DESIGN AND CONSTRUCTION OF VARIABLE – TONE SIREN SYSTEM

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DEDICATION

This project is dedicated to the Alpha & Omega, the Rose of Sharon and the Lilly of the valley, the Lord God Almighty.

DECLARATION

I, Adeoye M. Olusesan, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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ABSTRACT

Variable-tone siren is a type of siren system that generates variable audible sounds. It consists of electronics components such as 555 timer ICs, A.C supply, power amplifier and an output transducer (loudspeaker) which are assembled and interconnected to generate an oscillating signal. The 555 timer IC connected in astable mode generates an oscillating signal at its output which is used to trigger the second 555 timer IC and the resulting output is transformed into a continuous sound of varying frequency. This is caused by the variable resistor connected to the second 555 timer IC. With the aid of loudspeaker, this oscillating signal can be heard. The oscillating variable sound finds applications in hospital ambulances, police vans and factories. It can also be used in the construction of burglar alarm and light flasher.

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CHAPTER ONE

GENERAL INTRODUCTION

1.1 EXPOSITORY INTRODUCTION

Variable tone siren falls under the category of security alarm system. This form of detector forms the basis for all sorts so of burglar alarms. Sirens find applications in several facets of life. It is particularly useful for detection alerting passers by that there is an emergency at particular places, for examples homes, business organizations, industries etc which may under surveillance by professional burglars. Police vans and hospital ambulances have them incorporated in them to aid maneuvering in terrible traffic conditions. Factories also employ siren at strategic locations to expose or alert precarious conditions e.g. fire outbreak.

Owing to the above uses the design and construction of a variable tone siren should be meant to bridge the gap between imported technological equipments and locally made ones. Local industries collapse because they cannot sustain the exorbitant prices incurred in foreign technological equipment importation, there by causing unemployment. Thanks to the efforts of higher institutions in growing technologists for the nation but the fact that these scattered potentials around the country are few and countable cannot be ignored.

1.2 OBJECTIVE OF THE PROJECT

The aim of this project is to design and construct a variable tone siren and to corroborate the fact that investment in technology while engaging local experts can be worthwhile after all. It can serve as a return generating venture for the country comparable to that of crude oil through creation of business friendly environment for the business to thrive initiation and implementation of good policies etc.

As a result of this, our foreign reserve will improve consequently and Nigeria will become a technology producing nation.

1.3 METHODLOGY

This project is one which consists of electronic components such as one of the families of IC which is the 555 timer a step down transformer, divides (ac supply rectifiers), capacitors, voltage regulators, resistors, light emitting diodes (LED) and an output transducer (loud speaker) which are assembled and interconnected to generate an oscillating signal.

OLTAGE RANSFORMER	→	RECTIFICATION	→	FILTERING & SMOOTHENING	→	SIGNAL GENERATOR	→	LOUDSPEAK

FIG 1.1 BLOCK DIAGRAM OF VARIABLE – TONE SIREN

The emanation of IC timers dominated a wide range of mechanical and electromechanical devices. They also help in the generation of clock and oscillator circuits. Timing circuits are those which will provide an output change after a predetermined time interval. The 555 timer is the most popular of the present IC which is available in an 8 pin dual in line package in CMOS form. I t is a relatively stable IC capable of being operated s an accurate bitable, monostable or as table multivibrators. It is used as an oscillator to generate a very stable clock pulse whose frequency and duty are controlled by 23 transistors 2 divides and 16 resistors. The supply voltage to the timer varies from 5v to 15v.

However for the purpose of this project, the IC is connected in an as table mode to generate an oscillating signal at its output. This is used to trigger the other ones and the resulting output is transformed into a continuous sound with variable frequencies.

These variable frequencies of the resulting signal are determined by the capacitors and resistors connected across the 555 timers. The cascaded ICS use a 9v dv supply which is obtained by stepping down, rectifying and regulating the 240v ac supply. The output transducer (loud speaker) is used to convert the electrical signal into sound of variable frequencies gives rise to the variable tone siren.

1.4 SCOPE OF THE PROJECT

The variable tone siren is useful in many ways. The police vans and hospital ambulances use of the siren to aid maneuvering in traffic situations on roads.

In a nutshell, sirens are used in hospitals to facilitate communication between patients in hospital wards and doctors. It is also applicable in residential buildings, office building, factories, vehicles etc.

