Design and Performance Evaluation of a Highway Vehicle Speed Monitoring System.

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Abstract-
The menace of road traffic crashes and associated loss of lives and properties have continued to increase exponentially. This work is aimed at using piezoelectric pressure transducers to design a system which could be employed to detect over speeding vehicles and alert monitoring authorities which will subsequently result in the reduction of high rate of road accidents and material losses resulting from the problem of road traffic accidents caused by excessive speed. To achieve that, two arrays of piezoelectric pressure sensors were mounted across the road under study. The separation distances of the two sensors were determined using the maximum allowable speed on the road and a threshold time of travel. The sensor systems were connected to a PIC microcontroller and configured to monitor the threshold time (which is the least time of travel below which over-speeding would be recorded).When over speed is detected, a buzzer connected to the system microcontroller will be triggered on to alert the road safety officials around while a camera also connected to the microcontroller captures the particulars of the over speeding vehicle. Power model technique was adopted to analyze the data collated in the field test of the designed system. The result of the data analyses showed that the system, if fully implemented and enforced would cause a high level of compliance to speed limit regulation and about sixty five percent (65%) reduction of road traffic accidents will be achieved.

Key words: piezoelectric pressure sensor, piezoelectric pressure transducer, vehicle speed monitoring, braking distance, camera, buzzer.

1. Introduction

The 19th century industrial revolution resulted in some fundamental changes in the transport sector and providing more comfort, flexibility of movement and speed of motor vehicles (Ukoji, 2014). Since then, there has been an upsurge in both human and vehicular motor movement, a situation that has also resulted in more fatal road accidents (IRF press release, 2014).

Despite integrated efforts towards reducing fatal road accidents, Nigeria still remains one of the worst hit countries, ranking the second-highest in the rate of road accidents among 193 countries of the world (Agbonkhese et al, 2013). With a human population of about 167 million, a high level of vehicular population estimated at over 7.6million, a total road length of about 194,000 kilometers (comprising 34,120 km of federal, 30,500 km of state, and 129,580 km of local roads) (Sumaila & Femi, 2013). The country has suffered severe losses to fatal road accidents. Its population density varies in rural and urban areas at about 51.7% and 48.3% respectively and translates to a population–road ratio of 860 persons per square kilometer, indicating intense traffic pressure on the available road network (Sumaila & Femi, 2013).

Based on a survey of Road Safety Performance, excessive and inappropriate speed is the number one road safety problem in many countries, often contributing to as much as one third of fatal accidents and an aggravating factor in most accidents (Sumaila, & Femi 2013). Speed reduces the time people have available to process information in times of emergency, to decide whether or not to react and finally, to execute an action. Secondly, as braking distance is proportional to the square of the speed (V^2), the distance between starting to brake and coming to a complete standstill also increases greatly with increasing speed. The time needed is composed of two elements: the reaction time of the driver (approximately 1 second in standard condition) and the braking time. The possibility of avoiding collisions reduces as speed increases (Ankita et al, 2012). For example, as shown in Fig. 1.1, with a speed of 80 km/h on a dry road, it takes around 33 meters to react to an event, and a total of 69 meters to come to a standstill. If a child for example runs onto the road 36 meters ahead, the driver would most likely kill the child if driving at 70 km/h or more, hurt the child if driving at 60 km/h and avoid hitting the child if driving at 50 km/h. However, if the child runs out on to the road 15 meters ahead of the driver, the probability is that the child would be fatally injured at 50 km/h and all higher speeds.

Fig.1.1: Stopping Distance at Different Speeds (including reaction time of around 1 second, courtesy of Finch)

High speed reduces the possibility to respond in time when necessary. People need time to process information, to decide whether or not to react and, finally to execute a reaction. At high speed the distance covered in this period is longer. At high speed the distance between starting to brake and a complete stand still is longer as well. Since the braking distance is proportional to the square of speed (v^2), therefore, the possibility to avoid a collision becomes smaller as speed increases. Yet, drivers have continued to violate speed limits and as such, lives and properties have continuously been wasted on an exponential rate. This paper aims at reducing this violation.

2. Theory of the Work

The basic concept of this work is to use two arrays of piezoelectric sensors on the road surface at a determined distance between them. Based on a predefined speed limit and the distance of separation of the sensors, the time required to cover this distance is calculated using the fundamental formula of speed. The sensors monitor this time and send a signal to a microcontroller which will set off an alarm when the actual time of travel is less than the required time. All vehicles travelling in the zone marked for this speed limit are required by law to cover this distance in at least the required time or above, otherwise, the vehicle will be penalized for excessive speed.

A **piezoelectric sensor** is a device that uses the piezoelectric effect, to measure changes in pressure, acceleration, temperature, strain or force by converting them to an electrical charge. The prefix "*piezo*"- is Greek word for "press" or "squeeze".

Piezoelectric Sensors and their measurable physical quantities

Based on piezoelectric technology, various physical quantities can be measured; the most common are pressure and acceleration. For pressure sensors, a thin membrane and a massive base are used, ensuring that an applied pressure specifically loads the elements in one direction. For accelerometers, a seismic mass is attached to the crystal elements. When the accelerometer experiences a motion, the invariant seismic mass loads the elements according to Newton's second law of motion; F = ma.

