https://dx.doi.org/10.4314/dujopas.v11i1b.33
ISSN (Print): 2476-8316
ISSN (Online): 2635-3490
Dutse Journal of Pure and Applied Sciences (DUJOPAS), *Vol. 11 No. 1b March 2025*

Simulation and Construction of Intelligent Vehicle Parking System Using Embedded System Approach

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Abstract
In this work, we present an intelligent vehicle parking system using microcontroller mechanism system. The system searches, and displays available vehicle parking space. This vehicle parking system can confirm the availability of the parking space using a 7-segmented display system. The microcontroller is at the center of the work which sends coded command signals to both the entrance and exit gate and allows a vehicle to enter or leave the parking arena. Thereafter, the system will display the available parking space on the 7-segmented display. This work was also designed implemented and tested using computer-based simulation for accuracy, correctness and reliability which accommodate a maximum of 99 numbers of vehicles. If properly implemented in many different places like schools, offices, malls, and commercial buildings and it will drastically reduce or eliminate the problems of vehicles traffic.

Keywords; Microcontroller, LED Display, IR Sensor, Assembly language, MOSFET

INTRODUCTION
In densely populated cities In Nigeria and beyond, free vehicle parking space is increasingly and periodically becoming scarce, especially during the rush hour. Thus, open the opportunity for government to generate substantial amount of money in revenue through the utilization of every available space for parking of substantial number of vehicles in commercial and public places. However, as society grows with modern technology, eases the daily activities, the need for new vehicle parking regulations that may reduce or even curtail air pollution as a result of traffic congestion caused by driver's frustrations searching for parking space is needed. During rush hour, several drivers are found to be competing with each other for parking space which in most cases results in accidents in the parking arena Bonde, D. J. et al [2014]. For instance, according to the recent survey by Donald C. Shoup et al [2020] predicted a surge in demand for parking space to up to 40% will occur in the most densely populated cities in Nigeria. This means that densely populated cities in developing counties are prone to traffic congestion that causes delays and pollutes the environment.

However, another problem associated with the need for an automated vehicle parking system is normal parking lots are usually found to be more difficult and tight spaces to move along thereby causing unnecessary and preventable waste of time Tariq Jamil et al [2019]. The recent

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out-bust of automobile demand with inadequate available parking space in schools, hotels, and big companies requires the need for automation of vehicle parking systems thus providing an efficient utilization of the available space for automobiles and preventing congestion Sumathi and Pradeep Varma [2013]. A recent research study indicates that motorists searching for a parking space during busy hours in the business districts of Kano, Abuja and Lagos burn more than 47,000 liters of PMS (Petroleum Motor Spirit) as a result, burn over 740 tons of CO_2 corresponding to 45Km trips around the world. From both the ecological and economic point of view, there is the need for an immediate solution to the challenge.

Consequently, finding solutions to the problems that are associated with vehicle parking spaces is not an easy task. First, there is the need to satisfy all the parties involved such as the parking space providers and the vehicle drivers as well. This problem is not addressed by most of the present parking systems Suhas Mathur et al [2020] which only provide and direct motorists into available space using the available information collected demonstrating that the systems fail to be so "intelligent" enough to provide the solution to the problem, This usually worsens the situation to drivers for its inability to help them in locating the needed parking space especially in crowded areas. In a densely populated commercial areas for example, the available parking space are in most cases less than the demand as a result, causing too much traffic congestions. Under this circumstance, comprehensive information relating to the availability of parking space will help motorist in deciding where and when to get parking space.

The increase in demand for vehicles across most cities in the country contributed immensely to the present situation of shortages in the availability of car parking spaces which resulted in indiscriminate and unregulated parking of vehicles blocking highways meant for vehicle passages. In highly and densely populated settlements like Kano Old city and its environs, available vehicle parking space is becoming increasingly difficult to create by town planners and architects due to the unavailability of sufficient land. Therefore, the need to provide and utilize any available space for vehicle parking space cannot be over emphasized. This means that an automated vehicle parking system is the solution for all the respective stakeholders to achieve.

On the other hand, problems associated with conventional manual parking systems include vehicle vandalism and theft, accidents, indiscriminate parking, and uncensored movement of vehicles. Also, vehicle parking and avoidable car accidents are in most cases prevalent in the traditional or manual parking arena. A recent study shows that motorists looking for parking space in the commercial district of Sabon gari Market in Kano for example have risen from 20% to 80% of traffic jams M. M. Rashid and A. Musa [2024]. Also, the need for automated vehicle parking systems has dramatically risen from 20% in 2017 to 180% in 2023 even after the pandemic of COVID 19 the demand keeps raising in places like Kano and Abuja M. M. Rashid and A. Musa [2024].