This project is known for its low power consumption, attention going alarm output, high reliability and good long term stability. This implies that most effective designs are those which are relatively simple and durable . Long term stability however depends to a great extent on the type of input transducer. Also its low power consumption is due to the 555 timer's existence in CMOS form.

CHAPTER TWO

LITERATURE REVIEW

One of the earliest known electronic siren designs used vacuum tube technology and was developed by William Fleming of San Leandro, California in the late 1940s. Fleming's design was patented in 1951, and he had several objectives in mind with his rather novel invention. First, he noted that the traditional electromechanical siren requires high current to operate, as the electric motor must be powerful enough to spin the rotor (the rotating turbine or fan) and force air through the stator (the little square openings in the siren housing) in order to produce sound.

Fleming's device used only a fraction of the current, and he claimed that it would place less strain on a vehicle's electrical system. Second, electromechanical sirens were manually operated, and therefore would work only when a button or foot switch is pressed and released by the operator. Fleming's electronic siren allowed hand-free operation, as it was capable of producing a continuous wailing sound. Third, the electronic siren requires an audio amplifier and a loudspeaker to function, and Fleming claimed that his device could double as a mobile Public Address (P.A) system if a microphone was connected to it.

The problem with this device was that the components of the time made it quite bulky and other inventors developed subsequent devices that were smaller and would take up less space inside the cab of a vehicle. When transistors came into wider use, more compact designs were possible, but with tubes or transistors there was always a problem of overheating when components were located too close together. One solution was to separate the controls from the oscillator and audio amplifier circuits, somewhat like the control head/ remote amplifier siren systems that are used today. The remote amplifier would have a grille or a heat sink to keep the transistors cool which, in turn, would ensure more reliable operation. Wiring these two components together was not as simple as it is today, so it made for a rather awkward arrangement

In the late 1950s, Gerald Smith attempted to address this problem by building a compact self-contained siren control/amplifier unit with power transistors attached to the outside of the chassis, where they would be kept cool in the open air. Smith's siren was patented in 1962. It was this design that would form the basis for many others, as it was small enough to attach under the dashboard of a vehicle. As the 1960s progressed, several manufacturers were producing sirens that were based on Smith's design, including Federal, Triple, General Electronic, Dietz, Sireno, Motorola and others.

For about twenty years electronic siren circuitry remained basically the same. The siren tones were generated in a grid of transistors, resistors, and capacitors known as a siren oscillator or timing oscillator/sweep oscillator circuit.

New sounds were added along the way:

Yelp: PA5 & PA10, early 1960s

Alert or 'steady' tone: PA15 & PA20, early to mid 1960s

Hi-Lo (European) tone: PA20A, late 1960s.

By the early 1980s other manufacturers introduced new tones, including the 'air horn' sound, which sounds like a rather feeble attempt at imitating the growly Grover 'Stutter Tone' air horns used on some fire engines in the United States. This sound resembles an electric buzzer more than an air horn, and today this tone is available on most major brands of electronic sirens. The PA300 was Federal's first full-size siren with the air horn tone, and this design marked the end of traditional transistorized siren oscillator circuits. Integrated circuits (I C) are used to produce the siren tones, and the PA300 uses separate I.C chips for each of the sounds.

The use of integrated circuits and the applications of digital electronic technology meant that it was possible to come up with a siren design that would more accurately produce the sound of an electromechanical siren. This came a step closer to reality when Federal introduced the EQ2B, an electronic siren that uses digital signal processing to mimic the sound of Federal's famous Q series electromechanical sirens. Only time will tell whether electromechanical sirens will be done away with entirely, as the Q is still quite popular among fire departments in the United States.

Electronic sirens didn't come into widespread use until the early 1970s. In the 1960s they were somewhat of a novelty, and the sirens of that period were not without problems. If you are restoring an older vehicle, just remember that the further back you go in time, the harder it will be to find a period correct siren. This project aims at designing a variable tone siren. The attempt to make the tone variable is a modification on all the works done in the past. [4]

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.1 PRINCIPLE OF OPERATION

The operation of variable tones siren is dependent on the modulating capability of the 555 timer IC. Two different frequencies are generated. The first is a low frequency for modulation and the other is a high frequency for tone generation. Each time the modulating frequency enters the control voltage input (pin 5) the frequency of the tone generator changes and creates a different tone. The output of this is fed to a speaker (output transducer) via a capacitor to get the tone output on the speaker. Passing the output of the timer via a power amplifier increases the output power gain.

