Curbing High Rate of Accidents on Nigerian Roads Using High Speed Protecting Devices

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Abstract

The objective of the United Nations decade of action for road safety 2011-2020 is to reduce the projected number of road fatalities worldwide (1.9 million in 2020 on post trends) by 50%. The costs to society of road crashes are substantial and constitute a major burden for economies. Although no common international approach to assess crash cost has been agreed, estimations range from 1 to 30% of GDP, depending on the methodology used, but could grow significantly as research on the consequences of most severe injuries improves. Prior to the establishment of FRSC in 1998, World Health Organisation adjudged Nigeria as the most dangerous Country in the World to drive a motor vehicle. This necessitated the Federal government to address the situation by creating a statutory agency located at the Presidency, as Nigeria's lead agency for road safety management and traffic administration. FRSC's critical mandate is accident prevention and making roads safer. This paper looks at how high rate of accidents on Nigerian roads can be curbed using high speed warning and protecting device. The approach uses an input filter and amplifier which receives a regulated input signal from the spark plug and fed as an input to the tachometer which is a frequency to voltage converter, the output of the tachometer is fed as one of the inputs of the comparator whose other input is from the ignition coil of the vehicle, the output of the comparator is fed to the tone generator which is designed using a free running multivibrator. The tone generator is triggered as the set speed of the vehicle at the comparator circuit is exceeded, signaling that the speed is high and must be reduced.

Key Words: *Fatalities, High Rate, Protecting, High speed, Device, Injuries*.

INTRODUCTION

Man's invention of motor vehicle brought a great relief to man in terms of the transportation of goods, services and man himself. As more motor vehicles began to ply the road accident began to occur. According to Ademaro(2012) Road accident fatalities continue to attract the attention of policy makers and the populace all over the world. The incessant carnage on the roads, especially in developing countries, constitutes a major challenge to safety professionals. This is evident from available statistics on road accident crashes and injuries all over the world. However, as a result of safety measures adopted in developed countries, variation exists in the magnitude of this scourge between developed and developing countries. While for example developed countries have experienced a decreasing trend since the 1960s, the fatality rate in African countries ranges from 10-fold to more than 100-fold of those in the United States. While South-East Asia has the highest proportion of global road fatalities (one-third of the 1.4million occurring each year in the world), the road traffic injury mortality rate is highest in Africa (28.3 per 100,000 population) compared with 11.0 in Europe. Indeed, if major challenges are not made to reverse the trend, it is feared that road traffic crash fatality rate in Africa as a whole is anticipated to increase by 80 per cent between 2000 and 2020. Agbonkhese et al (2013) pointed out that road accidents have become a normal and re-occurring phenomenon in Nigeria which constitutes a menace in modern times. Although both the developed and developing nations of the world have suffered from varying degrees of road accidents, the developing countries clearly dominates with Nigeria having the second highest rate of road accidents among 193 ranked countries of the world. Deaths from reckless driving are the third leading cause of death in Nigeria. There is a serious need of ensuring that continues increasing trend of fatalities in road accidents should be curtailed especially in Nigeria.

LITERATURE REVIEW

Noncompliance with speed limits is one of the major safety concerns in roadwork zones. Although numerous studies have attempted to evaluate the effectiveness of safety measures on speed limit compliance, many report inconsistent findings. Their work was to review the effectiveness of four categories of roadwork zone speed control measures: Informational, Physical, Enforcement, and Educational measures. While informational measures (static signage, variable message signage) evidently have small to moderate effects on speed reduction, physical measures (rumble strips, optical speed bars) are found ineffective for transient and moving work zones. Enforcement measures (speed camera, police presence) have the greatest effects, while educational measures also have significant potential to improve public awareness of road worker safety and to encourage slower speeds in work zones. Inadequate public understanding of roadwork risks and hazards, failure to notice signs, and poor appreciation of safety measures are the major causes of noncompliance with speed limits. With modern engine management technology there is an opportunity to introduce top speed limiting of many new cars at a very low cost. This approach would mainly affect crashes in rural areas (Debnath, 2012). Automatic speed limiters, which have the potential to reduce speed-related crashes in rural and urban areas, would require expenditure on the road infrastructure, to provide a speed limit signal to the on-vehicle device. Coded magnetic strips which are bonded to the roadway could provide this signal at relatively low cost. Widespread implementation of such a signalling system could result in voluntary fitting of automatic speed limiters to existing vehicles.