Sensors often tend to be sensitive to more than one physical quantity. Pressure sensors show false signal when they are exposed to vibrations. Sophisticated pressure sensors therefore use acceleration compensation elements in addition to the pressure sensing elements. By carefully matching those elements, the acceleration signal (released from the compensation element) is subtracted from the combined signal of pressure and acceleration to derive the true pressure information.

3. Methodology

Top down approach was used in the design of this work as shown in Fig. 3.1. The base elements are recognized and then built as computer modules. After they are built, they are then put together, making the entire system from these individual components. The design is divided into three modules via: System design, Hardware design and Software design. These modules are designed independently before combining them together for simulation with proteus software.

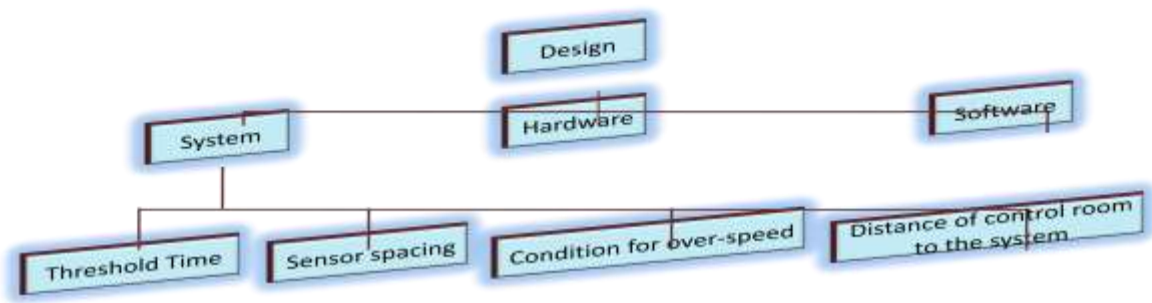

Fig.3.1: Design methodology using top-down stepwise refinement

3.1 System Design

The road adopted for this work is a motorway marked for a standard speed limit of 100 km/h. Two rows of piezoelectric pressure sensors are mounted at two locations on the road surface, one at the starting location and the other one at end location with an estimated distance of separation between them. A speed limit signboard was mounted across the road, near the starting location high above the ground level with “100 km/h “speed limit boldly written on it to warn oncoming vehicles that the maximum allowed speed is 100km/h. The sensors behave as capacitors, retaining charge for a short time after it has been deformed by the oncoming vehicle. For the purpose of this work, the discharging time of the sensors acts as the input variables to the program code written for the work and can be modified for similar design on roads with different speed limits. The system does not measure the actual speed of the vehicle; rather, it detects the condition for over-speeding which is a function of the time of travel of the vehicle from sensor1 to sensor2. The minimum time required (time limit) to cover the distance between the sensors is the determinant of the condition for over-speeding. If a vehicle covers this distance in a time which is less than the time limit, it implies that the vehicle has travelled at a speed which is higher than the speed limit. At this point, the PIC16F84A Microcontroller used for this work will detect this condition and activate the buzzer system in the ticket office (controlling office). A pair of cameras mounted on the speed limit signboard and opposite to each other is also connected to the system microcontroller. Camera1 is connected to sensor1 and mounted opposite the incoming vehicles, just about a few meters above the ground level to be able to capture the front plate numbers of all oncoming vehicles. Hence, camera1is activated by the electrical signal generated from sensor1 whenever a vehicle passes on it. Camera2 and the buzzer share the same interface since both are designed to be activated simultaneously. Camera2 is mounted in an anti-parallel direction with camera1 and about a few meters just above the ground level so as to capture clearly, the back plate number of the vehicle. Camera2 is activated only when the microcontroller detects the condition for over-speeding. At this condition, camera2 and the buzzer will come on simultaneously. Therefore, camera1 and camera2 captures the front and back plate numbers respectively.

3.1.1 Determination of the Threshold Time

Tailgating- Following a vehicle too closely is called 'tailgating'. Tailgating is an aggressive driving behavior that is easily mistaken for road rage**.** So many road traffic accidents are caused by drivers driving too fast and too close to the vehicle in front. The three-second rule is used to avoid tailgating. Three second rule is the standard prescribed safe time between two moving vehicles on a good dry road. However, if the weather conditions are very poor, e.g. heavy rain, heavy fog, or heavy snow, the three second rule is tripled to nine seconds for added safety. Based on this information, a driver should always ensure that the three seconds rule is maintained between him and the vehicle ahead to give one time and distance to respond to emergencies in the lane ahead.

3.1.2 Determination of the Sensor spacing

As said earlier, the discharging time of the sensor is an input variable in the program for this work. Now, let the discharge time duration of the sensor be denoted as "Ton" and the maximum allowable speed limit as Vlmt.

