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An Embedded Voice Activated Automobile Speed Limiter: A Design Approach for Cars

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Abstract : *The paper presents an improved design feature for conventional automobile speed limiters installed on cars used in Nigerian. The feature introduces an embedded voice activated prompt command system. The system was primarily designed to alert the Driver through a voice activated command when the speed of the car accelerates from 80km/hr to 95km/hr at an interval of 5km/hr. This became necessary to avoid abrupt jerking of the car at the maximum speed limit of 100km/hr and also functions as informative to the driver when attempts are made on unsafe movements such as inadequate/wrong calculated overtaking. Components such as resistors, diodes, transistors and relays were implemented in the design. Arduino UNO was used as the main controller of the system. Softwares such as Multisim and Proteus 8.5 professional were incorporated in the design with the use of C programming language for codes development. Algorithm was developed to enhance adequate system control. The simulated system demonstrated satisfactory performance based on the design specifications.*

Keywords: *Automobile Speed Limiter, Voice Activated Prompt Command, Arduino UNO, Proteus 8.5 professional, Multisim.*

I. INTRODUCTION

The concept of Automobile Speed Limiting Device (ASLD) was introduced due to the high rate of car crashes that occur on daily basis globally. The device was first introduced in 1948 by a Mechanical Engineer known as Teetor Ralph [1]. He was inspired to design a Cruise Control due to frustrations of riding in a car driven by his lawyer, who kept speeding up while talking and slowing down while listening. Several types of existing speed limiters include Centrifugal speed limiter, Pneumatic speed limiter, Hydraulic speed limiter, Mechanical speed limiter and Electronic Control speed limiter. Amongst those listed, the Electronic control speed limiter has advantage because it is more flexible and more dependable. The ASLD belongs to the electronic control device fitted in a vehicle to ensure the vehicle maintains a regulated speed limit. It is an embedded electronic device, basically a digital computer that reads signals coming from sensors placed at various parts and in different components of the car and depending on this information controls various important units such as the engine fuel injector and automated operations within the car.

In recent times, studies have proved that road traffic accidents claim more lives than the deadly Malaria Fever [2]. Besides, it was reported that road traffic injuries remain the major cause of death and disability globally, with a disproportionate number occurring in developing countries [3, 4]. Recently, the World Health Organization (WHO) stated that about 1.25 million people die each year as a result of road traffic crashes and 90% of the world's fatalities on the roads occur in low-and middle-income countries [5].

The modern vehicles in use today are equipped with lots of improved features, some of which were designed with speedometer calibration of 240km/hr and above. Such vehicles could be operated at unsafe speeds during navigation, overtaking and in areas where restrictions on the maximum speed limit had been made prominent through traditional road signage and electronic bill boards. The country-Nigeria has one of the worst driving records in Africa, nearly 34 deaths for every 100,000 residents [6]. Over 50% of road crashes in Nigeria are due to over speeding [7]. Some road users have formed the habit of over speeding while others believe in the abilities of their vehicles to wriggle out of any danger hence overestimating their own skills and underestimating likely potential hazards

The Government Agency with the statutory responsibilities for road safety administration in Nigeria known as the Federal Road Safety Commission (FRSC), recently reached a consensus with the Standards Organization of Nigeria (SON), Automobile Council of Nigeria (ACN), Transport Union Association (TUA) and other stakeholders to implement and enforce the use of speed-limiting devices for vehicles used in Nigerian roads, starting with commercial vehicles [2]. Though the speed limiter has only been installed to about 5% of commercial vehicles in Nigeria [8] and none to private cars due to poor compliance by the motorist. It is predictable that despite the speed limiting devices installed, some motorists could attempt to take some perilous actions such as overtaking without having an accurate knowledge of On-The-Motion Operating Speed

(OTMOP) which in many occasions could result to loss of lives and properties. It is observed that of all the automobile speed limiters introduced for use on Nigerian roads, none is equipped with any other feature other than the one designed for restricting the flow of the fuel and air once the maximum regulated speed is attained.

Following the urgent need to curb the accident menace on Nigeria roads further attributed the research study aimed at designing an Automobile Speed Limiter with Voice Activated Prompt Command System (ASLVAPCS), which is an added feature to the conventional devices employed for use on Nigerian cars. This will serve as a prior informative towards acceleration to the maximum limit speed. The speed limiter was specifically designed for cars at maximum speed of 100km/hr. The technique could also be applied to all other class of vehicles.

II. METHODOLOGY

This section introduces the specific materials and methods deployed in the design of the ASLVAPCS. They include Arduino UNO, Resistors, Diodes, Transistors, Relay, Proteus 8.5 professional and Multisim. Arduino UNO is a microcontroller module based on the ATMEGA328P microcontroller. It is selected as the main processor of the system. It is a general purpose device and is affordable when compared to Arduino Mega 2560.

