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Design and Implementation of a Police Alert Siren Case Study in Kigali City-Rwanda.

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ABSTRACT

As technology stills increasing all over the world, the researcher thought of how to implement something which may be useful in needed instead of going on foreign markets to buy it; that is a siren which may act or sound like a police siren with a sound very similar to it. This study measures the acoustic characteristics of an innovative low frequency police siren technology. Data collection comes during interview with road users, people around and villager in which the road pass through. The result and the findings during investigation made by the researcher push further to design a police siren's low frequency emissions which can travel further and have a greater ability to penetrate and induce structure-bone excitation in nearby vehicle cabins.In this study the researcher try to find a system that can generates variable audible sounds in emergency situation. The researcher found that the system design consists of electronics components such as 555 timer ICS, D.C supply, and output transducer (loudspeaker) which are assembled and interconnected to generate an oscillating signal. The result is a better ability to warn both nearby vehicles and pedestrians thus lessening the potential of emergency vehicle collisions. The system design were evaluated using three measurement scenarios to determine acoustic localization characteristics, drive-by effectiveness and the ability to overcome the problem shadowing phenomenon typical at congested intersections.The researcher found that It is not only for police cars where that sound is so important but also in homes where there may be a need to give an alert when there is a thief for instance. It may be sold also for cars which deserve to be like ambulances although the city of Kigali should recommend the usefulness of such alarm because the population are not familiar of using such kind of device that may give an answer to any solution.

Keywords: Siren, Ambulance, High-pitched, Nuisance, Decibel, Frequency, Piercing

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1. BACKGROUND

Now, it's pretty obvious that police lights and sirens are the two main things that help police officers set themselves apart from the crowd and thus let them to their job. Once upon a time, however, these two harmless “weapons” were a tad less effective, but only because the technology behind them was a lot different.

There's an interesting fact to be mentioned about sirens though. The term “siren” has been used in Greek mythology where it had the same meaning with “mermaid”, only that it represented the same thing we've seen in the last sequel of Pirates of the Caribbean: a dangerous temptation. Sirens however have been brought to life in the 1790s by John Robinson in Scotland and although it now has multiple uses, it was initially intended to serve as a musical instrument.

The first electronic police sirens emerged in 1960s and, as compared to their predecessors, used modulators, oscillators and an amplifier. Just as expected, the sound was transmitted to a speaker that is mounted on the roof and thus increased the overall efficiency of the whole system. Electronic sirens not only that come with increased efficiency, but they also allowed emergency services to create different patterns, thus helping drivers and pedestrians make the different between a police car, an ambulance or a fire truck.

In this police siren design, the researcher simulate electronic siren uses two 555timers IC to generate a sound similar to a police siren. The simulation show that the project can be implemented also by using a single 556 timer IC which consists of two 555 timers. In this circuit both of the timers are configured as a stable circuit.

In city of Kigali a Police sirens play a vital role in ensuring that people on the road and indeed pedestrians are alerted to the presence of a police vehicle. There are many uses and functions of a police siren in emergency situations as well as everyday processes for police officers on the road. These sirens are not just used to alert drivers, but people on the sidewalk as well. For instance, a police officer might be speeding through traffic in pursuit of an offending vehicle. In cases like this, it is important that pedestrians do not attempt to cross the road. This is just one example of the functions of the siren.

“In particular, the researcher found that it is mandatory to use police siren in emergency rescue, diplomat traveling, military convoy traveling with high speed, and other government activity which need some protection”.

2. METHODS

This research applies mixed-methods, which relates to the analysis of City of Kigali Road. The first phase of this study was a quantitative field study recording the noise intensity of the three sirens

types while stationary and driving at 40, 60 and 80 km/h. These readings were taken first with the windows open then repeated with the windows closed. Five separate vehicles were used for the siren tests. All sirens created a two tone noise, which gave a range of readings in dB (A) from the lowest to the highest tone. The readings for all two vehicles were averaged and the mean range for the two tone sirens have been stated.

Phase two of the research was the collection of exposure data from actual traffic police records from 2020 to 2021 inclusive. These records revealed the details of high speed pursuits undertaken with the sirens operating. This data was divided into categories of exposure duration to identify the frequency of the extended exposures to siren noise.

3. RESULTS

3.1. 555 TIME CIRCUIT

The 555 Timer is a commonly used IC designed to produce a variety of output waveforms with the addition of an external RC network and is on the forefront of this project design.

