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DESIGN AND CONSTRUCTION OF A CAR COUNTER USING PULSE INFRARED SENSOR

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***Abstract*—Due to insufficient parking spaces in our markets, hospitals, shopping malls and some big business areas, drivers face a lot of challenges while looking for a space to park their cars therefore wasting time and causing confusion at the parking lots. In this study, an electronic car counter was designed using a microcontroller and a pulse infrared sensor. The Arduino Atmega 328 was programmed using the C language and the circuit was simulated using the Proteus 8.0. The prototype of the circuit was constructed on a Vero board by soldering each component permanently after testing it temporarily on a bread board. The device was tested and the number of times the system detected a car, undetected cars and wrong output were used to calculate the sensitivity and accuracy of the device. Results show that, out of forty (40) trials the number of times the system responded was thirty eight (38), number of undetected was two (2) and the number of wrong output was zero (0) corresponding to a sensitivity was 100% and accuracy of 95.00%. The device can be of great important to be used in the public areas where there are limited parking space to control the traffic and minimize human effort.**

Keywords—Counter; Infrared; Sensors; Proteus; Arduino; Construction

I. INTRODUCTION

In today's world, properly maintaining the traffic system is a very laborious job. As the day goes by the number of vehicles increases in exponential rate and so it becomes paramount that traffic control becomes automated for easy access especially at the parking lots. Automatic vehicle counting is a key technique to monitor and estimate flow of traffic. Vehicle detectors have been in use for over fifty years and the most common are, inductive loops or ellipses of wire buried in the roadway [1]. Therefore, car counting is important and helpful to optimize the traffic signaling system [2, 3] and to help redirect incoming cars to less denser area for easy parking [4]. Traffic control requires measuring the number density of vehicles and their movement [5]. Traffic monitoring and measurement provide critical information for capacity planning, accounting and billing, anomaly detection, and service provision in modern computer networks [6, 7, 8].

In Nigeria, drivers face a lot of difficulties in trying to locate a parking space especially in the market areas. Spending much time to locate an empty slot may course some drivers to park their cars on the exit or entry lanes. Some drivers may even block the properly parked cars from proper exit, leading to driver's disagreements and collision as they attempt dangerous maneuvers to exit. Though, in some part of the country the technology of car counter are already in use, but most of which are very expensive due to high cost of importation and only few can afford it [9]. Therefore, there is a need to design and develop a car counter system; which is inexpensive, more reliable and qualitative in order to compete with other developed countries and minimize importation of similar systems [9]. In this study, a car counter system is designed, simulated, constructed, and tested using a pulse infrared sensor.

An infrared sensor is a sensor that detects the absence or presence of infrared beam and from the detection they give an output to the circuit to process the collected data [4]. There are two types of sensors in this category; Passive and active infrared sensors. According to [4] a passive infrared sensor (PIR sensor) measures infrared (IR) light radiating from objects in its field of view. They do not generate or radiate any energy for detection purposes; they work entirely by detecting the energy given off by other objects. An active infrared sensor consists of a photo transistor or diode which receives the transmitted signal from the infrared transmitter [10]. The photo transistor is in a mild or non-conducting mode until it receives the infrared signal. In this study, the active infrared sensor was used.

The car counter using a pulse infrared sensor is significant to all individual car owners' especially commercial drivers at the garage, governmental and non-governmental organizations like; office and shopping center. A good implementation in many car parks will guides the drivers to park at the available parking spaces in the shortest time, increase parking utilization, optimize parking environment and improve the customers' satisfaction.

II. MATERIALS AND METHOD

A. *Materials*

The materials and their specification that were used for the design and construction of a car counter using pulse infrared sensor includes Atmega 328 microcontroller, 16x2 LCD, IC555 timer, TCRT5000 IF sensor, 7805 Voltage regulator, IN4007 Diode, 5.1V Zener, 9-18V battery, 10k Potentiometer, Resistors, Capacitors and switch. The Atmega 328 pin out is shown in Fig. 1.