Apart from the resistors seen in the embedded system module, an external fixed resistor was used to connect the output of the Arduino board to the switching transistor. Three diodes were implemented in the design; one was used as a freewheeling diode (a freewheeling diode is used in a circuit to protect the switching device from being damaged by the reverse current of an inductive load). This was connected in reversed biased operation across the terminals of the relay. The output voltage of the car battery is usually 12V but often times when measured, could observe a voltage little higher than 12V. The supply voltage range of the Arduino board is 7V- 12V. Two silicon diodes were connected in series each having a voltage drop of 0.7V, a total voltage drop of 1.4V. The diodes were connected to protect the Arduino board from damage whenever the battery terminal voltage goes higher than the normal voltage (12V). All the diodes used in the system design are 1N4001 type. The diode was selected due to its potentials to handle up to 1A and the car speed limiter is designed not to consume more than 0.5A.

The transistor used for the design is a BC547NPN bipolar junction transistor. The BC547 NPN transistor was selected because it is found to be a simple switching transistor; also it is readily available in local stores. A relay was used for interfacing the system to the fuel pump fuse located at the control box of the vehicle for proper fuel flow control. A 12V DC relay was selected for the design. The simulation was carried out in Proteus 8.5 professional and NI Multisim windows. NI Multisim simulation is an Integrated Development Environment (IDE) that provided advanced analysis and design to optimize the system performance and reduce design errors. The source codes were written in the high level C and processing languages. Figure 1 illustrates the diagram of the proposed system design.

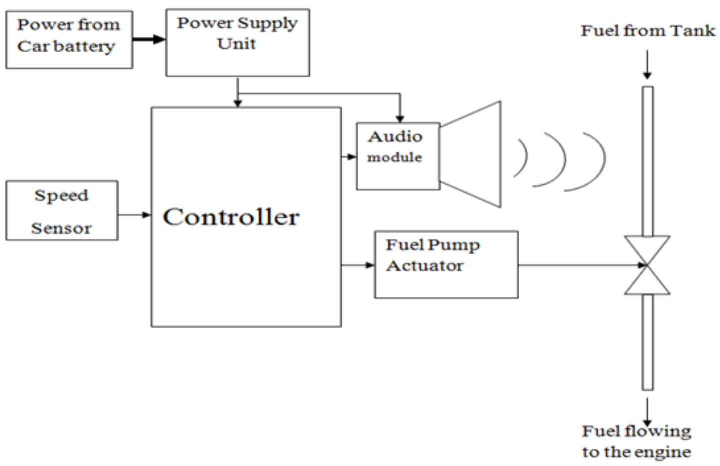

Figure 1. Block diagram of the proposed Automobile Speed Limiter with Voice Activated Prompt Command System (ASLVAPCS).

The speed sensor from Fig. 1 is responsible for measuring the speed of the car. The sensor incorporates a light source and receiver mounted at the shafts of vehicles. As the wheel turns, it cuts the transmission link between the light source and receiver. The speed sensor will in turn produce an output of pulses whose frequency is dependent of the number of interruption of the communication link between the light source and receiver. The pulse is then calibrated with some parameters like the size of the wheel to give the actual vehicle speed in km/hr. This speed is then displayed on a speedometer. The controller receives the pulses generated by the speed sensor in respect to the speed of the car; it compares the measured value to the threshold and determines the state of the car speed. It enables the voice activated prompt command system when there is need; also it interrupts the flow of fuel to the engine in order to disrupt the vehicle movement when the car has reached the maximum control speed. The audio module or sound module generates sounds using samples or synthesis. They are used to playback stored audio human voice. The fuel actuator is an electrically controlled solenoid valve; it controls the flow of fuel to the fuel pump.

- **Computation of System Parameters**

From the basic transistor equation

$$I_C = \beta I_B \quad (1)$$

Where I_C is the current passing through the relay, β is the current gain and I_B is the current flowing through the base. From the datasheet of the relay, its resistance is 400Ω and its voltage is 12V [9].

$$I_C = \frac{Voltage}{Resistance} \quad (2)$$

$$\therefore I_C = \frac{12}{400} = 0.03\ A = 30\ mA$$

β for BC547 is 150 from datasheet, substituting I_C and β into equation 1,

$$I_B = 0.0002\ \ A = 0.2\,mA$$

This means that the minimum current that should flow through the base of the transistor is 0.2mA. Also, it is the same current that will pass through the base resistor. For silicon transistors, there is a voltage drop of 0.7V at the base. The output voltage of the Arduino UNO board is 5V, this means that there will be a voltage drop of 5V - 0.7V= 4.3V, across the resistor. Value of the base resistor can be calculated using Ohm's law.

$$R = \frac{V}{I} = \frac{4.3}{0.0002} = 21.5\,k\Omega \quad (3)$$

- **Algorithm to drive the Controller**

Step 1: The system once installed, measures the speed of the vehicle in motion.
Step 2: Compare the current speed with the defined threshold (set point).
Step 3: Determines if the vehicle speed has advanced to 80km/hr
Step 4: Warn the driver through an audio activated prompt command device.
Step 5: Repeat step 3 and step 4 at 85km/hr, 90km/hr, and 95km/hr.
Step 6: Interrupts the flow of fuel, if the speed gets to 100km/hr

The entire algorithm is represented by the flow chart of Fig. 2.

