DEVELOPMENT OF AN IMPROVED VEHICLE SPEED TRACKING DEVICE

Supported by tetfund TERTIARY EDUCATION TRUST FUND

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Received: November 12, 2016 **Accepted:** March 27, 2017

Abstract: This research developed an improved vehicle speed tracking device for the purpose of reducing road accidents. There is a compelling need for a device which can be used to detect vehicles driving above the approved speed limit set for various roads. The developed Vehicle Speed tracking device uses two infra-red sensors which are installed at a fixed distance of 50 cm apart on the side of the road. When the first sensor detects the presence of an oncoming vehicle, the microcontroller to which it is connected starts a digital timer which is then stopped when the second sensor detects the vehicle. The time interval taken for both sensors to detect the vehicle and the distance between the sensors is used by the microcontroller to calculate the speed of the vehicle which is then displayed on the Liquid Crystal Display (LCD) screen. A buzzer, alerting traffic police, is activated if the vehicle's speed is higher than the specified speed limit of the road. The novelty of this work is in the precision of the machine speed, up to micro seconds and robustness of the developed vehicle speed tracking device.

Keywords: Digital timer, infrared sensors, microcontroller, vehicle speed tracking, speed limit

Introduction

The 19th century industrial revolution resulted in some fundamental changes in the transport sector and provided more flexibility of movement, speed and timing. 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 (Atubi, 2012). The International Road Federation, Geneva Programme Center reported that approximately 2.4 million people have died in road accidents across the world, with a yearly record of 1.3 million deaths and daily record of 3,000 deaths (IRTAD, 2007). The most affected are middle-income countries (Pratte, 1998). Most African countries fall within the middle income category and thus are worst hit by fatal road accidents (Chen, 2010). Nigeria is ranked second-highest in the rate of road accidents among 193 countries of the world (Aderemo, 2012). The causes of fatal car accidents in Nigeria have been categorized into human, mechanical and environmental factors. These factors have independently and/or collectively contributed to the high rate of fatal road accidents in Nigeria (Agbonkhese, 2013).

Speed has been identified as a key risk factor in road traffic injuries, influencing both the frequency of road accidents as well as the severity of the injuries that result from crashes (Lagarde, 2007). The higher the speed of a vehicle, the shorter the time a driver has to stop and avoid a crash (Erik, 2009). A number of interventions have been identified to be effective in the management and control of vehicle speed. Setting and enforcing speed limits are two of the most effective measures in reducing road traffic injuries (Atubi, 2008). Experience in many countries has shown that the introduction of speed limits will only have a short lived effect on reducing speeds unless accompanied by sustained, visible enforcement of these limits (Taylor, 2000). Consequently, there is a need for a device to track the speed of vehicles on various highways in order to ensure proper speed limit enforcement.

Speed limit enforcement is the action taken by appropriately empowered authorities to check that road vehicle users comply with the speed limit allowed on roads and highways. Methods used include roadside speed traps set up and operated by the police and automated roadside speed camera systems which may incorporate the use of an automatic number plate recognition system. Traditionally, the police would have used stopwatches to measure the time taken for a vehicle to cover a known distance, but more recently, they have had speed guns and automated in-vehicle systems at their disposal (Foster, 2004).

In advanced countries, vehicle tracking systems to monitor speed compliance requires traffic surveillance on the basis of video image processing technology. The vehicle trajectory is used as input to sophisticated, automated surveillance applications which relies on Global Positioning System (GPS) satellite. A neural network model is used to interpret the vehicle location and speed. This system is very capital intensive and is not affordable for most developing countries.

The main aim of this project is to develop a cost effective device to detect rash driving on highways and to alert the traffic authorities in case of any speed violation. This will enable them arrest the drivers of such vehicles and also impound the vehicles after which they will be prosecuted in accordance with the provisions of the law. The objective of this research includes improving the precision of the speed tracking machine to capture events in microseconds. All the components used are tested for durability, temperature stability and sensitivity to harsh environmental factors. The patenting and commercialization of the developed speed tracking device will lead to availability of the machine for the enforcement of speed limits on roads. The reduced cost of the device and the ease of operation make it suitable for all roads especially in the developing countries of Africa where there are no closed circuit television monitor (CCTV) on the roads.