3.2 VARIABLE TONE SIREN CIRCUIT

This alarm circuit is a variable tone siren type alarm. It falls under the category of security alarm system, and its purpose is to alert passers by or people around that there is an emergency at a particular place

The alarm circuit is a combination of two astable multivibrators. The astable oscillate at different frequencies of which one is used to modulate the other. Modulation is achieved from pin 5 (control voltage). For normal astable operation, pin 5 of the first multivibrator goes to zero or grounded through a capacitor of 10μF (this helps to maintain immunity from noise). But if a voltage of between 45% and 90% of Vcc is applied to the pins, frequency modulation occurs. Coupling the voltage via a capacitor creates a kind of warble tone (a high unsteady tone) due to the charging and discharging of the capacitor. The figure below shows the circuit of variable-tone siren type alarm using two 555 timer I.Cs.

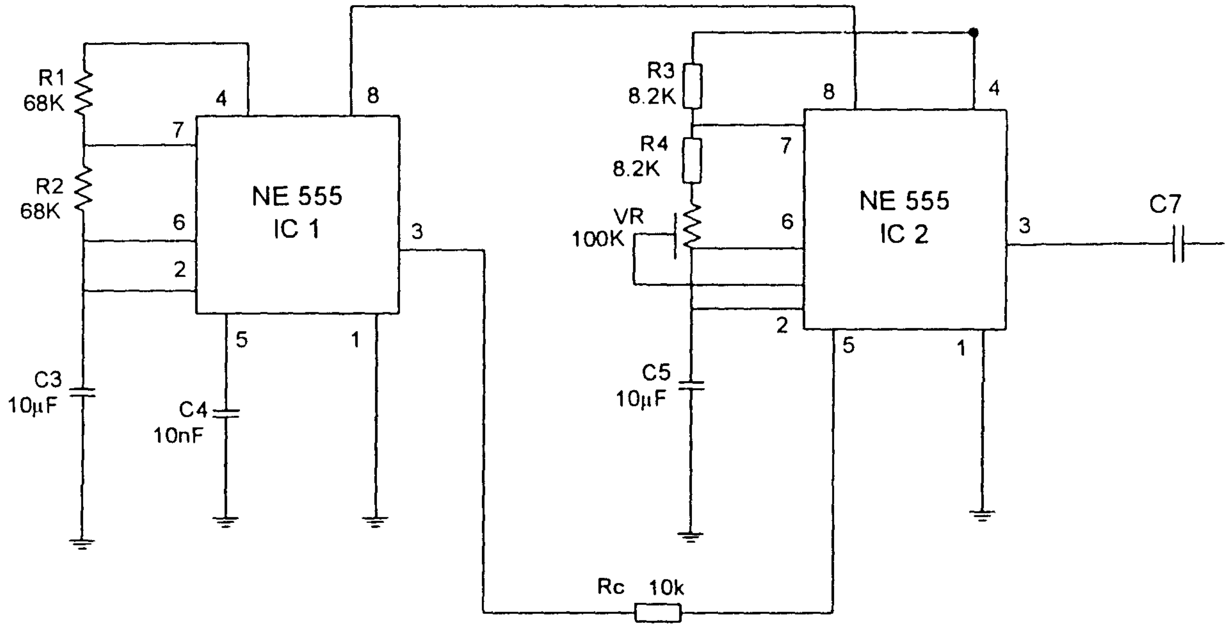

FIG 3.1 VARIABLE – TONE SIREN STAGE

The first astable is used to modulate the second, which in turn generates a constant time. The warble effect of the tone is achieved by coupling the modulating signal through capacitor C3. The general circuit diagram of the variable-tone siren is given below.