The value of Vlmt for Nigeria Motorways is 100 km/h (IRTAD, 2014)

If spacing distance between sensors as given as "X", therefore employing the fundamental formula of speed gives

$$Speed\ (S) = \frac{Distance\ (D)}{Time\ (T)} \qquad (3.1)$$

Therefore,

$$V_{lmt} = \frac{X}{T_{on}} \qquad (3.2)$$

and,

$$X = V_{lmt} \times T_{on} \qquad (3.3)$$

But $V_{lmt} = 100km/h$

Converting V_{lmt} to meters per seconds gives:

$$V_{lmt} = \frac{100 \times 1000}{3600} = 28m/s$$

With a tolerance of 5%, $V_{lmt} = (28 \pm 1.4)m/s$

"T_{on}" has been programmed as 3 seconds.

Using these parameters, the sensor spacing is calculated using equation 3.3.This yields $X = V_{lmt} \times T_{on} = \frac{29.4m}{s} \times 3 = 88.2\ meters.$

The maximum speed of 29.4m/s has been used instead of 28m/s which is the actual speed limit. The reason is that a vehicle which is travelling at exactly the speed limit has not really violated the speed limit regulation. Therefore, any vehicle that travels beyond 29.4m/s will be caught for violating the speed limit.

Conditions for the operations of the alarm and cameras

The operations of the sensors, buzzer and cameras are explained with the truth table shown below.

Descriptions:

1st state (00): both sensors are off; no vehicle has passed; buzzer is off; cameras are OFF

2nd state (01): sensor1 is activated but has fully discharged before the vehicle could activate sensor2; buzzer is off; only camera1 is ON

3rd state (10): same as 2nd state

4th trial (11): sensor1 is still ON by the time the vehicle gets to sensor2; the vehicle has activated the first sensor and was just fast enough to get to the second sensor before the first sensor could discharge;

This is the condition for over-speeding. At that condition buzzer alarm is ON; the two cameras are ON

Functions of the cameras

If an offence is detected, a digital image of the vehicle is recorded. The image clearly shows the color, type, make and number plate of the vehicle. Digital images also include:

- Date of the offence
- Time of the offence
- Location details of the camera that took the picture
- Direction of travel of the offending vehicle

The cameras have been installed for a number of other important reasons: To help give insight on the possible number of users of a particular road (this is possible since camera1 snaps the plate number of every vehicle that passes on the road (i.e. on sensor1). This information is very important for statistical analysis and other needs as may be required.

To assist in surveillance purposes to track the positions of vehicles at a given point in time. However, for the purpose of this work, the key function of the cameras is to minimize the confusion in determining the over-speeding vehicle from a stream of vehicles inherent in speed limit monitoring systems. Therefore, when the buzzer sounds, the officer in the ticket office must match the plate numbers on his system display unit/readout as captured from both cameras to confirm that they are the same and also establish that the difference between the times of capture of the images is less than "T_{on}."

3.1.4 Determination of the location of an enforcement officer

From the information in the diagram of Fig.1.1, it can be estimated that for a vehicle moving at a speed above 100 km/h, a distance of at least 200 meters is enough to safely bring the vehicle to a halt. Therefore, an enforcement officer will be stationed at least a distance of 200 meters from sensor2, to apprehend any vehicle that has violated the speed limit.

3.2 Hardware Design

The Pic16f84a microcontroller is the main component of this design.PIC microcontrollers (Programmable Interface Controllers) are electronic circuits that can be programmed to carry out a vast range of tasks. Its program memory contains 1K words, which translates to 1024 instructions, since each 14-bit program memory word is the same width as each device instruction. The data memory (RAM) contains 68 bytes. Data EEPROM is 64 bytes.

There are also 13 I/O pins that are user-configured on a pin-to-pin basis. Some pins are multiplexed with other device functions. The pin diagram for the microcontroller is shown in Fig. 3.2 below, while table 3.1 explains the various pins of the processor

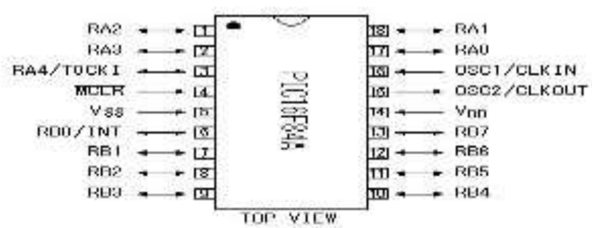

Figure 3.2: PIC6F84A PIN Diagram

3.2.1 System architecture

The overall architecture of the model showing the connection of all the modules designed by the top-down methodology is shown in Fig.3.2

