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MODELING AND SIMULATION OF AN AUTOMATIC CAR PARKING SYSTEM

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ABSTRACT

In handling the difficulty of parking cars at the Polytechnic, Ibadan where there is no distinct parking bay, a solution to reduce the drivers' searching time for parking their cars will greatly save time and improve the traffic flow on campus. The objective of this Paper therefore, is model and an Automatic Car Parking System with a single entrance barrier and a single exit barrier. A Liquid Crystal Display (LCD) unit is provided to display the information about the total number of cars already parked and to specify if the park is full. The major component used is the PIC microcontroller programmed in Micro-C. The model is unique in that it is controlled by software, which can be modified at any time the system demands a change. It should be noted that the automatic car parking system is not a security device and should not be construed as one.

In conclusion, recommendations were drawn for an improved, effective, and security gate system.

Keywords: Microcontroller, Traffic, Micro-C Language, Car Sensors and Parking.

1.0 INTRODUCTION

Parking is a challenging endeavour in Nigeria especially in Oyo state and at the Polytechnic, Ibadan in particular. This is because there are no standard car parks in the state. Drivers as such have no option but to park indiscriminately along the road sides causing traffic congestion. Finding an available parking spot might take a very long time leading to missed appointments, traffic violations, or even accidents. Pollution due to exhaust, congestion due to driving around

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for the search, and illegal parking due to lack of other options are also possibilities. Among the various types of parking lots are; multilevel parking, roadside, roadside with ticket and barrier gate. Drivers do not have any choice but to search for parking areas on their own thus, creating traffic congestion.

2.0 LITERATURE REVIEW

Today, people (motorists) greatly depend on automobiles (such as motor vehicles, motor bikes, trucks to mention but few) to commute to their destinations. Current car park management is dependent on either human personnel keeping track of the available car park spaces or a sensor based system that monitors the availability of each car park space or the overall number of available car park spaces. In both situations, the information available was only the total number of car park spaces available and not the actual location available [1]. Parking of cars in a parking area is becoming a difficult task as the number of cars increases while the number of parking spaces is finite [2]. As a result, people would spend a certain amount of time looking for parking space and thus cause a situation where the traffic would be slowed down and cause congestion [3]. However, various measures have been taken in attempt to overcome the traffic problems.

Related Work

This section therefore, reviews and compares the various car parking systems available stating their methods of operations, and disadvantages.

[4], developed a vision based system using a number of cameras to detect available parking bay locations. The method is robust and cost effective [5], 6]. It provides the specific location of vacant spaces and not just the total number of spaces. However, detection performance is affected by environmental conditions [7].

Car Park Occupancy Information System (COINS) was designed by [8], using Image/Video based techniques. The system is expensive and involves large some of data to be transmitted along the network.

A Reservation-based Smart Parking System was designed by [9]. It is used to detect and provide information on the location of available parking areas. However, its performances are affected by types and sizes of sensors used [10].

[11, 12], developed a Car Park Management System that reduces parking time using Infrared sensors. The system is simple but slow [13]. [14], modeled a less space, low cost and secure Password-Based Rotational Multistory Car Parking System. However, the system cannot take care of large volume of traffic. A remote controlled gate system was designed by [15], to avoid

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the stress of manually controlling the gate. [16, 17, 18], designed a parking system that uses Ultrasonic Detector to assist drivers searching for vacant spaces in the park. The system provides relevant information for the drivers [19]. An Electronic Parking Fee Collection Based on Vehicle Number Plate Recognition was developed by [20]. The system is effective but waste drivers' time. [18], designed a Camera-Based Sensor Parking System that has a display board used at the entrance to show whether the bay is full or not. However, it doesn't give the exact empty space.

3.0 METHODOLOGY

The model is divided into Hardware and Software sections.