The researcher have seen that Multivibrators and CMOS Oscillators can be easily constructed from discrete components to produce relaxation oscillators for generating basic square wave output waveforms. But there are also dedicated IC's especially designed to accurately produce the required output waveform with the addition of just a few extra timing components.

One such device that has been around since the early days of IC's and has itself become something of an industry "standard" is the **555 Timer Oscillator** which is more commonly called the **"555 Timer".**

The 555 timer chip is extremely robust and stable 8-pin device that can be operated either as a very accurate Monostable, Bistable or Astable Multivibrator to produce a variety of applications such as one-shot or delay timers, pulse generation, LED and lamp flashers, alarms and tone generation, logic clocks, frequency division, power supplies and converters etc, in fact any circuit that requires some form of time control as the list is endless.

The single 555 Timer chip in its basic form is a Bipolar 8-pin mini Dual-in-line Package (DIP) device consisting of some 25 transistors, 2 diodes and about 16 resistors arranged to form two comparators,

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3.2 Timer Block Diagram

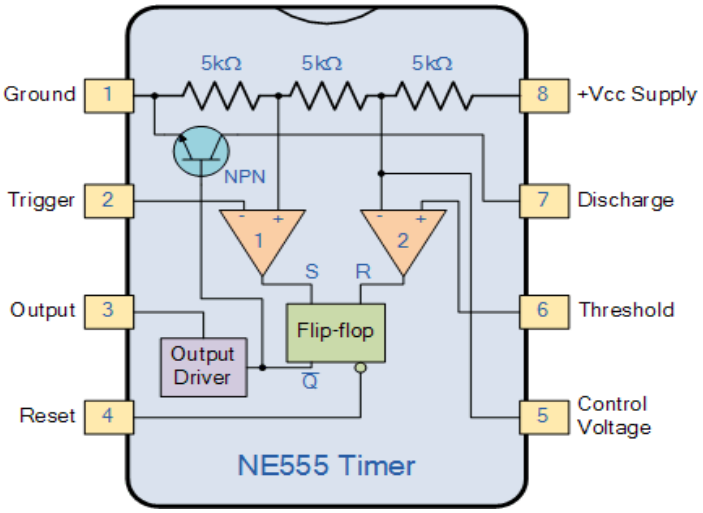

Figure 1: 555 timer internal structure

- • Pin 1. – **Ground**, The ground pin connects the 555 timer to the negative (0v) supply rail.
- • Pin 2. – **Trigger**, The negative input to comparator No 1. A negative pulse on this pin "sets" the internal Flip-flop when the voltage drops below 1/3Vcc causing the output to switch from a "LOW" to a "HIGH" state.
- • Pin 3. – **Output**, The output pin can drive any TTL circuit and is capable of sourcing or sinking up to 200mA of current at an output voltage equal to approximately Vcc – 1.5V so small speakers, LEDs or motors can be connected directly to the output.
- • Pin 4. – **Reset**, This pin is used to "reset" the internal Flip-flop controlling the state of the output, pin 3. This is an active-low input and is generally connected to a logic "1" level when not used to prevent any unwanted resetting of the output.
- • Pin 5. – **Control Voltage**, This pin controls the timing of the 555 by overriding the 2/3Vcc level of the voltage divider network. By applying a voltage to this pin the width of the output signal can be varied independently of the RC timing network. When not used it is connected to ground via a 10nF capacitor to eliminate any noise.
- • Pin 6. – **Threshold**, The positive input to comparator No 2. This pin is used to reset the Flip-flop when the voltage applied to it exceeds 2/3Vcc causing the output to switch from "HIGH" to "LOW" state. This pin connects directly to the RC timing circuit.
- • Pin 7. – **Discharge**, The discharge pin is connected directly to the Collector of an internal NPN transistor which is used to "discharge" the timing capacitor to ground when the output at pin 3 switches "LOW".

• Pin 8. – **Supply +Vcc**, This is the power supply pin and for general purpose TTL 555 timers is between 4.5V and 15V.4.1.3 Relay Circuit.

3.3 555 Timer monostable circuit

The operation and output of the **555 timer monostable** is exactly the same as that for the

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transistorised one we look at previously in the Monostable Multivibrators tutorial. The difference this time is that the two transistors have been replaced by the 555 timer device. Consider the 555 timer monostable circuit below.