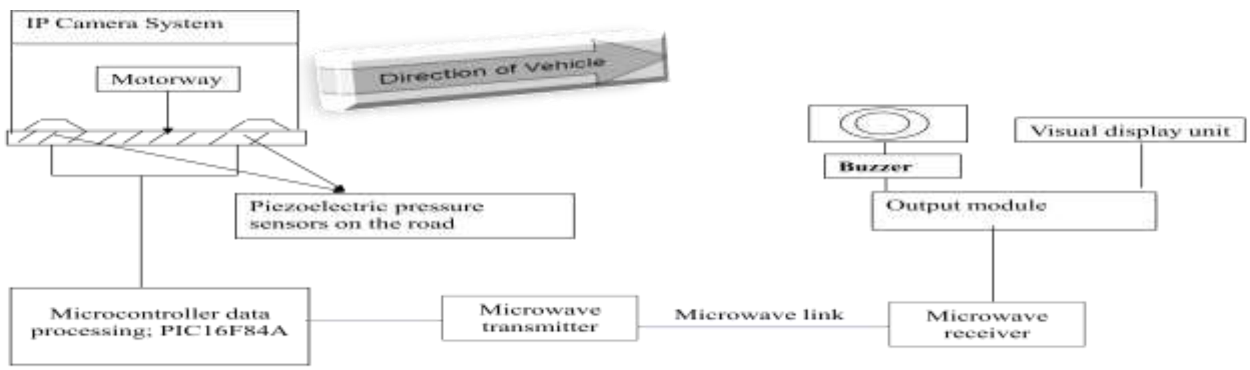

Figure 3.3: The Architecture of the system

3.2.2 System Configurations

I/O Port

Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. All enabled peripherals were used as a general purpose I/O pins.

PortA and TrisA Registers

PortA is a 5-bit wide, bi-directional port. The corresponding data direction register is TrisA. Setting a TRISA bit (= 1) will make the corresponding PortA pin an input (i.e., put the corresponding output driver in a Hi-Impedance mode). Clearing a TrisA bit (= 0) will make the corresponding PortA pin an output (i.e., put the contents of the output latch on the selected pin). Reading the PORTA register reads the status of the pins, whereas writing to it will write to the port latch. All write operations are read-modify write operations.

A register reads the status of the pins, whereas writing to it will write to the port latch. All write operations are read-modify write operations.

Therefore, a write to a port implies that the associated port pins are read. This value is modified and then written to the port data latch. Pin RA4 is multiplexed with the Timer0 module clock input to become the RA4/T0CKI pin. The RA4/T0CKI pin is a Schmitt Trigger input and an open drain output. All other RA port pins have TTL input levels and full CMOS output drivers,. Tables 3.1 and Table 3.2 shows the pin functions for ports B and A

Table 3.1 PORTB Functions

Port Name	Bit	Buffer Type	I/O Consistency Function
RB0/INT	bit0	TTL/ST(1)	Input/output pin or external interrupt input. Internal software programmable weak pull-up.
RB1	bit1	TTL	Input/output pin. Internal software programmable weak pull-up
RB2	bit2	TTL	Input/output pin. Internal software programmable weak pull-up
RB3	bit3	TTL	Input/output pin. Internal software programmable weak pull-up
RB4	bit4	TTL	Input/output pin (with interrupt-on-change). Internal software programmable weak pull-up.
RB5	bit5	TTL	Input/output pin (with interrupt-on-change). Internal software programmable weak pull-up.
RB6	bit6	TTL/ST(2)	Input/output pin (with interrupt-on-change). Internal software programmable weak pull-up. Serial programming clock
RB7	Bit7	TTL/ST(2)	Input/output pin (with interrupt-on-change). Internal software programmable weak pull-up. Serial programming data

Table 3.2 PORTA Functions

Name	Bit0	Buffer Type	Function
RA0	bit0	TTL	Input/output
RA1	bit1	TTL	Input/output
RA2	bit2	TTL	Input/output
	bit3	TTL	Input/output
RA4/TOCKI	bit4	ST	Input/output or external clock input for TMRO. Output is open drain type