According to Balashanmugan, Balasubramaaniyan, Balasubramaniyan, and Vinoth (2013) in this fast moving world accidents are becoming proportional to high speed. As for the Indian road transport scenario is concerned, accidents are becoming a day to day cause an attempt was been made to reduce such mishaps. A high speed indication is given and automatic braking is applied by cutting off the fuel supply to the engine when the setup speed is exceeded. In their work, solenoid valve was used and an operational amplifier circuit using LM324IC. Abdelgawab and Mardourah (2014) in their submission said millions of people are killed or seriously injured on the roads due to terrified accidents every year. Most of these accidents are attributed to the over-speeding of the road vehicles. Thus, the road speed limiter (*RSL*) is a very important technique to reduce the possibility of road accidents. An interesting idea to control the speed of the vehicle is to apply electronic control of the air-supply that enters the vehicle carburetor according to road transmitters that are connected and operated either by local network or satellite. In their work, a control system was designed and implemented. It is consisted of a control mechanism and an electronic circuit to control the air-inlet to the carburetor according to pre-set programming based on the vehicle speed. Although, it is a challenging job to design and implement modifications to existing systems, the present speed control system was successfully implemented and tested. The present proposed mechanism is simple, inexpensive and suitable to be implemented in developing countries where a big number of cars still work using the traditional carburetor mechanism.

Devikiruba (2013) worked on the use of GSM/GPRS, his work was an attempt to control the speed of the vehicle designed with computer software to enable the third party or owner to get the location, speed and activity of the driver. To achieve this, the system can transmit the information in real time. The use of GSM/GPRS technologies allows the system to track the objects and provide the up-to-date information. This information is authorized to specific users over the internet as the server gets the information. It is the tele-mointoring system to transmit data to the remote user. Thus the applications are used in real time traffic surveillance. The work proposes a prototype model for location tracking using Geographical Positioning System (GPS) and Global System for Mobile Communication (GSM) technology. The development was based on the windows phone 8 application by means it can provide flexibility and portability for the user to get the information from anywhere. As these GPS technologies having greater range of frequencies, the user can get the information as quicker as possible. This system is very useful to speed control at specific traffic roads.

In another approach Kewate, Karmare, Sayankar, and Gavhale (2014) pointed out that speed control is in the need of the hour due to the increased rate of accidents reported in our day-to-day life. During 2011, in India a whole of 4, 97,686 road accidents were reported which is a result of lack of speed control and violating the road rules. Road accidents can be prevented by adopting measures such as Traffic management, improving quality of road infrastructure and safer vehicles. The existing techniques still doesn’t able to reduce the number of accidents. Hence there is a need to implement Intelligent Speed Adaptation (ISA) in which vehicles speed can be automatically controlled by various limit techniques which are based on zones, highway, traffic density etc. Their work proposes automatic speed control system based on color strips for highway road and the roads where the speed control within limit is required. The methodology explains that a various color strips are marked on highway road or the roads where the speed control within limit is required and vehicle will have a color sensor attached which will recognize the color marked on the highway road and accordingly maintain the vehicles speed in that particular limit. In this developed system, the color detecting sensor of specific intensity is used to activate/deactivate the system of speed control within the color strips marked on the road. In actual practice, the system works that when vehicle enter in speed limiting roads like express–high way, high way and any other roads where the speed limit is required etc., the vehicle sensor detect the color to activate the system and send the signals to programmable ECU/MCU and the programmable ECU /MCU controls the position of throttle valve/fuel pump/motor which result in controlling the speed of engine at given limit. When the system activated then our vehicle is controlled at given limited speed or below that limiting speed and cannot exceed beyond that limit till the next color strip crossed. This reduces the road accidents and gets driving comfort for the driver, after implementation of this automatic speed control system.

