Rotary Parking System

(RPS)

By

Mosab Alshaer

Mohammad Jondi

Mohammad Samamra

Supervisor: Dr. Jasem Tamimi

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Abstract

Lack of space availability has always been a problem in urban areas and major cities and there are cars parked randomly on the streets that further limit the space. In order to handle the issue of parking in busy places various types of vehicle parking systems are used worldwide such as multi-level automated car parking. A rotary parking system (RPS) is a mechanical system that is designed to save the area that is required for parking cars. Like a multi-story parking garage, an RPS provides parking for cars on multiple levels stacked vertically to increase the number of parking spaces while saving land usage. However, the RPS 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 traditional parking. An RPS is more similar to an automated storage and retrieval system for cars. The present research is aimed to design and implementation a control system and model for the rotary automated car parking system to accommodate six cars.

الملخص

إن عدم توفر المساحة مشكلة دائمة في المناطق الحضارية والمدن الكبرى وإضافة إلى ذلك هناك سيارات متوقفة عشوائياً في الطرق تؤدي إلى الحد من المساحة. من أجل التعامل مع مشكلة وقوف السيارات في الأماكن المزدحمة تستخدم أنواع مختلفة من أنظمة مواقف السيارات في جميع أنحاء العالم مثل مواقف السيارات الآلية متعددة الطوابق، ونظام موقف السيارات الدوار وهي أنظمة ميكانيكية تم تصميمها للحفاظ على المساحة المطلوبة لإيقاف السيارات. نظام موقف السيارات الدوار يوفر مواقف للسيارات على مستويات متعددة يتم رصها بشكل عمودي لزيادة عدد مساحات المواقف وتوفير استعمال الأراضي حيث إن موقف السيارات الدوار يستخدم نظام ميكانيكي لنقل السيارات من وإلى مساحة الإيقاف (دون الحاجة إلى السائق) للحد من المساحة الكبيرة الضائعة في مواقف السيارات التقليدية. النظام يبدو كنظام آلي يتم فيه حفظ واسترجاع السيارات.

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Chapter 1: Introduction

A rotary parking system (RPS) is a mechanical system designed to minimize the area that is required for parking cars. On the other hand, Rotary parking is known as “robotic parking garages”, however, this technology is not used a lot in traffic engineering everywhere. Nowadays, with the huge increase in number of cars it becomes difficult to find a parking place; therefore, many countries such as Germany and Japan tend to build rotary parking systems in the areas near to the buildings and markets. The concept for automated parking system is driven by two factors: 1- a need for parking spaces and 2- a scarcity of available land. However, the RPS utilizes a mechanical system to transport cars to/from parking spaces (rather than the driver) in order to eliminate much of the space lost in a multi-story parking garage. While a multi-story parking garage is similar to multiple parking lots stacked vertically. An RPS is more similar to an automated storage and retrieval system for cars.

1.1 Project motivation:

The RPS take advantage of a common concept to save the area of parking spaces - leaving the driver and passengers from the car before it is parked. This is fully automated RPS, the car is driven up to an entry point to the RPS and the driver and passengers will leave the car. The car is then moved automatically to its parking space place; in the following the advantages of the RPS will be summarized:

1) Space saving

The saved space that is provided by the RPS, compared to the multi-story parking garage, is derived primarily from a significant reduction in space not directly related to the parking of the car; however, to save spaces through our project the following conditions are taken in consideration:

- Parking space width and depth (and distances between parking spaces) are dramatically is reduced, since no permission is needed to be made for driving the car into the parking space or for the opening of car doors (for drivers and passengers).
- No driving lanes or ramps are needed to drive the car to/from the entrance/exit of a parking space.
- Ceiling height is minimized since there is no pedestrian traffic (drivers and passengers) in the parking area.
- No walkways, stairways or elevators are needed to accommodate pedestrians in the parking area.

With the elimination of ramps, driving lanes, pedestrians and the reduction in ceiling heights, the RPS requires substantially less structural material than the multi-story parking garage. Many RPSs utilize a steel framework; however, some use thin concrete slabs, rather than the monolithic concrete design of the multi-story parking garage. These factors contribute to an overall volume reduction and further space savings for the RPS.

2) The parked cars and their contents are more secure since there is no public access to parked cars

3) Minor parking lot damage such as scrapes and dents are eliminated

4) Drivers and passengers are safer since they do not have to walk through parking slots or garages

5) Driving around for searching of the parked cars is eliminated, thereby reducing engine emissions

6) Only minimal ventilation and lighting systems are needed

7) The volume and visual impact of the parking structure is minimized

1.2 Goals and objectives

The Goal of This Project:

The Objectives of this research is to design and implementation of a control system for the rotary parking system to accommodate six cars.

Objectives:

In order to reach the main goal of this project, there are many objectives to achieve, and the system must have these properties:

- Firstly, the system should be reliable enough, and so it will deal with any kinds of cars
- However, this system will provide parks for six cars.
- This system will be private parking system and the accessibility will be through PIN code for each position.
- Designing a friendly user interface, so the system will have a screen to deal with.

1.3 Methodology

- Study of all preview related works.
- Selecting a suitable control.
- Coding of the control algorithm is written using C language.
- Drawing control circuit using PROTEUS simulation program.
- Design a small model to testing the control system

1.4 Literature Review

Every car park owners have their different parking system. Some systems have successfully attracted and meet the requirement of customers. Three parking systems are list as followed:

1.4.1 Integrated Car Parking Solution:

Customize application suitable for various types of landscapes and buildings Structures available below the ground. Ease control by soft touch on the operation panel screen. When a vehicle stops in front of the entrance, automatically door opens and trolley transfers the vehicle to parking cell as shown in Figure 1. 1. (Sawankumar G. Narone, 2015)

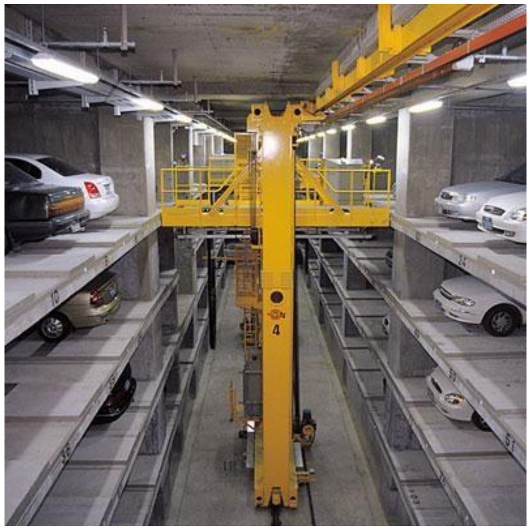

Figure 1.1: Integrated car parking solution

1.4.2 Robot Car Parking:

It is the first of several large-scale robotic car parks being built to address parking problems in the UAE. All the customer sees are a parking garage with space for one car, though the floor is platform which rides on the top of a robotic trolley. When the customer leaves the vehicle and collects a ticket, the wall of the garage drops away and the car is whisked to an elevator, which in turn takes the car to another trolley. From there, the machine parks the car in the dark depths of the structure. In total, the process takes around three minutes.

With this technology, you do not need to drive through the garage to find a parking space. You simply drive your car to an entry station and leave your car to be picked up by the computerized lifts that will safely place it inside the building on a shelving system as shown in Figure 1. 2. When you leave, you return to a central point and your car is swiftly retrieved for you. (Sawankumar G. Narone, 2015)

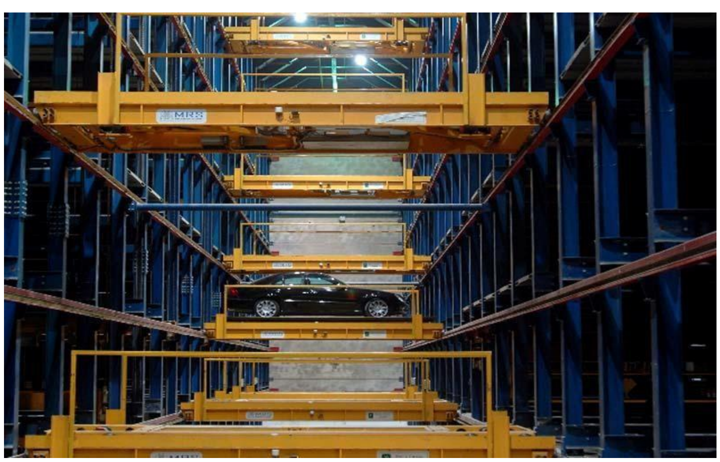

Figure 1.2: Robot car parking

This robotic car park will be especially convenient for the office tenants, parking or retrieval can be completed in less than 160 seconds. It is safe and secure and obviously doesn't expose expensive paint work to the abrasive elements during lengthy office hours.

1.4.3 Multi-Level Parking:

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. Therefore, these car parks need less building volume and less ground space as shown in Figure 1. 3 and thus save on the cost of the building. It also does away the need for employing too many personal to monitor the place. In an automated car parking, the cars are left at the entrance and are further transported inside the building by robot trolley. Similarly, they are retrieved by the trolley and placed at the exit for the owner to drive away. (Sawankumar G. Narone, 2015)

Figure 1. 3: Multi-level Parking

1.4.4 Rotary Parking System:

The rotary parking system shown in Figure 1. 4, consists of one automated mechanical system, which rotates at an angle of being perpendicular to the ground. By this way, cars parking and retrieving is reliable. It runs in a rotating way that driven by the reducer, transmission device drives the parking pallets rotating for cars parking and retrieving. The rotary parking system has the following advantages: (Sawankumar G. Narone, 2015)

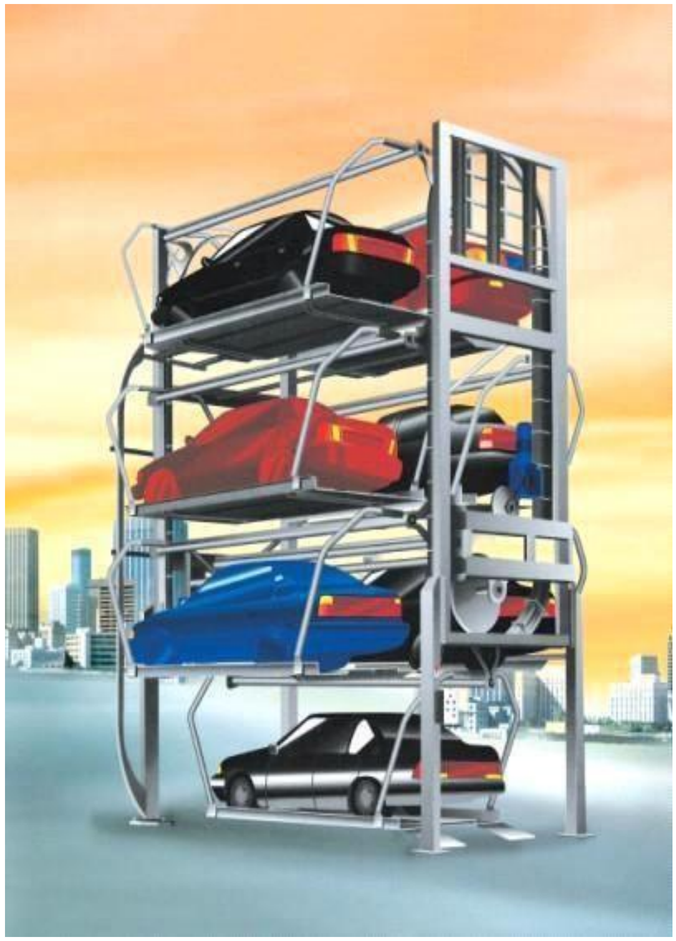

Figure 1.4: Rotary parking system

Chapter 2: Conceptual Design

This chapter will suggest a mechanical design of the project, this design will match the following procedures

2.1 Project Procedures:

1- When the car arrives RPS area, the driver enters PIN code and the room's number

2- the motor will run if the driver gives correct PIN and parking room's number.