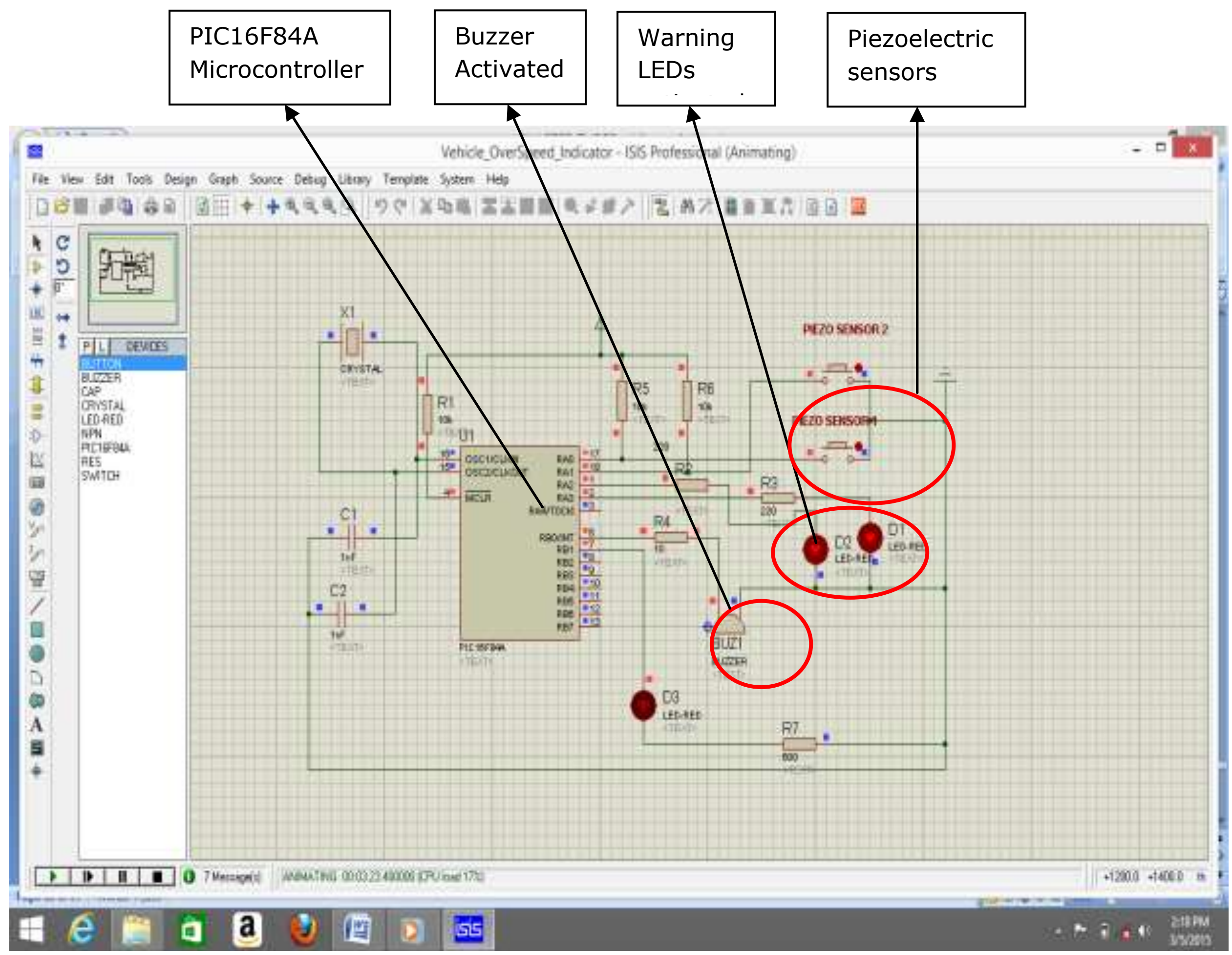

Fig.3.4 screenshot of the Hardware model of the system showing (circled in red) over-speeding condition with the buzzer and warning LEDs activated in a Proteus program environment

3.3: The Software Design

The software for this work was designed using the flow chart of Fig. 3.5 below. This work was written in C language, simulated in C compiler and modeled in Proteus simulation software for microcontroller. The simulation was run for 216 milliseconds. In the above programming Port A is configured as input.