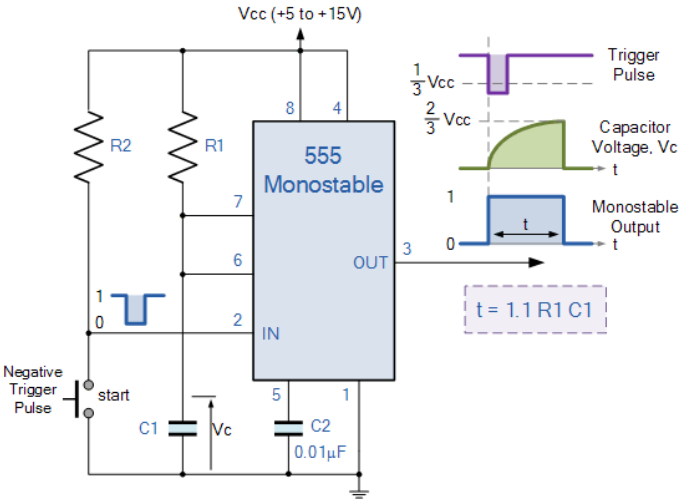

Figure 2: Monostable 555 Timer

When a negative (0V) pulse is applied to the trigger input (pin 2) of the Monostable configured 555 Timer oscillator, the internal comparator, (comparator No1) detects this input and "sets" the state of the flip-flop, changing the output from a "LOW" state to a "HIGH" state. This action in turn turns "OFF" the discharge transistor connected to pin 7, thereby removing the short circuit across the external timing capacitor, C1.

3.4 Bistable 555 Timer

As well as the one shot **555 Monostable** configuration above, we can also produce a Bistable (two stable states) device with the operation and output of the **555 Bistable** being similar to the transistorised one we look at previously in the Bistable Multivibrators tutorial.

The **555 Bistable** is one of the simplest circuits we can build using the 555 timer oscillator chip. This bistable configuration does not use any RC timing network to produce an output waveform so no equations are required to calculate the time period of the circuit. Consider the Bistable 555 Timer circuit below.

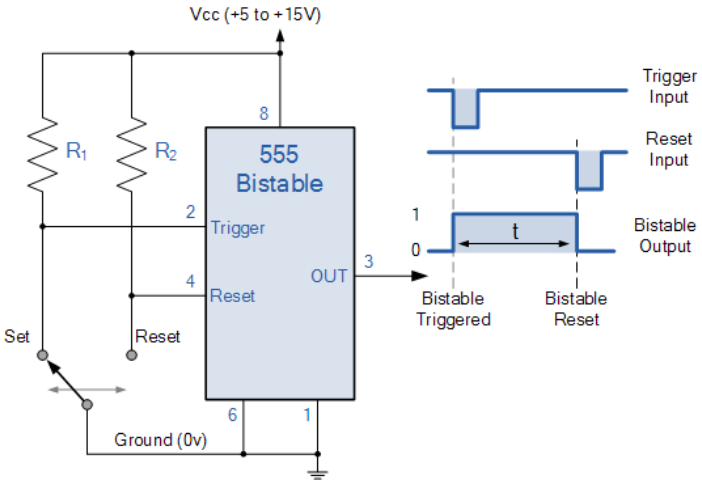

Figure 3: Bistable 555 Timer (flip-flop)

The switching of the output waveform is achieved by controlling the trigger and reset inputs of the 555 timer which are held "HIGH" by the two pull-up resistors, R1 and R2. By taking the trigger input (pin 2) "LOW", switch in set position, changes the output state into the "HIGH" state and by taking the

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reset input (pin 4) “LOW”, switch in reset position, changes the output into the “LOW” state.

4. Project Prototype design

In completing the project prototype, there are lots of works done to design the door that could facilitate to success of our objectives. The door was obtained from recycle shop at IPRC Karongi. The design work has been done first in order to create a good prototype which can be equal as an exact situation.

Design was first sketch on a sheet of paper and the measurement was taken based on the suitable cases. The door consists of the lid, handle, frame of the door and lastly is the magnetic lock which is attached to the steel that hold the magnetic lock. The door was properly design and lastly the result is that a good prototype of door lock was built.

