Fabrication of Car Parking Prototype Using Piezoelectric Sensors

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***Abstract*— The present system of parking activity creates frustration to the user. All the vehicles have to be parked in some space when the drivers leave them. Due to unorganized parking lots, people face problem in finding a parking space in lesser time and remembering it. Time is spent in obtaining parking pass while entering the lot and roaming around the lots to see any free space is available. Sometime, the driver may not notice the vacant space or would be wandering without knowing the parking lot is full. Unless the driver recollects the exact parking space, he/she cannot pinpoint the vehicle in huge lots while collecting it back. These consume precious time and lead to Frustration, Fuel wastage, environmental pollution, and traffic congestion. To overcome all these problems, these kind of smart parking systems are essential in major cities. This is the latest trends in the technology that can be used to solve the parking problems.**

***Index Term*— IR sensors, Micro processor Piezoelectric sensor, &rolling structure**

I. Introduction

THE present system of parking activity creates frustration to the user. All the vehicles have to be parked in some space when the drivers leave them. Due to parking lots, people face problem in finding a parking space in lesser time and remembering it. Time is spent in obtaining parking pass while entering the lot and roaming around the lots to see any free space is available. Sometime, the driver may not notice the vacant space or would be wandering without knowing the parking lot is full. As the project work falls under the subject of "mechatronics" this project report is aimed to describe it and the following is the brief introduction.

II. Micro Controller

A. Piezoelectric Sensor

Although optical and electrochemical transducers are the two most popular transducers for biosensors, piezoelectric transducers have also gained some popularity in the past couple of decades. Like optical and electrochemical transducers, piezoelectric transducers can be used as physical sensors (to sense mass).

In this work a piezoelectric material is attached to the ramp of parking slot. The ends of piezoelectric material are directly supplied to the microcontroller as the voltage generated is very low to harm the circuit. Its aim is to detect the arrival of car into the system. As shown in **Fig. 2.**

B. Infrared (IR) Sensors

This circuit designed with infrared sensors is aimed to detect the parking vehicle that is present over the rotate compartment. This circuit is designed with IR sensors and LM 567 (tone generator) IC that generates logic signal for the microcontroller. Based on this information, the controller can identify weather the vehicle is present over the platform or not.

The circuit contains one IR LED and one IR signal detector; these two devices are arranged parallel to each other at both sides of the compartment (externally). The IR energy delivered from the IR LED will be fallen on the IR sensor, by which the IC generates logic low signal for the microcontroller. [5] Based on this signal the controller can understand that there is no vehicle present over the platform. Whenever the vehicle is placed over the platform, the signal beam will be interrupted and hence the IR sensor doesn't detect any IR energy. This in turn circuit output will become high; based on this signal the controller identifies the presence of car over the compartment. [7] As shown in **Fig. 2.**

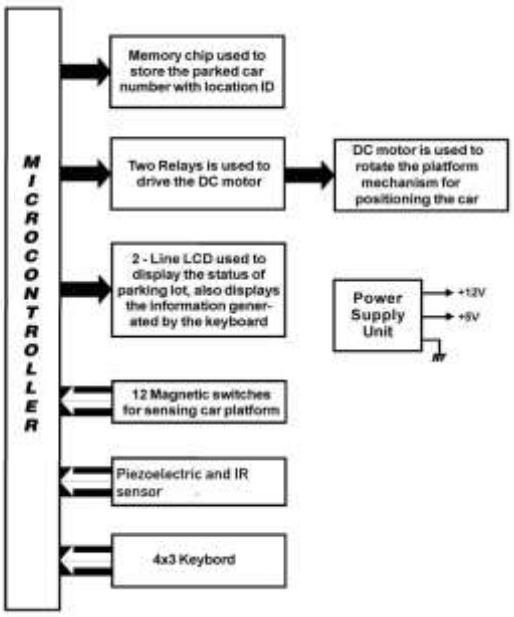

Fig. 1. Block diagram

Fig. 2. Total structure With IR , PIEZO sensor &Magnetic switches

C. Key Board

After parking the vehicle in the compartment the process begins with the keyboard, this keyboard interfaced with microcontroller as input source is aimed to enter the vehicle number and the corresponding password. Now the keyboard used here is configured in matrix mode of operation, 12 keys are used and they are formed as three rows and four columns. Out of these 12 keys, 10 are the numbers (0 to 9), one is the clear button and the last is the enter button. The function of this keyboard is to dial the vehicle number (3-digit) and by pressing the enter button, the display (LCD) asks to enter the password. As shown in **Fig.3.**