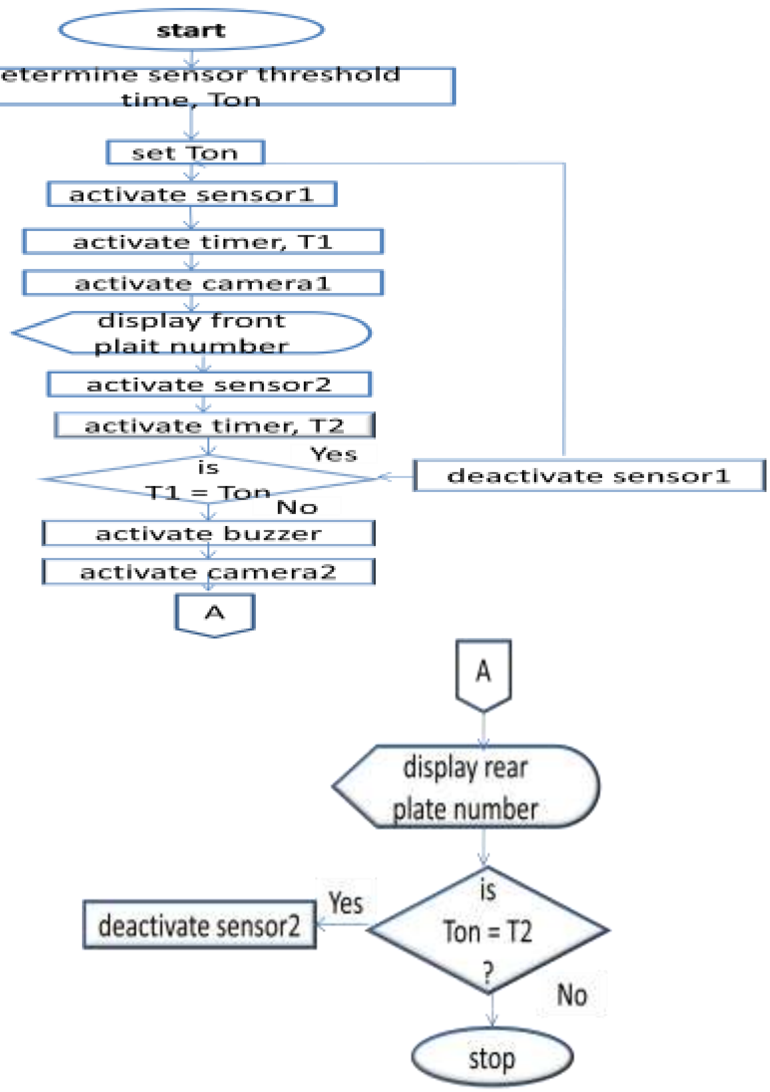

Fig.3.5 Flowchart of the simulation program

4. Results and Discussions

4.1 Data presentation

This model was validated by sampling the speed of vehicles travelling on the single lane road of a section of Owerri-Port Harcourt expressway in South-East, Nigeria. It was taken at the section where the road is relatively straight and without any pothole or any obstruction of any kind that has a sign indicating that the speed limit is 100km/hr. The sensors were mounted at a separation distance of 88.2 meters. The cameras, buzzer and microcontroller were installed according to design. The readings were taken each day between 1.00pm and 2.30pm. The time it took for a vehicles to move from sensor1 (S1) to sensor2 (S2) were measured by the use of a clock timer. The speed of the vehicles was then calculated using this time and the distance (88.2m) which was constant all through the experiment. The system LED display for each of the over-speeding vehicles was confirmed to be equal to the calculated speed of the corresponding over-speeding vehicles. These values were collected over a period of three days and a total of 88 vehicles monitored and the readings obtained are tabulated in the Table 4.1 below:

Table 4.1: Data obtained from the validation experiment performed at a section of Owerri-Port Harcourt Expressway

Vehicle No.	Time to move from S1 to S2 (in seconds)	Vehicle Speed (V) (km/h)	Sensor 1 (S1)	Sensor 2 (S2)	Camera 1	Camera 2	Buzzer
1	1.87	170	ON	ON	ON	ON	ON
2	1.74	182	ON	ON	ON	ON	ON
3	2.01	158	ON	ON	ON	ON	ON
4	3.87	82	OFF	ON	ON	OFF	OFF
5	2.69	118	ON	ON	ON	ON	ON
6	2.04	156	ON	ON	ON	ON	ON
7	3.02	105	ON	ON	ON	ON	ON
8	3.61	88	OFF	ON	ON	OFF	OFF
9	3.21	99	OFF	ON	ON	OFF	OFF
10	3.14	101	ON	ON	ON	ON	ON
11	3.97	80	OFF	ON	ON	OFF	OFF
12	2.97	107	ON	ON	ON	ON	ON
13	3.92	81	OFF	ON	ON	OFF	OFF
14	2.12	150	ON	ON	ON	ON	ON
15	2.30	138	ON	ON	ON	ON	ON
16	1.76	180	ON	ON	ON	ON	ON
17	1.80	176	ON	ON	ON	ON	ON
18	3.83	83	OFF	ON	ON	OFF	OFF
19	2.19	145	ON	ON	ON	ON	ON
20	2.81	113	ON	ON	ON	ON	ON
21	2.05	155	ON	ON	ON	ON	ON
22	3.41	93	OFF	ON	ON	OFF	OFF
23	2.76	115	ON	ON	ON	ON	ON
24	1.92	165	ON	ON	ON	ON	ON
25	2.15	148	ON	ON	ON	ON	ON
26	3.78	84	OFF	ON	ON	OFF	OFF
27	2.52	126	ON	ON	ON	ON	ON
28	2.79	114	ON	ON	ON	ON	ON
29	2.56	124	ON	ON	ON	ON	ON
30	3.53	90	OFF	ON	ON	OFF	OFF
31	3.38	94	OFF	ON	ON	OFF	OFF
32	2.50	127	ON	ON	ON	ON	ON
33	2.39	133	ON	ON	ON	ON	ON
34	2.28	139	ON	ON	ON	ON	ON
35	2.10	151	ON	ON	ON	ON	ON
36	2.89	110	ON	ON	ON	ON	ON
37	1.95	163	ON	ON	ON	ON	ON
38	1.88	169	ON	ON	ON	ON	ON
39	2.97	107	ON	ON	ON	ON	ON
40	2.09	152	ON	ON	ON	ON	ON
41	1.81	175	ON	ON	ON	ON	ON
42	1.75	181	ON	ON	ON	ON	ON
43	1.94	164	ON	ON	ON	ON	ON
44	1.85	172	ON	ON	ON	ON	ON