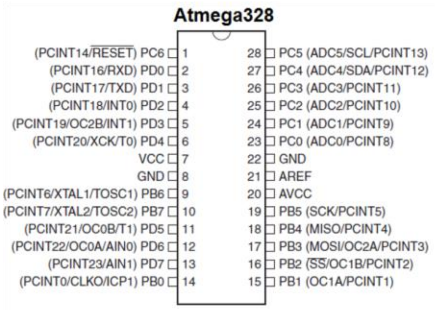

Fig. 1. *Pin out for ATmega328 (Learn About Electronics, 2019)*

B. *Methods*

The method for the implementation of the car counter system is in four (4) stages including design analysis, simulation, construction, and testing. The design is carried out using TCRT5000 infrared sensors and ATmega328 microcontrollers. The microcontroller is programmed using the Arduino C language and simulated using Proteus 8.0 software. The construction of the prototype was carried out on a Vero Board. The device was tested for accuracy and sensitivity to ensure optimum performance.

1) *Design method:* The design of the car counter was carried out stage by stage following the block diagram in Fig. 2.

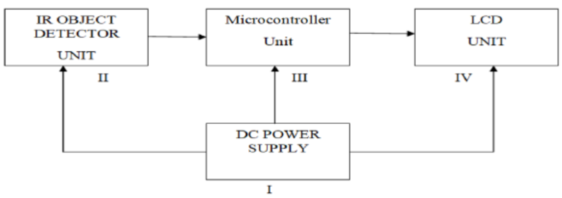

Fig. 2. *Block diagram of the car counter*

a) *Power unit:* This unit takes care of the power supply required for the systems operation, it consists of a 12V battery, D1 diode, switch, 7805 voltage regulator, C1 and C2 capacitors, D2 zener diode which also serves as a backup for the 7805 voltage regulator and R1 variable resistor. To calculate the capacitance of the capacitor we have:

$$C = \frac{I}{V} \tag{1}$$

where,
C = Capacitance of the capacitor
I = Output current of the 7805 voltage regulator
V = Output voltage of the 7805 voltage regulator

b) *Infrared unit:* This unit consists of two TCRT5000 infrared reflectors.

c) *Microcontroller unit:* This unit consists of Crystal, ATmega328 microcontroller, R2 variable resistor, R3 resistor and D3 diode. Ohms law is used to evaluate the resistance of R3 resistor.

$$R = \frac{V}{I} \tag{2}$$

where, V and I are the output voltage and current of the ATmega328.

d) *LCD unit:* This unit consists only of an LCD and a voltage limiting resistor R4, whose value is calculated using equation. 2.

2) *Simulation method:* The simulation method involved the development of software and flowchart for the operation. The flow chart is as shown in Fig. 3. The basic software program is written using the Arduino language program. The choice of Arduino C language programming is chosen because it is more compatible with the Arduino programming software.

3) *Construction method:* The construction of the circuit was done in two parts which include component temporary assembly and placement on a bread board and then Soldering of components on a Vero Board on a permanent basis.

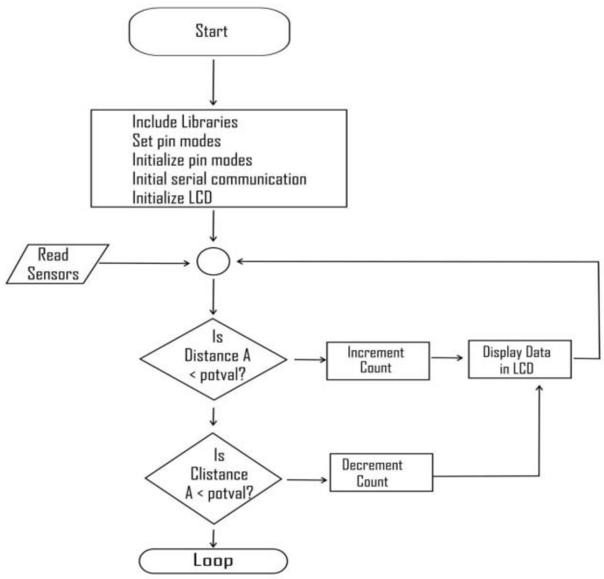

Fig. 3. *Flow chart of the system*

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4) Testing method: The following tests were conducted on the constructed device to ensure proper functioning.

a) Sensitivity test: This test helps determine how sensitive the car counter is to cars moving within its range.

$$Se = \frac{N_R}{N_R + N_U} X\ 100 \qquad (3)$$

b) Accuracy test: This test determines how accurate the car counter is in its counting for both incoming and outgoing cars.