Causes of Accident on Nigerian Roads

There are many factors that could be said to be responsible for accidents on Nigerian roads; these factors may be from the vehicle drivers, the vehicles and other road users. According to Agbonkhese et.al (2013) On a lot of Nigerian roads across the country deterioration often begins with the origin of cracks or pot holes on the road pavements either at the edges or along the drive way which differs by their shapes, configuration, amplitude of loading, movement of traffic and rate of deformation. The presence of these pot holes aside from human and vehicle related factors are known to be major causes of road traffic accidents in Nigeria. The immediate cause of a road accident may also be attributable to mechanical factor and carelessness in the form of omission to check and maintain the vehicle at the appropriate time. Road traffic accident is therefore an unexpected phenomenon that occurs as a result of the operation of vehicles including bicycles and handcarts on the public highways and roads. Table 1 shows global road fatalities (IRTAD, 2014).

Table 1: Global Road Fatalities.

		Recent Data			**% Average annual change**					
S/N	**County**	**2012**	**2011**	**2010**	**2012-2011**	**2012-2000**	**2010-2001**	**2000-1991**	**1990-1981**	**1980-1971**
1	Argentina	5104	5040	5004	1.3	-	-	-	-	-
2	Australia	1299	1277	1353	1.7	-28.5	-2.7	-1.7	-3.9	-1.0
3	Austria	531	523	552	1.5	-45.6	-5.9	-5.0	-2.5	-3.9
4	Belgium	767	861	840	-10.9	-47.8	-6.1	-2.7	-1.3	-2.8
5	Cambodia	1966	1905	1816	3.2	-	-	-	-	-
6	Canada	2104	2006	2237	4.9	-27.5	-2.3	-2.6	-3.3	-0.2
7	Chile	1980	2045	2074	-3.2	-10.3	0.2	-	-	-
8	Colombia	5922	5528	5502	7.1	9.6	1.6	-	-	-
9	Czech Rep.	742	773	802	-4.0	-50.1	-5.5	1.2	0.8	-4.9
10	Denmark	167	220	255	-24.1	-66.5	-5.7	-2.2	-0.5	-6.1
11	Finland	255	292	272	-12.7	-35.6	-5.0	-5.1	1.8	-7.8
12	France	3653	3963	3992	-7.8	-55.3	-7.8	-2.5	-2.1	-2.8
13	Germany	3600	4009	3648	-10.2	-52.0	-7.0	-4.4	-	-
14	Greece	984	1141	1258	-13.8	-51.7	-4.4	-0.4	2.8	3.0
15	Hungary	605	638	740	-5.2	-49.6	-5.6	-6.1	4.7	-1.3
16	Iceland	9	12	8	-25.0	-71.9	-11.5	-1.9	0.0	2.0
17	Ireland	162	186	212	-12.9	-61.0	-7.1	-0.8	-2.0	-0.2
18	Israel	263	341	352	-22.9	-41.8	-4.5	0.4	-0.2	-4.0
19	Italy	3653	3860	4114	-5.4	-48.3	-5.9	-1.5	-2.2	-1.9
20	Jamaica	260	307	319	-15.3	-22.2	-1.4	-3.1	-	-
21	Japan	5237	5507	5806	-4.9	-49.7	-5.9	-3.6	2.8	-6.7
22	Korea	5392	5229	5505	3.1	-47.3	-4.2	-4.5	8.7	5.6
23	Lithuania	301	296	300	1.7	-53.0	-9.1	-6.5	2.6	-
24	Luxembourg	34	33	32	3.0	-55.3	-8.3	-1.0	-3.7	1.5
25	Malaysia	6917	6877	6872	0.6	14.6	1.8	-	-	-
26	Netherlands	650	661	640	-1.7	-44.3	-5.7	-1.0	-3.0	-5.0
27	New Zealand	308	284	375	8.5	-33.3	-2.1	-3.7	1.0	-1.4
28	Nigeria	6092	6054	6052	0.6	-28.1	-	-	-	-
29	Norway	145	168	208	-13.7	-57.5	-3.1	0.6	-0.2 - 4.2	
30	Poland	3571	4189	3908	-14.8	-43.3	-3.8	-2.5	2.1	-
31	Portugal	718	801	937	-19.4	-65.0	-7.3	-4.5	0.3	3.5
32	Serbia	688	731	660	-5.9	-34.4	-7.1	-6.4	0.9	-
33	Slovenia	130	141	138	-7.8	-58.6	-7.5	-4	2	-1.0 - 1.6
34	Spain	1903	2060	2478	-7.6	-67.1	-8.5	-4.6	3.9	1.9