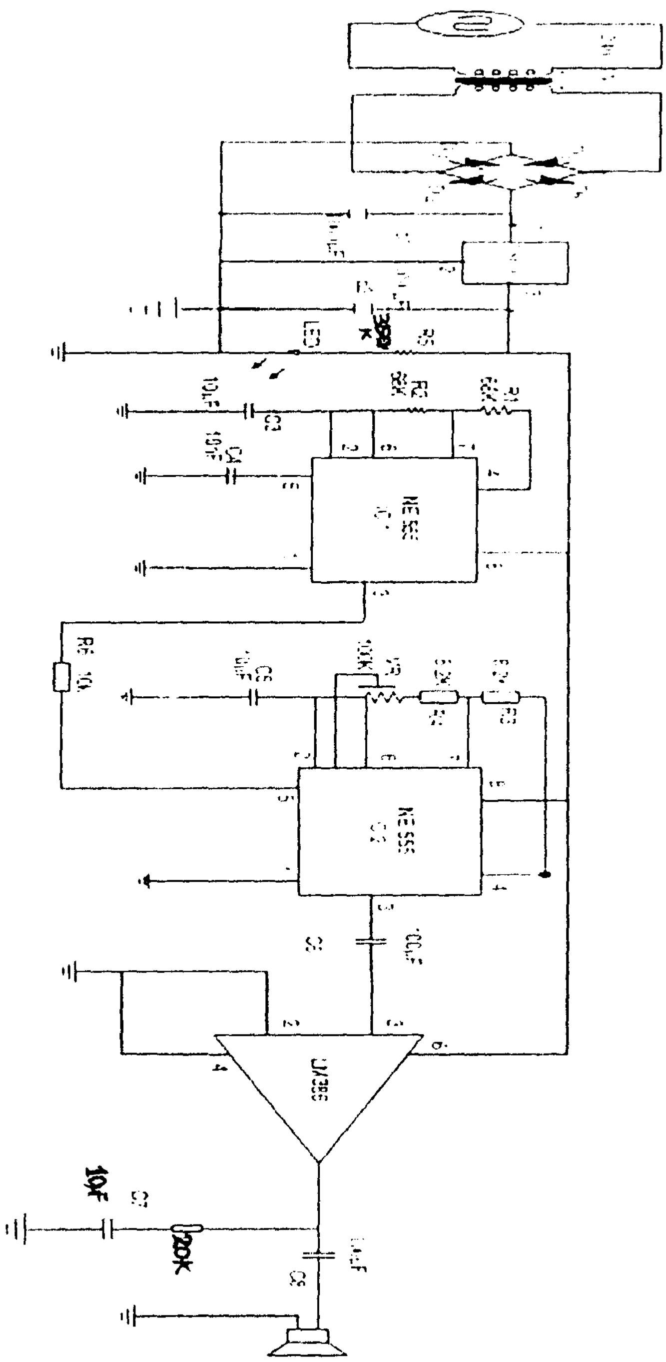

FIG 3.2 CIRCUIT DIAGRAM OF VARIABLE – TONE SIREN

3.3 DESIGN OF OSCILLATOR CIRCUIT

3.3.1 OSCILLATOR 1 (TONE GENERATOR)

For this circuit, a duty cycle of 67% or 0.67, a capacitor of 10μF and another capacitor of 10nF (to ground pin 5 in order to maintain immunity from noise) and resistor value Ra = 8.2 KΩ were selected.

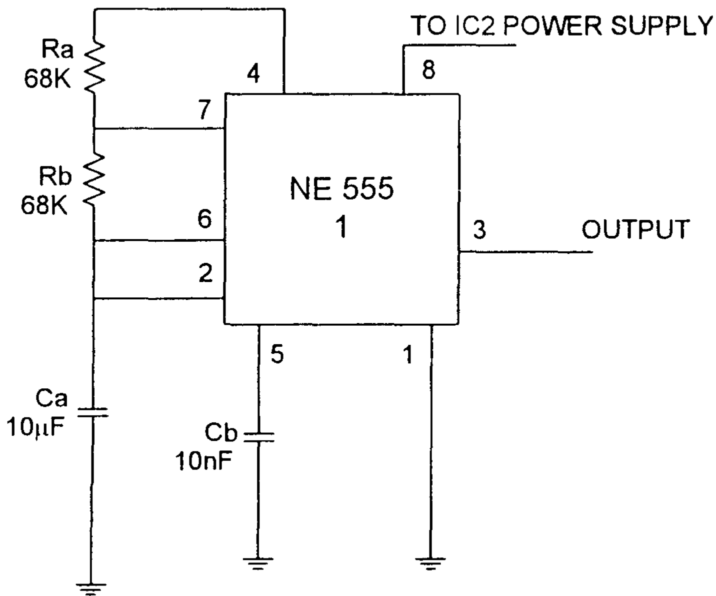

FIG 3.3 TONE GENERATOR CIRCUIT

To calculate for the value of the second resistor i.e Rb

Duty cycle = (Ra + Rb)/(Ra + 2Rb) ×100%

0.67 = (68 + Rb)/(68 + 2Rb)