Many researchers in the past postulate that only limited parking system without any provision of information about vacant parking areas cannot provide the needed efficient and effective way of vehicle parking system. This is because where there are too many cars to park during rush hour, there is always the possibility of someone blocking the way while searching for somewhere to park El Mouatezbillah et al [2022]. However, the intelligent vehicle parking system enables the user to count the available maximum number of parking lots and allocate a motorist into the space while decreasing the number of available parking and if a vehicle exits the space, the automated system increases the number of available slots.

This intelligent vehicle parking system is a digital system using a sequence of detecting electronic devices and sensors used to control the passage of vehicles at the entry and exit gates. The exit and the entry gates have been automated (Entry and Exit Gate) are connected to sets of sensors. Signals obtained from the sensors show when a vehicle is on the verge of the entrance gate or is at the exit gate which displays this information on a 7-segmented LED display. When fully implemented, the intelligent vehicle system works automatically without the need for any operator or attendant to control the passage of vehicles. It is cost-effective when compared with the manual or conventional parking system which allows more vehicles to park within a less given space.

METHODOLOGY

Simulation for the Intelligent Vehicle Parking System was conducted based on real traffic which uses GPS to navigate and trace the parking map, and consequently demonstrates the performance of the work in terms of the metrics using computer-based simulation Hongwei Wang et al [2011] On the other hand, the hardware circuit system uses a microcontroller generic part number which includes but is not limited to the family of 8031 up to 8751 that uses N-Channel MOSFET and uses Complementary Metal Oxide Silicon CMOS, which is interfaced with sensors to detect the parked vehicle. This microcontroller is a 4Kbytes of erasable and programmable Read Only Memory (PEROM) Lam, A. Y et al [2017].

The microcontroller used in this work is a product of Atmel's technology (high-density nonvolatile memory technology). This technology is designed to be compatible with standard MCS-51 (a set of instructions that control the microcontroller pins out). The on-chip Flash of the microcontroller is the program memory reprogrammable at the instances of the user. However, a combination of Flash monolithic chip with an 8-bit CPU provides the microcontroller AT89C52 to be efficient microcomputer with highly flexible and cost-effective for various standard user applications. Other hardware circuit components used in this work are as follows;

(i) The Microcontroller (AT89C52): This is the center of the work which mainly controls the other segment of the circuit through the attached 16 pins. Sensors that control the entry and exit gates are directly connected to the pins from where signals from the sensors are received by the microcontroller. In this work, for example, the microcontroller checks and detects the presence of a vehicle at the gate entry, and thereafter crosschecks the availability of free parking space. If the logic is true, then the entrance gate opens and decreases the number of available parking spaces by one after which the entrance gate closes. However, if the system senses the presence of a vehicle at the exit gate, the system automatically opens the exit gate thereby increasing the number of available parking spaces by one factor.

(ii) The ULN2003 Relay: This relay is used to control the amount of loads on the entire circuitry components. This device is also used to drive Stepper Motors.

(iii) The IC 74LS47: This device is also called the BCD to 7-segment decoder. This device accepts BCD (Binary Code Decimal) as input and subsequently converts the coded signal into a pattern for a 7-segmented displaying module from 0 – 9. The device uses an encoding module where each digit represents a binary sequence which is usually in the form of four digits.

(iv) The Stepper Motor: It is a digitized electric motor. The discrete movement of the motor is controlled by the command from the microcontroller, unlike the conventional motor which rotates continuously. When the need arises, the stepper motor can hold the entire load with

accuracy and stability to stabilize the torque. This motor is directly connected to the microcontroller P3.6, and P3.7 and connected to sensors via P3.0 as presented in Figure 1.

(v) The Common Anode 16 x 2 Segment LCD Display: This is a components that display the coded signal from **IC 74LS47 via** cathodes terminals of the 7-segments module. This device is connected via the 16-segmented pins each which functions as the received coded signals. The device is presented in Figure 2.

(vi) The Infrared Sensor: This device senses the incoming vehicle to the entry gate and the outgoing to the exit gate for allocation and closing of parking space. The sensor also helps the microcontroller to open or close the two gates respectively. Two infrared sensors are used in this work, one at the entrance and the other at the exit gate respectively.

(vii) The External oscillator circuit: This device is used in this work for the transmission of the coded signals connecting devices using an 11.0592 MHz channel.