3- The car will be then moved to the parking room by the driver.

4- The driver leaves the parking room and press the "HOME" button

5- the system will return to the home position and the car will be parked

6- When the driver wants to return his car, he will enter the room's number and PIN, the car will come down to the parking position.

7- The driver will leave with his car and press "HOME" button for returning the system to the home position.

To match the procedures, the conceptual design shown in Figure2.1. a, and the mechanical design shown in Figure2.1. b.

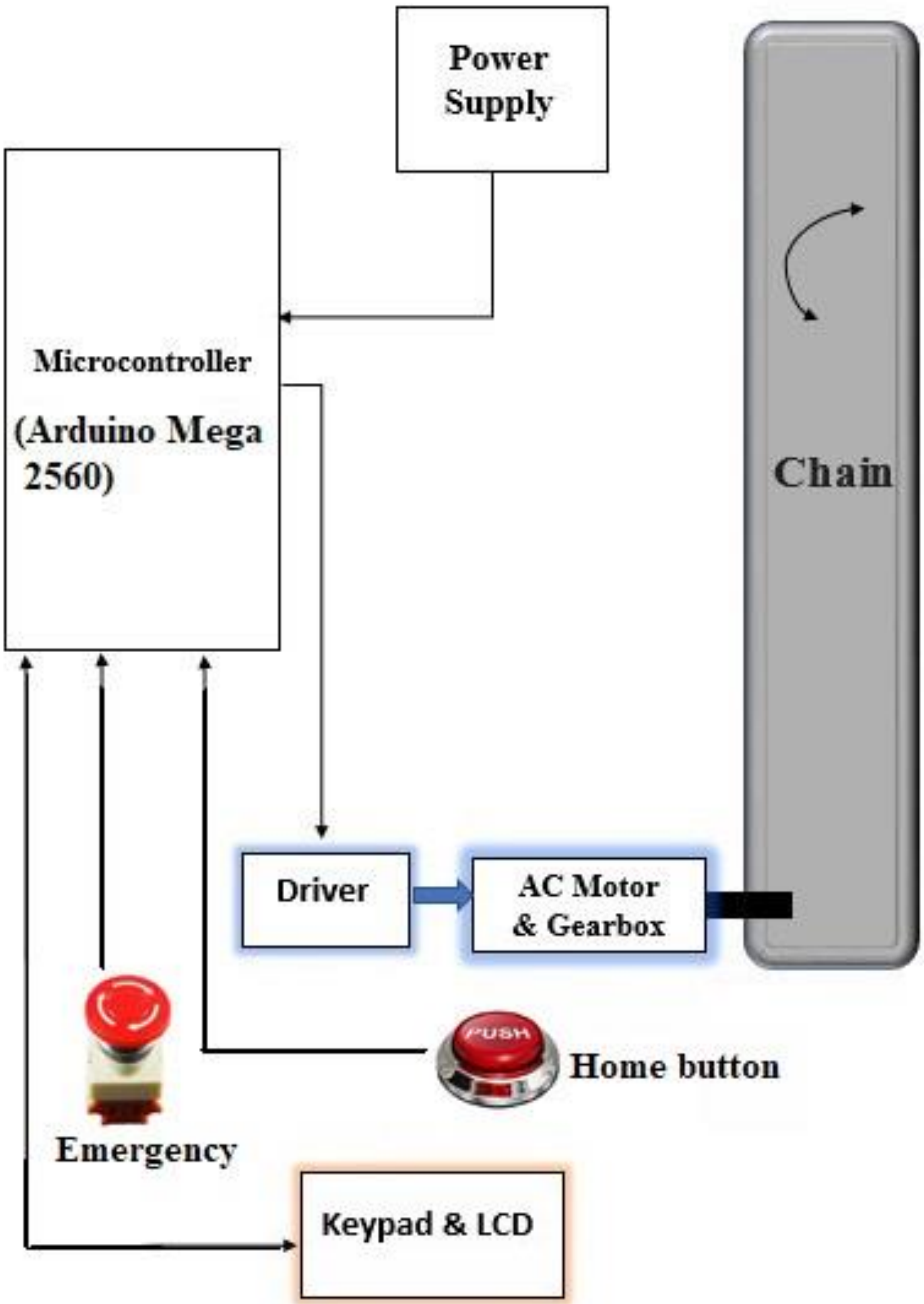

Figure2.1. a: Conceptual design

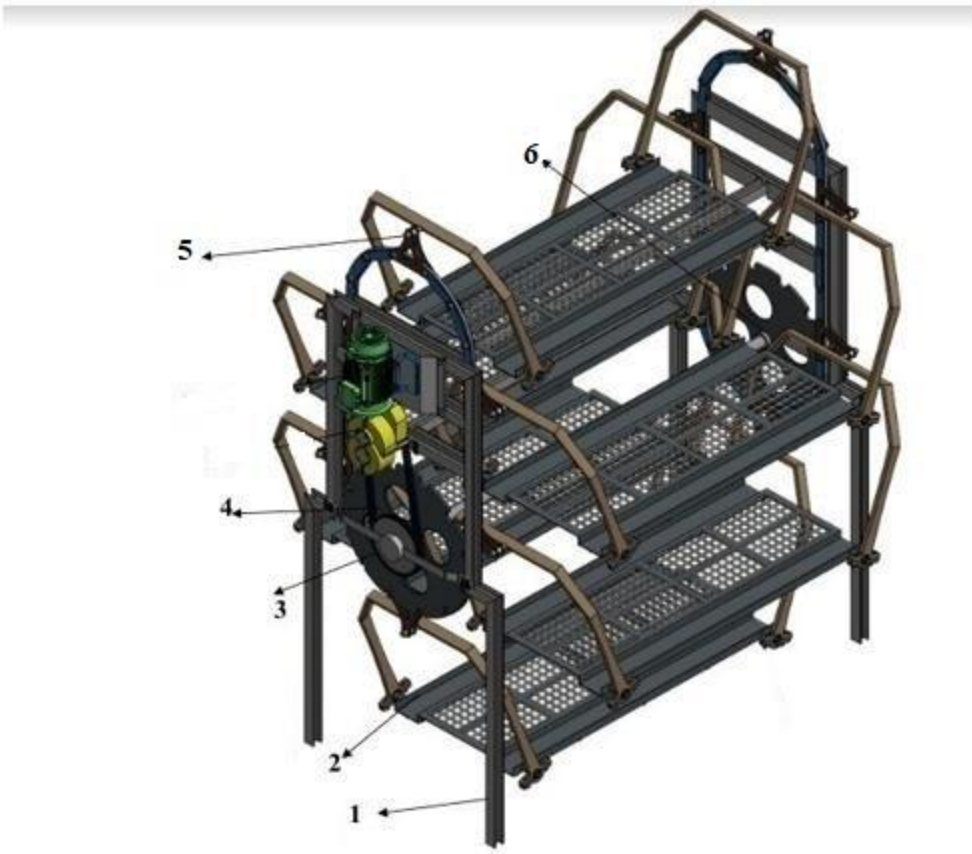

Figure2.1. b: Mechanical design

2.2 Mechanical Components

This design contains the following parts as appears in Figure2.1. b

1-Frame

2-Pallet

3-Sprocket

4-Roller chain

5-Triangle

6-Beam Rod

In the following, this will browse the elements of the mechanical structure as shown in

Figures (2.2-2.10):

2.2.1 Frame:

It is the structural body which holds the total rotary system it connects the most of pieces with together. Every component like the assembly of pallet, motor drive chain, sprocket, is installed over it.