3.1 Hardware Design Consideration Section (see Figure 1).

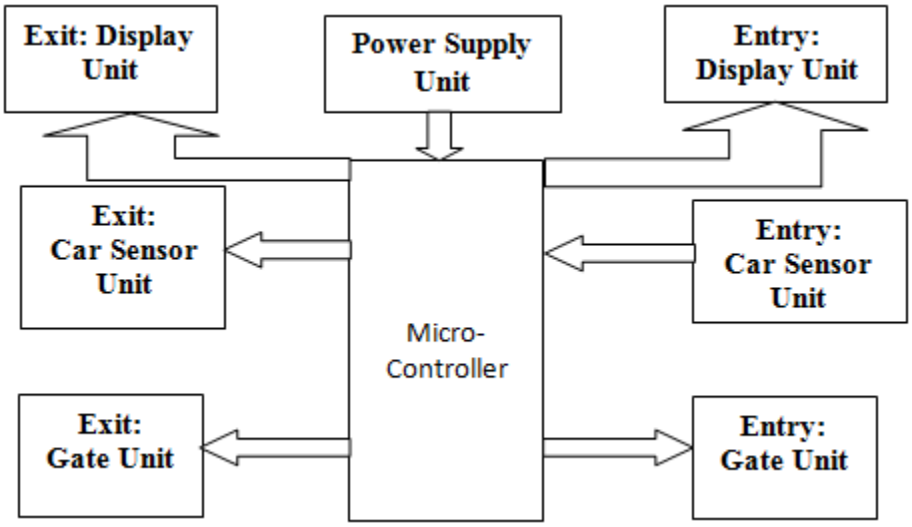

Figure 1: Block diagram of the Automatic Car Park

This section consists of the Sensors, CPU, Display, Gate Control, Power Supply, and Keypad (optional) Units.

1. Sensors (for (Entrance and Exit) **Units** – (see Figure 2).

The sensors provide an input signal to the system. They detect the presence of a car when approaching the barriers. In this design, Infra-Red LED (IR-LED) and Phototransistor circuits are used as sensors. The IR module was chosen because a receiver having a line of sight communication with the transmitter is needed.

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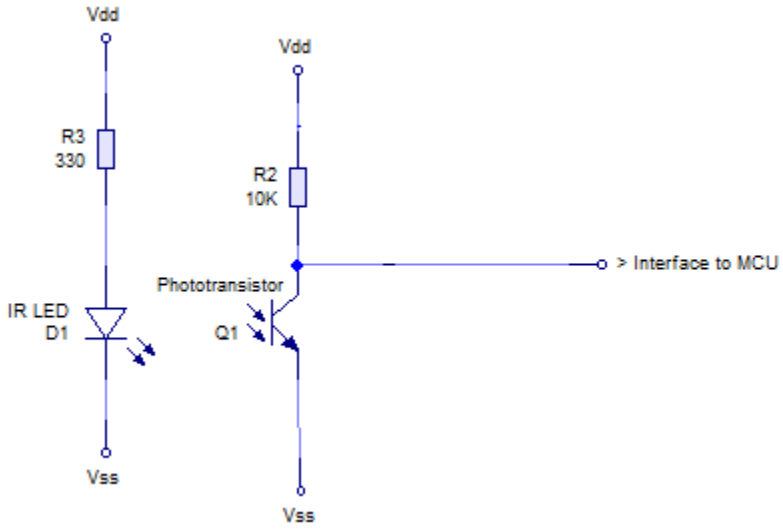

Figure 2: Car Sensor Unit (Entry and Exit)

In this design, six (6) pairs of sensors are used; three pairs are used for the entrance gate, and the other three pairs for the exit gate. The outputs from the sensors unit are part of the triggering circuitry and are connected to the ADC input of the microcontroller.

These sensors are as follows; Car-Sensor_En, Barrier-Sensor_En, Barrier-Sensor_En2, Car-Sensor_Ex, Barrier-Sensor_Ex and Barrier-Sensor_Ex2.

2. CPU Unit

A low-cost Microcontroller and a PIC 16F84 type 8-bit Microcontroller was chosen. The PIC 16F84 contains a flash program memory which can easily be programmed using a suitable programmer device. This makes the development and testing an easy and a relatively quick task.

3. Display Unit

The display unit consists of the Liquid Crystal Display (LCD-1602). This can display sixteen (16) characters on a line and has two rows and uses a 7-segment configuration to form the decimal characters 0 through 9 and sometimes the hexadecimal characters, A through F. The output of the Counter cannot be connected directly with the 7-segment display; it needs a driver. The unit sends signals to the driver each time a vehicle crosses the gate.