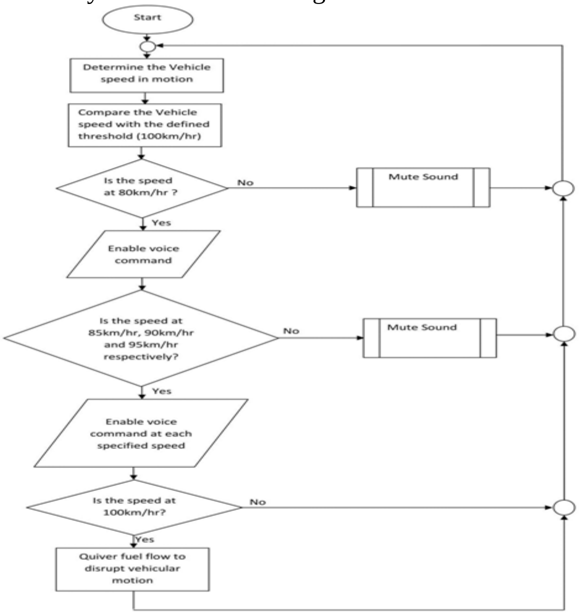

Figure 2. Flow chart of ASLVAPC.

- **Circuit Diagram of the Project**

The circuit diagram of the designed system is shown in Fig. 3. For simplicity, care was taken to avoid unnecessary clustering of connections. Connecting points are adequately labeled for ease of troubleshooting.

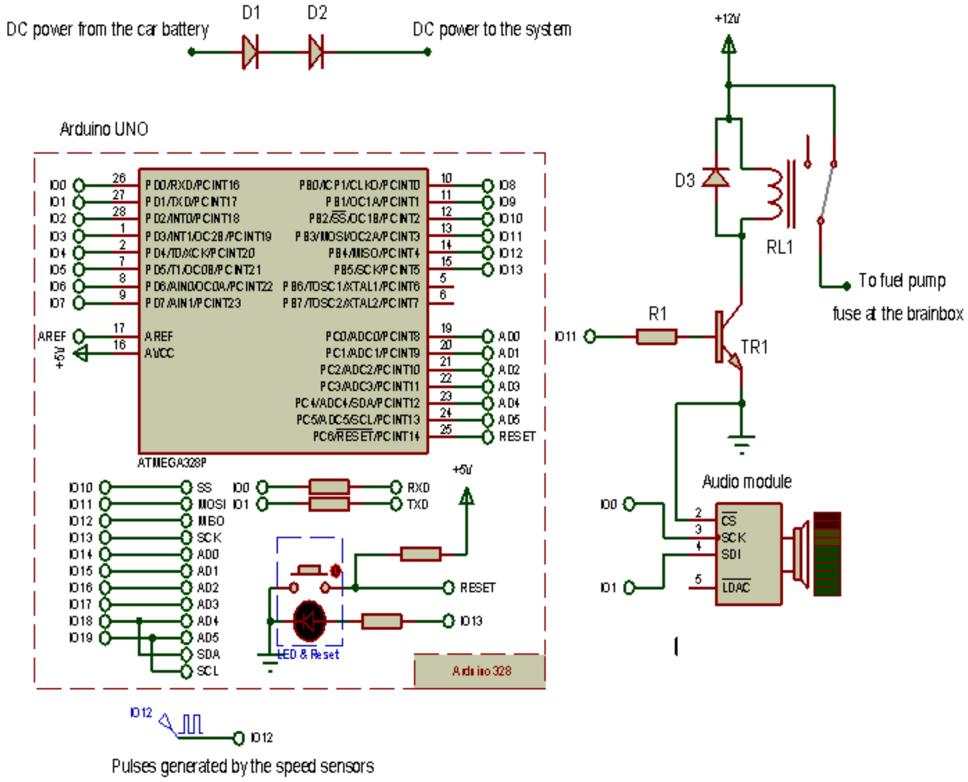

Figure 3. Circuit diagram of ASLVAPC.

The source code for the software was written in C language. It was compiled, debugged and uploaded to the target hardware using the Arduino IDE 1.6.8. The system was virtually simulated using the Proteus 8.5 professional. From the simulation, a pulse generator was used to generate the speed sensor waves; the frequency of the wave generated was varied from low level until the system began to see it as high speed. The results obtained from the simulation process are presented in the session III.

III. RESULTS

Table 1 represents the relationship between the Car Battery Terminal Voltage and Arduino Input Voltage.