45	2.37	134	ON	ON	ON	ON	ON
46	2.60	122	ON	ON	ON	ON	ON
47	2.06	154	ON	ON	ON	ON	ON
48	2.21	144	ON	ON	ON	ON	ON
49	1.91	166	ON	ON	ON	ON	ON
50	2.34	142	ON	ON	ON	ON	ON
51	1.70	187	ON	ON	ON	ON	ON
52	1.72	185	ON	ON	ON	ON	ON
53	1.67	190	ON	ON	ON	ON	ON
54	3.65	87	OFF	ON	ON	OFF	OFF
55	1.74	183	ON	ON	ON	ON	ON
56	1.71	186	ON	ON	ON	ON	ON
57	1.74	182	ON	ON	ON	ON	ON
58	1.69	188	ON	ON	ON	ON	ON
59	1.76	180	ON	ON	ON	ON	ON
60	1.96	162	ON	ON	ON	ON	ON
61	3.11	102	ON	ON	ON	ON	ON
62	3.00	106	ON	ON	ON	ON	ON
63	2.84	112	ON	ON	ON	ON	ON
64	1.85	172	ON	ON	ON	ON	ON
65	2.17	146	ON	ON	ON	ON	ON
66	2.48	128	ON	ON	ON	ON	ON
67	1.68	189	ON	ON	ON	ON	ON
68	1.73	184	ON	ON	ON	ON	ON
69	1.89	168	ON	ON	ON	ON	ON
70	2.33	136	ON	ON	ON	ON	ON
71	2.30	138	ON	ON	ON	ON	ON
72	3.18	100	ON	ON	ON	ON	ON
73	2.01	158	ON	ON	ON	ON	ON
74	3.34	95	OFF	ON	ON	OFF	OFF
75	2.54	125	ON	ON	ON	ON	ON
76	2.67	119	ON	ON	ON	ON	ON
77	3.24	98	OFF	ON	ON	OFF	OFF
78	1.98	160	ON	ON	ON	ON	ON
79	2.65	120	ON	ON	ON	ON	ON
80	3.69	86	OFF	ON	ON	OFF	OFF
81	2.74	116	ON	ON	ON	ON	ON
82	2.41	132	ON	ON	ON	ON	ON
83	1.65	193	ON	ON	ON	ON	ON
84	2.94	108	ON	ON	ON	ON	ON
85	2.02	157	ON	ON	ON	ON	ON
86	2.35	135	ON	ON	ON	ON	ON
87	3.08	103	ON	ON	ON	ON	ON
88	3.45	92	OFF	ON	ON	OFF	OFF

4.2 Discussions

The tabl**e**4.1 contains the status of the sensors, cameras and buzzer for all the 88 vehicles that was profiled in the data collection. As was emphasized in the design in chapter 3, the vehicle travelling at a 100 km/h on the 100 km/h maximum allowable speed did not activate the over-speed alerts (camera2 and buzzer). This row was highlighted in the table for emphasis. It can be seen that any vehicle that takes less than 3.18 seconds to cover from S1 to S2 is over speeding.

Expected Percentage reduction of accidents achieved by the piezoelectric system

The percentage reduction of fatalities that would have been achieved by implementing and enforcing this system over the time period of the experiment was calculated using MATLAB with the code written below:

```
% "t" is the measured value of time in seconds it took the vehicles to cover a distance "X"

t = [1.87 1.74 2.01 3.05 2.69 2.04 3.02 3.08 2.54 3.14 2.35 2.97 1.98 2.12 2.30 1.76 1.80 2.65 2.19 2.81
2.05 2.67 2.76 1.92 2.15 2.74 2.52 2.79 2.56 2.41 2.94 2.50 2.39 2.28 2.10 2.02 1.95 1.88 2.89 2.09 1.81
1.75 1.94 1.85 2.37 2.60 2.06 2.21 1.91 2.34 1.70 1.72 1.67 1.65 1.74 1.71 1.69 1.76 1.96 3.11 3.00 2.84
1.85 2.17 2.48 1.68 1.73 1.89]

% the measured value of the distance "X" is 88.2 meters
X = 88.2
% speed is the ratio of distance to time and Vms is the speed in meters per second
Vms = X./t
% 1 m/s equals 3.6 km/h
C = 3.6
% converting Vms to speed in km/h
V = C.*Vms
% Baseline speed Vb, is the maximum allowable speed
Vb = 100
% Nfr represents the Nilsson's factor ratio
Nfr = Vb./V
I = Nfr.^4
K = 100.*I
% R is the relative percentage reduction of traffic crashes
R = 100.-K
Rtotal = sum(R)
% about seventy one over-speeding vehicles were sampled, so
Rmean =Rtotal/71
```

The result generated by the matlab after receiving the above commands is as follows:

$R_{mean} = 65.4949$

This shows that about sixty five percent reduction in mortality resulting from traffic crashes would have been achieved for the short time spent on this experiment