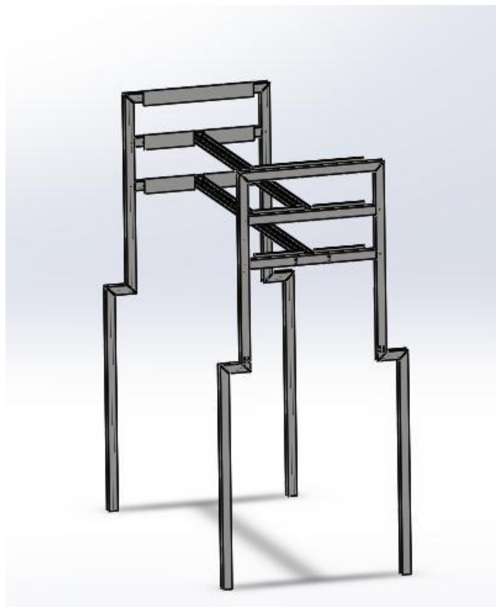

Figure 2.2.1.a: Frame structure

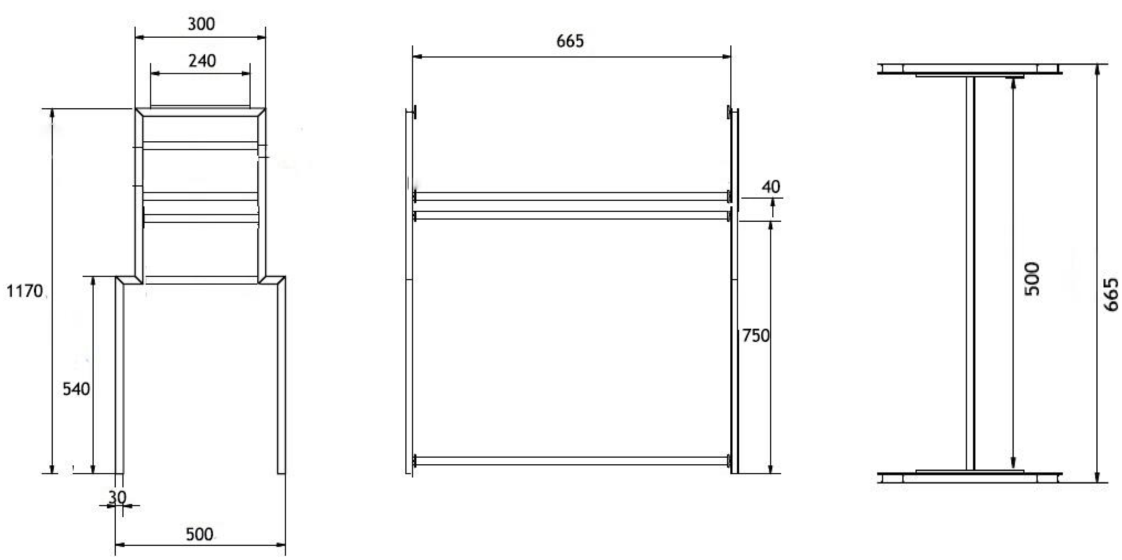

Figure 2.2.1.b: Frame dimension

2.2.2 Sprocket

A sprocket or sprocket-wheel is a profiled wheel with teeth, cogs, or even sprockets that mesh with a chain, track or other perforated or indented material. The name 'sprocket' applies generally to any wheel upon which radial projections engage a chain passing over it. It is distinguished from a gear in that sprockets are never meshed together directly and differs from a pulley in that sprockets have teeth and pulleys are smooth.

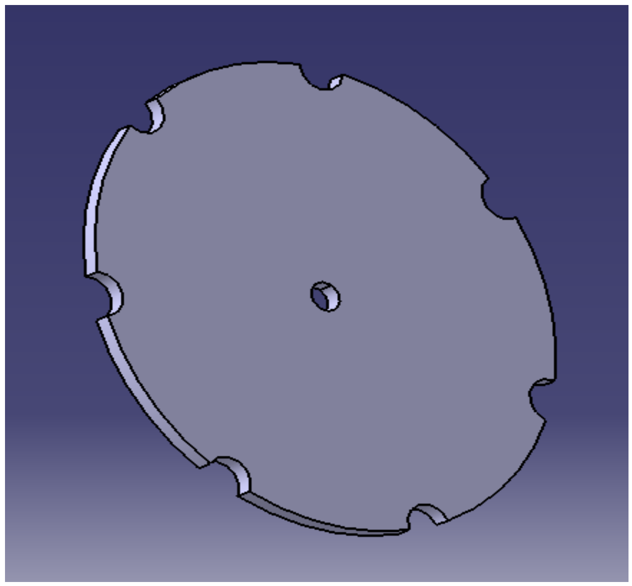

Figure2.2.2. a: Sprocket

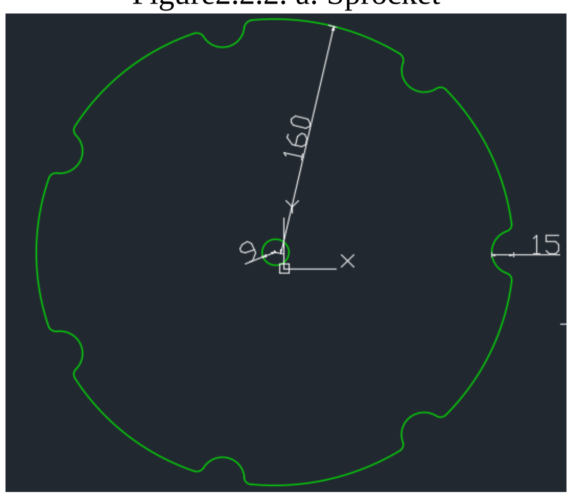

Figure2.2.2. b: Sprocket dimension

2.2.3 Roller chain:

The goal of this element is to connects between gearbox and sprocket

Roller chain or bush roller chain is the type of chain drive most commonly used for transmission of mechanical power on many kinds of domestic, industrial and agricultural machinery, including conveyors, wire- and tube-drawing machines, printing presses, cars, motorcycles, and bicycles. It consists of a series of short cylindrical rollers held together by side links. It is driven by a toothed wheel called a sprocket. It is a simple, reliable, and efficient means of power transmission.

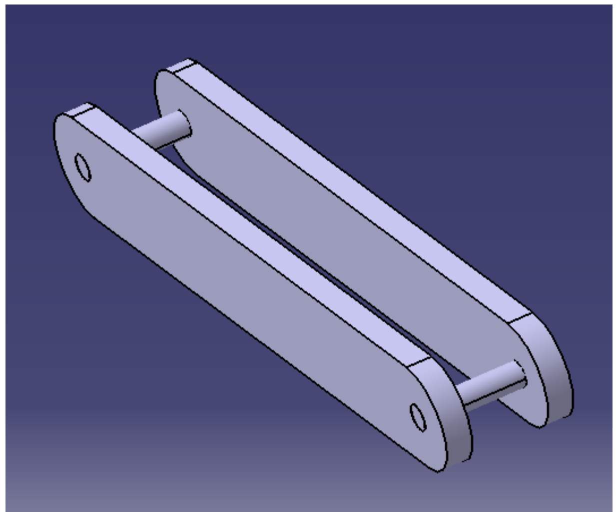

Figure 2.2.3. a: Roller chain

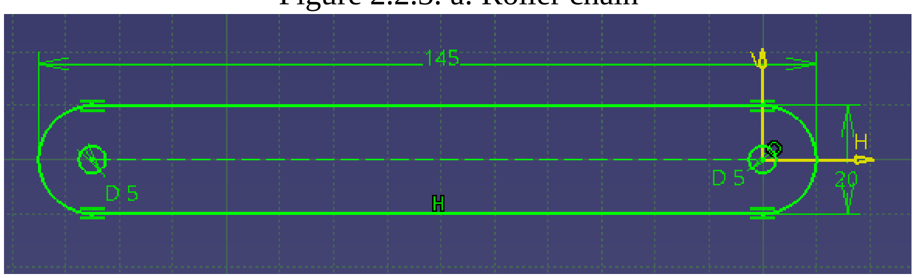

Figure 2.2.3. b: Roller chain dimension

2.2.4 Pallet:

The main function of the pallet in our system is to hold the car in its place; so, it has to be withstand the load of the car and to be stable while the system is moving.

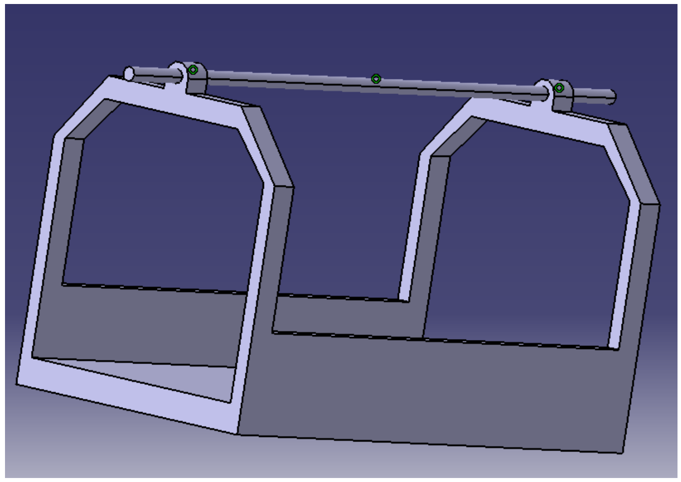

Figure 2.2.4.a: Pallet

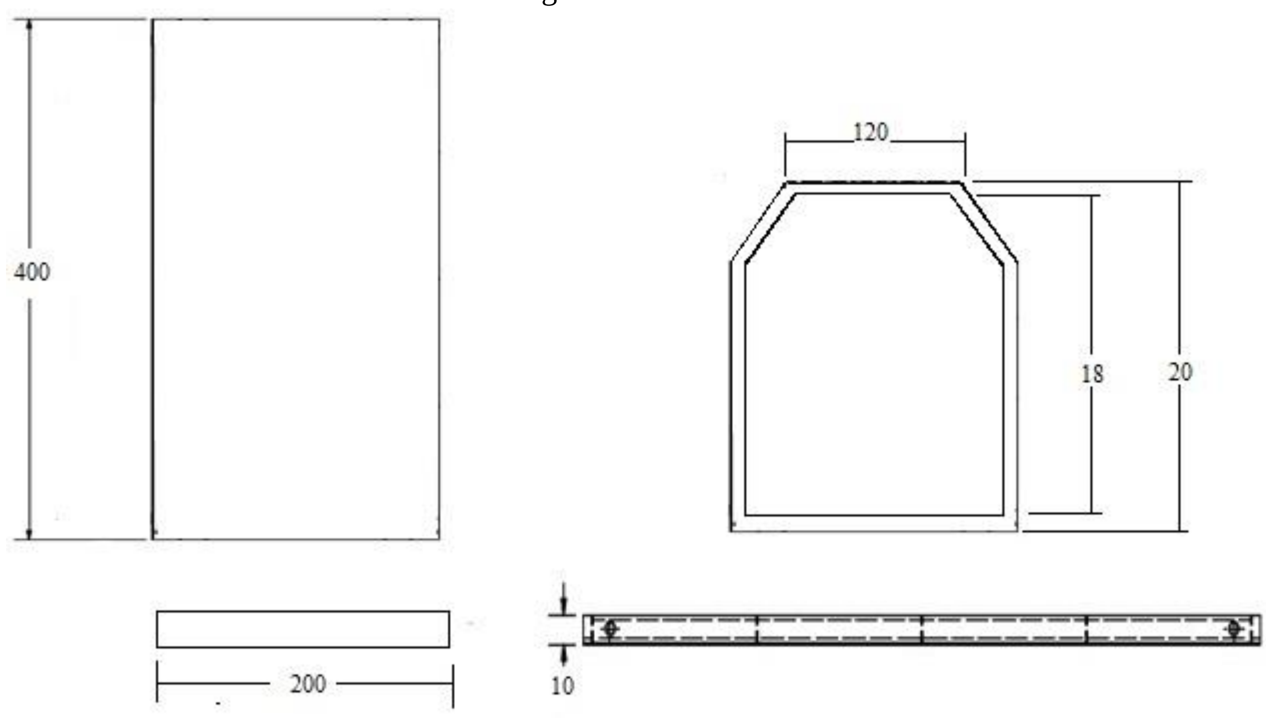

Figure 2.2.4.b: Pallet dimension

2.2.5 Beam Rod:

Used for connecting between the sprockets and allow the system to rotate also it is connected to the gearbox.