Battery Terminal Voltage	**Arduino Input Voltage**
13	10.2
12.8	10
12.6	9.8
12.4	9.6
12.2	9.4
12	9.2
11.8	9
11.6	8.8
11.4	8.6
11.2	8.4
11	8.2
10.8	8
10.6	7.8
10.4	7.6
10.2	7.2
10	7.2

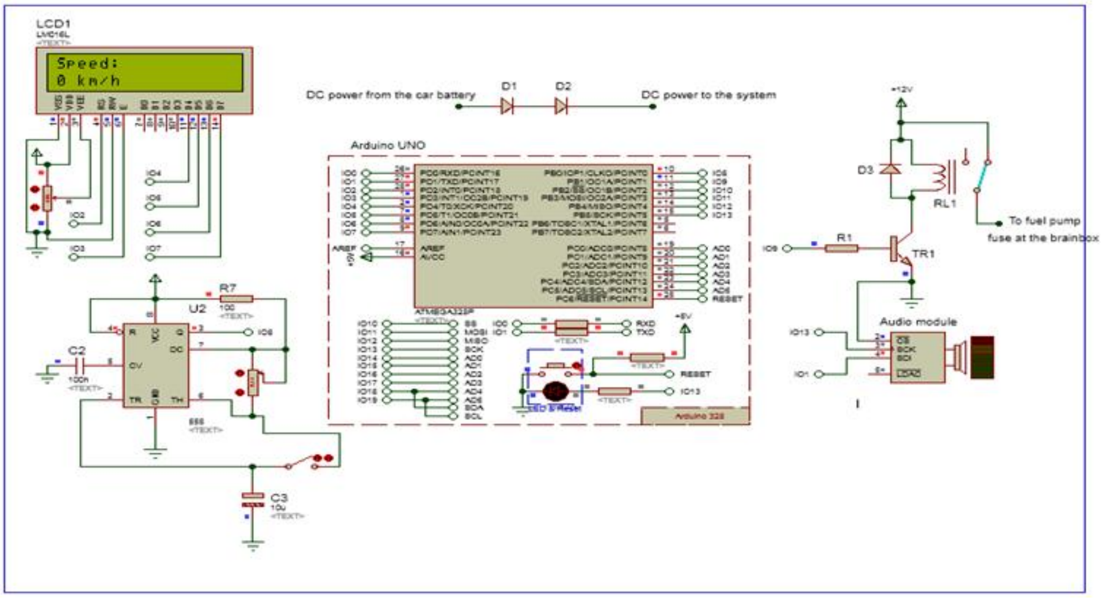

Figure 4. Snapshot of the system when the car was at rest (0km/hr)

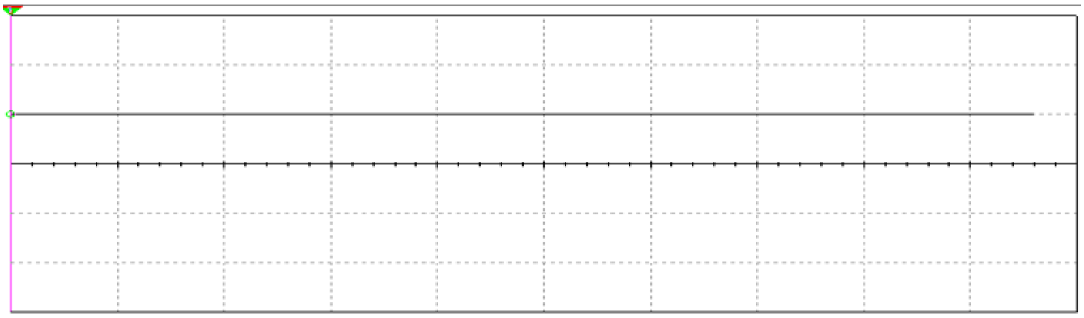

Figure 5. The generated pulses at 0km/hr.