Source: WHO

Table 2: Nigerian Road crashes in 2011, 2012 and 2013

Reported safety data	**2011**	**2012**	***2013***	***% increase from 2013 to 2012***
Road crashes	13191	13262	13583	2%
Injuries	41165	3 348	40057	2%
Fatalities	6054	6092	6450	6%

Source: FRSC.

In 2012, there were 13 262 reported road crashes, which caused the deaths of 6 092 persons, 1% more than in 2011. In 2013, there was a 2% increase in road traffic crashes, a 2% increase in injuries and a 6% increase in fatalities when compared with the 2012 figures. In addition, speed violation accounted for 32% of identified probable causes of crashes, followed by Loss of control and Dangerous driving, at 17.1% and 12.1%, in 2013 respectively (IRTAD, 2014)

Accident Prevention

There are various ways in which accidents could be prevented and this is anchored by the agency formed by government for such an important task. In Nigeria the Federal Road Safety corps which was established vide decree 45 of 1988 as amended by decree 35 of 1992 is responsible for insuring that our roads are safe for use. Among the risk factors to be addressed by road safety agencies globally as contained in WHO Road traffic injuries; fact sheet No 358 (2013) are ; speed, drink- driving, helmets, seat- belts and Child restraints. The road safety and traffic data is shown in Table.3. Table 4. Shows the passenger car speed limits by road type for 2014.

Table 3:Road Safety and Traffic Data

						2012 % change from		
Year	1990	2000	2010	2011	2012	2011	2000	1990
Population	90 557 000	118 953 000	156 051 000	164 224 341	169 653 245	3%	43%	87%
Reported number of fatalities	8 154	8 473	6 052	6 054	6 092	1%	-28%	-25%
Reported number of injury crashes	22 786	20 677	35 691	41 165	39 348	-4%	90%	73%
Reported number of deaths per 100 000 inhabitants	9	7	4	4	4	-3%	-50%	-60%
Estimation of the number of registered vehicles	Na	5 772 061	12 366 366	13 147 865	13 539 090	3%	135%	Na
Deaths per* 10 000 registered vehicles	Na	15	5	5	4	-2%	-69%	Na
Registered vehicles per 1 000 population	Na	49	79	80	80	0%	64%	Na

Source: FRSC.

In 2011, inappropriate or excessive speed was the main contributing factor in 32% of fatal crashes. (IRTAD, 2014). The first listed risk factor is which is considered as very serious is our main focus in this paper.

Table 4: Passenger Car Speed Limit by Road Type 2014

Road Type	**Speed Limit (Km.h**
Urban	50
Rural Roads	80
Motorways	100

Source: FRSC

MATERIALS AND METHODS

The design and construction of the high speed warning and protecting device was carried out using the first principles of electronic circuit design. Discrete electronic components were used for the construction of the individual circuits which were observed to have been functioning well in the tropics.

The High Speed Warning and Protecting Device

The block diagram of the high speed warning and protecting device is made up of basically six blocks (Ceippel, 1983). It is seen as an important component in the auto industry in regards to safety.

Input from spark plug

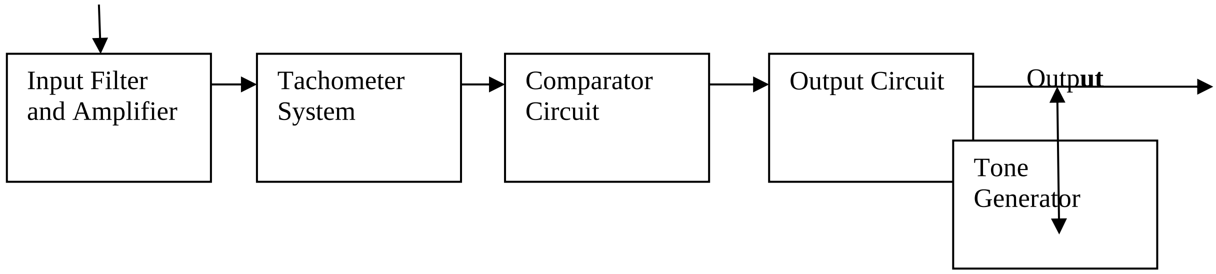

Figure 1: Block Diagram of High Speed Warning and Protecting Device

Design of High Speed Warning and Protecting Device

Input Amplifier and Filter

Design of High –pass Filter

Data:

