technical
2) Bad planning
3) Parking customers

Most problems with parking garages are not of technical nature. Architects can be blinded by the large number of cars on very limited space and decide to use mechanical parking system, though they are not suitable for their specific application. Manufacturers are sometimes happy to make a sale, even though they should consult their customers better. So the main reason for dis-satisfied customers is the result of bad planning. Mechanical car parks are a solution for applications with a relatively balanced throughput, like shopping malls, train stations, etc. Most can handle peaks during the rush hour in the morning and evening quite well, but they are not recommended for high peak hour volume. Therefore, if one installs a mechanical car park at a movie theatre or stadium, trouble is pre-programmed. One big peak in the morning and another one in the evening without much in between are not suitable for automated parking. And finally many delays are caused by confusion that comes when unfamiliar parkers first use this type of system.

II. OBJECTIVES

- Design and manufacturing of mechanism for car parking through optimisation of structure which accommodates maximum cars in the available space.
- Development of CAD models and analysis of structure.

- Selecting suitable controller for automating the car parking process
- Intimate the customers about the ending of parking time through suitable software or application.
- Testing, Validation and Interfacing of hardware and software components

III. PARKING SYSTEM TYPES

Generally the process of parking a vehicle for drivers in automated parking systems remains the same regardless of the technology used, it's just the methodology of moving the vehicles to and from the parking module that differs. The types of technology used in automated parking systems can be divided into six main categories:

- AGV systems
- Puzzle systems
- RGC systems
- Shuttle systems
- Silo systems
- Tower systems[9]

Following are the most commonly used system:

AGV SYSTEMS

More recently Automated Guided Vehicle (AGV) technology is being used in automated parking and although AGVs have been used in automated warehousing for decades, they remain unproven in automated parking systems. Vehicles are parked on pallets in the parking modules which are collected from the parking modules by the AGVs driving beneath the vehicle pallet, lifting it, and then moving it out of the parking module into the system. The number of AGVs in the system is flexible and can be based around the client's throughput and budgetary requirements. The AGV system is as shown in fig no.1.

Typically AGV systems operate on solid, finished concrete floors and can move in both lengthways and sideways directions along fixed paths and are also able to rotate on the spot. This potentially allows for the vehicle pallets to be collected by an AGV from any direction, and with several AGVs operating on a floor, it also allows for multiple, simultaneous parking and retrieval movements along multiple paths.

Fig No. 1: AGV system

PUZZLE SYSTEMS

Puzzle systems provide flexible layout options as the system configuration is highly adaptable as a pallet can be move from one support frame to an adjacent on in any direction. This means the system shape can vary greatly instead of being rectangular or square, puzzle systems can also be "T" shaped, "U" shaped, "L" shaped, "H" shaped, etc. as long as there is a route for pallets to get from their current location to their destination location via an adjacent support frame. This also makes moving around structural members possible that may not otherwise be possible with other system types. The puzzle parking system is as shown in fig. no. 2.

The puzzle parking system is a car parking system with a mechanical device that multiplies parking capacity inside a parking lot. Parking systems are generally powered by electric motors or hydraulic pumps that move vehicles into a storage position. This system features combination pallets carrying cars. Individually load and unload of the cars is possible. Thus system is independent system. This system is electromechanically operated. Mostly preferred in residential complexes, IT Parks commercial complexes, malls, hotels etc.

Fig No. 2: Puzzle parking system

TOWER TYPE

Tower systems typically consist of a vehicle elevator with a parking space either side of the elevator shaft. This configuration is repeated over a number of levels to complete the parking tower as shown in fig no 3. Typically there is a parking module located on the ground floor, where the vehicle is turned, and the vehicle elevator simple raises to one of the parking levels of the tower and deposits the vehicle sideways into a parking space. This process is reversed to retrieve a vehicle.