45.56 + 1.34Rb = 68 + Rb

0.34Rb = 22.44

Rb = 22.44/0.34

Rb = 66kΩ

68kΩ is preferred for more accuracy ; Rb = 68kΩ

The frequency oscillator, fo

fo = 1.44/(Ra + 2Rb) Ca

$fo = 1.44/(68 + 136) \times 10 \times 10^{-6}$

$fo = 1.44/0.00204$

$fo = 706Hz$

The time a high output tone is obtained is given as

$t1 = 0.69\ (Ra + Rb)\ Ca$

$t1 = 0.69\ (68 + 68) \times 10^3 \times 10^{-6} \times 10$

$t1 = 0.94$ sec

The time for a low output signal

$t2 = 0.69\ Rb\ Ca$

$= 0.69 \times 68 \times 10^3 \times 10 \times 10^{-6}$

$= 0.47$ sec

The total time of oscillation is given as

$T = t1 + t2 = 0.94sec + 0.47sec$

$T = 1.41sec$

3.3.2 OSCILLATOR 2

Still choosing duty cycle of 67%, Capacitor Cb of 10μF, resistor Rc = 8.2kΩ and variable resistor Vr = 100kΩ. The purpose of the variable resistor is to be able to tune the generated tone to various tones of different frequencies as preferred.

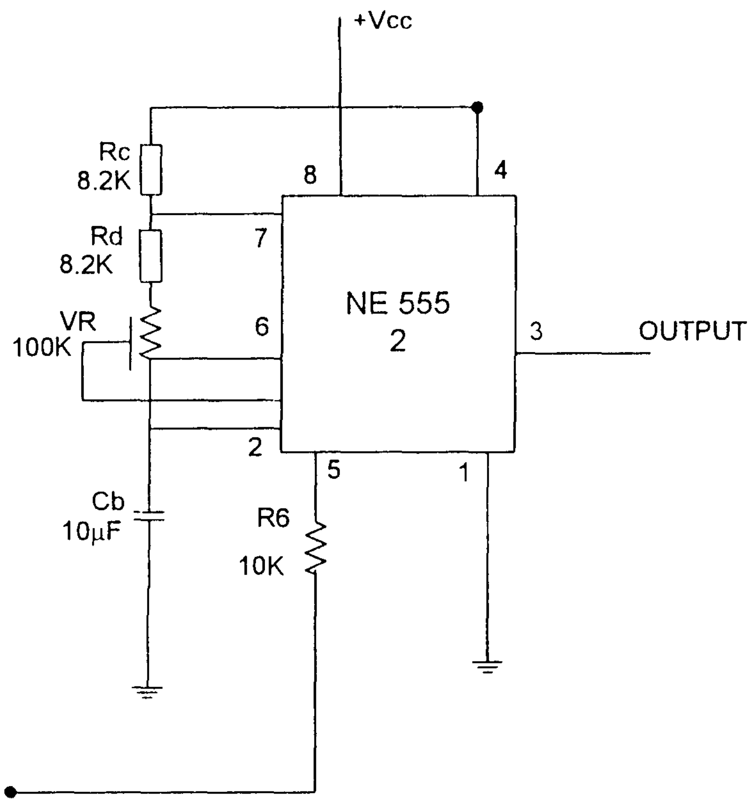

FIG 3.4 OSCILLATOR 2 CIRCUIT

To calculate the value of Rd

$0.67 = (Rc + Rd)/(Rc + 2Rd)$

$0.67 = (8.2 + Rd)/(8.2 + 2Rd)$

$5.5 + 1.34Rd = 8.2 + Rd$

$0.34\ Rd = 2.7$

$Rd = 2.7/0.34$

$Rd = 7.94 = 8.0k\Omega$

For this project $8.2k\Omega$ is more desirable, therefore $Rd = 8.2k\Omega$

3.4 POWER SUPPLY STAGE

The project design uses a 9V power supply which involves a step-down transformer, filter capacitor, rectifier and voltage regulator to give the desired voltage level. The power supply circuit diagram is given below.