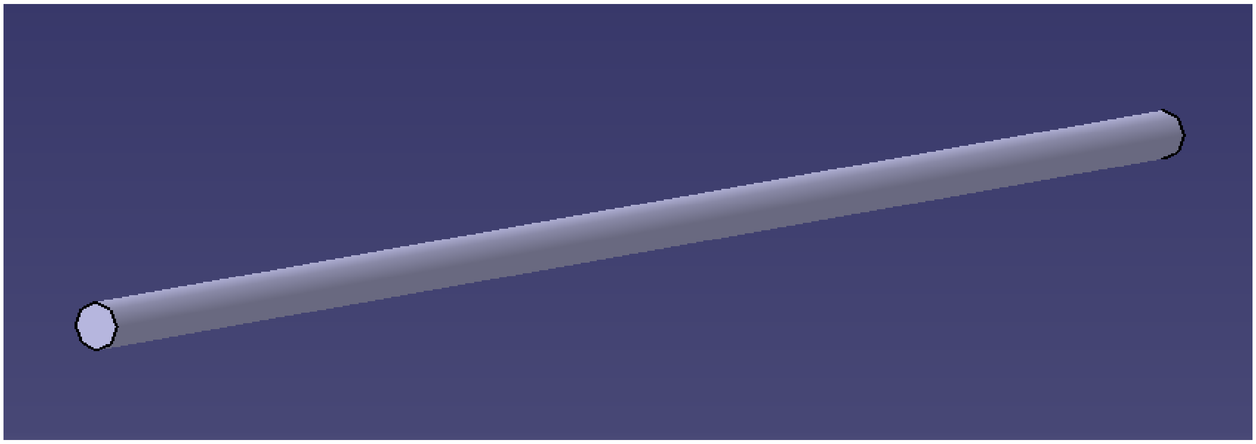

Figure 2.2.5.a: Beam rod

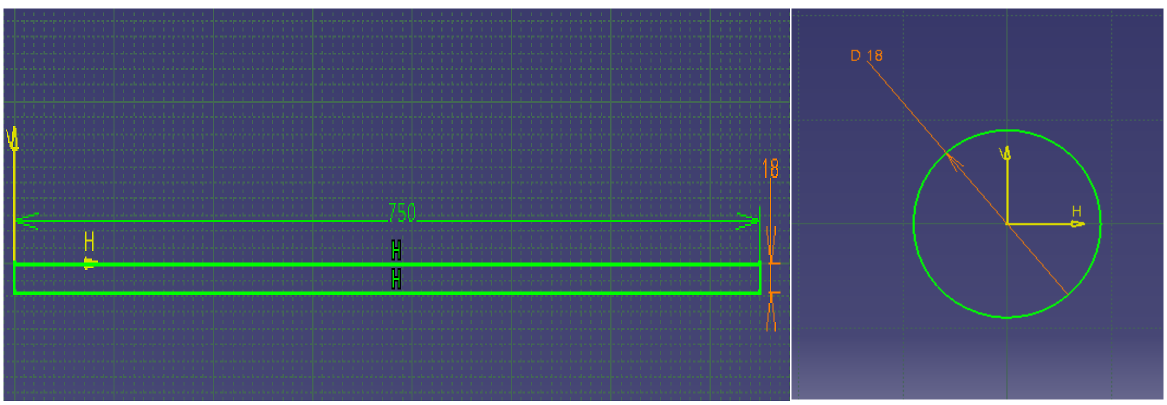

Figure 2.2.5.b: Beam rod dimension

2.2.6 Triangle:

Used to Connect between Pallet and frame and make rotating pallets much easier.

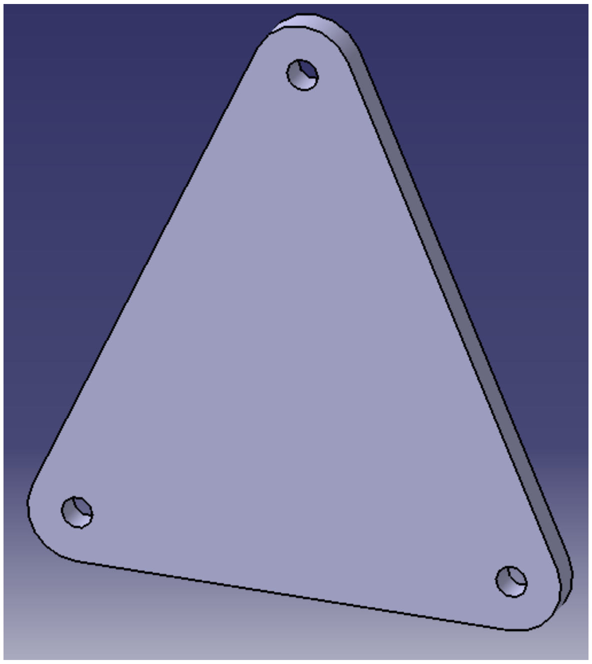

Figure:2.2.6. a: Triangle

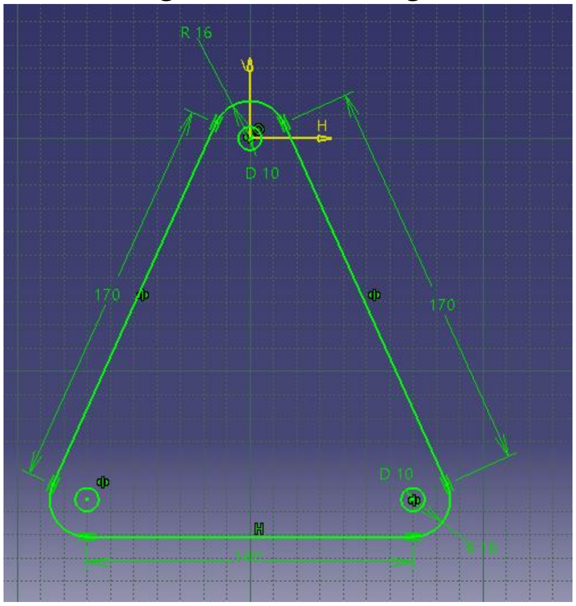

Figure:2.2.6. b: Triangle dimension

Chapter 3: Electrical System

This chapter will review the electrical system of the project; the electrical elements are connected together as shown in Figure 3. 1. RPS Mainly consists of an Arduino microcontroller, AC motor with driver, LCD display, keypad, push button switch, emergency and power supply.

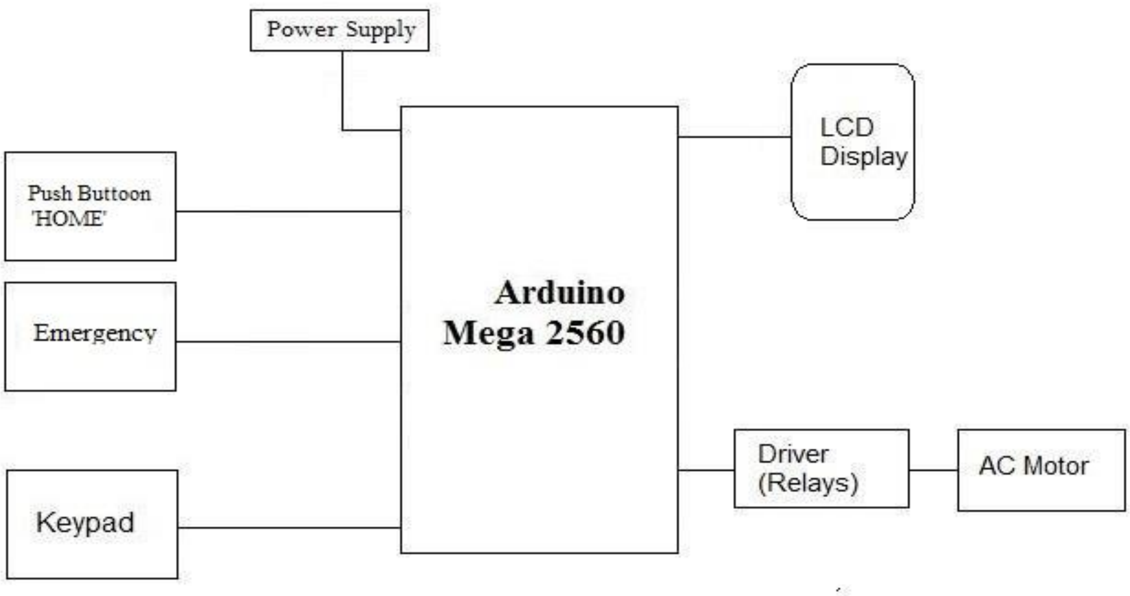

Figure 3. 1: Block diagram for the circuit

Electrical Components:

Browsing the components of the electrical design:

3.1 Arduino Mega 2560:

The Arduino Mega is a microcontroller board based on the ATmega1280.It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. As show in Figure 3.2 (Arduino Mega, 2017)

Figure 3. 2: Arduino mega 2560

3.2 Keypad 4x4:

Keypads allow users to input data while a program is running. This tutorial shows you how to connect a twelve-button keypad to an Arduino and how to use the library.

A keypad is often needed to provide input to an Arduino system, and membrane-type keypads are an economical solution for many applications. They are quite thin and can easily be mounted wherever they are needed.