This system features a lift which is electromechanically operated. At the loading point as per the design the lift shall receive the car and then travels to the respective location of the parking slot. It parks the car to the parking slot. This system can design with pallet or without pallet. This system is preferable for 30 to 40 cars. The auto parking elevator type often called the Parking Tower, is designed to automatically move the vehicles on a pallet vertically on the elevator, it then transfers it horizontally left or right for storage. Very fast retrieval time is accomplished in less than two minutes. This system is suitable for medium or large scale buildings. It can also be used as a standalone tower for a parking garage business.[10]

Fig No. 3: Tower parking system

TWO STEP SIMPLE STACKER PARKING SYSTEM

This system features a pallet that is lifted up and then after the car is loaded. Thus additional parking can be made available in the space below the loaded pallet as shown in fig. no. 4. Both indoor and outdoor installation is possible. Installation can be done on simply flat area with no additional architectural work. These systems are electromechanically or hydraulically operated. Preferably these systems are valet parking systems. We have specially designed PIT Stacker Parking also suitable for Indoor & Outdoor installations. This type of parking system is mostly preferred in residential complexes, IT Parks and Hotels.

IV. FEATURES OF PARKING MANAGEMENT SYSTEM

- ***PARKING MANAGEMENT SOFTWARE***

The software regulates & monitors the parking facility requirements, designed to manage the car parking slots & provide useful reports or information to the management.

- ***PARKING GUIDANCE SYSTEMS (PGS)***

A system created to guide drivers to the closest available parking space. Real time information is used to improve and increase the effectiveness of the system.

- ***SECURITY ANALYSIS***

The security analyses of the situation are vital before recommending a solution, for example how sensitive is the parking facility and these questions will determine the devices and software solutions that can be integrated in creating a strong and secured parking solution. The access control can be implemented with both smart card readers and biometric readers.

- ***AUTOMATED TICKETING SYSTEMS***

The Ticketing System will be programmed to the clients parking policies and integrated with the ticketing dispenser machines and Payment systems.

- **REAL TIME VEHICLE COUNTING**

Real time information of all vehicles in parking areas can be displayed and this information can be used to allocate parking slots efficiently.

- ***VIDEO SURVEILLANCE SYSTEM***

CCTV can be integrated with parking management system in creating a secured parking space to help create a safer environment.

- ***AUTOMATIC NUMBER PLATE RECOGNITION READERS (ANPR)***

The ANPR system enables monitoring of every car entering & exiting the premises, monitoring the complete activity of the parking area.

V. COMPARISON BETWEEN TYPES OF PARKING SYSTEM

Sr	Criteria	Stacker	Puzzle	**Tower**
1	Space Optimization	Poor	Poor	**Maximum**
2	Capital Investment	Low	High	**Medium**
3	Operating Cost	Medium	High	**Low**
4	Maintenance Cost	Medium	High	**Low**
5	Ease Of Installation	Complex	Complex	**Simple**
6	Construction time	Medium	High	**Low**
7	Retrieval Time	Medium	High	**Low**
8	Movement Of Transformer	Horizontal & Vertical	Horizontal & Vertical	**Vertical**

From above table it was suitable to design parking system for tower type as it is feasible and number of cars which will be parked in tower type are more as compared to the other types of parking system. The operating and maintenance cost is also low. Therefore we have selected to design the tower type car parking system

VI. VEHICLE TRANSFER METHODS:

There are various methods of transferring a vehicle to and from the parking mechanism and the parking module or parking spot in an automated parking system. The types of vehicle transfer methods can be divided into four main categories:

- Conveyor Belts
- Lifting arms
- Pallets

CONVEYOR BELTS

Conveyor belts, or rollers, are sometimes used for vehicle transfer where conveyor belts are typically located in the parking module or parking space and the parking mechanism. Considerations for conveyor belts or rollers in automated parking include:

- High speed of vehicle pick up
- Replacement belt frequency, cost and maintenance
- Mechanical contact with tires
- Indexing of vehicles

LIFTING ARMS

Lifting arms are sometimes used to cradle the vehicle tires when lifting a vehicle so it can be moved within the automated parking system. A vehicle is parked on a flat surface or car stand in the parking module before being collected by part of the parking mechanism.

Considerations for lifting arms transfer in automated parking include:

- Maintenance access
- Mechanical contact with tires
- Dealing with flat tires and differing wheel bases
- More moving parts
- Height savings, if no car stand is used
- Vehicle ground clearance

PALLETS

Vehicle pallets are probably the most common method of vehicle transfer in automated parking systems. The vehicle is parked on the pallet in the parking module and the automated parking system moves the pallet around the system without touching the vehicle as shown in Fig. No.5. Considerations for pallet transfer in automated parking include:

Fig No.4: Pallets

- Empty pallet management
- No mechanical contact with vehicle
- Fixed pallet size within system
- Pallet maintenance cost and weight
- Pallet storage height on parking floor
-

From above types **the pallet type lifting mechanism** is feasible. So we have selected it.