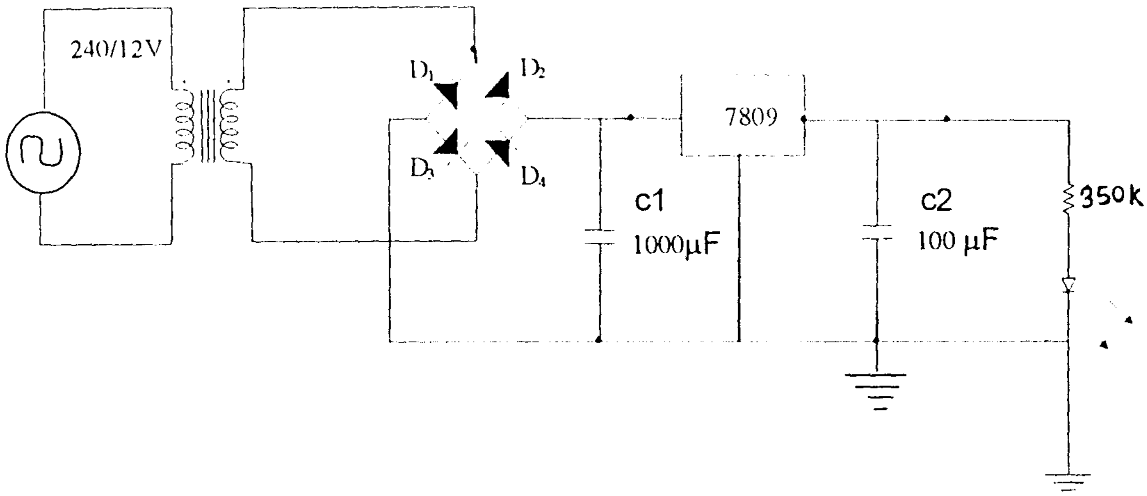

FIG 3.5 POWER SUPPLY STAGE

Considering the block diagram of power supply unit (fig 3.6),it is clear that a power supply makes use of a step-down transformer, rectifying circuit, filter and voltage regulator to create a regulated dc power supply for the purpose of this variable-tone siren design.

The transformer steps down the 240V alternating current supply to regulated 9V, 1000mA DC power supply. The transformer also provides isolation of the AC supply line from the rest of the system.

Bridge rectifier was used in order to achieve full wave rectification of AC to DC supply and the filtering was accomplished by using a 1000µF capacitor. This capacitor is required to remove ripples from the rectified dc voltage. To regulate the output voltage at specified value of 9V dc, a 7809 voltage regulator IC was used. This produces a fixed output voltage of 9V for the system.

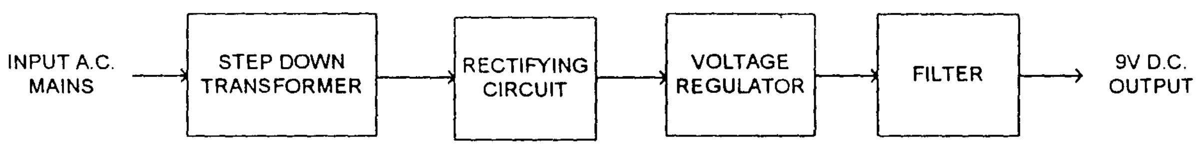

FIG 3.6 BLOCK DIAGRAM OF POWER SUPPLY UNIT

The purpose of the LED (light emitting diode) connected across the power supply stage is to show the presence of regulated power at its output. And with voltage value of 2V, it is connected in series with a resistor whose value is obtained as below

$V_s = IR + V_{led}$ .... (i)

$R = (V_s - V_{led})/I$

The LED current value is given as 20×10^-3 or 20mA

R = 9V-2V/20×10^-3

R = 350kΩ

The value of the diodes used for full wave rectifier are IN4007 because of its high peak inverse voltage (PIV) which is 1000V.