Materials and Methods

The block diagram for the development of the Speed Tracking Device is as shown in Fig. 1.

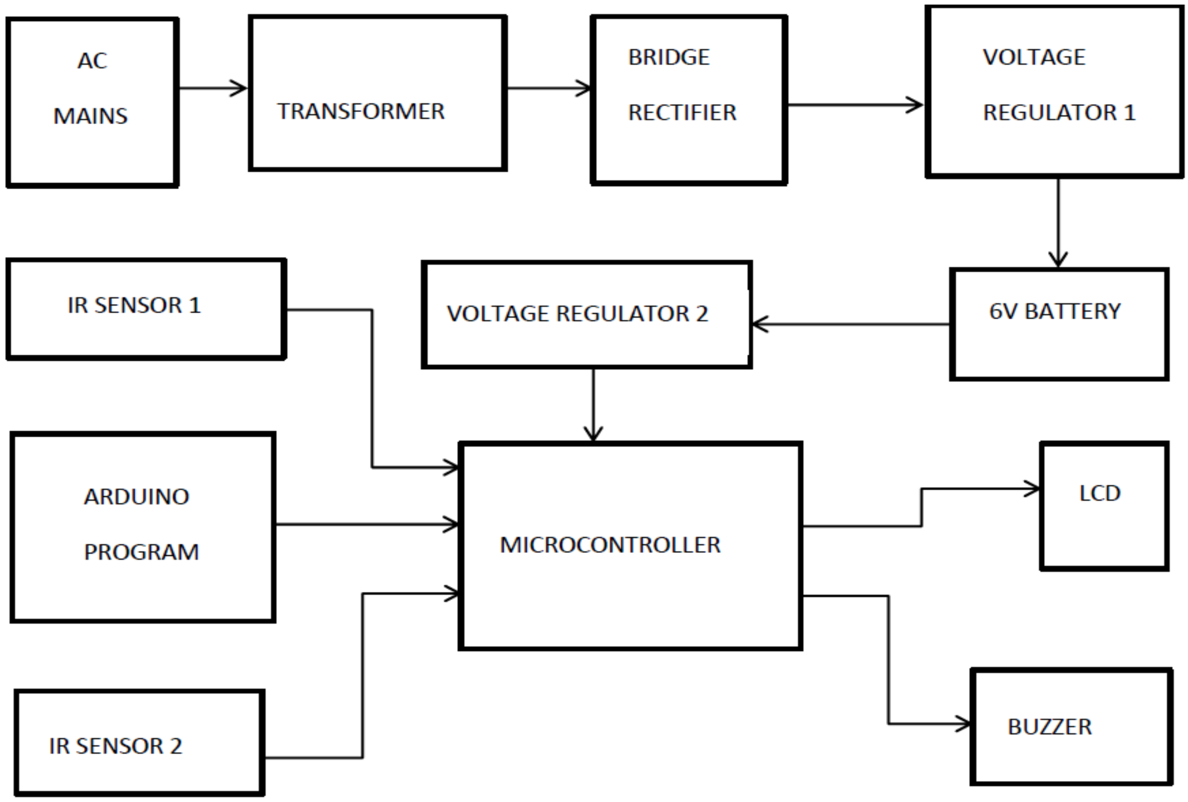

Fig. 1: Block diagram of the Vehicle Speed Tracking Device

The system can basically be broken down into four sections. These are:

The power supply

The developed vehicle speed tracking device uses input power from Alternating Current (AC) mains which is about 220 volts. This voltage is relatively too high for the system, hence the need to step it down. This was achieved by making use of a step down transformer which steps down the voltage to about 12 volts Alternating Current (AC). This voltage was then converted to Direct Current (DC) by the diode bridge rectifier. A steady DC voltage was obtained by feeding the output voltage from the rectifier into the adjustable DC voltage regulator (LM317T). The voltage output from LM317T was adjusted to about 9 volts by the use of a variable resistor and this was then used to charge the 6 volts battery that serves as backup power source. The battery was also connected to a second voltage regulator (7805 IC) which provides the steady 5 volts output voltage needed to power the microcontroller. At remote locations where electricity is scarce, a solar cell can be used for power supply together with an inverter and storage battery.