VII. HARDWARE DESIGN TECHNIQUE

SELECTION OF MICRO CONTROLLER (µC):

A microcontroller is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.

AT89C51 Microcontroller was selected and features are as follows:

1. 80C51 based architecture
2. 4-Kbytes of on-chip Reprogrammable Flash Memory
3. 128 x 8 RAM

4. Two 16-bit Timer/Counters
5. Full duplex serial channel
6. Boolean processor
7. Four 8-bit I/O ports, 32 I/O lines
8. Memory addressing capability – 64K ROM and 64K RAM
9. Power save modes: – Idle and power-down
10. Six interrupt sources
11. Most instructions execute in 0.3 us
12. CMOS and TTL compatible
13. Maximum speed: 40 MHz @ Vcc = 5V
14. Industrial temperature available
15. Packages available: – 40-pin DIP – 44-pin PLCC– 44-pin PQFP

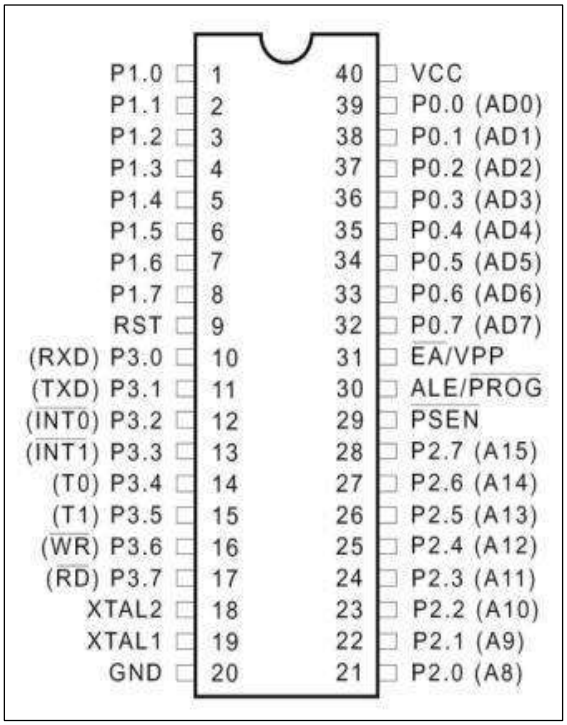


Fig No.5: AT89C51 Microcontroller

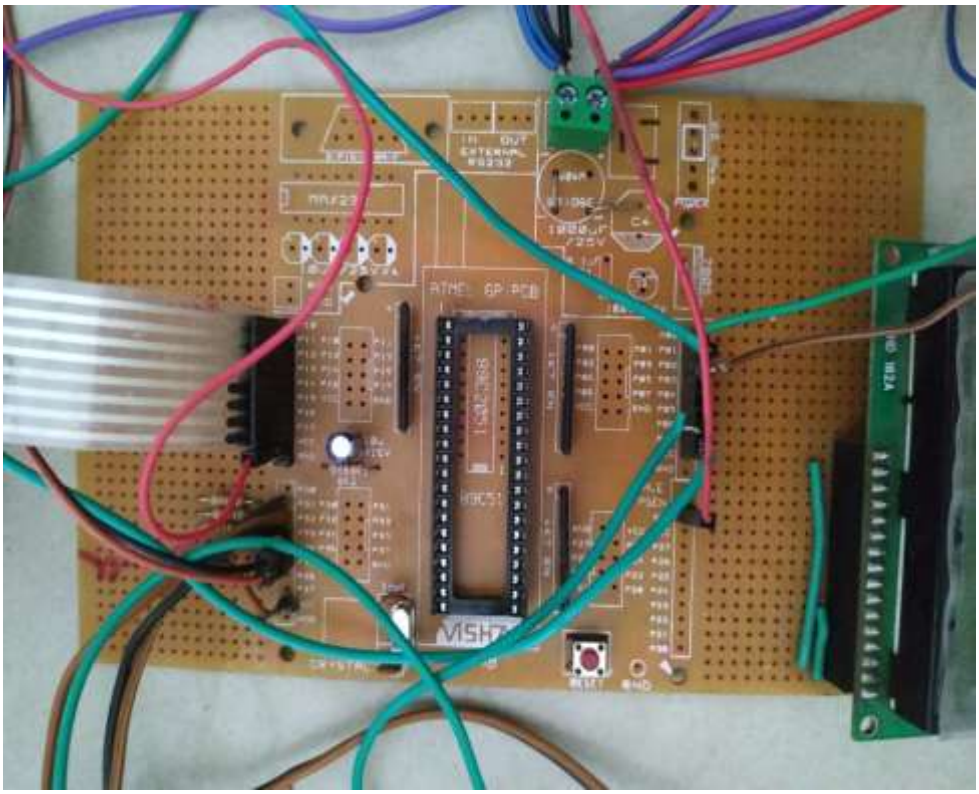


Fig No.6: Microcontroller

Port pin	Alternate Functions
P3.0	RXD(serial input port)
P3.1	TXD(serial input port)
P3.2	X INT0(external interrupt 0)
P3.3	INT1(external interrupt 1)
P3.4	T0(timer 0 external input)
P3.5	T1(timer 1 external input)
P3.6	WR(external data memory write strobe)
P3.7	RD(external data memory read strobe)

Table No. 1: Port Pins

Description of Microcontroller Pins and Function:

PIN NO	NAME	FUNCTION
1	VSS	Ground pin
2	VCC	Power supply pin of 5V
3	VEE	Used for adjusting the contrast commonly attached to the potentiometer
4	RS	RS is the register select pin used to write display data to the LCD (characters), this pin has to be high when writing the data to the LCD. During the initializing sequence and other commands this pin should low.
5	RW	Reading and writing data to the LCD for reading the data R/W pin should be high (R/W=1) to write the data to LCD R/W pin should be low (R/W=0)
6	E	Enable pin is for starting or enabling the module. A high to low pulse of about 450ns pulse is given to this pin.
7	DB0	
8	DB1	
9	DB2	
10	DB3	
11	DB4	DB0-DB7 Data pins for giving data(normal data like numbers characters or command data) which is meant to be displayed
12	DB5	
13	DB6	
14	DB7	
15	LED+	Back light of the LCD which should be connected to Vcc
16	LED-	Back light of LCD which should be connected to ground

So reading the above table gives a about a brief idea about how to display a character. For displaying a character, enable the enable pin (pin 6) by giving a pulse of 450ns, after enabling the pin6 the register select pin (pin4) should be selected to write mode. To select the register select pin in write one has to make this pin high (RS=1).After selecting the register select it is necessary to configure the R/W to write mode, so that R/W should be low (R/W=0)