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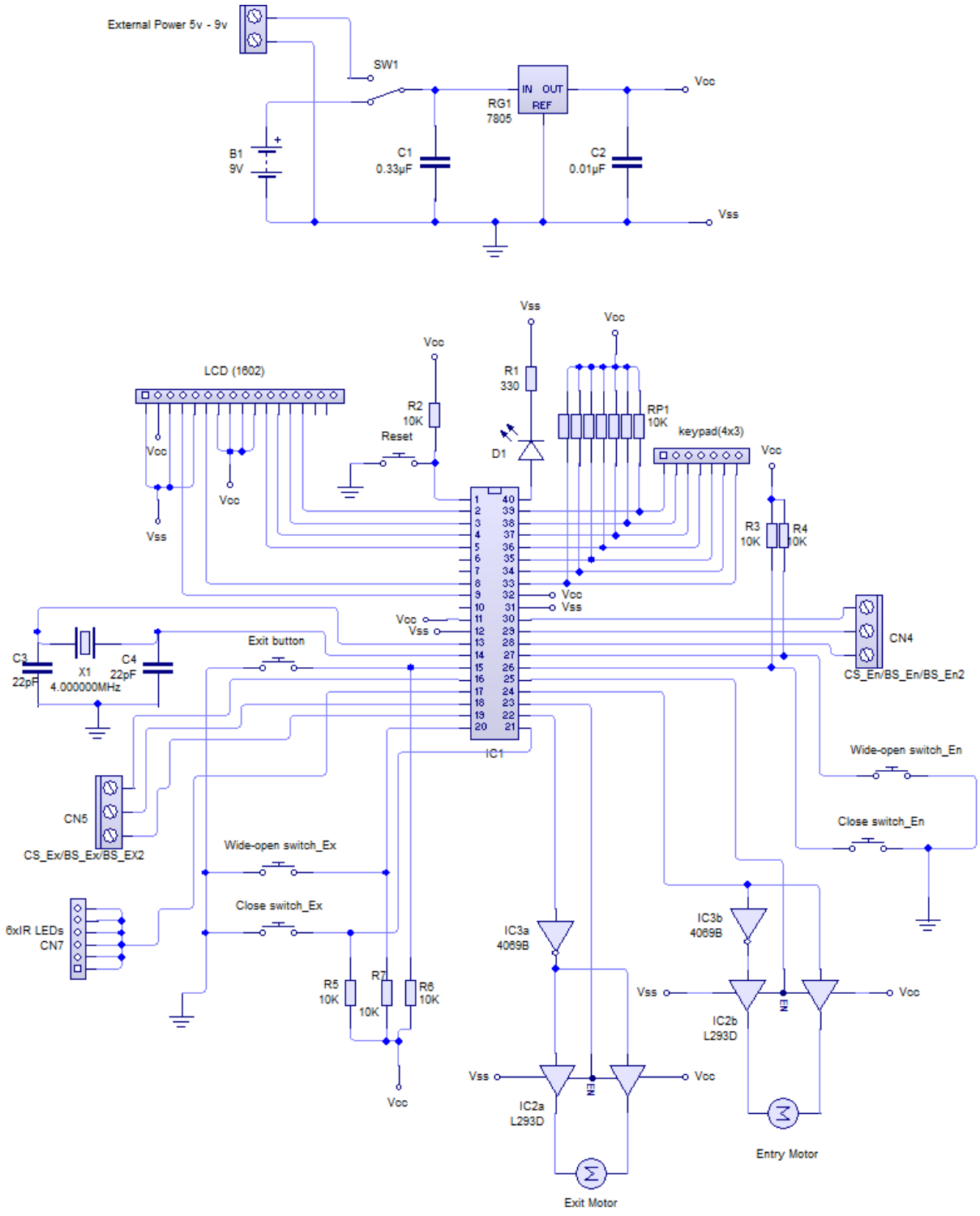

Figure 3: Modeled Circuit Diagram of the Automatic Parking System

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4. Gate Control Unit (see Figure 3)

The gate control circuit is used for both entrance and exit gates. The D.C. motor is used to control the opening and closing of the gates. The motor has the ability to rotate in both directions simply by reversing the polarity. The L293D used provide bidirectional drive currents of up to 600mA at voltages from 4.5 V to 36 V. it is designed to drive D.C. motors.