(viii) The 10KΩ POT: This device is directly connected to the input terminal of the infrared sensors. It is mainly adjustable to increase the sensitivity of the Infrared sensor. It is also attached to the 16 x 2 LCD display which stabilizes the current on the LCD display. The device is connected to a microcontroller via PORT 1 Pins.

(ix) The Power supply: is the power segment of the entire work. This segment changes high AC voltage into a suitable low DC voltage supply.

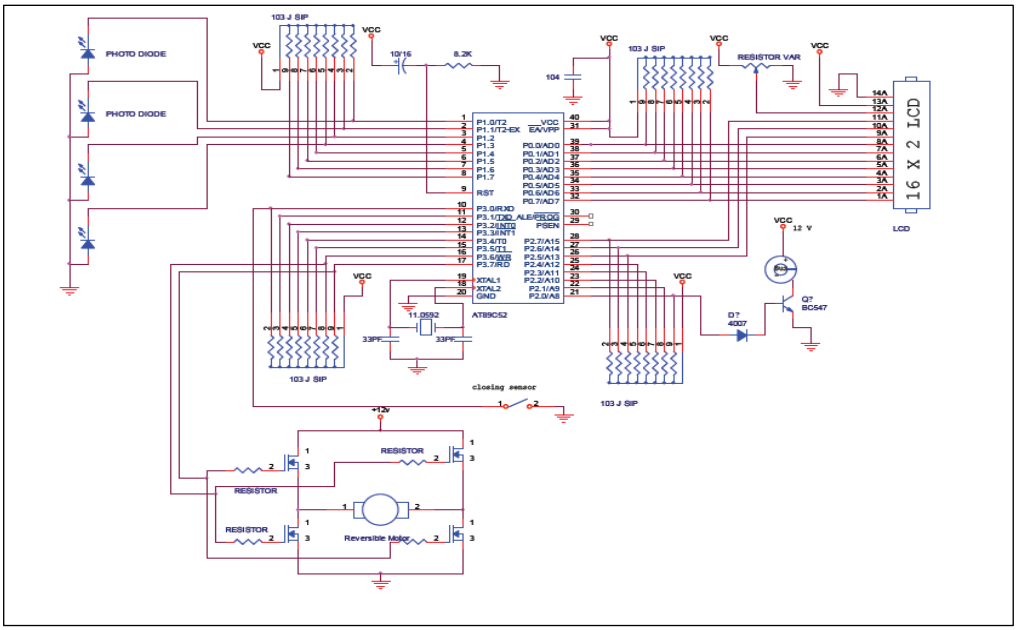


Figure 1. Complete circuit diagram for intelligent vehicle parking system

(x) The Software

There are two programmable software used in this work. The first is the RC-5 protocol which works in the receiver module that controls the hardware for **Microcontroller 8052 Cross compiler** for communication between CAN bus. It is used to control the communication between the microcontroller and the infrared devices attached to it. When tested, a number from 35 to 40 feats were successful for data transfer to the CAN bus via the loopback self-test mode. The prototype software was developed using C-programming language. The entire module was categorized into different modules according to the requirements for the work.

As demonstrated below in the snippet code, the program controls from the initial operation to the device internal requirement, setup and interrupt communication. The software was tested in sampling mode and consistently checks its progress if complete or not. After the process is entirely completed, the generated data is encoded for compilation and sent as a message, and execute the command at the other end is for message interpretation. If the command at the other end conforms to the coded signal, then the authentication process becomes successful thereby the vehicle parking process concludes with the operation successfully done. However, if the same procedure occurs, but the authentication process fails, an alarm is generated for security and a signal is sent for unauthorized exit.

Assembly language for 8052: This is the programming language that is used and by default understood by the microcontroller. The instruction is typed on a notepad or dos environment and saved with, .ASM extension

The Microcontroller 8052 Cross compiler: executes instructions from files with, .ASM file extension for all types of 8052 assemblers

The Universal Programmer software: This is the type of microcontroller assembler that changes the, .ASM file to. HEX file.