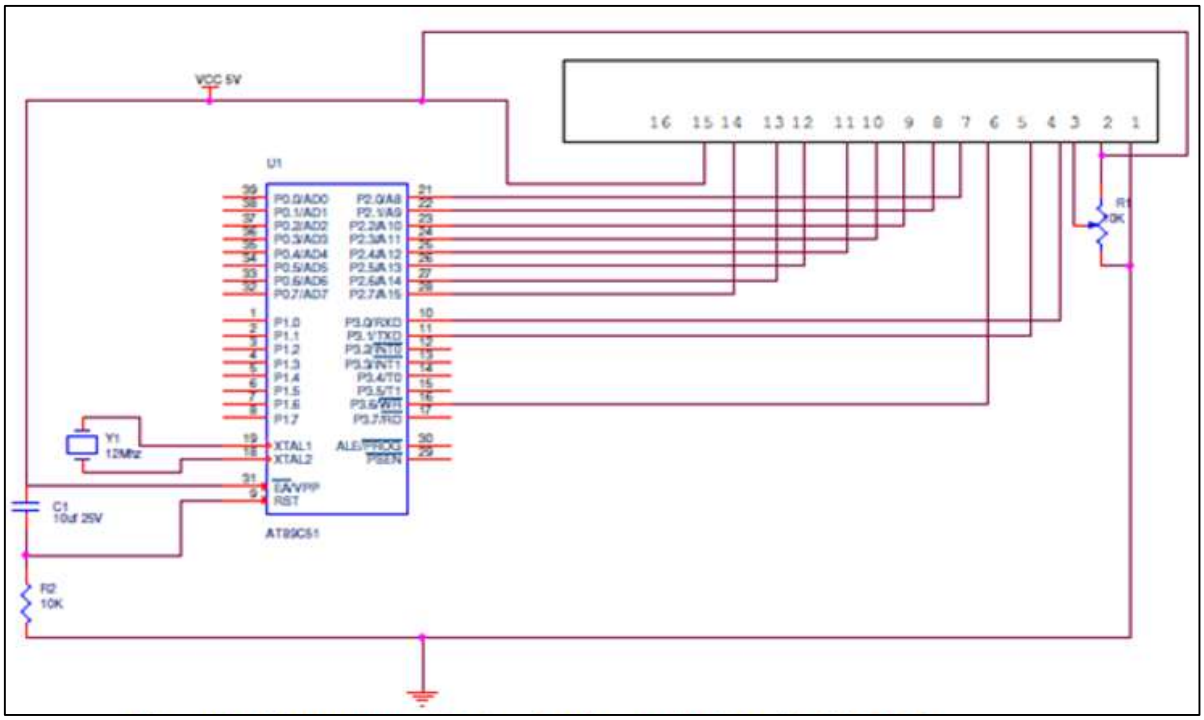
Code (Hex)	Command to LCD Instruction Register
1	Clear display screen
2	Return home
4	Decrement cursor (shift cursor to left)
6	Increment cursor (shift cursor to right)
5	Shift display right
7	Shift display left
8	Display off, cursor off
A	Display off, cursor on
C	Display on, cursor off
E	Display on, cursor blinking
F	Display on, cursor blinking
10	Shift cursor position to left
14	Shift cursor position to right
18	Shift the entire display to the left
1C	Shift the entire display to the right
80	Force cursor to beginning to 1st line
C0	Force cursor to beginning to 2nd line
38	2 lines and 5x7 matrix

Table No.2: LCD Command Codes

INTERFACING 16×2 LCD WITH 8051

In this session have brief discussion on how to interface 16×2 LCD module to AT89C51which is a 8051 family microcontroller. LCD display is used for the messages for more interactive way to operate the system or displaying error messages etc. Interfacing LCD to microcontroller is very easy .If working of LCD is understood.

Interfacing16×2 LCD with 8051 Circuit Diagram



TIMERS:

On-chip timing/counting facility has proved the capabilities of the microcontroller for implementing the real time application. These include pulse counting, frequency measurement, pulse width measurement, baud rate generation, etc. The 8051 has timers: Timer 0 and Timer1.they can be used either as timers or as event counters.

LCD:

16×2 Liquid Crystal Display which will display the 32 characters at a time in two rows (16 characters in one row). Each character in the display of size 5×7 pixel matrix, Although this matrix differs for different 16×2 LCD modules JHD162A is taken, this matrix goes to 5×8. This matrix will not be same for all the 16×2 LCD modules. There are 16 pins in the LCD module

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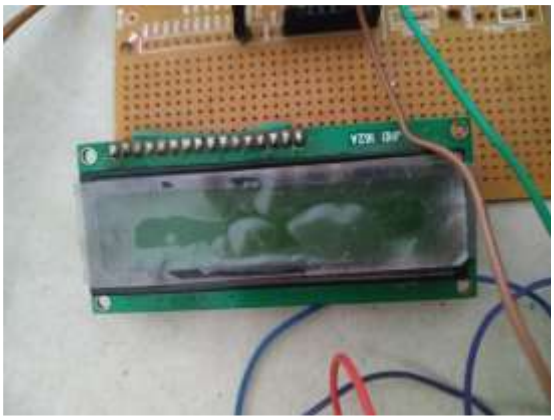