In this project, demonstrate how to use a 16-button numeric keypad, similar to what you might find on a telephone. A 16-button keypad has four columns and four rows as show in Figure 3. 3. Pressing a button will short one of the row outputs to one of the column outputs. From this information, the Arduino can determine which button was pressed. For example, when key 1 is pressed, column 1 and row 1 are shorted. The Arduino will detect that and input a 1 to the program. (Arduino with Keypad Tutorial, 2017)

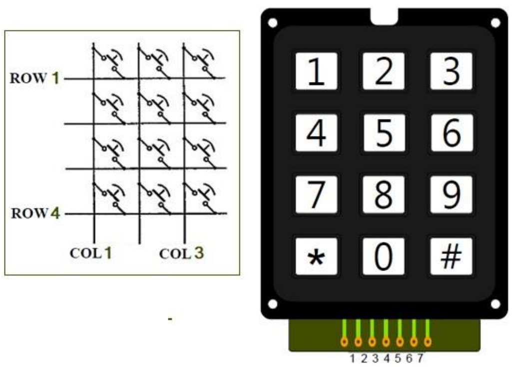

Figure 3. 3: Keypad 4x4

3.3 LCD Display 16×2:

Interfacing a character LCD to an Arduino adds a nice element of readability to your project.

Many of the best Arduino projects around the world sport LCD displays as show in Figure 3.4. These LCDs can be used to display information from the Arduino or any sensor connected to it.

Figure 3. 4: LCD display

3.4 Single Phase AC Motor with Driver:

3.4.1 Single Phase AC Motor:

Single phase power system as shown in Figure 3. 5is widely used as compared to three phases system for domestic purpose, commercial purpose and to some extent in industrial purpose. As the single-phase system is more economical and the power requirement in most of the houses, shops, offices are small, which can be easily met by single phase system. The single-phase motors are simple in construction, cheap in cost, reliable and easy to repair and maintain.

Due to all these advantages the single-phase motor finds its application in vacuum cleaner, fans, washing machine, centrifugal pump, blowers, washing machine, small toys etc.

We will review the fundamentals and working principle of single phase induction motor.

- **Construction of Single Phase Induction Motor:**

Like any other electrical motor it has two main parts namely rotor and stator.

1- Stator:

As its name indicates stator is a stationary part of induction motor. A single phase AC supply is given to the stator of single phase induction motor.

2- Rotor:

The rotor is a rotating part of induction motor. The rotor is connected to the mechanical load through the shaft. The rotor in single phase induction motor is of squirrel cage rotor type. The construction of single phase induction motor is almost similar to the squirrel cage three phase motor except that in case of asynchronous motor the stator have two windings instead of one as compare to the single stator winding in three phase induction motor.

- **Working Principle of Single Phase Induction Motor:**

When single phase AC supply is given to the stator winding of single phase induction motor, the alternating current starts flowing through the stator or main winding. This alternating current produces an alternating flux called main flux. This main flux also links with the rotor conductors and hence cut the rotor conductors. According to the Faraday’s law of electromagnetic induction, emf gets induced in the rotor. As the rotor circuit is closed one so, the current starts flowing in the rotor. This current is called the rotor current. This rotor current produces its own flux called rotor flux. Since this flux is produced due to induction principle so, the motor working on this principle got its name as induction motor. Now there are two fluxes one is main flux and another is called rotor flux. These two fluxes produce the desired torque which is required by the motor to rotate (Introduction to THREE PHASE AND SINGLE PHASE, 2017).

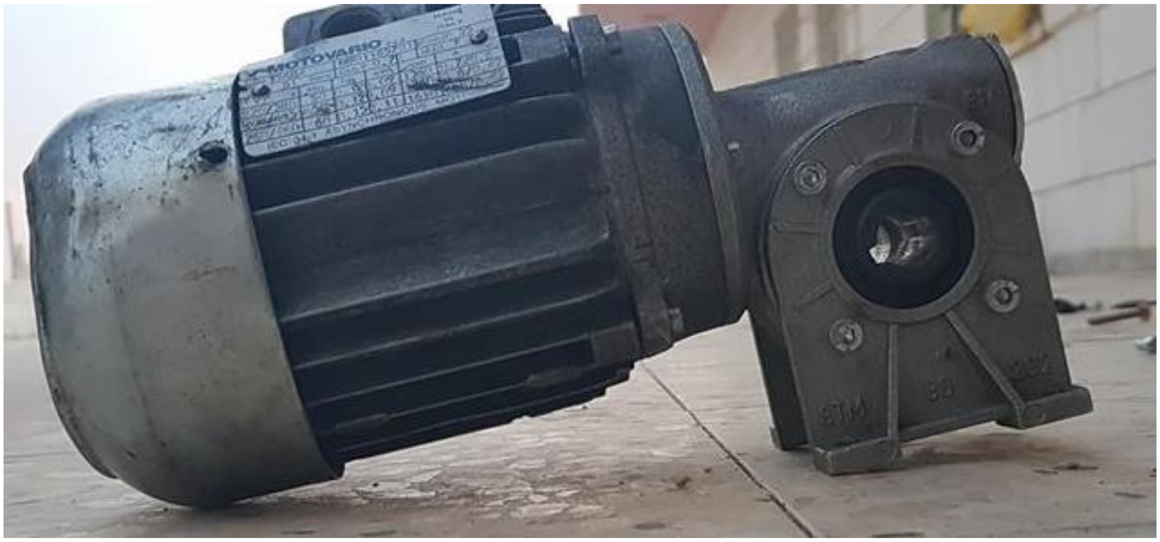

Figure 3.5.a: Single phase Induction motor

Figure 3.5.b: Motor nameplate

3.4.2 AC Motor Drivers (inverter Delta):

General Purpose AC Micro Drive. Delta Electronics' most cost effective general-purpose drive. The VFD-S series drive is famous for its low-noise carrier frequency feature and easy to use keypad. Applications: Air conditioner for large buildings; water supply system for large buildings; temperature control of middle/large oven; webbing loom; packing machine; conveyor belt; fan of drying machine, etc. As shown in Figure 3.6:

Figure 3.6.: Delta inverter

Delta VFD007S21A – Small and Easy Used Drives

Delta Products
AC Drives, VFD-S Series
ITEM # VFD007S21B
MFG # VFD007S21B
Series VFD-S

Drive, AC, 1HP, 230V 1-Ph Input

Table3. 1: Power inverter specification

Item Number: VFD007S21B	Max. Frequency: 400 Hertz
Manufacturer: Delta Products	Braking Type: DC Injection; Dynamic Braking
Item Category: Drives	Motor Control-Max Level: V/Hz (Scalar)
Subcategory: AC	Closed Loop: No
Series: VFD-S	AC Line Regenerative? No
Nominal Input VAC: 208;240 Volts AC	Dynamic Braking Trans? Included
Input Range VAC: 200 to 240 Volts AC	Enclosure Rating: IP20
HP (CT): 1 Horsepower	
Amps (CT): 1 Amps	
Input Phase: 1	
Operator Controls: Built In	

3.5 DC Power Supplies:

Which is a device that is responsible for converting the 220 V AC to DC as shown in table3.1 with any required volt as shown in Figure 3. 7 (5V power supply circuit, 2017)

Table3. 2: Power supply input-output

Input	220 AC
Output	5 DC

Figure 3. 7: Power supply

- Power supply circuit:

Power supply as shown in Figure 3. 8 consists of:

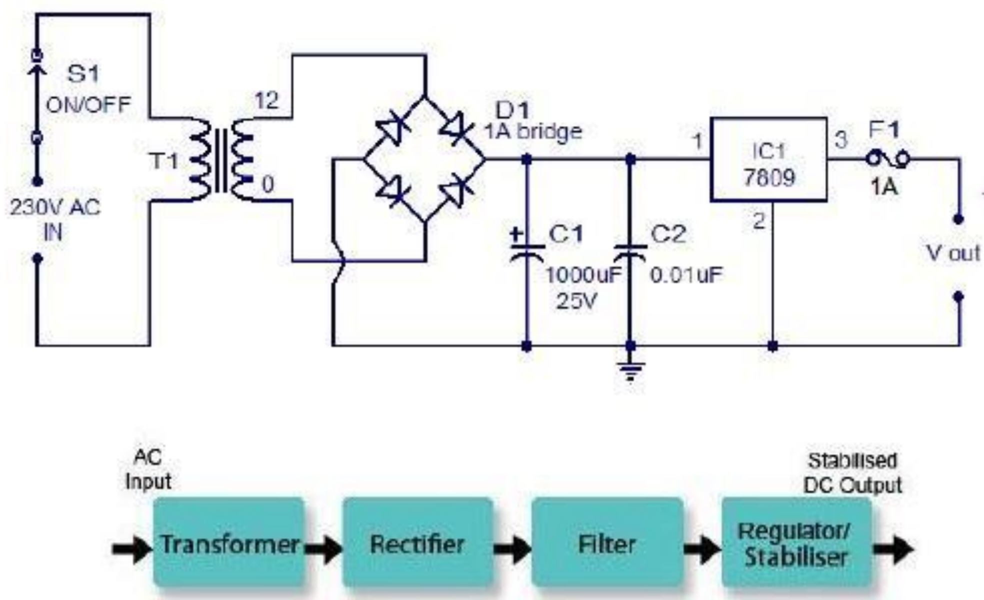

Figure 3. 8: Power supply circuit

1- Transformer

The transformer is a static device that transfers electrical energy from the primary winding to the secondary winding without affecting the frequency. It is used to step up or step-down the ac voltage level and isolates the remainder of the electronic system from the ac power.

2- Rectifier

The rectifier is a device used to change the ac power into pulsating dc. The basic rectifier is the diode. This diode is a unidirectional device that operates as rectifier in the forward direction. The three basic rectifier circuits using diodes are the half-wave, full-wave center-tapped and full-wave bridge type.

3- Filter

The filter of the power supply is used to keep the ripple component from appearing in the output. It is designed to convert pulsating DC from rectifier circuits into a suitably smooth dc level.

The two basic types of power supply filters are the capacitance filter (C-filter) and RC-filter. The C-filter is the simplest and most economical filter available. On the other hand, RC-filter is used to reduce the amount of ripple voltage across a capacitor filter. Its primary function is to pass most of the dc component while attenuating the ac component of the signal.

4- Voltage Regulators

A voltage regulator is designed to provide a very steady or well-regulated dc output. It is always ideal to have a steady output voltage so that the load will operate properly. The output level is maintained regardless of the variation of the input voltage. The commonly used transistor voltage regulators are the series voltage regulator and the shunt voltage regulator.

A. Electrical Switches

Are electromechanical devices that are used in electrical circuits to control power, detect when systems are outside their operating ranges, signal controllers of the whereabouts of machine members and work pieces, provide a means for manual control of machine and process functions, control lighting, and so on. Switches come in a variety of styles and are actuated by hand, foot, or through the detection of pressure, level, or objects. Switches can be simple on-off types or can have multiple positions that, for instance, can control the speed of a multi-speed fan. Switch operators can be found in various shapes and sizes as shown in Figure 3. 9 such as toggles or buttons and can be furnished in a variety of colors.