$$Acc = \frac{N_R}{N_R + N_U + N_W} X\ 100 \qquad (4)$$

where;
N_T = Number of trials
N_R = Number of times the system responded
N_W = Number of wrong output
N_U = Number of undetected cars

III. RESULTS

A. *Design Analysis*

1) Power supply unit: The circuit diagram with its corresponding components value is shown in Fig. 4. This unit is made of the input DC battery, Diode, 7805 voltage regulator and capacitor whose capacitance is calculated using equation (1) as follows.

$$C = \frac{5\ X\ 10^{-3}}{5} = 1mF$$

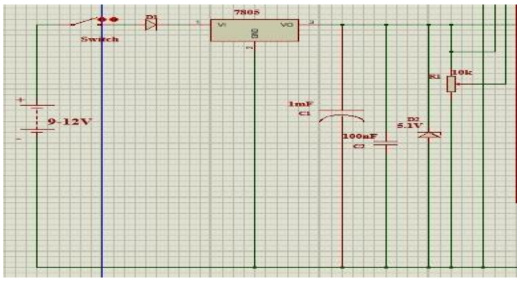

Fig. 4. *DC Power supply unit*

2) Infrared object detection unit: This unit is made up of two TCRT5000 infrared detectors connected to both the microcontroller and 5V power supply. Fig. 5 shows this circuit with its components.

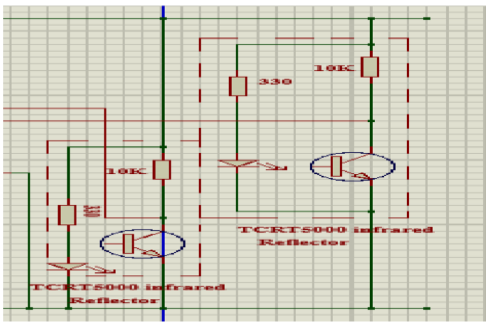

Fig. 5. *Infrared object detection unit*

3) Microcontroller unitt: This unit consists of two TCRT5000 infrared reflectors.

a) Microcontroller unit: The circuit diagram for this unit is as shown in Fig. 6. The resistance of the R3 resistor is obtained using ohms law equation (2) having in mind that ATmega328 outputs a maximum of 40mA and in this case a 5V voltage. Thus, R3 can be calculated as follows.

$$R_3 = \frac{5}{40\ X\ 10^{-3}} = 125\Omega$$

(120Ω was used as standard value and a good substitute).

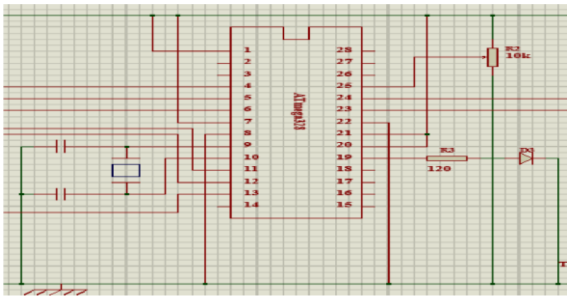

Fig. 6. *Microcontroller unit*

4) LCD unit: The LCD display for the circuit system is as shown in Fig. 7. The value of the voltage limiting resistor R_4 is obtained using equation (2) as follows:

$$R_4 = \frac{5}{5\ X\ 10^{-3}} = 1k\Omega$$

B. *Circuit Simulation*

After the circuit was designed Proteus 8 software was used to simulate so as to check its workability. Fig. 8 shows the final circuit design from the simulated output. At the start, the microcontroller is initiated and the TCRT5000 infrared sensors are now ready to sense incoming or outgoing cars. Once it senses a car on entrance and its distance is less than the potval (potvalue), the count is increased and displayed on the LCD. Whereas, on exit, if the distance is again less than the potval, there is a decrease in the count and so is also displayed on the LCD. The process keeps looping at every end of a particular process of entrance or exit.