Cut-off Frequency required = $10KHZ$

Gain = 100

Chose R1,

W $=\frac{1}{RC}$, f = $\frac{1}{2\pi RC}$, $C_1 = \frac{1}{2\pi R1C}$

Design of Amplifier;

Gain = 100

For flat response over the audio frequency range

Chose R1 = 1K, Av= $\frac{R3}{R2}$, $R_4 = \frac{R2R2}{R2+R3}$

Supply Voltage Vcc ± 15V

Choose VBE for Silicon diode

Find Voltage across $R_{2,}$

Find Current through the diode.

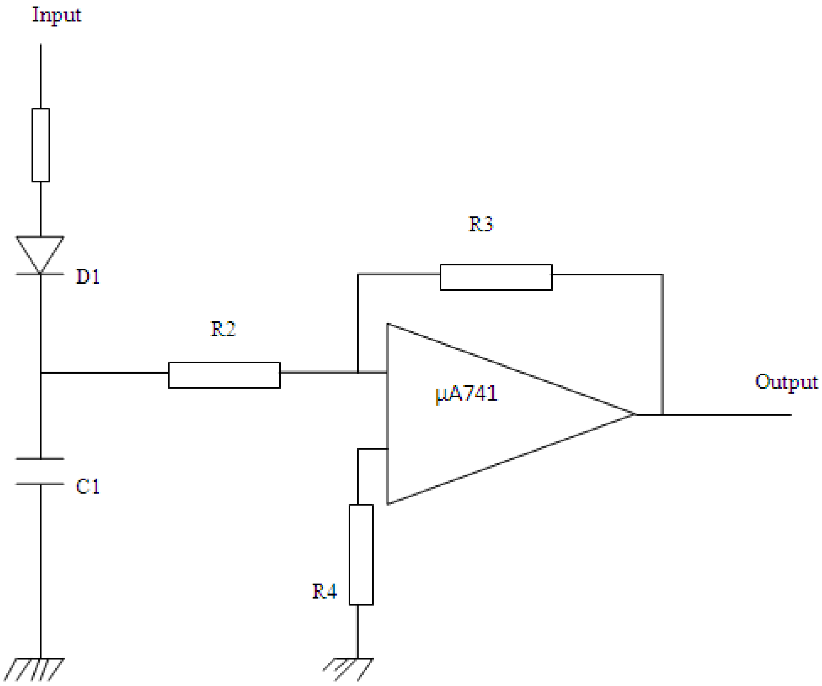

Figure 2: Input Filter and Amplifier

From figure 2 the filter and input amplifier stage receives signal from the spark plug and is regulated through R1, D1 and C1. It is then amplified by µA and the output fed to the tachometer.

Design for Tachometer

Frequency Band = 4KHZ, Gain 100

Choose Power Supply = ± 15V

Choose Value of C_F =10µF

R5 = $\frac{RV}{Gain}$

R_5 = $\frac{RVR5}{RV+R5}$, C2_= $\frac{1}{2\pi Rvf}$, D2 & D1 =In4148, C2 = $\frac{1}{2\pi Rgf}$