Fig. No.7: LCD

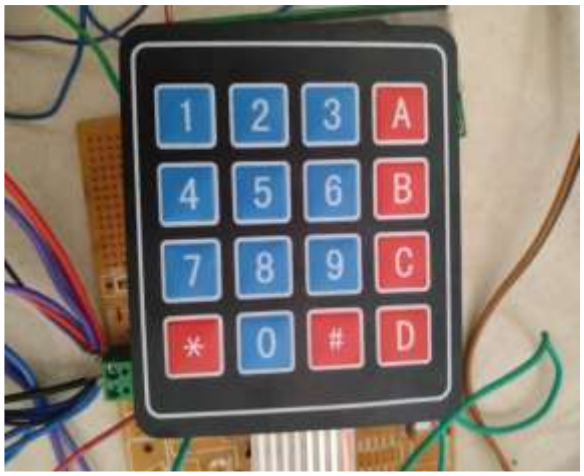

Fig. No. 8: Keypad

IR SENSOR

Infrared radiation is the portion of electromagnetic spectrum having wavelengths longer than visible light wavelengths, but smaller than microwaves, i.e. rigid regions are defined differently by many.

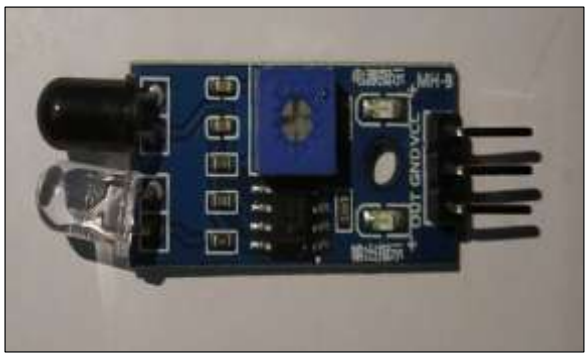

Fig. No. 9: IR Sensor

The transmitter section includes an IR sensor, which transmits continuous IR rays to be received by an IR receiver module. An IR output terminal of the receiver varies depending upon its receiving of IR rays. Since this variation cannot be analysed as such, therefore this output can be fed to a comparator circuit.

DC GEAR MOTOR

Geared DC motors can be defined as an extension of DC motor. A geared DC Motor has a gear assembly attached to the motor. The speed of motor is counted in terms of rotations of the shaft per minute and is termed as RPM. The gear assembly helps in increasing the torque and reducing the speed. Using the correct combination of gears in a gear motor, its speed can be reduced to any desirable figure. This concept where gears reduce the speed of the vehicle but increase its torque is known as gear reduction. DC gear motor is used to drive conveyor system.

Fig. No. 10: IR Sensor

DC Gear Motor Specifications:
1. RPM: variable
2. Operating Voltage: 12V DC
3. Gearbox: Attached Metal Gearbox
4. Shaft diameter: 10 mm
5. Torque: 7 kg-cm

LIMIT SWITCHES
Limit switches are used in a variety of applications and environments because of their ruggedness, ease of installation, and reliability of operation. They can determine the presence or absence, passing, positioning, and end of travel of an object. They were first used to define the limit of travel of an object; hence the name "Limit Switch".