5. Keypad (Optional) – see Figure 3.

It will be located at the Entry barrier, to restrict unauthorized access into the car park.

6. Power Supply Unit

The PIC 16F877microcontroller used operates on a voltage (V_{DD}) of 5V (see Figure 4).

Power Supply Requirements:

Power must be kept at maximum of 500mW and an output Voltage of 5V.

Hence, the maximum current $(I_{max}) = \frac{Power}{Voltage} = \frac{0.5}{5} = 100mA \; or \; 0.1\text{A}$

$$= Resistor's \; value \; (R_1) = \frac{Voltage \; Drop}{Maximum \; Current}$$

$$= \frac{9-5}{0.1} = 40\Omega$$

The smoothing Capacitor, C1 is obtained from;

$$C_1 = \frac{I_{dc}}{4f(V_m - V_{dc}}$$

$$C_1 = \frac{0.1}{4\times50(9-5)}$$

$$C_1 = 125\mu F$$

It should be noted that C_2 could be of any value to improve the performance of the regulator. Therefore, C_2 is taking to be 10µF.

The regulator used (7805) regulator maintains a 5V DC supply voltage to the system.

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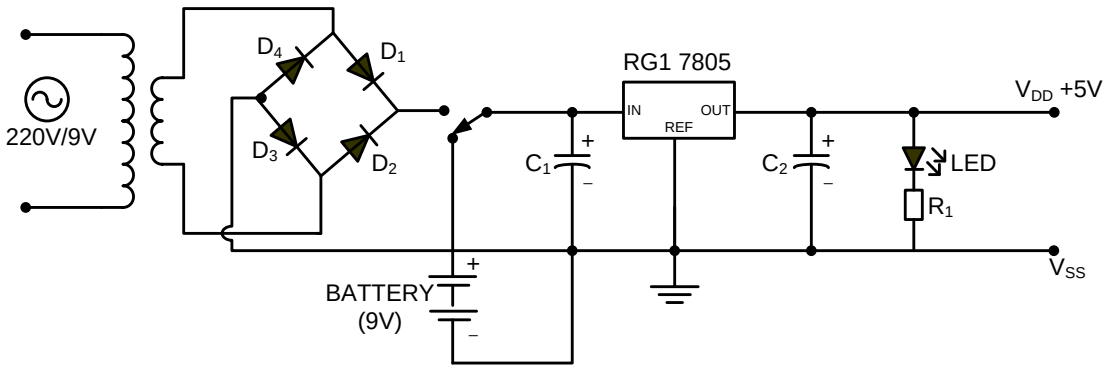

Figure 4: Power Supply Unit

3.2 Software Design Consideration

The software was designed using the following steps:

1. Algorithm/Flowchart.

2. Main Program (Micro-C Language)

1. Algorithm

The Algorithm used to implement the program for the Automatic Car parking System in the design is as follows:

1. Start
2. Configurations
3. Check if car park is full
    I. If full: update the LCD as FULL and go back to step 3
    II. Else Display the number of car in the park
4. Check if key is pressed and a valid code entered
    I. If pressed and a valid code entered go to step 5
    II. Else go to EXIT BUTTON (Step 10)
5. A car detected by Car-Sensor_En (CS_En)
    I. If detected:
        i. open the Entry Barrier
        ii. Restrict the barrier from over open by Wide-Open_switch_En

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II. Else Go to EXIT BUTTON (Step 10)

6. While a Car is not under the barrier (by Barrier-Sensor_En), Go to Step 7
7. While the tail of the Car is not under the barrier (by Barrier-Sensor_En2), Go to Step 8
8. Step 8
   I. Increment car counter
   II. Close Entry Barrier
   III. When the is full closed, stop the barrier dc motor
9. Go to Step 3