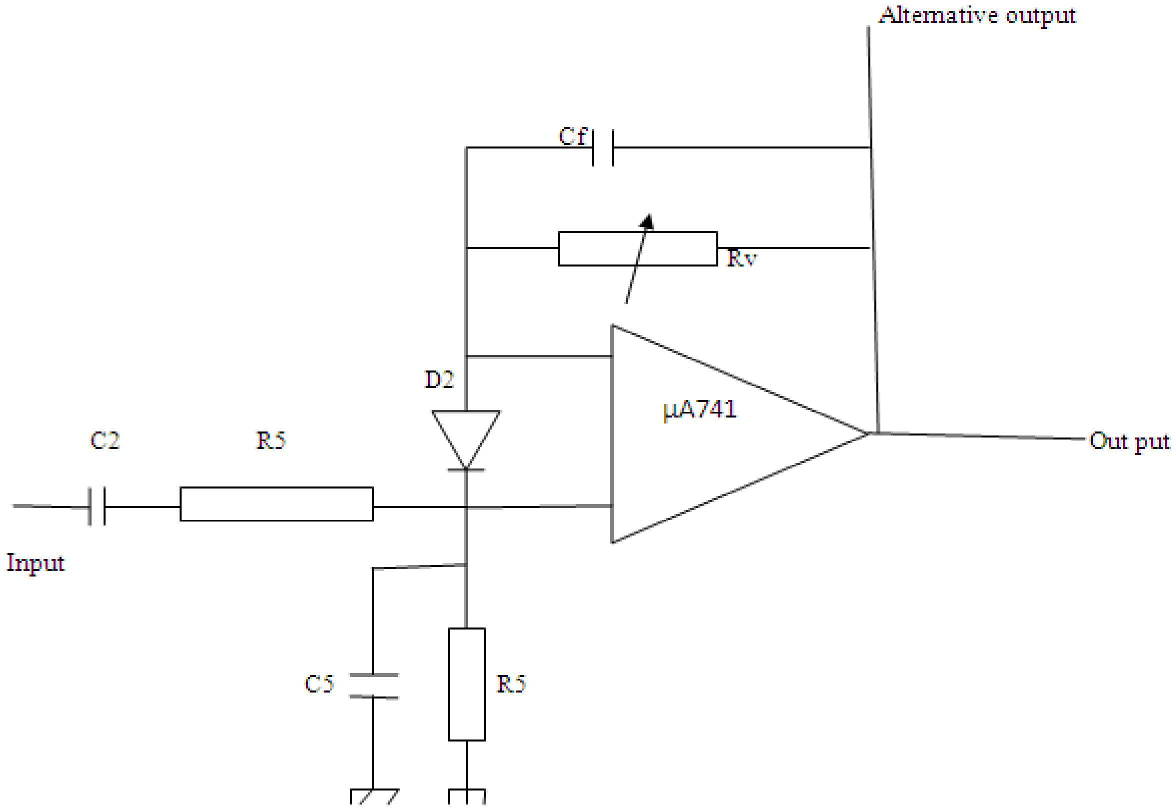

Figure 3: Tachometer

The Tachometer which is a frequency to voltage converter produces an output voltage proportional to the derivative of the input frequency signal. The signal from the output of the input amplifier is the input to the tachometer and it is fed through pin 3 of the Op amp µA741 which is the non-inverting input and fro high input impedance. Rv is used for setting the speed limit of the vehicle at which the tone generator is triggered. Cf is used for system stability and high frequency noise reduction.. D2 is used as a frequency doubler. Rs is for prevention of input bias current from producing a dc offset at the Op amp output. Cs is to bypass thermal noise of R2 to ground.

Design of Comparator
Gain = 100
Determine R6, R7 = RV.R6
For Switching Transistor XTR2,
Vcc =12V
Ic = 30mA
Vcc = 7V , Silicon.
Collector Resistance Rc = $Vcc - \frac{Vce}{Ic}$
RC=R11
The base of XTR2 is supplied 7V
Vbe = 0.7, Silicon
Ic =30mA
Base resistance RB = R10 = $\frac{(VCC - VB)\,B}{IC}$

Clamping Circuit : -
Choose XTR – BC 108
The Ignition has a current of about 0.09A through R9,
Calculate; for R8.