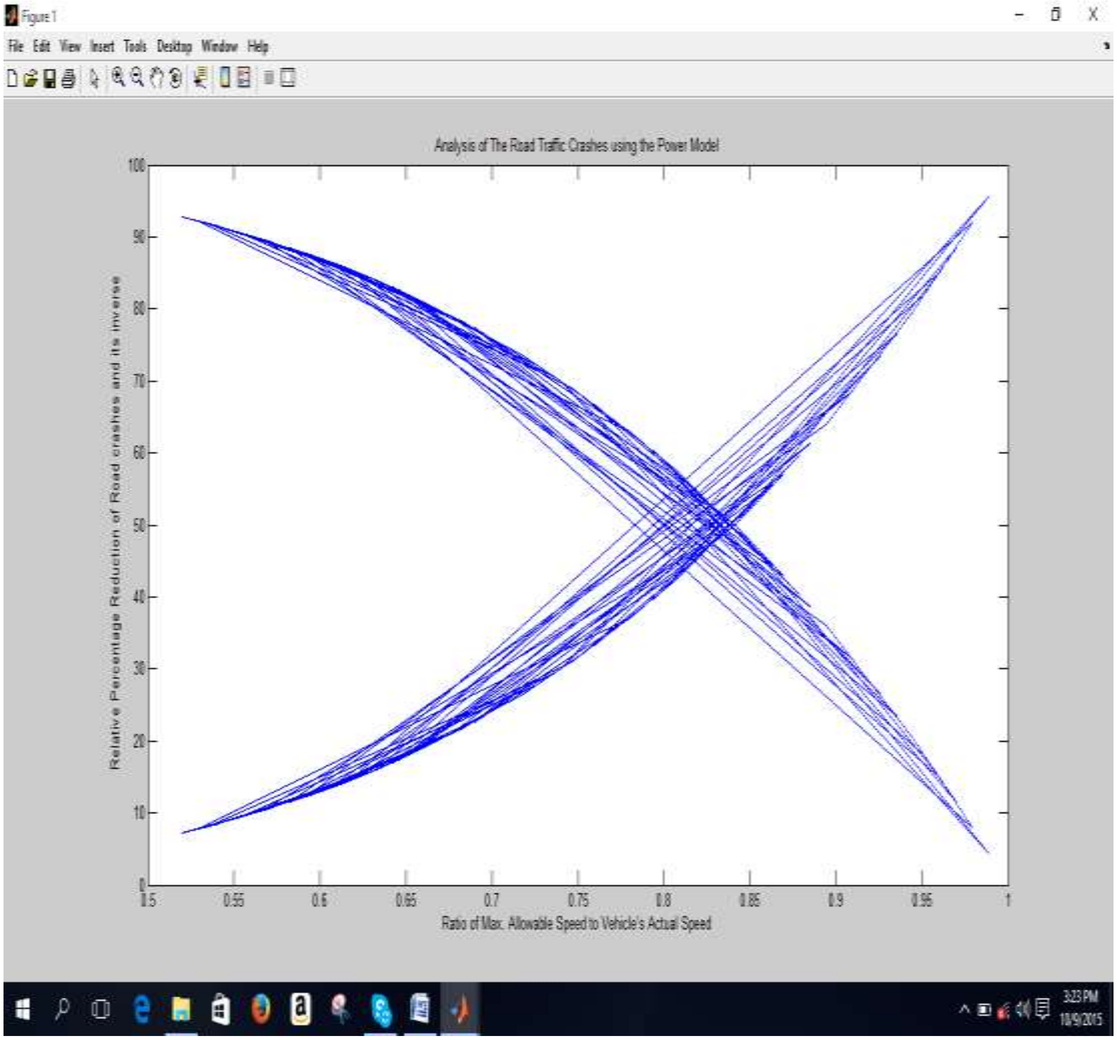

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Fig. 4.1 using the idea of power model to plot a graph showing how both the relative reduction of traffic crashes and its inverse vary with the Nilsson's ratio factor Vlmt/V at a baseline speed of 100 km/h using the Matrix Laboratory Program

5. Conclusion

This research has systematically investigated the use of the piezoelectric sensors as an alternative method for reducing high mortality by monitoring and controlling vehicle speed. It shows that external speed monitor by the piezoelectric sensors do indeed provide a reliable and an attractive alternative approach for vehicle accident prevention system. It also provides for a system that is very cost effective. The approaches that were adopted gives a broad awareness as the driver, passenger(s) and the law enforcer would all be alerted when a vehicle goes beyond the allowable speed limit; that way, there will always be somebody or something to warn the driver when he over-speeds.

References

Agbonkhese, O, Yisa, G.L, Agbonkhese, E.G, Akanbi, D.O, Aka,E.O, Mondigha, E.B (2013), **Road Traffic Accidents in Nigeria: Causes and Preventive Measures**, International Journal on Civil and Environmental Research Vol. 3

Ankita Mishra, Jvoti Solanki, Harshala Bakshi, Priyanka Saxena, Pranay Paranipe (2012), **Design of RF-Based Speed Control System for Vehicles, Vol. 1**, Research publication, College of Information Sciences and Technology, Pennsylvania State University

IRF press release (2014), **Trends and Pattern of Road Accidents in Nigeria**, International Road Federation Bulletin, Nigeria Chapter.

Sumaila Abdul, Ganiyu Femi, (2013). **Road Crashes, Trends and Safety Management in Nigeria**, Department of Transport Management Technology, Federal University of Technology, Minna

Ukoji Vitus .N. (2014), **Trends and Patterns of Fatal Road Accidents in Nigeria (2006-2014),** Working papers series, No. 35, Institute for Research in Africa (IFRA-Nigeria), University of Ibadan