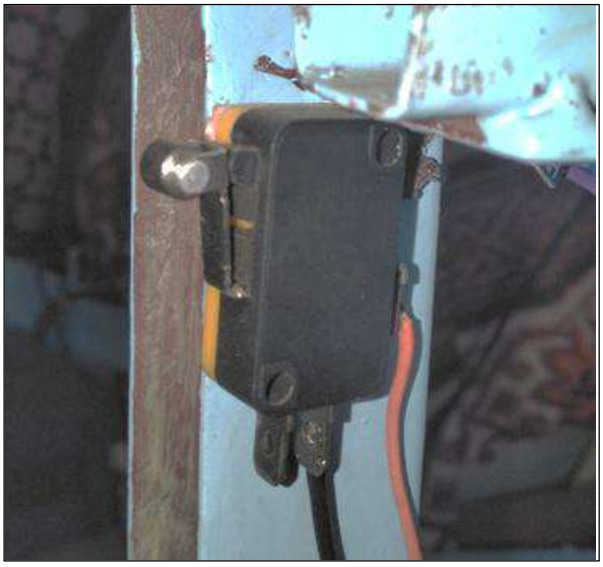

Fig. No. 11: Limit Switch

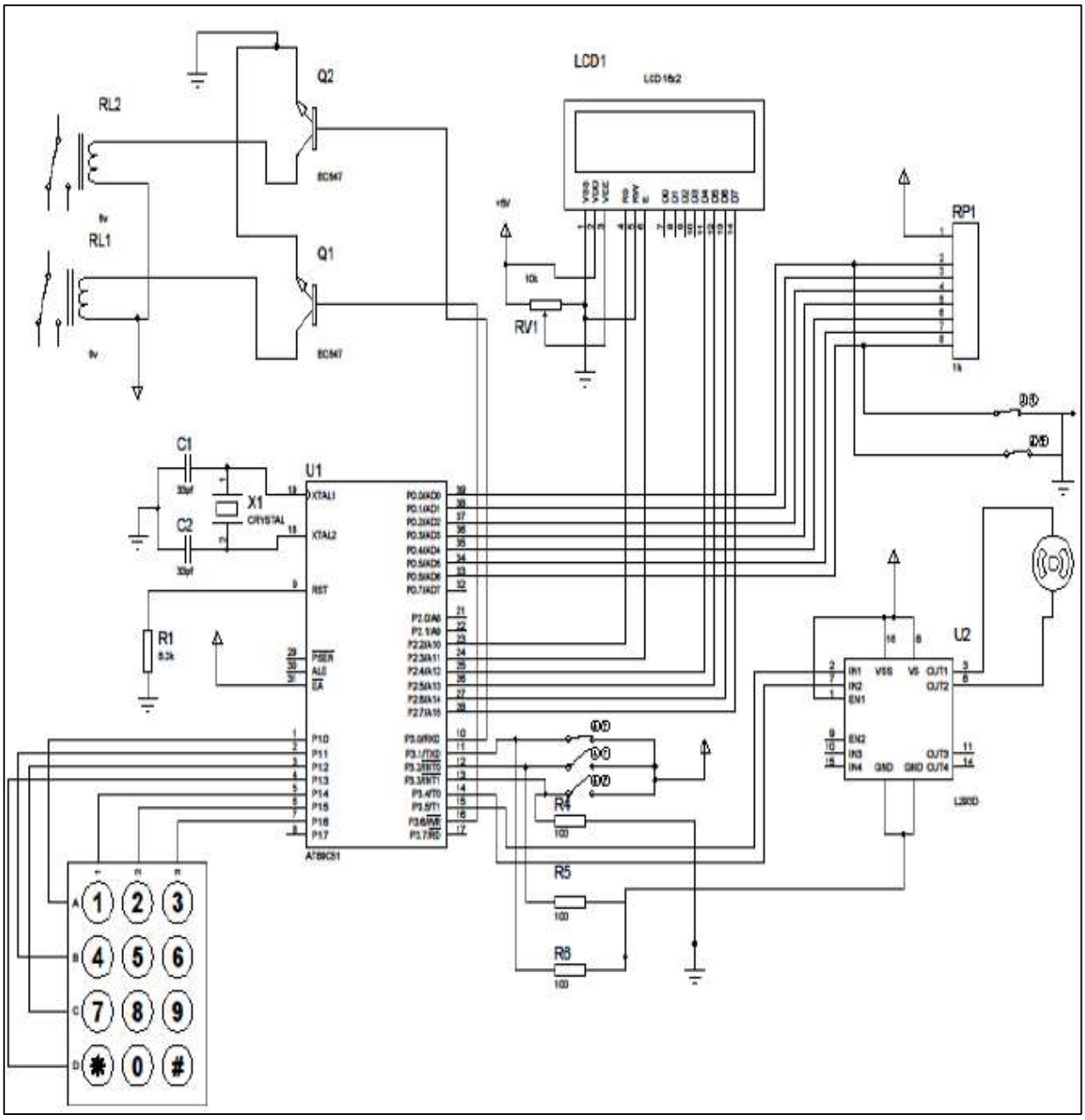

Fig No.12: Circuit Diagram

VIII. PNEUMATIC COMPONENTS

Pneumatic flow control valve:

Flow Control Valves are used to reduce the rate of flow in a section of a pneumatic circuit, resulting in a slower actuator speed. Unlike a Needle Valve, a Flow Control Valve regulates air flow in only one direction, allowing free flow in the opposite direction.