Sensors

Basically sensors are transducers which utilizes different technologies for operation (Oduah, 2016). Light emitting diodes sometimes are used to generate the optical signals which are sensed by the receivers. The process for the fabrication of enhanced Light Emitting Diode has previously been developed with improved operational efficiency (Oduah, 2014). This system uses two infrared Light Emitting Diode (LED) transmitter and receiver sensor pairs installed at a fixed distance apart on the side of the road. The Infrared (IR) sensors detect the presence of oncoming vehicles on the highway. For this project, the LTH-209-01 reflective object sensors consisting of an infrared (IR) emitting diode and N-P-N silicon photo-transmitter mounted side by side on converging optical axis in a plastic housing was used. A fixed distance of 50 cm was used for this project to eliminate any possibility of cheating the system by slowing down before getting to the point where the sensors are fixed. It will be difficult for a vehicle to significantly reduce its speed over a distance of 50 cm.

Microcontroller

The microcontroller is the brain of the entire system. It controls all the functions of the entire circuit using the program stored in its memory. The microcontroller used in this project is the ATMEGA328P 8-bit Advanced Virtual RISC (AVR) microcontroller. RISC denotes Reduced Instruction Set Computer.When IR rays from the first sensor are interrupted by an oncoming vehicle, the microcontroller starts the count up timer which is stopped when the other IR sensor senses the presence of the vehicle. It then uses the distance between the two sensors and the time it takes the vehicle to travel between both points to calculate the speed of the vehicle using the formula shown below;

Speed $= {}^{distance}/_{time}$

Where distance is refers to the total distance between the pair of sensors and time is represents the interval between crossing the first sensor and the second sensor. The microcontroller also activates the buzzer if the speed limit is exceeded. The mode of operation of the developed speed tracking device is described in the flowchart in figure 2 below. The digital counter starts immediately the sensor captures the vehicle. At the point when the second infrared sensor captures the same vehicle, the distance and the speed will automatically be registered on the display screen.

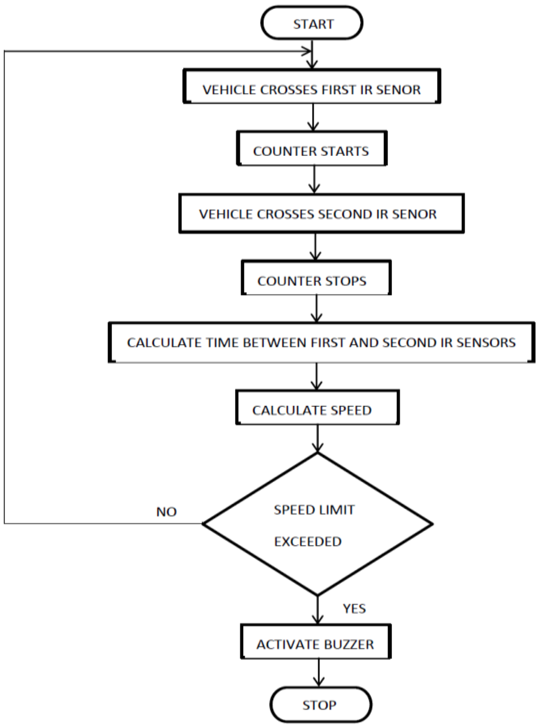

Fig. 2: Program flowchart

Display

The display used for this project is the 16*2 Liquid Crystal Display. The LCD display is used to show the speed of the vehicle as well as the time taken by the vehicle to travel the distance between both sensors. Furthermore, the packaging of this device was done with water resistant, temperature resistant, and physical stress resistant corrugated steel.