Figure 3. 9: Electrical switches (Push Button)

Other pushbutton switches are momentary contact switches, where contacts change from their default state only when the button is pressed and held down. The two types of momentary contact switches are

i. Normally open (NO): In a normally open switch, the default state of the contacts is open. When you push the button, the contacts are closed. When you release the button, the contacts open again. Thus, current flows only when you press and hold the button.

ii. Normally closed (NC): In a normally closed switch, the default state of the contacts is closed. Thus, current flows until you press the button. When you press the button, the contacts are opened and current does not flow. When you release the button, the contacts close again and current resumes.

- A pushbutton switch is a switch that has a knob that you push to open or close the contacts. In some pushbutton switches, you push the switch once to open the contacts and then push again to close the contacts. As shown in Figure 3. 10.

In other words, each time you push the switch, the contacts alternate between opened and closed.

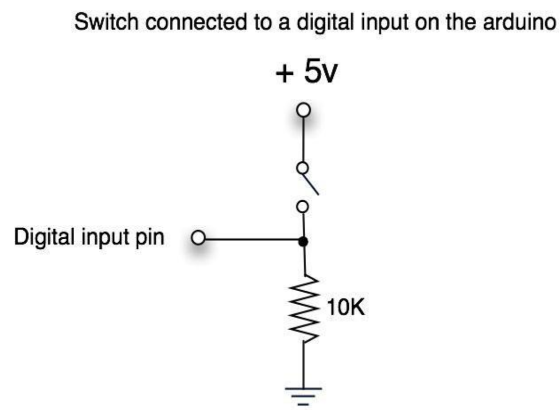

Figure 3. 10: Push button switch

B. The Potentiometer:

The most commonly used of all the "Position Sensors". As shown in Figure 3. 11 is the potentiometer because it is an inexpensive and easy to use position sensor. It has a wiper contact linked to a mechanical shaft that can be either angular (rotational) or linear (slider type) in its movement, and which causes the resistance value between the wiper/slider and the two end connections to change giving an electrical signal output that has a proportional relationship between the actual wiper position on the resistive track and its resistance value. In other words, resistance is proportional to position. (Voltage Divider Calculator, 2017)

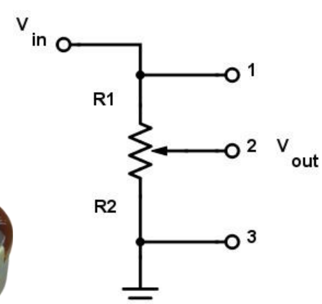

Figure 3. 11: The potentiometer

Chapter 4: Project Calculations

4.1 Rotary Parking System Design(Prototype)

The design of prototype for rotary parking system includes a frame, car carriage, mechanical driving chain and rotary pallet. Each part of the system will be designed and select the appropriate dimension and materials according to specific length and width of the system also according to the car weight and dimension. The standard dimension of the system will be**:**(Mr. Prasad Pashte, 2016)

Table 4. 1: Maximum dimensions of system

Maximum length	1050mm
Maximum width	800mm
Maximum height	1420mm

The system is built to be use by a car; the characteristics of the car:

Maximum Car Size:

Table 4. 2: Maximum Dimensions of Cars

Length	300 mm
Width	100 mm
Height	150 mm
Weight	0.25 kg

4.1.1 System Calculation:

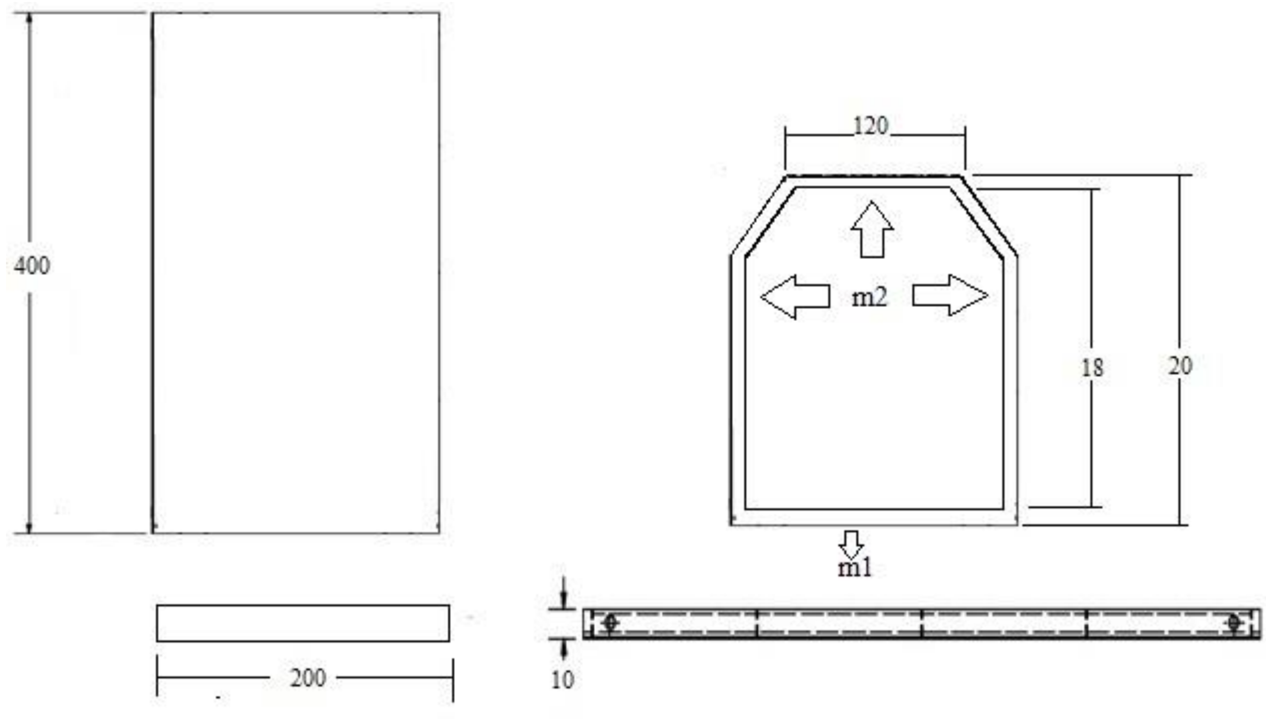

Figure 4.1 Pallet dimension

As shown in Figure 4.1:

m_1= 0.8 kg (pallet 'slower part)

m_2 = 0.2kg (pallets first upper part), m_3 = 0.2kg (second upper part)

$m_{pallet} = m_1+m_2+m_3 = 1.2$ kg

$m_{car} = 0.25$ kg

$m_{chain}+ m_{triangles} = 1.8$ kg

Number of cars = 6

$m_{Total\ cars} = 6x0.25kg = 1.5$ kg

$m_{Total\ pallets} = 6x1.2 = 7.2$ kg

$M_{system} = m_{Total\ cars} + m_{Total\ pallets} + m_{chain} + m_{triangles}$

= 1.5kg + 7.2 kg + 1.8 kg = 10.5 kg

4.1.2 Motor Calculation

F = m*g = 10.5kg*9.8 = 103.005 N

T = F*r =103.005(0.16) = 16.5Nm

V= (πDN)/60

Chain velocity (V) = 0.05 m/s [desired system speed]

N = 2.98 rpm

P = (2πNT)/60 = 60 Watt

P = 60 w/746 = 0.08Hp

4.1.3 Pallet Calculation

The design of pallet is done by referring following procedure.

1) Vehicle Specifications:

- Vehicle size=300mm*100mm*150mm
- Mass of Vehicle= 0.250 kg

2) Pallet Specifications:

- Thickness = 10 mm…. (Considering the load of vehicle & Analysis is done)
- Length = 400 mm
- Width = 200 mm
- Height = 400 mm
- Mass of a vehicle is 0.250 kg

Total load on pallet = Weight of the vehicle + Weight of Pallets rod

= 0.250*9.81+0.05*9.81 =2.94 N

4.1.4 Rod Calculation

Specifications and Calculation of Forces of Rod:

- Length = 750 mm
- Diameter = 18mm
- Mass of the Pallet = 1.2kg

Total load on the Rod = Weight of vehicle + weight of Pallet.

= 0.25×9.81 + 1.2×9.81

= 14.2245 N

4.1.5Joint Calculation

Total load on a joint = [Weight of vehicle + Weight of Pallet + Weight of Rod] /2

= [0.25×9.81 + 1.2×9.81 + 0.6×9.81] / 2

= 10.06 N

4.1.6 Frame Calculation

Dimensions of the Frame:

- Height: 1170 mm
- Width: 500 mm
- Length: 665 mm

Total load on the Frame =) Weight of vehicle × 6 + Weight of Pallet×6 +Weight of Rod×2

+ Weight of Chain×2 + Weight of Joint×12+Weight of Motor + Miscellaneous)

= (0.25×9.81*6+ 1.2×9.81*6+ 0.6×9.81*2+ 0.9×9.81*2 + 0.145×9.81*12 + 3*9.81 + 5*9.81)

= 211 N

4.2 Material Specification:

4.2.1 Material for Steel Plate:

As per the IS standard number of materials are available. There is selected one material for steel plate of fabrication.

The material is "IS 2062: 1992, MTD 4", Steel for general structural purpose.

4.2.2 Details of the Materials:

Detail of the Material "IS 2062: 1992 "as shown in Table 4. 3 and Table 4. 4:

Table 4. 3: Manufacturing range

Product	**Thickness(mm)**	**Width(mm)**	**Length(mm)**	**Surface Finish**	**Edge Condition**
Slab	160 mm	1000-1500 mm	Up to 8000 mm	As cast and ground	As cast
Hot Rolled Plate	6 to 100 mm	1000-1500 mm	Up to 8000 mm	Hot Rolled annealed and pickled	Sheared/Mill Edge

Table 4. 4: Dimensional tolerances

Product	**Thickness Tolerance**	**Length Tolerance**	**Width Tolerance**
Slab	+/- 5 mm	+/- 50 mm	+/- 10 mm
Hot rolled black and Hot rolled annealed and picked plate	+0.50/-0.25 for 5 to 10 mm +0.75/-0.25 for 10 to 25 mm +1.0/-0.25 for 25 to 40 mm +1.5/-0.25 for Above40 mm	+ 30/-0 mm (Mill Edge) + 10/-0 mm (Trim Edge)	+100/-0 mm (Mill Edge) +20/-0 mm (Trim Edge)

Chapter 5: Project Control

This chapter presents control design of the moving parts in the RPS in order to obtain the desired output in high accuracy. On the other hand, the software and programming detail that will be used in this project will be introduced using flowchart. In addition, explanation of the RPS procedure operation will be given.