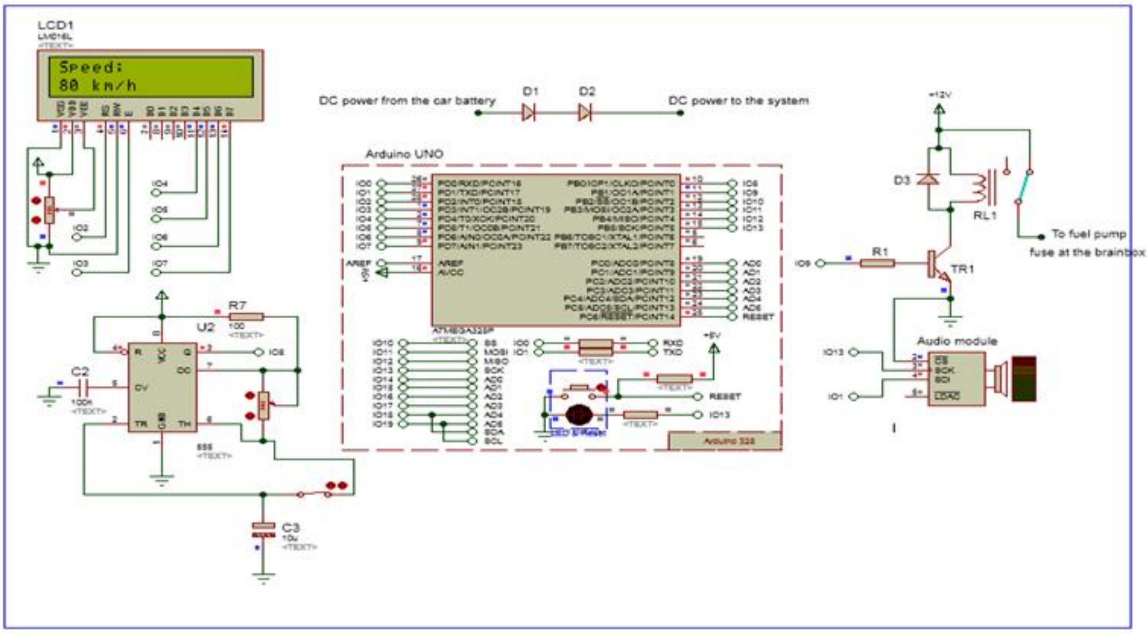

Figure 6. Snapshot of the system when the car was at 80km/hr.

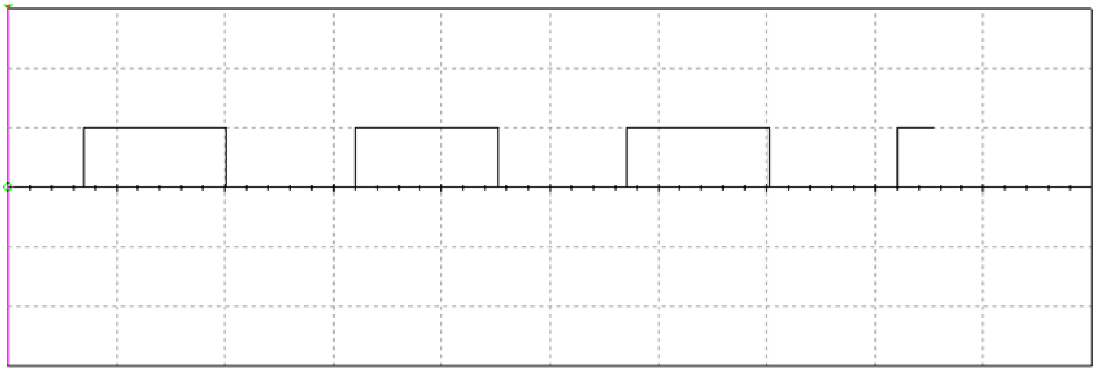

Figure 7. The generated pulses at 80km/hr.

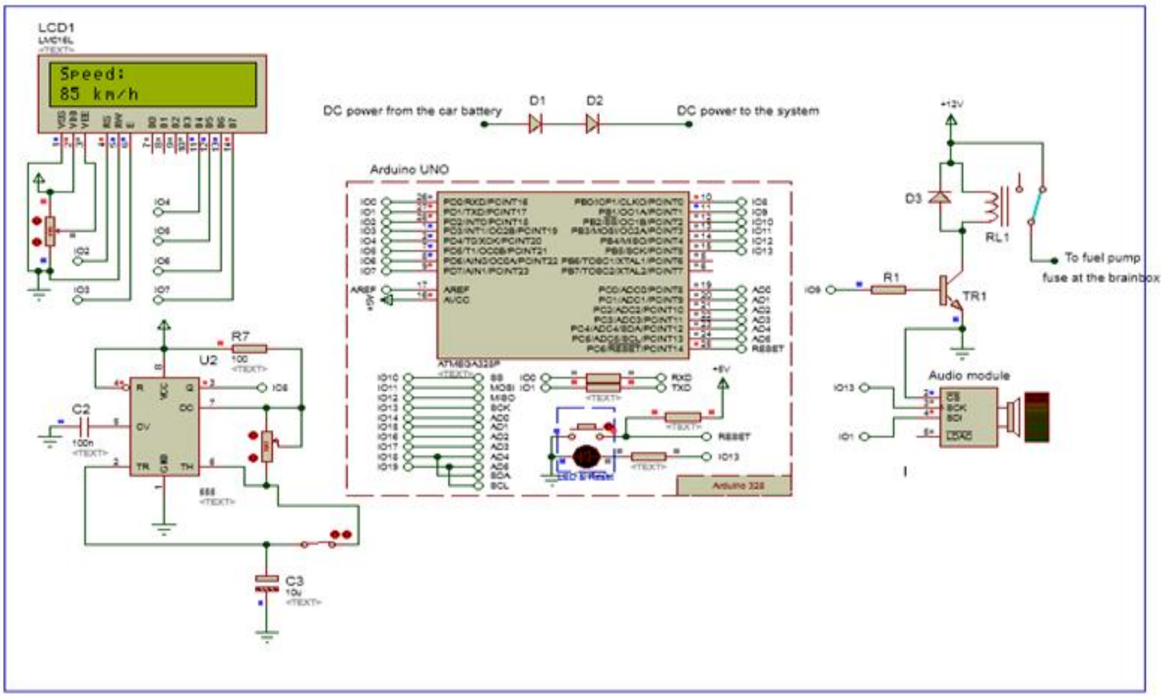

Figure 8. Snapshot of the system when the car was at 85km/hr.