The ORCAD for PCB designs the layout: This is the second compiler that reads the data and translates the instruction into the universal operating programming language

The Microcontroller Assembly Code

The microcontroller assembly language is a set of instructions written in pseudo-code. This code when written will automatically translate its equivalence to drive the microcontroller under the given set of instructions. The code e used in this work is presented below;

Pseudo Code:

```
Initialize
Free Space = 99
Number of Parked Car = 0
IF (Number of Parked Car <= Free Space)
Write number of Free Space on Display Unit
IF (Entry Gate sensor is ON)
Unlock the Entry Gate
Number of parked car ++
Free Space --
        Lock the Entry Gate
ELSE (Exit Gate Sensor is ON)
        Unlock the Exit Gate
Number of parked car –
Free Space ++
        Lock the Exit Gate
        ENDIF
ELSE
        Write Free space is zero
ENDIF
```

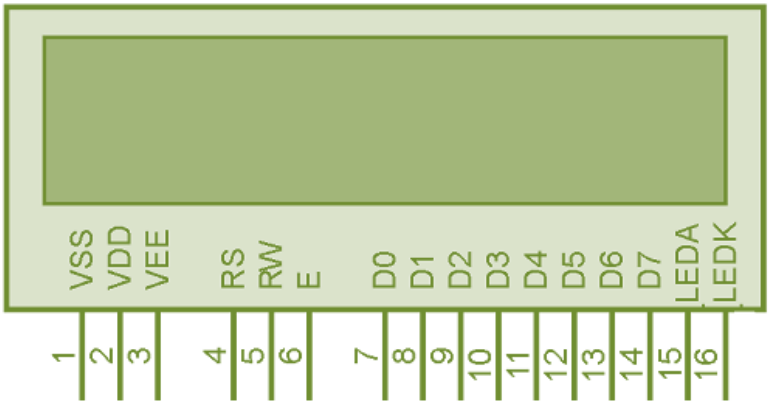


Figure 2. Represents 16 x 2 Segment LCD Display showing the configuration fins

RESULTS AND DISCUSSION

The complete circuit for the Intelligent Vehicle Parking System is presented in Figure 1. The microcontroller is the backbone of the whole electronic circuit. When data is received, the microcontroller reads and processes the data after which subsequently sends the processed sequence of signals to stepping the motor. However, if the input signal of sensor 1 is jammed or blocked, the stepper motor rotates in the clockwise direction indicating the vehicle movement. Sensor 2 function as a device that limit the gate-opening sensor. This means that when sensor 2 is activated by the vehicle movement, the entry gate begins the opening process. But if the motor starts rotating in the anti-clockwise direction, the gate closes. However, if sensor 3 = 0, this indicates that the gate is completely closed. An indicator with a green LED shows that a car has entered the parking lot. This display is basically for the motorists while the serial interfacing display is for the person in the control room. However, when the first car enters the gate, the LED displays "Welcome to parking place". Next, the Light Emitting Diode displays whether the next space is full or empty. If there exists a vacant parking slot, the LED shows the vacant parking slot number and then activates the motor to open the entry gate.

As the process continues, if there is no vacant vehicle parking space, the LED display board shows 'All slots full'. Finally if there exist no available parking space, the module deactivates the exit gate permanently. The infrared used functions as a motion sensor that responds only to the motion of four-wheeler vehicles. The transmission infrared sensor is tagged as (TX) while the receiving infrared sensor is also tagged as (RX). The block diagram for the intelligent vehicle parking system is presented in Figure 3 below.