The diagram of the developed Speed Tracking device and the power supply unit are shown in Figs. 3 and 4, respectively.

Fig. 3: Complete package of the vehicle speed tracking device

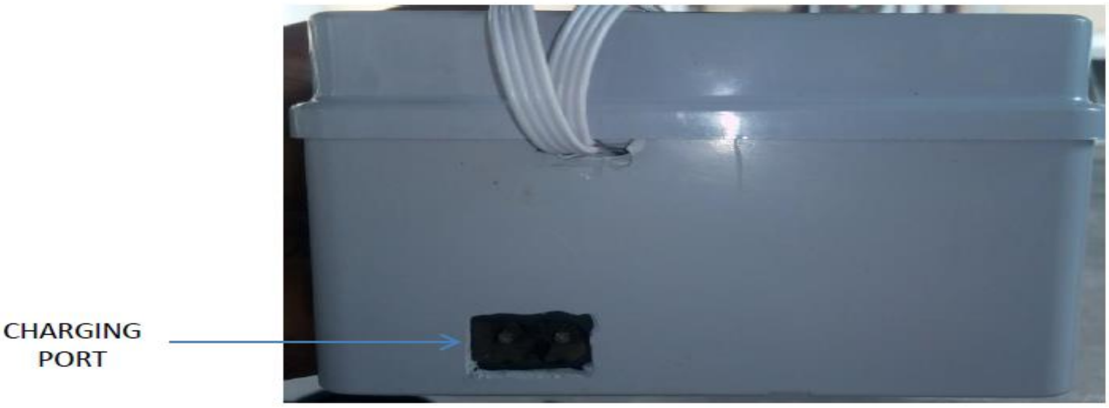

Fig. 4: AC port for the Vehicle speed tracking device

The list of all the components used in the development of the Speed Tracking Device is described in Table 1.

Table 1: List of all components of the Speed Tracking Device

Category	Quantity	References	Value	Stock Code
Capacitors	2	C1-C2	22pF	
Capacitors	1	C3	100nF	
Capacitors	1	C4	10 nF	
Capacitors	1	C5	10u F	
Capacitors	1	C6	1000 u	MaplinDT69A
Capacitors	1	C7	10 n	MaplinYR75S
Resistors	2	R1,R6	10 k	M10K
Resistors	1	R2	330 R	M330R
Resistors	3	R3-R4,R14	1 k	M1k
Resistors	1	R5	100 k	M10K
Resistors	1	R7	1 k	M330R
Resistors	3	R8,R10,R12	100 R	M100R
Resistors	1	R9	270 R	M270R
Resistors	2	R11,R13	33 k	M10K
Integrated Circuits	1	U1	ATMEGA328P	
Integrated Circuits	1	U2	7805	
Integrated Circuits	1	U3	LM317T	
Transistors	2	Q1-Q2	2N3904	
Diodes	3	D1,D3,D10	LED	
Diodes	6	D2,D4,D6-D9	1N4007	
Diodes	1	D5	1N5408	
Miscellaneous	4	6V BAT,ACR,RESET,VIN	TBLOCK-I2	
Miscellaneous	6	AC,BUT,BUZZER,C++,C--,SWITCH	CONN-SIL2	
Miscellaneous	2	DETECTOR0-DETECTOR1	CONN-SIL4	
Miscellaneous	1	LCD	CONN-SIL12	
Miscellaneous	1	RL1	G5CLE-1-DC5	
Miscellaneous	1	RV1	10 k	
Miscellaneous	1	RV2	5 k	
Miscellaneous	1	RV3	1 k	
Miscellaneous	2	RV4-RV5	102	
Miscellaneous	1	UART	CONN-SIL5	
Miscellaneous	1	X1	CRYSTAL	

The cost of all the components used for the construction of the Speed Tracking Device is presented in Table 2. This is relatively cheap compared to the existing vehicle speed tracking devices which costs about ₦80,000 to ₦200,000 in the market.