5.1 Arduino:

The Arduino Mega 2560 is a microcontroller board based on theATmega2560as shown in Figure 5. 1 It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button as show in Table 5.1. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

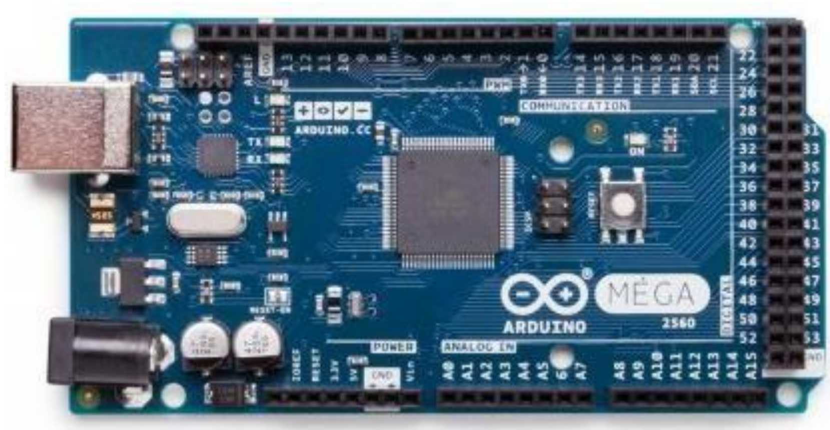

Figure 5. 1: Arduino mega 2560

Power

The Mega 2560 can be powered via the USB connection or with an external power supply. The power source is selected automatically.

External (non-USB) power can come either from an AC-to-DC adapter or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and Vin pin headers of the POWER connector.

The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- Vin. The input voltage to the board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin. o5V. this pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator and can damage your board. We don't advise it. o3V3. A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND. Ground pins.
- IOREF. This pin on the board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs for working with the 5V or 3.3V.

Memory

The ATmega2560 has 256 KB of flash memory for storing code, 8 KB of SRAM and 4 KB of EEPROM, as shown in Table 5. 1 explicated a some of Arduino specification (Arduino Mega, 2017)

Table 5. 1: Arduino mega specification

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	54 (of which 14 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz

5.2. Connection Circuit:

Computer simulations have become a useful part of mathematical modeling of many natural systems to observe their behavior. It allows the engineer to test the design before it is built in the real situation; the simulations for this system were performed in PROTEUS program shown in Figure 5. 2. These software applications are widely used in control engineering for both simulation and design.

And as shown in Table 5.2 explicated system Inputs and Outputs.

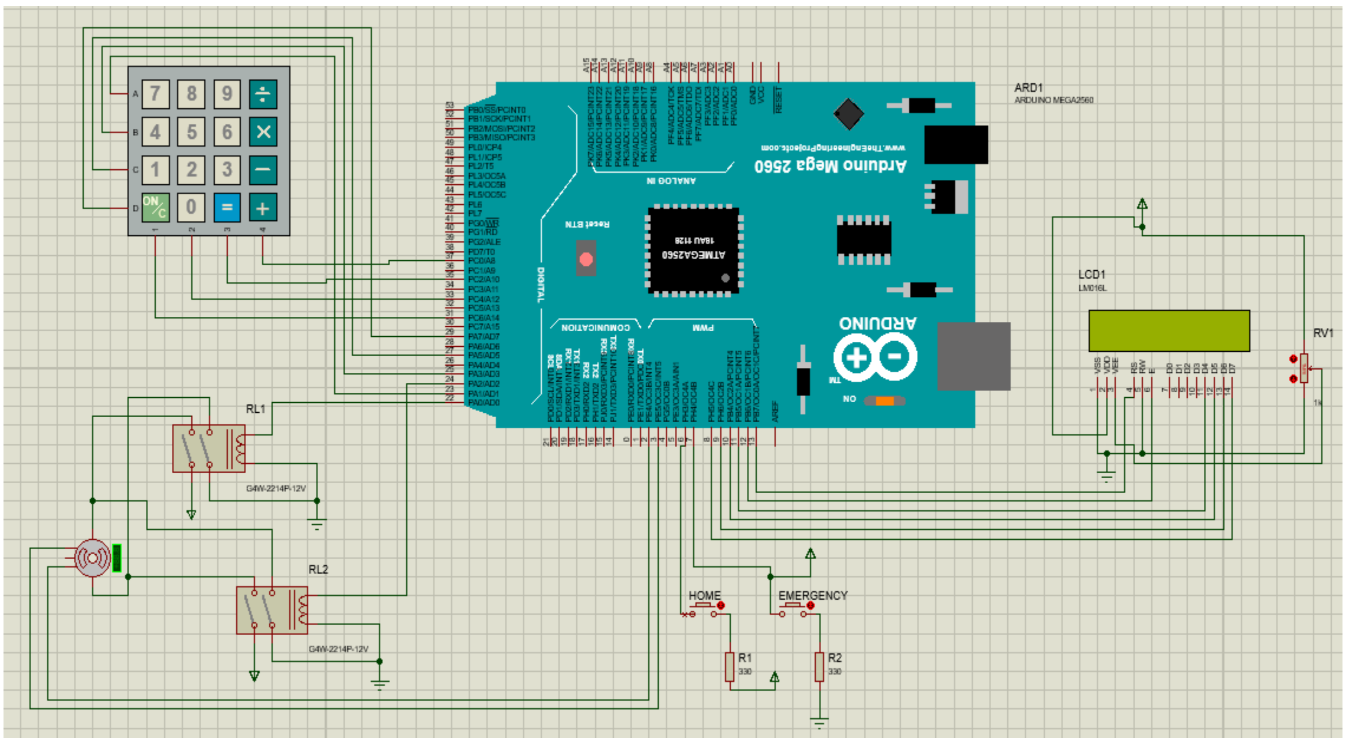

Figure 5. 2: Connection circuit

Table 5. 2: System Inputs and Outputs Table

Inputs	**Outputs**
Push Button	AC Motor
Emergency Button	LCD Display
Keypad 4*4	

5.2.1 Working principle of circuit:

The control circuit contains keypad that user will press the room's number through it, if the code is right the room will be ready for parking, user park the car and exit parking area, then the gate will be closed when he presses 'HOME' push button or after 2 minutes delay. In returning car case the system will operate in the same principle.

5.3 System Flowchart:

A flowchart is a type of diagram that represents an algorithm, workflow or process, showing the steps as boxes of various kinds, and their order by connecting them with arrows. This diagrammatic representation illustrates a solution model to a given problem. Flowcharts are used in analyzing, designing, documenting or managing a process or program in various fields.

The flowchart illustrates the principle of system as shown in Figure 5.3

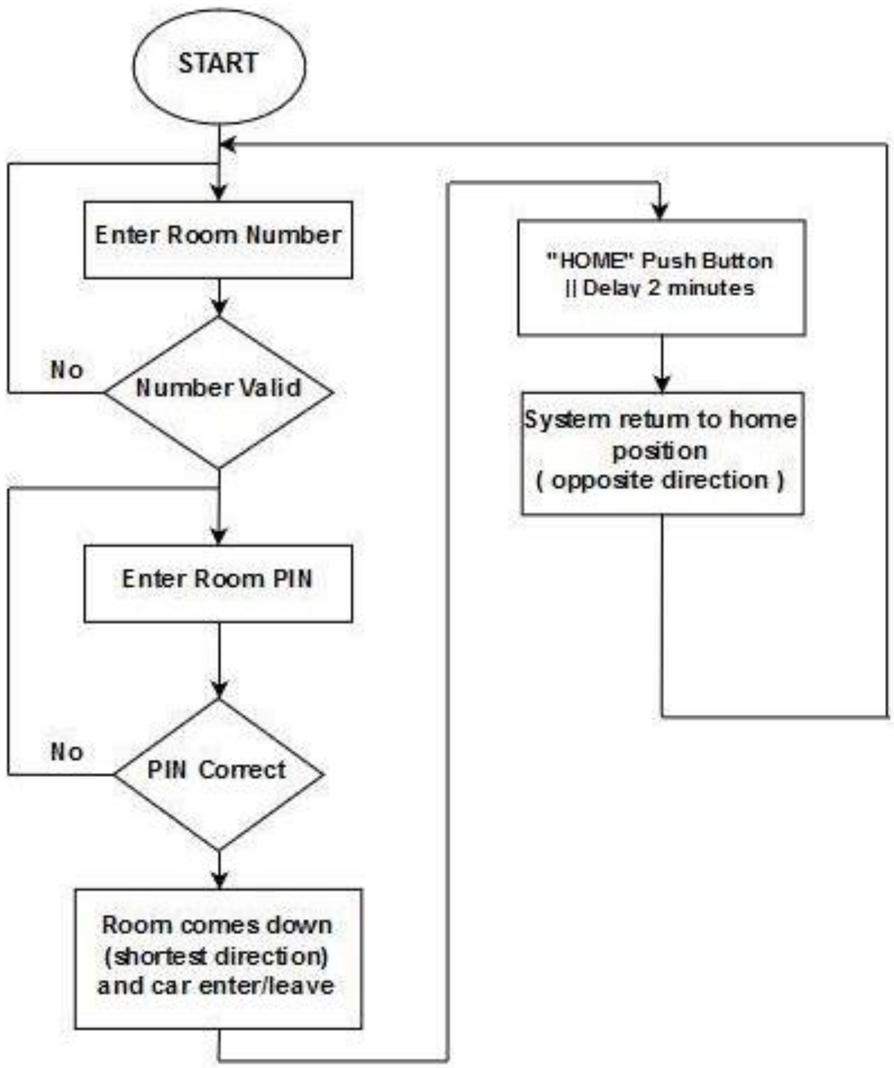

Figure 5. 3: System Flowchart

5.4 System Code:

The Code has been written in C language using Arduino program, after program is completed it has been converted to Hex file to install it in Arduino mega 2560. Where was the use of primary and non-complex instructions in writing program such as IF-statement instruction and While-loop instruction to implement the control conditions. The illustrative code in Appendix A.