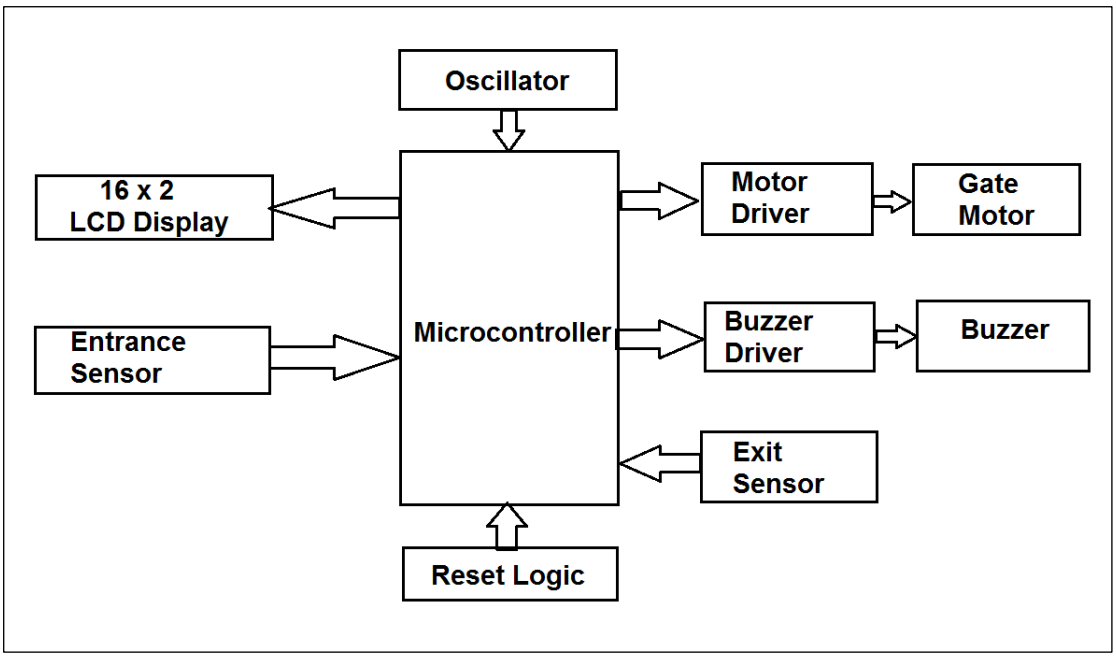
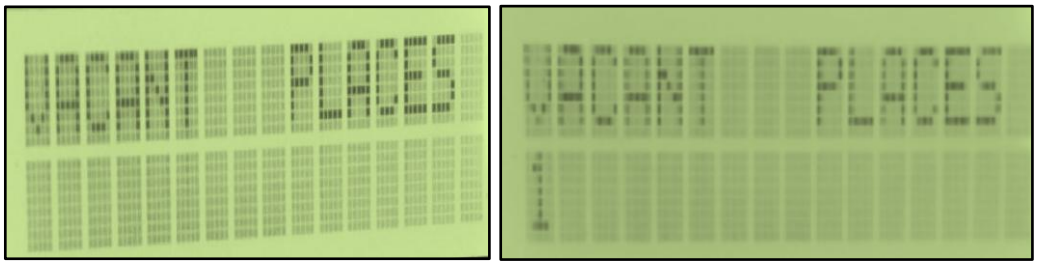


Figure 3: Block diagram for the Intelligent Vehicle Parking System

IMPLEMENTATION METHODOLOGY



A B

Figure 4. Demonstrates case A and B where the number of available parking spaces are displayed

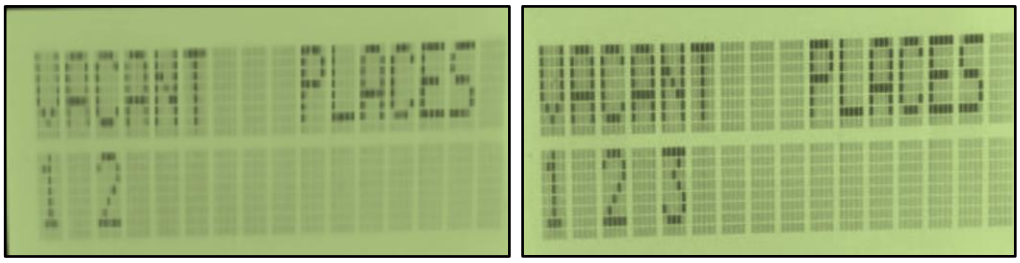


Figure 5. displays increasing number of available parking spaces.

This intelligent vehicle parking system was designed and tested using computer-based simulation to crosscheck its efficiency and correctness of its working condition. Both the simulation and the physical work show its perfect working condition of up to 99 numbers of vehicles. The simulation environment we used to crosscheck working conditions is Proteus V 7.2. The first result we received using simulation shows the maximum number of vehicle spaces that can accommodate and display "99 VACANT PLACES". However, when the system was tested by increasing the number of the vehicle to the module using the switch button that represents the entrance door, the modules display 1 to 98 and thereafter every switch button pressed, the number of available spaces decreased by a factor of 1 up to 99 where it displays "THERE IS NO VACANT PLACE"

This work represents another milestone different from the ones available in the literature. The modules' flexibility to accommodate more vehicles in the process without a limit makes it more powerful than before. An additional circuit can be attached on pin 16 of the main detachable circuit to increase any number of parking slots from 1 to 99 on the existing spaces.

CONCLUSION

In this work a model for an intelligent vehicle parking system is proposed and implemented. The model was constructed using a microcontroller based electronic circuit and tested in a computer-based simulation environment. When tested, the system can accommodate up to a maximum number of 99 vehicles. The system works perfectly and displays the available number of parking slots via 16 x 2 Light Emitting Displays (LED). Moreover, the work helps the motorist to identify the free available parking spaces. Future works can include a module that can identify and measure the distance between intending vehicles to improve the accuracy and reliability of space usage.

Acknowledgement

This work is sponsored by TeTFUND (Tertiary Education Trust Fund) under Institution Based Research IBR 2024, Aliko Dangote University of Science & Technology, Wudil.

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