Fig. 3. 12keys Key Board

D. Display Section

The display section is designed to display the status of parking places, means which car is parked in which place. Status of entire 8 parking places (i.e. full or empty) will be displayed simultaneously in short form. Means if any particular number of slots is empty it shows 'E', similarly if it is full then the display shows 'F'. Like that all the slots status will be displayed. While parking the car its number and password has to be entered and while entering, the number will be displayed in the LCD. And for retrieving the vehicle again vehicle number and password has to be entered. The compartment number need not to be entered as the empty slot will be automatically placed at the ground level. The vehicle number, password and the compartment number are stored in the EEPROM by the controller. Likewise occupied car positions with their numbers are displayed in the LCD. Similarly vacant containers numbers will be displayed as 'E', which means empty. As the display section is designed with 2 - line LCD, all the 8 slots status can be displayed simultaneously. As this LCD contains 16 characters in each row, and 32 characters together in two rows, all slots information can be displayed in short-cut manner. As shown in **Fig.4.**

Fig. 4. 2 line LCD

E. Micro processor

The controller used here is belongs to 8051 family architecture & often it is referred to as MCS-51. This microcontroller is having an 8-bit data bus. As shown in **Fig.5.** In this family some of the controllers are capable of addressing 64K of program memory and a separate 64K of data memory. The 8051 has 4K of code memory implemented as on-chip Read Only Memory (ROM). The 8051 has 128 bytes of internal Random Access Memory (RAM). The 8051 has two timer/counters, a serial port, 4 general purpose parallel input/output ports, and interrupt control logic with five sources of interrupts. Besides internal RAM, the 8051 has various Special Function Registers (SFR), which are the control and data registers for on-chip facilities. The SFR's also include the accumulator, the B register, and the Program Status Word (PSW), which contains the CPU flags. Programming the various internal hardware facilities of the 8051 is achieved by placing the appropriate control words into the corresponding SFR's. [10].

Fig. 5. Processor

Fig. 6. Controller

Fig. 7. Programming

F. DC Motor

DC motors are widely used, inexpensive, small and poweful for their size. They are most easy to control. One DC motor requires only two singals for its operation. They are non-polarized, means you can reverse the voltage without any damage to motor. DC motors have +ve and –ve leads. Connecting them to a DC voltage source moves motor in one direction (clockwise) and by reversing the polarity, the DC motor will move in opposite direction (counter clockwise). As shown in **Figure. 8.**

Microcontroller is programmed to give outputs at port pins which are fed to the DC motor driver circuit i.e., relays. The driver output is fed to the DC motor, responsible for driving the mechanism. Crystal frequency used in the circuit is 12 MHz .The code to drive DC motor is written in 89C51 using assembly language and consequently simulated on "Keil µVision". The program is uploaded on 80C51 controller using "Flash Magic". [12] As shown in **Figure. 7.**

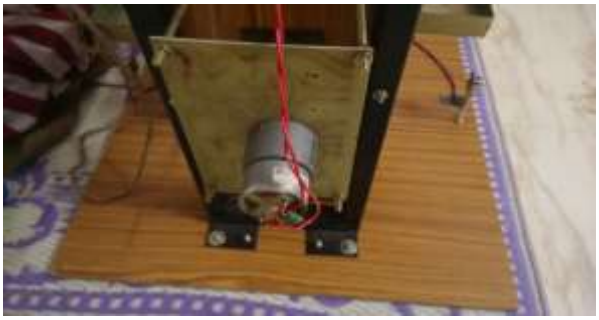

Fig. 8. D.C. Motor

G. Magnetic switches

The magnetic switch arranged at a fixed position of metal structure is for identifying the home positions at both mechanisms. In idle condition, the compartment should always remain at its home position, i.e. ground level when compartments are empty. As shown in **Fig.2.**

III. Design of Mechanical Structure

Design is the creation of a plan or convention for the construction of an object or a system (as in blueprints, engineering, and circuit diagrams). Design has different connotations in different fields. In some cases the direct construction of an object (as in pottery, engineering, and graphic design) is also considered to be design. As shown in **Fig. 2.**

A. Cabin Design

Under design of cabin there are certain assumptions to be made such as car dimensions (as length, width, height) based on which the dimensions of plate can be assumed. So car dimensions (length × width × height) = (6 × 3 × 3) inch. In addition to that cabin should withstand the load of car which was assumed as 500 grams. Taking clearance of 1.5 inch between each cabin, we had assumed eight cabins in our Prototype model of "rolling car parking". Based on that cabin dimensions are assumed as (7.5 × 4.5 × 4.5) inch. As shown in **Fig.9.**

B. Cabin Rods

Cabin rods are joined to the bottom plate by welding technique called arc welding. We know the strength of arc welding so joined the cabin roads to the bottom plates by arc welding technique. As shown in **Fig.9.**

(Since total weight of the cabin with car = 0.5kg)

$$\sigma = \frac{Load}{Area} = \frac{0.5kg \times 9810mm/s^2}{\frac{\pi}{4}(4mm)^2} = 390MPa \quad (1)$$

Maximum Stress on the welded joint is calculated which is less than 470 MPa.