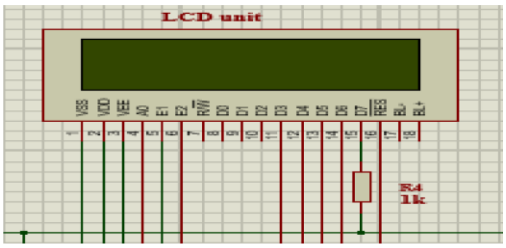

Fig. 7. *LCD unit*

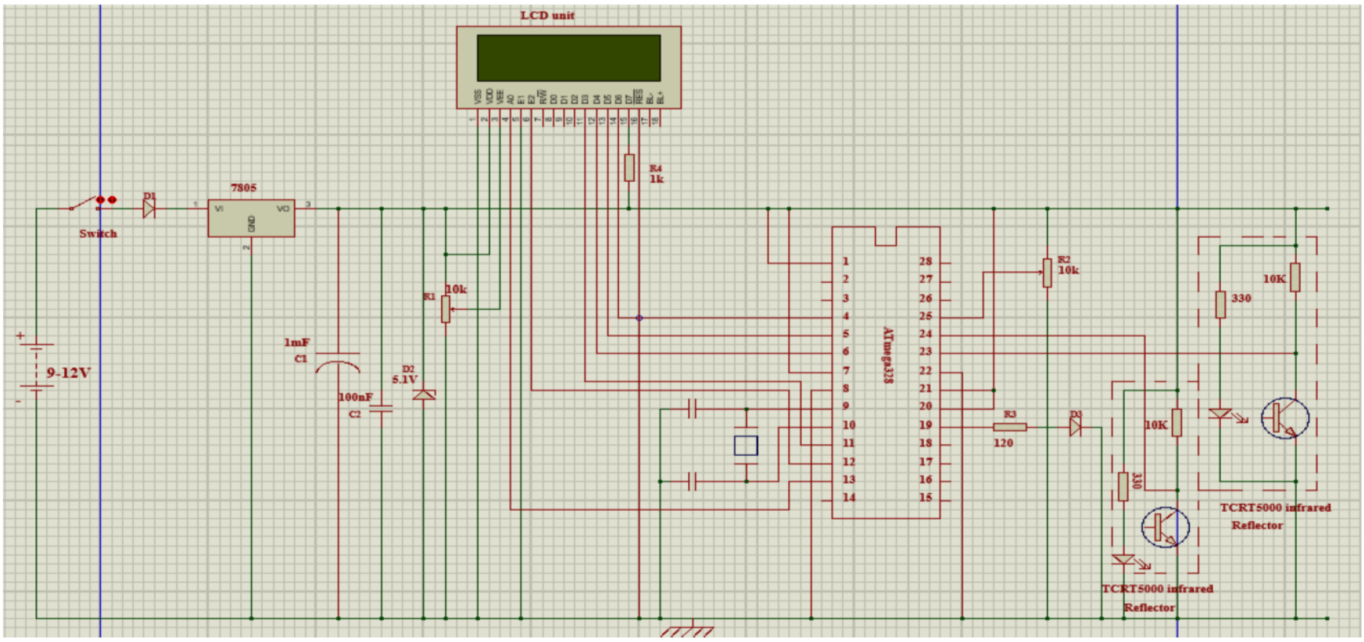

Fig. 8. *Complete circuit diagram of car counter as designed in Proteus 8.0*

C. Circuit Construction

For the hardware construction, IC socket was used and the circuit was first tested on a Bread board before carrying out a more permanent soldering on a Vero board. The constructed circuit is as seen in Fig. 9. There are two sensors placed at both the entry and the exit. The light emitting diode (LED) at the entry IR LED1 continuously transmit an infrared signal which is directly facing the Photo Transistor PT1, this transistor conducts as a result of light intended on it by the LED, as such the collector of the transistor PT1 is in LOW state. The phototransistor opto-coupler is connected in the dark activation so that when a car passes through the entry gates the infrared light is interrupted and the photo transistor PT1 stop conducting, providing a HIGH signal to the S-input of the S-R latch, and hence allows the counter to advance through its state by incrementing its count. The operation of the Exit sensor is similar to that of entry sensor only that when a car passes through the exit sensor (IR LED2, PT2) placed at the exit gate the photo transistor stop conducting and provide HIGH signal to R-input of the S-R latch which causes the counter to decrement its count. A multi-meter was used to ensure continuity within the system before taking it to the casing.