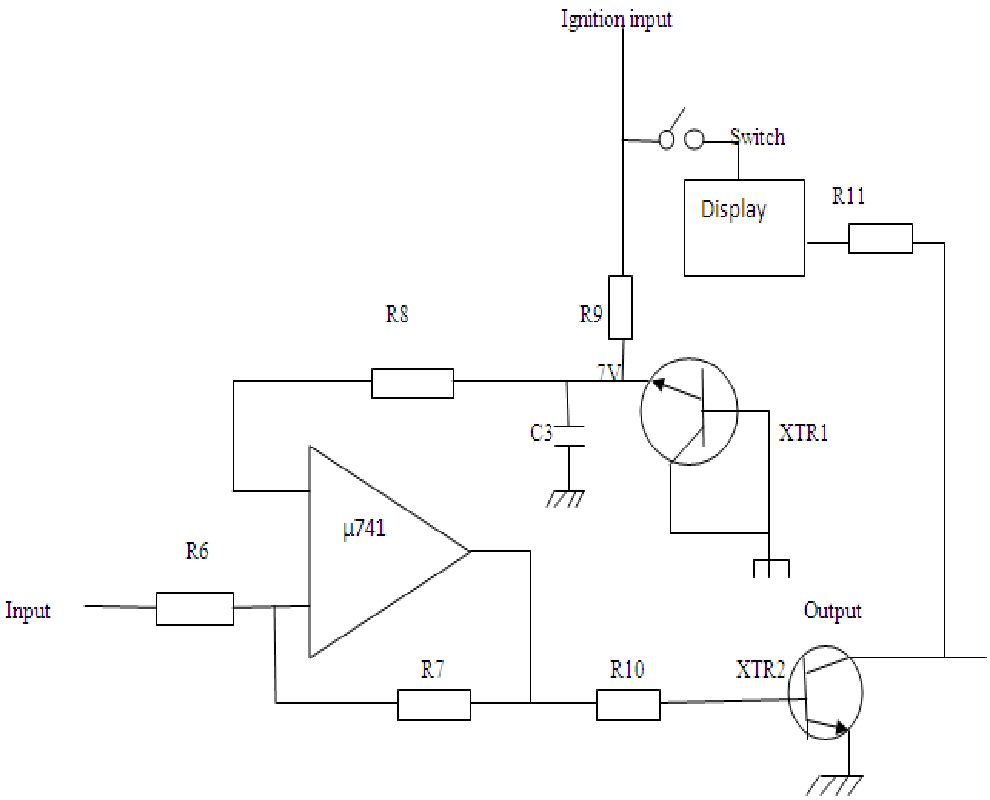

Figure 4: Comparator/Output

The comparator circuit receives input from two sources, one from the Tachometer output and another from the ignition coil. These two voltages are compared by the comparator, the ignition voltage being the reference voltage. At high speed the output voltage from the Tachometer becomes high, and when compared with the reference voltage, it turns ON transistor XTR2 which acts as a switching transistor. The collector of XTR1 is connected to the ignition terminal.XTR1 acts as a diode and so XTR1 in parallel with C3 forms a clamping circuit (Negative dc restorer). The voltage 7V is clamped through XTR1 and C3,R3 and it is sent as an inverting input to the Op amp so as to effect comparison.

Tone Generator Design

Choose μ741 – Operational Amplifier
Choose a ±15V Power Supply
Choose R14 = R13 = 100KΩ
Frequency (fs) = 200HZ
Calculate C4 $= \frac{1}{2\pi f R13}$
R12 = 2.TC (R14)
Where TC = 63%
2TC = 86%