EXIT BARRIER

10. Check if EXIT BUTTON pressed
    I. If pressed: Go to Step 2
    II. Else Go to Keypad (Step 4)
11. A car detected by Car-Sensor_Ex (CS_Ex)
    III. If detected:
    IV. open the Entry Barrier
    V. Restrict the barrier from over open by Wide-Open_switch_Ex
    VI. Else Go to KEYPAD (Step 4)
12. While a Car is not under the barrier (by Barrier-Sensor_Ex), Go to Step 4
13. While the tail of the Car is not under the barrier (by Barrier-Sensor_Ex2), Go to Step 5
14. Step 5
    VII. Increment car counter
    VIII. Close Entry Barrier
    IX. When the is full closed, stop the barrier dc motor
15. Go to Step 3
16. END

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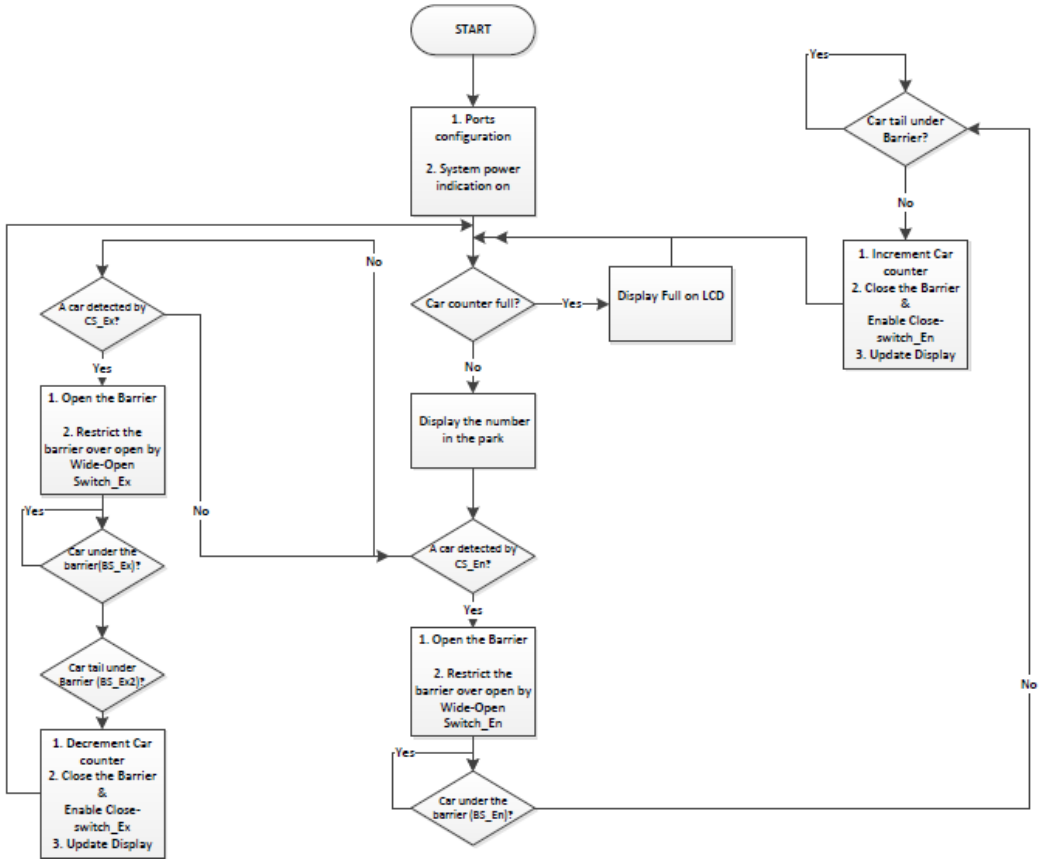

Figure 5: Flowchart of the Automatic Car parking System

2. Main Program (Micro-C Language)

The program for the system is written in Micro-C language. The program modules are segmented into: Declaration, Main program, Sensor subroutine, Delay subroutine, and Output (Gate Control) subroutine.

4.0 RESULTS AND DISCUSSION

Results (see Tables 1 and 2).