4.1 POLICE ALERT SIREN CIRCUIT

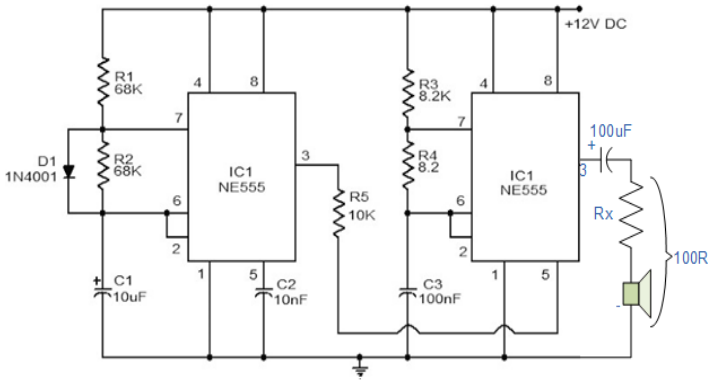

Figure 4: circuit door lock based on telephone

4.2 Working principle of the circuit

When someone connect the supply voltage to the circuit and switched it on, the electric signal are passed through the NE555 Timer, that act as astable multivibrator where by the siren is generated at first before sending the output to the speaker. The signal heard from the speaker will be an increasing or decreasing tone depending on whether the switch S1 is pressed or released. A lot of electronic circuits using NE555 timer IC Here is the circuit diagram of a police siren based on NE555 timer IC. The circuit uses two NE555 timers ICs and every of them are wired as astable multivibrators.

IC1 is wired as a slow astable multivibrator operating at around 20Hz at 500th duty cycle and IC2 is wired as quick astable multivibrator operating at around 600Hz. The output of first astable mutivibrator is connected to the control voltage input (pin5) of IC2. This makes the output of IC2 modulated by the output frequency of IC1, giving a siren effect. In easy words, the output frequency of IC2 is controlled by the output of IC1.

4.3 RESULT AND DISCUSION

A good way to start is to assemble all the components on a breadboard and connecting all of them using jumper wires on the board. Power up the board using 9V DC power supply and test the functionality of the circuit before proceeding to solder them onto the PCB strip board.

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If you want to go further, try drawing the schematic diagram followed by the layout of the PCB pattern, etch the board, drill, assemble and solder the parts before testing them.

During the practical implementation of the project, some of the values or components had to be changed in order to get more accurate result. The circuit was first performed on National Instrumentation software and only after successful implementation and satisfied output.

- In the output, an 8 ohms speaker is used for the siren sound.
- A 9 volts power supply has been used instead of the 5 volts power supply to get satisfied results.
- The siren can be used in any type of alerting/warning device such as police siren, emergency vehicle, schools etc.

The loudness is the most fundamental of the sound quality, and one that many other sound quality metrics are based on. Loudness has been shown to have much better correlation to human perception than simple A-weighting of the measured data. The mechanical siren system has more loudness than the electrical siren, which would also correspond to better perceptibility.

The rate of Crime in the world is increasing day by day due to urbanization, unemployment, poverty, economic recession, and social inequality, which will bring chaos to the country.

5. SUGGESTED AREAS OF STUDY FOR FURTHER RESEARCH

Most of the crimes that are usually done are abduction, robbery, theft and housebreaks, but the most common one done today is armed robbery. This disturbing increase rate of crime in the world today, thus, threatened the life and properties of the people. A police alarm system should be used as a standard device.

The need for an operative and cost-effective system that caters to catastrophes and accomplishes safety concerns. Therefore, a police siren alarm system is an essential device in Alerting organizations, industries or buildings and improving the quality of people’s life since is going to be an actual means of communicating the public that their existence in the area for reducing the threat of abduction, burglary, and thefts in the modern world.

While some frequencies are better heard than others, warnings sounds will generally be more resilient against environmental. Electronic siren warning will be effective in all types of lighting and weather conditions.

6 Project Prototype

This works contribute to the creative thinking and problem solving technique to the finished project, all components that were used were list together to help the work become smooth. The component was

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plan according to the need of the project as listed bellows:

No	Material	Type
01	Jumper wires	With solid tips
02	Integrated Circuit	NE555
03	Resistors	Fixed resistor
04	Capacitor	Celamic
05	Battery	9V DC
06	Variable resistor	100K
07	Speaker	

Table 1: Component Used

7. LIST OF ABBREVIATIONS

A.C:_____ Alternating Current

A: _____ Amps

C: _____ Capacitor

Cosα: _____ Power factor

D.C:_____ Direct current

e.m.f:_____ electromotive force

FET: _____ Field Effect Transistors

I: _____ Current

L: _____ inductance

O C: _____ Cercius degrees

P: _____ power

Q: _____ charge in capacitor

R: _____ resistance

V: _____ Voltage

Vav: _____ average voltage

Vdc: _____ Direct current voltage

I/O: _____ Input/Output

7. ACKNOWLEDGEMENT

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Authors' contributions

HN, conceptualize the idea and both others contributed equally thereafter.

Authors' affiliation

Author is affiliated to Distance production House University/ IST Burkina Faso.

Conflict of interest

The researcher declares not conflict of interest

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