Fig.No 13: flow control valve

Solenoid valve:

A solenoid valve is an efficient method of converting electrical signals into pneumatic functions. Applying electricity to the solenoid quickly directs air through the valve and into the circuit.

Fig No.14: Solenoid valve

P*neumatic double acting cylinder:*

Pneumatic double acting cylinder is mechanical device which use the power of compressed gas to [produce a force in a reciprocating liner motion. Pneumatic double acting cylinder shown in fig.No:26.

Fig No 15: Double Acting Cylinder

IX. DESIGNING THE COMPONENTS OF PARKING SYSTEM

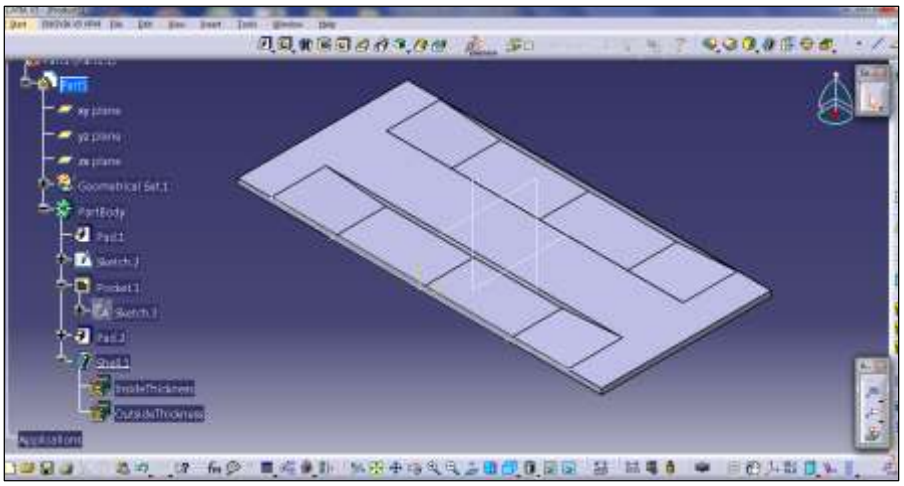

Fig No 15: Pallet CAD Design

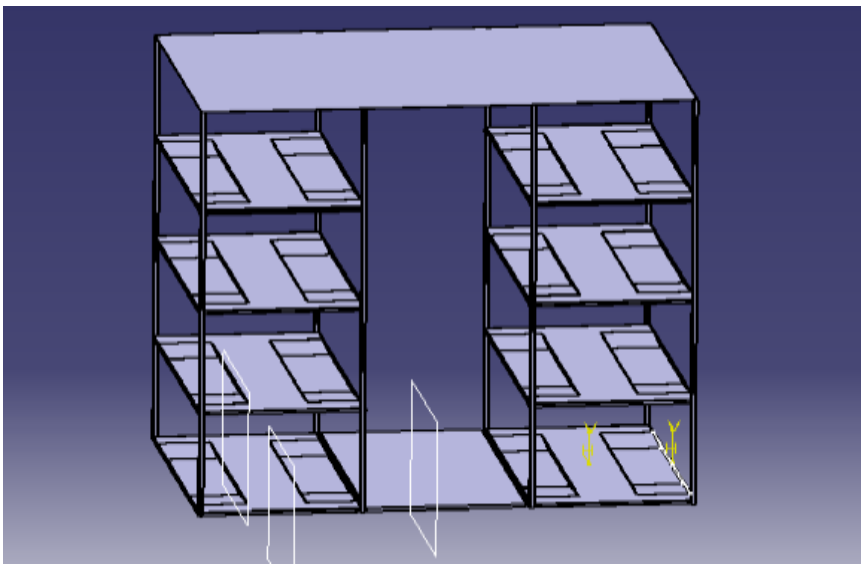

Fig No 15: Assembly of Structure

X. CONCLUSION:

Through automatic parking system and optimization of structure maximum cars were accommodated in the available space. From the study of CAD model and analysis best structure was selected for car parking. By utilizing suitable software and application, customers were intimated about the ending of parking time. Along with it testing, validation and interfacing of hardware and software showed positive results and indicated enhanced overall functionality of automated parking system.

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