Chapter 6: System Implementation and Testing

This chapter will introduce the implementation process is done and how components connected with each other step by step:

6.1 Electrical Circuit Implementation

For the implementation of the control circuit correctly we follow the following steps:

6.1.1 Step one

Connect Arduino with the PC and start Programming of Arduino mega 2560 as shown in Figure 6.1.

Figure 6.1: Arduino with the PC

6.1.2 Step two

Preparing relays with Arduino, AC motor, Keypad, LCD display and as shown in Figure 6.2.

Figure 6.2: Circuit preparing

6.2 Mechanical Structure Implementation

For the implementation of the mechanical structure correctly we follow the following steps:

6.2.1 Step one

Preparing the six pallets and painting them as shown in Figure 6.3

Figure 6.3: Six pallets

6.2.2 Step two

Prepare the frame which will hold the whole system components as shown in figure 6.4

Figure 6.4: Frame

6.2.3 Step three

Prepare the sprockets and install them on the frame as shown in figure 6.5

Figure 6.5: Sprockets with frame

6.2.4 Step four

Installing the chain on the sprocket as shown in Figure 6.6

Figure 6.6: Chain on the sprocket

6.2.5 Step five

Installing the pallets and Prepare the final structure as shown in figure 6.7:

Figure 6.7: Final structure

6.3 System Testing

After the electrical circuit is completed, it has been installed on the model to simulate the real parking and to

test the electrical circuit and assure its efficiency and apply the possible conditions and it has been illustrated in the following steps:

6.3.1 Entry of first car

After the user enters room number and its PIN, his car which enters the parking must fulfill the conditions that mentioned previously so the system could deal with it and provide new position and take in consideration the nearest one to save time. The Figure 6.8 demonstrates system's position for entering a car.

Figure 6.8: Entering a car

6.3.2 System Home Position

After the car become on the pallet, the system will return to the home position after the user presses the “Home” push button or after 2 minutes time delay as shown in Figure 6.9:

Figure 6.9: Home position

6.4 Work plans

In order to achieve the main objective of this project, it is necessary to divide the work into several tasks and the distribution of the tasks along the first and second semester 2017/2018 as shown in Table 6.1.

Table 6.1: Work plans

Task	**Duration**	**Introduction of graduation project**	**graduation project**
1.Getting information	2 weeks	**X**	
2.Summarize the project idea	2 weeks	**X**	
3.Software design	6 weeks	**X**	
4.RPS Control	3 weeks	**X**	
5.Simulation	2 weeks	**X**	
6.Obtaining at mechanical and electrical tools	2 weeks		**X**
7.prepare the mechanical structure	5 weeks		**X**
8.prepare the electrical system	5 weeks		**X**
9.Run the project	2 weeks		**X**
10.Conclusion	1 week		**X**

6.5 Budget and Costs

The approximate cost of the required components is shown in Table 6.2. The total cost of the RPS project is estimated below:

Table 6.2: Project Budget

Programmers (Arduino, Sensor, Keypad)	**100 JD**
Material	**100 JD**
Tools: (Motor, Gearbox, Roller chains, Bush bearings, Beam rods, Triangles)	**100 JD**
manufactory	**300 JD**
Total	**600 JD**

6.6 Conclusion

Designing and manufacturing of a rotary parking system is one of the responsibilities towards our country as these types of parking will help to solve the traffic jam issue in Palestine.

Making a rotary parking system prototype as a graduation project was very helpful issues that can help the project team to practice and illustrates different discipline in that are offered in Mechanical Engineering Department at Palestine Polytechnic University.

This prototype including the mechanical structure will moved using suitable electrical actuates which will be drive and controlled by microcontroller system "Arduino Mega"

Finally, several points have been concluded throughout the preparation of this repot, such as:

1. Choosing a suitable microcontroller type that fit the requirements of our application.
2. Building the appropriate connection of the electrical circuit.
3. Controlling and driving the project actuators
4. Develop a full solidworks drawing for mechanical structure

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Appendix A

Code:

```
#include <LiquidCrystal.h>
#include <Keypad.h>
 #define outputA 40
 #define outputB 41

// Keypad
const byte ROWS = 4; //four rows
const byte COLS = 4; //four columns



char keymap[ROWS][COLS] = {
  {'1','2','3','A'},
  {'4','5','6','B'},
  {'7','8', '9','C'},
  {'*','0','#','D'}
};

byte rowPins[ROWS] = {23, 25, 27, 29}; //connect to the row pinouts of the keypad
byte colPins[COLS] = {31, 33, 35, 37}; //connect to the column pinouts of the keypad

//initialize an instance of class NewKeypad
Keypad myKeypad = Keypad( makeKeymap(keymap), rowPins, colPins, ROWS, COLS);



// create and initialize the LCD object
// LiquidCrystal(rs, enable, d4, d5, d6, d7)
```

```
LiquidCrystal lcd(13, 12, 11, 10, 9, 8);

char password[] = {'4', '5', 'B'};
char room1[] = {'1'};
boolean flag;
int val = 150;
int counter = 0;
int aState;
int aLastState;
const int buttonPin = 3;
int buttonState = 0;
int buttonState2 = 1;
int counter2 = 0;
int aState2;
int aLastState2 =0;
const int buttonPin2 = 2;


void setup() {
  lcd.begin(16, 2);
  lcd.cursor();
pinMode (outputA,INPUT);
pinMode (outputB,INPUT);
pinMode(buttonPin, INPUT);
pinMode(buttonPin2, INPUT);
aLastState= digitalRead(outputA);
aLastState2= digitalRead(outputA);
}
```

```
}

void loop() {
   attachInterrupt(digitalPinToInterrupt(buttonPin2),EMERGENCY,CHANGE);
   attachInterrupt(digitalPinToInterrupt(buttonPin),HOME,CHANGE);

  lcd.print(" Enter Room: ");
    buttonState = digitalRead(buttonPin);              //Enter room

  char key1 = myKeypad.waitForKey();
   if(key1 != room1){
      flag = false;
    }

   if(key1 = room1){
      flag = true;

  lcd.clear();
  lcd.print("Enter PIN :");

  for(int i = 0; i < sizeof(password); i++){      // Enter password of room

    char key = myKeypad.waitForKey();
    if(key != password[i]){
      flag = false;
    }

    lcd.print("*");

  }
```

```
  lcd.setCursor(0 ,1);

  if(flag == false){
    lcd.print("Incorrect !!");
  }else{
    lcd.print("Correct");
    delay(1000);
          lcd.clear();
///cc
counter=0;
while(counter<=90) {            // Encode value

 if(counter==-90 || counter==90) {
// 90 : Determine the distance needed to reach the desired location
    analogWrite(7,0);
  analogWrite(6,0);
        lcd.clear();
 lcd.setCursor(0,0);
 lcd.print("Click HOME");
 delay(10000);
    if (buttonState == HIGH) {
        lcd.clear();
 lcd.setCursor(0,0);
 lcd.print("Homing");
  delay(2000);

while(counter2>=-90) {
```

```
if(counter2==-90 || counter2==90) {
 analogWrite(7,0);
 analogWrite(6,0);
 }
 else {
 analogWrite(7,0); // cw , off
 analogWrite(6,val); // ccw , constant speed
 do {
   if (buttonState2 == HIGH ){
 aState2 = digitalRead(outputA);
     if (aState2 != aLastState2){
   // If the outputB state is different to the outputA state, that means the encoder is rotating clockwise
   if (digitalRead(outputB) != aState2) {
     counter2 --;
   }     else
     counter2 ++;



   lcd.clear();
   lcd.print("Position: ");
   lcd.println(counter2);
     }
     aLastState2= aState2;
   }
    if (buttonState2 == LOW ){
        analogWrite(7,0); // cw , constant speed
 analogWrite(6,0); // ccw off
 return 0;
```

```
      }
       }
    while (counter2>-90);




}
  }
    lcd.clear();
  return 0 ;

  }
  if (buttonState == FALLING ){
    lcd.clear();
 lcd.setCursor(0, 0);
 lcd.print("Click HOME Button ");
 delay(3000); //DELAY IF USER DIDNT CLICK BUTTON
   while(buttonState == RISING) {
         lcd.clear();
 lcd.setCursor(0,0);
 lcd.print("Click HOME Button");
  delay(10000);
   }
   }
      }

  else {
```

```
  if (buttonState2 == HIGH ){
 analogWrite(7,val); // cw , constant speed
 analogWrite(6,0); // ccw off
 }
 if (buttonState2 == LOW ){
 analogWrite(7,0); // cw , constant speed
 analogWrite(6,0); // ccw off
 return 0;
 }
 do {
  if (buttonState2 == HIGH ){
 aState = digitalRead(outputA);
     if (aState != aLastState){
   // If the outputB state is different to the outputA state, that means the encoder is rotating
clockwise
   if (digitalRead(outputB) != aState) {
     counter --;
   }     else
     counter ++;



   lcd.clear();
   lcd.print("Position: ");
   lcd.println(counter);
     }
     aLastState = aState;
  }
    if (buttonState2 == LOW ){
      analogWrite(7,0); // cw , constant speed
```

```
  analogWrite(6,0); // ccw off
  return 0;
    }
       }
    while (counter<90);




}

  }
lcd.clear();
lcd.print("HOME");
        }

  delay(2000);
   }
}

void EMERGENCY(){
   lcd.clear();
   lcd.print("Emergency Interrupt !!");
   counter=90;
   counter2=-90;
   delay(3000);
   return 0;
   }
```

```
void HOME(){
  lcd.clear();
  lcd.print("HOMING");
  counter=0;
  while(counter2>=-90) {
 if(counter2==-90 || counter2==90) {
  analogWrite(7,0);
  analogWrite(6,0);
  }
  else {
  analogWrite(7,0); // cw , constant speed
  analogWrite(6,val); // ccw off

  do {

  aState2 = digitalRead(outputA);
       if (aState2 != aLastState2){
    // If the outputB state is different to the outputA state, that means the encoder is rotating
clockwise
     if (digitalRead(outputB) != aState2) {
       counter2 --;
     }      else
       counter2 ++;
     if (buttonState2 == LOW ){
  analogWrite(7,0); // cw , constant speed
  analogWrite(6,0); // ccw off
  return 0;
       }
```

```
      lcd.clear();
      lcd.print("Position: ");
      lcd.println(counter2);
        }
        aLastState2= aState2;
     }


     while (counter2>-90);





}
  }
    lcd.clear();
  return 0 ;

  }
```