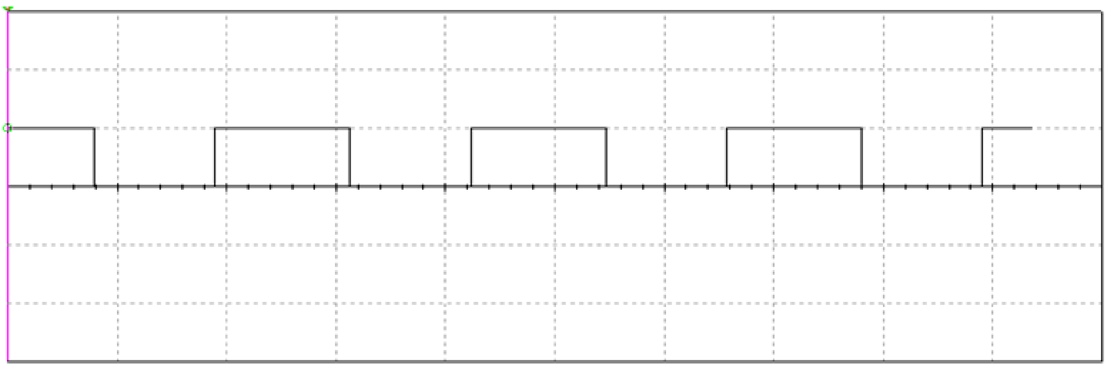

Figure 9. The generated pulses at 85km/hr.

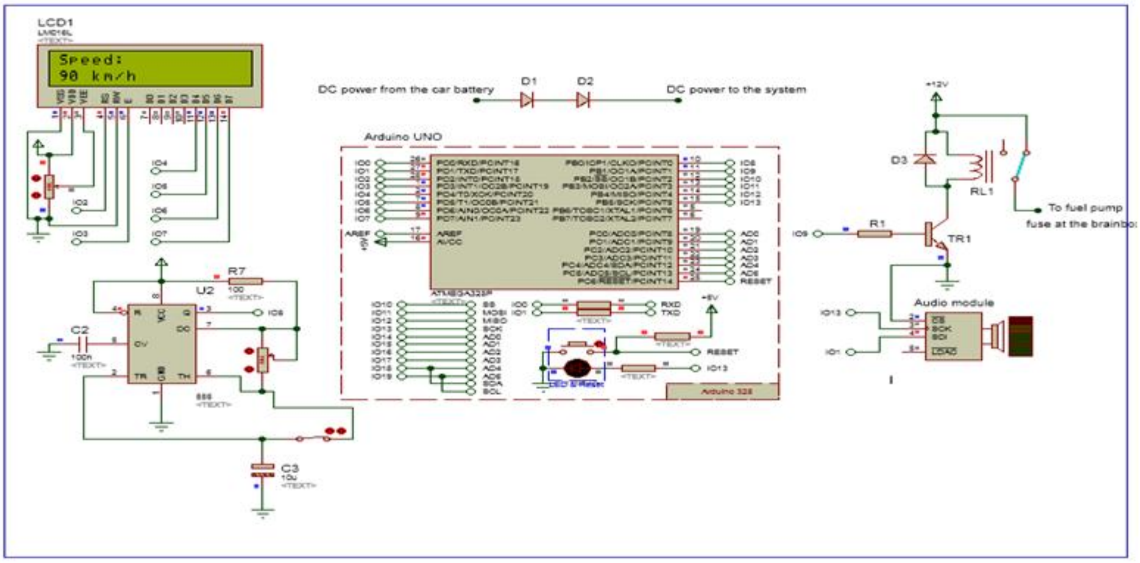

Figure 10. Snapshot of the system when the car was at 90km/hr.

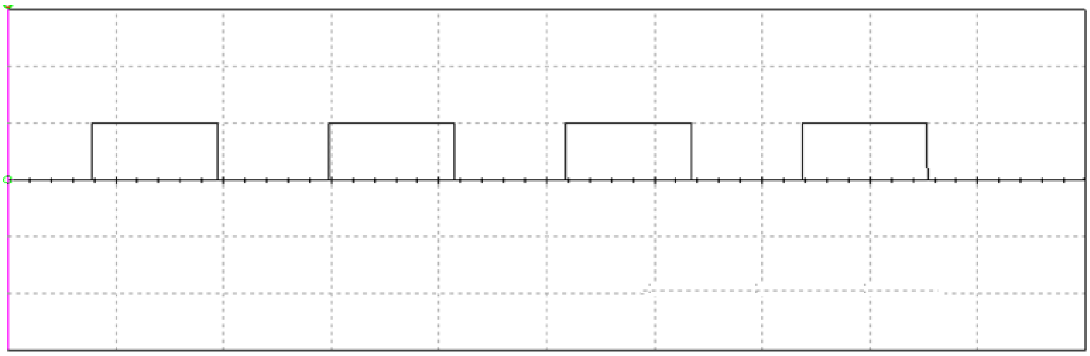

Figure 11.The generated pulses at 90km/hr.