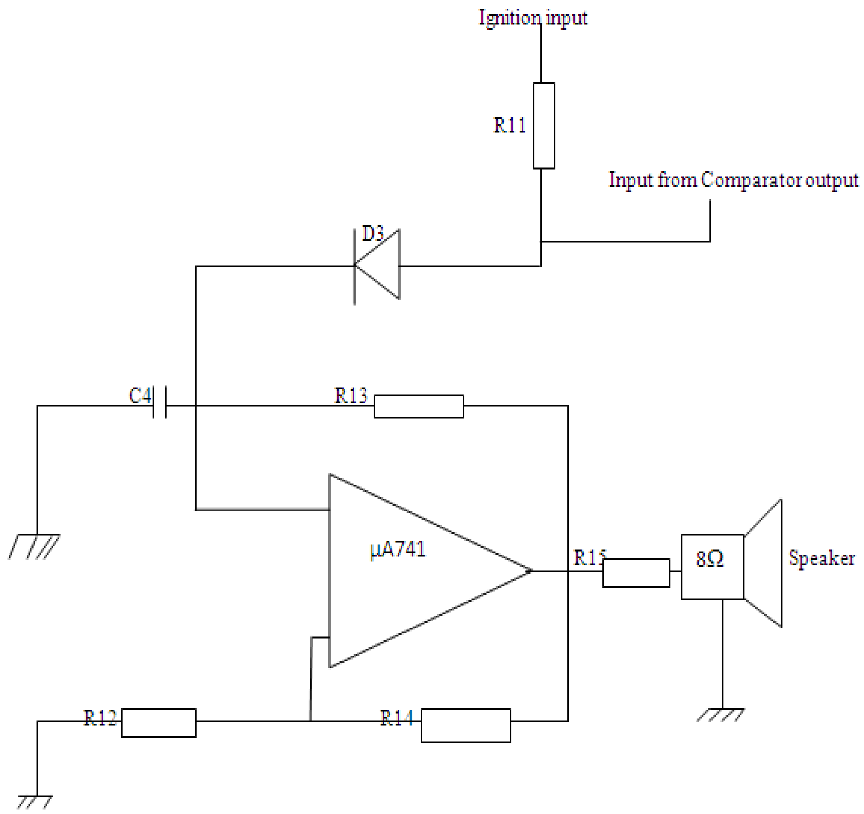

Figure 5: Tone Generator

The tone generator is designed using a stable (free running Multivibrator). It is designed with no need for input, but it is connected to the comparator collector so as to have input signal at low speed but at high speed there will be negative or no input signal which enables it to trigger ON. Its voltage gain at this time approaches infinity. The circuit oscillates whenever the transistor XTR2 is OFF or gives a negative voltage and it stops oscillating as XTR2 is ON, that is when the vehicle speed is slowed down. It can be made adjustable to ensure exact frequency by making R12 and C4 variable.

Advantages of Low Speed

- Lower speed results in fewer road crashes and fewer casualties on roads.
- Lower speed means reduced fuel consumption and vehicle emissions.
- Driving at lower speed causes less wear and tear on the engine, brakes, and tires, thereby indirectly improving road safety and environmental performance.

DISCUSSION

Since the issue of high rate of fatal road accidents is a global problem, lot of research has been carried out and is ongoing so as to bring to minimum the number of lives lost annually on our high ways. Debnath (2012) used the Coded Magnetic strips signaling for roadway, Balashanmugan et. al (2013) worked on the use of automatic braking in case of high speed, Abdelgawab and Mardourah (2014) explored the use of electronic control of air supply that enters the vehicle carburetor and Devikiruba (2013) made use of GSM/GPRS to control the vehicle speed. The high speed warning and protecting device was designed using discrete components and the input signal was from the spark plug , the speed limiter was set to trigger at a speed limit of 120Km/h for a four stroke engine. This was simulated using a signal generator. The vehicle in which this device is installed cannot be driven normally above the set speed of 120Km/h, this is because the alarm which is connected to the car horn will continue to alarm. The alarm switches off only when the speed of the vehicle drops to below 120Km/h. The speed limit may be adjusted lower or higher by the use of Rv in the tachometer circuit. There might be advantages due to a reduction in accidents, it is estimated that 10% of rural speed-related crashes could be prevented by high speed protecting all cars. Small savings in fuel consumption, tyres and brake maintenance should result from running cars at the controlled speed.

CONCLUSION

The high speed warning and protecting device was designed and constructed so as to be installed in motor vehicles. It is believed that when the device is used by motorist the high rate of lost of lives on our high ways due to motor vehicle accidents will be reduced. The objective of the United Nations decade of action for road safety will to a large extent be achieved. High speed has been discovered to be one of the major causes of road accidents on Nigerian roads; making it a policy to ensure that commercial motor vehicles installed this device will be commendable. Most of the European Countries have speed limit laws for different categories of motor vehicles. The Nigerian safety regulator (FRSC) has given truck drivers ultimatum to install speed limiters on their trucks before loading of petroleum products. This is a good start on speed regulation in Nigeria. The speed limits for the Nigerian roads need to be enforced to save lives.

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