Table 2: Cost of components for the vehicle speed tracking device

Component	Quantity	Unit Price (₦)	Cost (₦)
Capacitors (22 pF)	2	10	20
Capacitors (100 nF)	1	15	15
Capacitors (10 nF)	1	10	10
Capacitors (10 µF)	1	10	10
Capacitors (1000 µF)	1	20	20
Resistors (10 kΩ)	2	20	40
Resistors (330 Ω)	1	20	20
Resistors (1 kΩ)	3	50	150
Resistors (100 kΩ)	1	50	50
Resistors (100 Ω)	3	50	150
Resistors (270 Ω)	1	10	10
Resistors (33 kΩ)	2	50	100
Integrated Circuits (ATMEGA328P)	1	400	400
Integrated Circuits (7805)	1	500	500
Integrated Circuits (LM317T)	1	400	400
Transistors (2N3904)	2	300	600
Diodes (LED)	3	20	60
Diodes (1N4007)	6	40	240
Diodes (1N5408)	1	40	40
Packaging			500
Logistics			400
Total			**3,735**

Results and Discussion

The results gathered by comparing the speed displayed by the device with the speed calculated using the ratio of distance between the sensors to the time taken by a vehicle to travel between sensors one and two are presented in Table 3.

Table 3: Table of result

S/N	Distance between Sensors (m)	Time Displayed (s)	Speed Displayed (m/s)	Speed Calculated (m/s)	Speed Limit (m/s)	Buzzer Sound
Vehicle 1	0.50	0.037	13.335	13.50	14	NO
Vehicle 2	0.50	0.028	17.732	17.85	14	YES
Vehicle 3	0.50	0.026	19.001	19.20	14	YES
Vehicle 4	0.50	0.040	12.500	12.50	14	NO
Vehicle 5	0.50	0.025	19.563	20.00	14	YES
Vehicle 6	0.50	0.025	19.446	20.00	14	YES
Vehicle 7	0.50	0.050	10.445	10.00	14	NO
Vehicle 8	0.50	0.027	18.225	18.50	14	YES
Vehicle 9	0.50	0.027	18.611	18.50	14	YES
Vehicle 10	0.50	0.025	20.003	20.00	14	YES

The use of this system is advantageous over other conventional means of speed detection because it involves very little human contact, unlike the handheld radar/lidar gun. The isolation of this device from human contact eliminates any associated human error from the process vehicle speed tracking. Infrared sensors used are also very sensitive and less susceptible to changes in weather conditions. Other notable improvements include: speed is calculated and displayed instantaneously. The device is affordable as shown in Table 2 and easily reproducible since the materials and components required are readily available.

Although the infra-red sensors used are sensitive and can operate optimally irrespective of prevailing weather conditions, Hall Effect sensors are preferred in place of the infrared sensors but they are more expensive. This is because it is much more sensitive than the infrared sensor and it varies its output voltage in response to a magnetic field which gives it the ability to differentiate between vehicles and humans or animals. Other possible modifications of the developed device includes incorporating cameras into the system such that when the speed limit is exceeded, the camera is activated to capture the physical characteristics of the vehicle, preferably, the number plates and the picture of driver of the vehicle which can be saved by the system and recovered at a later time. Images gathered can be reproduced as evidence during trials of road traffic offenders.

Conclusion

The Vehicle Speed Tracking Device was constructed to help traffic officers and road safety authorities identify vehicles driving above approved speed limits for various highways. This was achieved by using two infrared sensors to detect the presence of a vehicle travelling between two fixed points on the road and consequently, the calculation and display of the speed of the vehicle on the LCD screen. A buzzer is activated if the speed of the vehicle exceeds the set speed limit. After testing the device and carefully observing the results, it was observed that the speed displayed by the device was accurate and the device therefore can be relied upon to measure vehicular speed with precision in micro seconds. The developed speed tracking device is relatively cheaper than the existing devices and is very suitable for application in Nigerian roads.

Acknowledgement

Our sincere gratitude goes to the Department of physics, Faculty of Science, University of Lagos, for providing the laboratory facilities for this research.

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