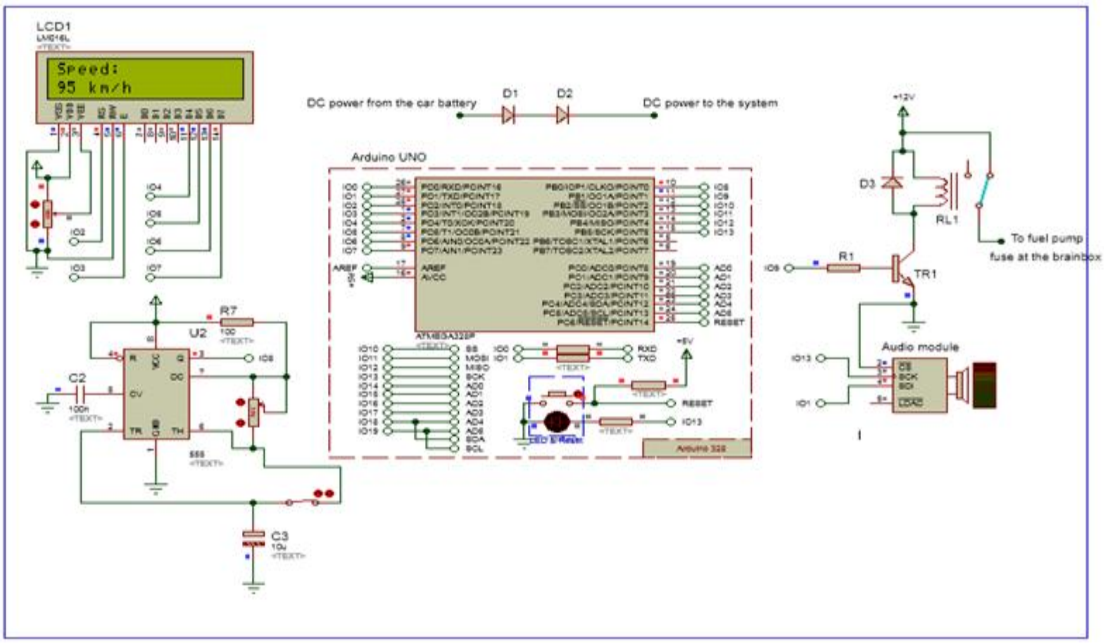

Figure 12. Snapshot of the system when the car was at 95km/hr.

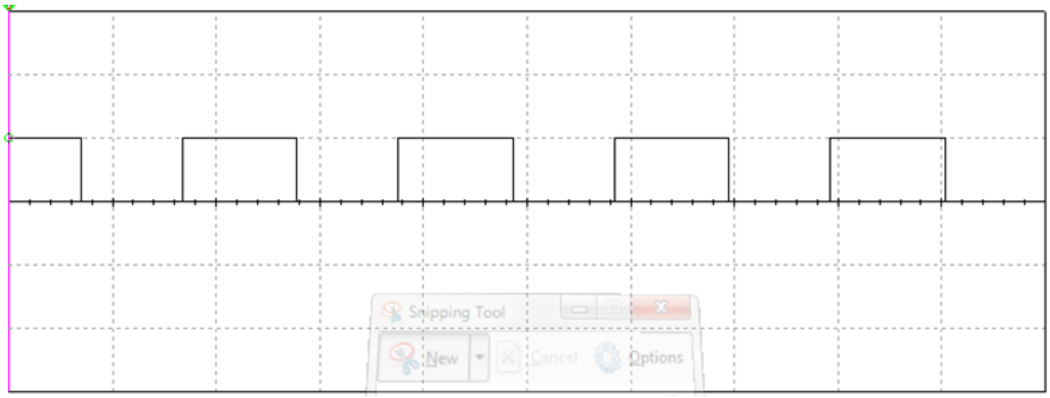

Figure 13. The generated pulses at 95km/hr.