When the system is powered, the LCD will display the information about the total number of cars that are already parked in the car park and the free space available for parking. Six (6) IR TX – RX pairs are used to identify the entry or exit of the vehicles into/out of the park. Three (3) IR TX – RX pairs are arranged either side of the Entry gate and the other three (3) pairs at the Exit gate.

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The TX and RX are arranged face to face across the road so that the RX would receive IR signals continuously. When the main switch of the circuit was switched ON, the LCD displayed the message "Automatic Car Park System". The number of the cars already parked will be displayed. When a vehicle approached the gate, the IR signal gets intercepted and the microcontroller opens the barrier/gate by rotating the D.C. motor.

Discussion

Two (2) conditions are considered:

(a) When the light rays from the IR LEDs are directed at the Phototransistors (i.e Q_1, Q_2 and Q_3):

The output voltages of Q_1, Q_2 and Q_3 are low (approximately 0V).

(b) When the light rays from IR LEDs are intercepted by any passing car:

The output voltages of Q_1, Q_2 and Q_3 are high (approximately 5V).

The wide open switch connected to the barrier prevents it from opening beyond its limits (see Figure 3). The second and third IR TX – RX pairs prevent the barrier from closing until the tail of the car has left it. The barrier is closed only after the car has left the third IR pair.

The microcontroller then increments the value of the counter and displays it on the LCD. If the count reaches '10', i.e. if the park is completely filled up, the microcontroller will display "Car Park is Full" on LCD. However, if any vehicle tries to enter the park, the gate will not open since there is no more free space for parking (see Table 1).

Whenever a car leaves the park at the Exit gate, the sensors will send signal to the microcontroller. This will in turn send a feedback signal to the LCD, decrements the count and allows more cars into the park (see Table 2).

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Table 1: Results of the Test Strategy of the Automatic Parking System at the Entrance Gate.

Vehicle's Arrival at the Entrance Gate				Vehicle's in the Park (Already out of the Barriers)					
Car Sensor	Barrier Sensor 1	Barrier Sensor 2	Wide Open Switch	Car Sensor	Barrier Sensor 1	Close Switch	LCD Display (Counter)	Barrier Sensor 2	Close Switch
ON	ON	ON	ON	OFF	OFF	ON	Increment (1)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Increment (2)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Increment (3)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Increment (4)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Increment (5)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Increment (6)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Increment (7)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Increment (8)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Increment (9)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Increment (10) Car Park is Full	OFF	OFF
OFF	OFF	OFF	OFF	OFF	OFF	OFF	Car Park is Full	OFF	OFF

Table 2: Results of the Test Strategy of the Automatic Parking System at the Exit Gate.

Vehicle's Arrival at the Gate Exit				Vehicle's Departure from the Park (Already out of the Barriers					
Car Sensor	Barrier Sensor 1	Barrier Sensor 2	Wide Open Switch	Car Sensor	Barrier Sensor 1	Close Switch	LCD Display (Counter)	Barrier Sensor 2	Close Switch
ON	ON	ON	ON	OFF	OFF	ON	Decrement (9)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Decrement (8)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Decrement (7)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Decrement (6)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Decrement (5)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Decrement (4)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Decrement (3)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Decrement (2)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Decrement (1)	OFF	OFF
ON	ON	ON	ON	OFF	OFF	ON	Decrement (0) Car Park is '0'	OFF	OFF

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5.0 RECOMMENDATIONS AND CONCLUSION

5.1 Conclusion

The modeling and simulation of a microcontroller-based automatic car parking system had been achieved. It can be easily modified for implementation in any form of control system such as, the public car parks, residential parking lots, and automobile termini where no form of security measure is a priority. The advantages of this automated car parking system are; automatic opening and closing of gates, efficient usage of spaces thereby increasing the number of vehicles to be parked, time saving, reducing traffic congestion caused by illegal and indiscriminate parking along the road. However, It should be noted that the automatic car parking system is not a security device and should not be construed as one.

5.2 Recommendations

A form of Vehicle Identification and sensors such as 'radar sensor' or Wireless Sensor Networks (WSN) are recommended to improve on this model for faster operations and improved security purposes. Upgrading the system using higher bit-microprocessors for faster optimization is also recommended.

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