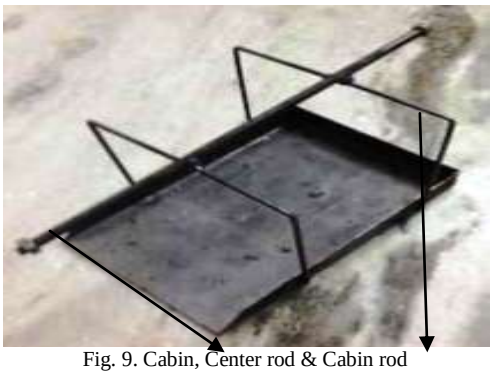

Fig. 9. Cabin, Center rod & Cabin rod

C. Centre Rod

Centre rod is attached to cabin by welding, cabin rods are welded to centre rod at two different points. The two point load is acting on centre rod at two different points at equal distance from both ends. so all reaction forces acting at the respective points are equal, due to symmetrical load is acting at equal distances.

Maximum deflection will be at the centre of the rod so deflection is found at the centre.

$$Y_{Max} = -\frac{wa(3l^2 - 4a^2)}{24EI} \quad (2)$$

$$= \frac{0.5 \times 9.81 \times 8.5(3 \times 25.5^2 - 4 \times 8.5^2)}{24 \times 2 \times 10^2 \times \frac{\pi}{64} \times 7^4} = 1.44 \times 10^{-5} mm$$

D. Centre Distance

At any given instance there are three cabins between the two vertical gears as we assumed eight cabins in project accordingly calculated.

Height of the cabin = 4.5 inch.

Clearance between cabin = 2 inch.

Based on the height of the cabin and clearance between the cabins vertical height of side wall is taken appropriately.
Centre distance between cabins = (4.5+2) × 2.5 × 3

=48.75 ≅ 50 cm

E. Gear Selection

There are three types of chains hauling chains, conveyor chains, and roller chains. Roller chain is the type of chain drive most commonly used for transmission of mechanical power on many kinds of domestic, industrial & agricultural machinery, including conveyors, wiredrawing machines, Vehicles. It consists of a series of short cylindrical rollers held together by side links. [24] Because for silent roller chains there should be minimum number of teeth is 18.Based on number of teeth the gear we have chosen is spur gear.
For silent gears minimum number of teeth is 18 for 10 R.p.m speed.

Speed ratio = 1, Speed of gear = 10 R.p.m
Hence number of teeth = 18

F. Chain links

A chain is a series of connected links which are typically made of metal. A chain may consist of two or more links. Chains are usually made in one of two styles, according to their intended use. More complex methods may be used to link together indices that overlap by more than period. We know the pitch of the chain, center distance between the gears and number of teeth. Accordingly the calculation of the number of links required and length of the chain was done.[13]
Pitch = 1.3 cm
Centre distance = 50 cm
$Z_1 = Z_2 = 18$

$$Link = 2\times\frac{50}{1.3}+18+\frac{(18-18)^2}{2\pi}\times\frac{1.3}{50}=96links$$

G. Motor rating calculation

Motor required specification for our application.
Total weight of cabins = 8 × 0.5 × 9.81 = 40 N
Torque required = $\frac{40\times6}{1000}$ N-*M*
Power = $\frac{2\pi NT}{60}=\frac{2\times\pi\times10\times0.29}{60}$ = 0.25 watt
Motor is of +12 volt rating so,

$$P=VI\Rightarrow I=\frac{P}{V}$$

∴I = 0.25/12 = 20 milli Amps.

IV. Result and Discussion

- Eight cabins in our Prototype model of "rolling car parking". Based on that cabin dimensions are assumed as (7.5 × 4.5 × 4.5) inch.
- Cabin supporting rod working stress was 390MPa, but Maximum Stress on the welded joint is calculated which is less than 470 MPa. So Cabin supporting rod diameter 4mm is safe dimension.
- Centre distance between cabins 50mm.
- Spur gears with minimum number of teeth are 18 for 10 R.p.m speed.
- Number of links are 96 required and 124.8 cm length of the chain was required.
- DC Motor (+12 volt rating) was required.
- Microcontroller is programmed to give outputs at port pins which are fed to the DC motor driver circuit i.e., relays. The driver output is fed to the DC motor, responsible for driving the mechanism. Crystal frequency used in the circuit is 12 MHz .The code to drive DC motor is written in 89C51 using assembly language and consequently simulated on "Keil µVision". The program is uploaded on 80C51 controller using "Flash Magic".

V. Conclusion

The advantages of this parking model are: -

- Quick Automated Parking and retrieval of vehicles.
- Up to 8 cars can be easily and safely parked.
- Surface space required equivalent to just 2 surface car parking spaces.
- Does not require a parking attendant.
- Easily constructed in a small area, just requiring a simple concrete base and phase supply.
- This system is cost effective when extra land for surface parking is not available.

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