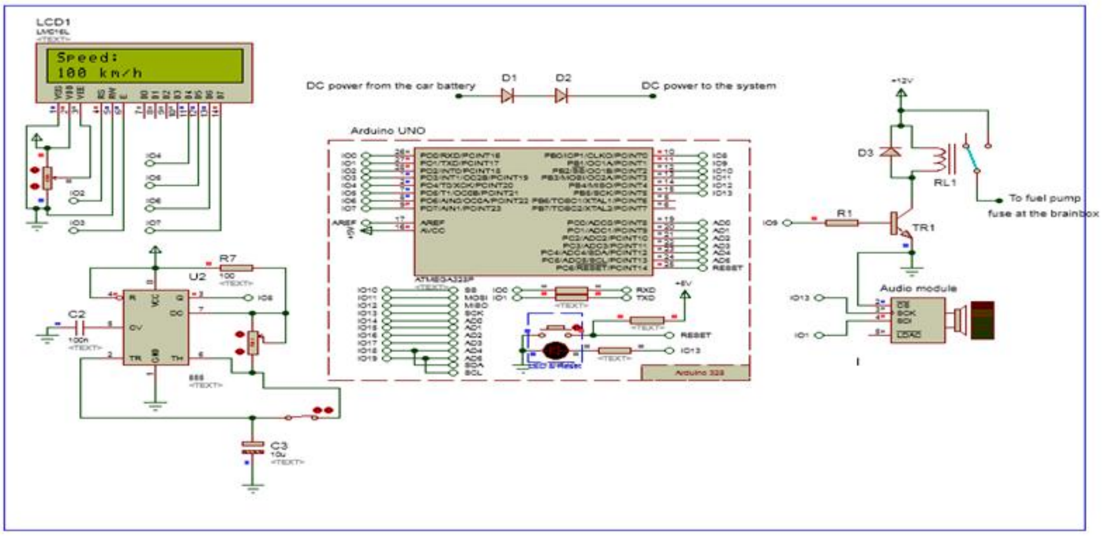

Figure 14 Snapshot of the system when the car was at 100km/hr.

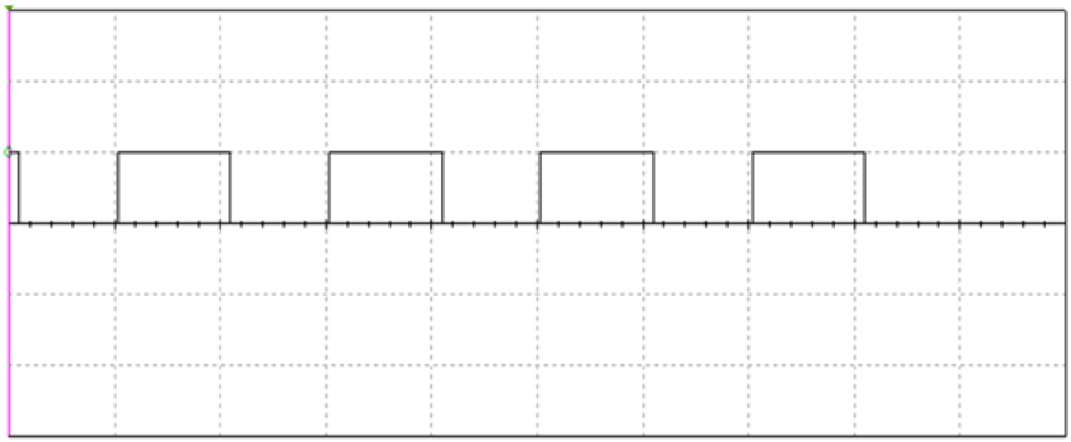

Figure 15. The generated pulses at100km/hr

IV. DISCUSSION

Table 1 shows the relationship between the car battery terminal voltage and the Arduino input voltage. The Arduino input voltage represents the voltages obtained after the output battery voltages were passed across the two diodes with a voltage drop of 1.4V. Figs. 4, 6, 8,10,12 and 14 illustrate the snapshot of the designed system using Proteus 8.5 IDE at 0km/hr, 80km/hr, 85km/hr, 90km/hr, 95km/hr and 100km/hr respectively while Figs. 5,7,9,11,13,and 15 represent the generated pulses by the speed sensor from the digital osciloscope. Fig. 5 shows a flat pulse response signifying the system at rest. The intervals of the generated pulses of each figure excluding that of Fig. 5 decreases gradually relative to the increase in speed. At interval of 5km/hr starting from 80km/hr to 95km/hr, the audio module was activated (turned ON) to intiate a voice prompt command to the driver as a prior warning towards accelerating to the maximum speed limit (100km/hr). At those instants, the relay remains open until at 100km/hr when the relay closes as illustrated in figure 14, to restrict the free flow of air and fuel to the fuel injector hence limiting the maximum speed at 100km/hr.

V. CONCLUSION

Improved speed management measure for road accident reduction involves limiting the operating speed of vehicles and incorporating an embedded activated voice system. An Automobile Speed Limiter with Voice Activated Prompt Command System (ASLVAPCS) was designed, simulated and observed working adequately according to the design specifications. Components such as resistors, diodes, transistors and relays were implemented in the design structure. Arduino UNO was deployed as the main controller of the system. Multisim software and Proteus 8.5 professional were incorporated in the design while C programming language was used to write the codes. A set of algorithm was developed and implemented in the design system for adequate control. The activated voice command system added a feature as a prior notifier to the drivers when attempts are made to navigate or overtake dangerously relative to the on-the-motion operating speed. On that note, the designed system is strongly recommended for onward implementation on Nigerian cars. Other benefits includes reduce the wear and tear of vehicles, operating cost and vehicle emission and noise. The automobile speed limiters deployed for use on Nigerian roads lack the improved feature. For this reason, the study becomes very imperative for the stakeholders to adopt and implement the enhanced design system.

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