D. Output Test and Analysis

Fig. 10 shows the LCD display as the device sensed and recorded a car movement in and out of a parking lot. Further test was carried out with forty (40) trials and the number of times the system detected a car, undetected cars and wrong output were recorded and presented in Table 1. Then using equations (3) and (4) the sensitivity and accuracy of the system were calculated.

TABLE I. RESULT OF OUTPUT TEST

N_T	N_R	N_W	N_U
40	38	2	0

1) Sensitivity test: This was calculated using equation (3) as follows.

$$Se = \frac{38}{38+0} X\ 100\% = 100\%$$

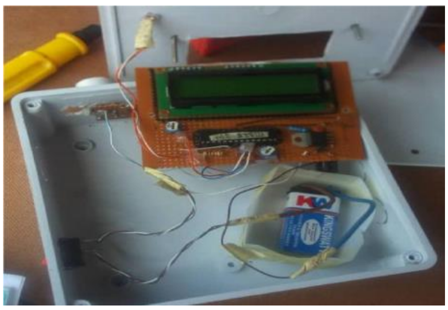

Fig. 9. *Constructed circuit on a Vero board*

2) Accuracy test: This was calculated using equation (4) as follows.

$$Acc = \frac{38}{38+0+2} X\ 100\% = 95.00\%$$

From the calculated results it shows that the system is highly sensitive and has a good accuracy level which implies a good functionality of the system.

Fig. 10. *Output display of recorded activity on LCD*

E. Casing and Packaging

The importance of casing a circuit is to prevent it from distortion from external harm. The casing was made of plastics with dimensions 8cm x 8cm x 4cm. Then holes were perforated to enable cooling. Fig. 11 gives a representation of the casing and its dimensions.

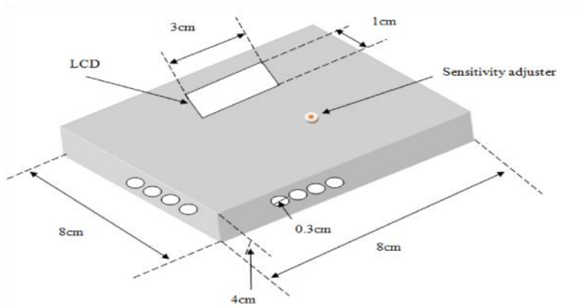

Fig. 11. *Casing and its dimensions*

IV. DISCUSSION

The car counter circuit using the pulse infrared sensor depicts a simple effective device that can be fixed at any corner within the range of the infrared sensors to detect incoming and outgoing cars for proper counting. The evaluated parameter gives the device performance based on available result. This gives reasonable results showing the effectiveness of the algorithm used and the programming accuracy. The result is similar to the work of [12] as it is used for car counting on entrance and exit points and also keeps the record of available car space (if at all) in the parking lot. However, it differs from the works of [5] that used digital signal processing techniques and pyroelectric sensor as their major component. Also, it differs from the work of [13] because their work requires being online (internet) for proper functioning, whereas the present study is designed to work offline and [14] focused majorly on customer counting while this research work is about car counter.

Analysis of result for sensitivity and accuracy revealed 100% and 95.00% respectively. Such analysis was not found in most previous works in the literature, except for the work of [4] who only analyzed accuracy of their work by implemented Gaussian background subtraction and over feet framework to count cars with an accuracy of 96.55%.

V. CONCLUSION

The design and construction of a car counter using pulse infrared sensor is a well needed project work to be fully implemented into parking lots as it eliminates human efforts and stress due to its automation. The major component, the ATmega328 microcontroller dishes out various command prompts to various parts of the system depending on external activities as detected by the infrared sensors. The design and construction was carried out and found to be working properly as can be evident in the testing of the device where the number of cars at the entrance and exit is displayed on the LCD screen. Though, the non-rechargeable battery can drain off while in operation, implying that, it can only work for certain duration of time after which the battery must be replaced and the presence of a switch makes it more manual to some extent. The system can be improved by replacing the battery with a rechargeable battery and a voltage level controller that can trigger ON/OFF the battery charging if there is constant power supply. The switch can also be replaced with an automatic control for automation of the system. The device if planted in parking areas of hospitals, schools, business areas, stadiums etc.; can inform commuters of available parking spaces (if any) so that one doesn't waste scarce fuel and time in searching for a space to park their cars.

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