FILTER CAPACITOR

The choice of filter capacitor used is obtained as follow

Ripple factor = Ripple AC Voltage/DC Voltage ×100%

$= V_{peak}/V_{dc}$ .... (ii)

= 15V/5V = 5%

$V_{rms} = V_{peak} \times \sqrt{2}$

$= 15V \times \sqrt{2}$

= 21.2V

For a ripple factor of 5%

Vrms = 0.05 × 21.2V = 1.06V

But $V = 1/C \int Idt$ .... (iii)

For a full wave rectifier of frequency value of 1/2f

$Vrms = 2I_L / Cf$

Where Cf = filter capacitor

1.06V = (2 × 500mA)/ Cf

Cf = 1000 × 10^-3/1.06

Cf = 943.4 μF ~ 1000μF

C2 is to filter out any noise at the output of the regulator.

3.5 POWER AMPLIFIER UNIT

Amplification is one of the most basic ideas in electronics. Amplifier makes sounds louder and signal level greater, and in general, it provides a function called gain.

This project makes use of the LM386 power amplifier designed for use in low voltage consumer applications. The gain is internally set to 20 to keep external part count low, but the addition of an external resistor and capacitor between pins 1 and 8 will increase the gain to any value from 20 to 200.

LM386 amplifier is suitable for battery operation, because its quiescent power drain is only 36 milliwatts when operating from a 9V supply with low quiescent current drain of 4mA. It also has minimum external parts and wide supply voltage range from 4V – 12V or 5V – 18V, low distortion of 0.2% and available in 8-pin package.

It has applications in AM-FM radio amplifiers, portable tape player amplifiers, TV sound systems, line drivers, ultrasonic drivers, small servo driveɪs and power converters.

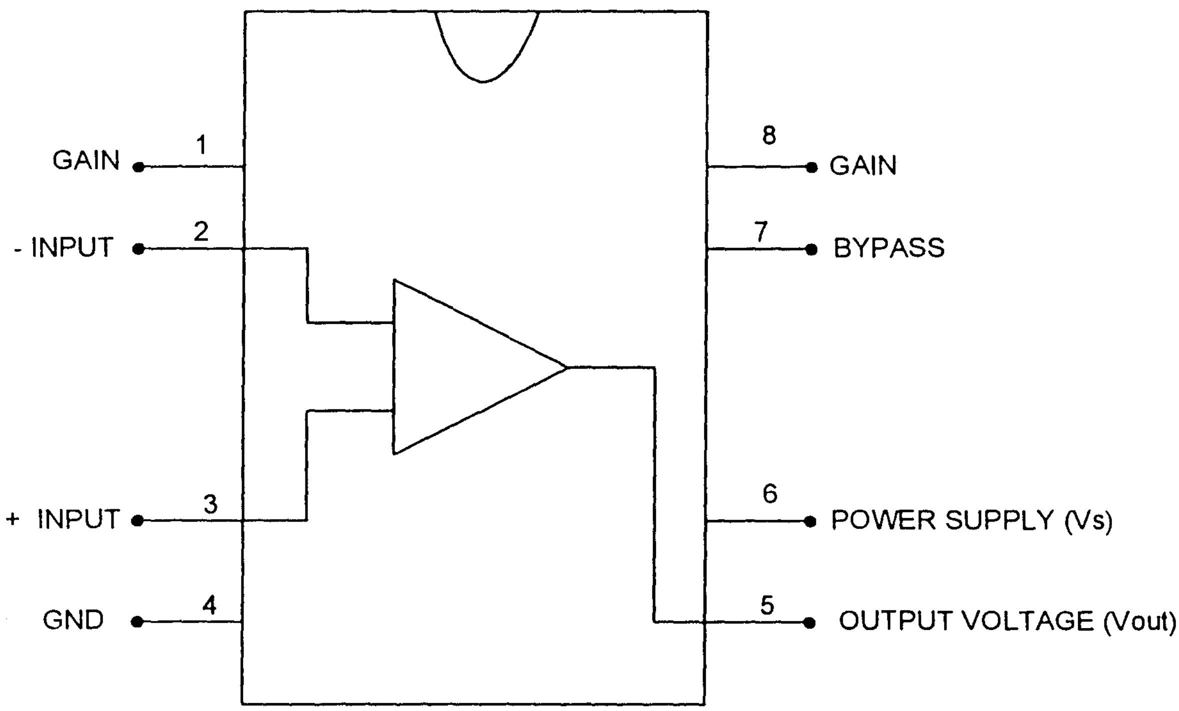

FIG 3.7 POWER AMPLIFIER PIN CONNECTION

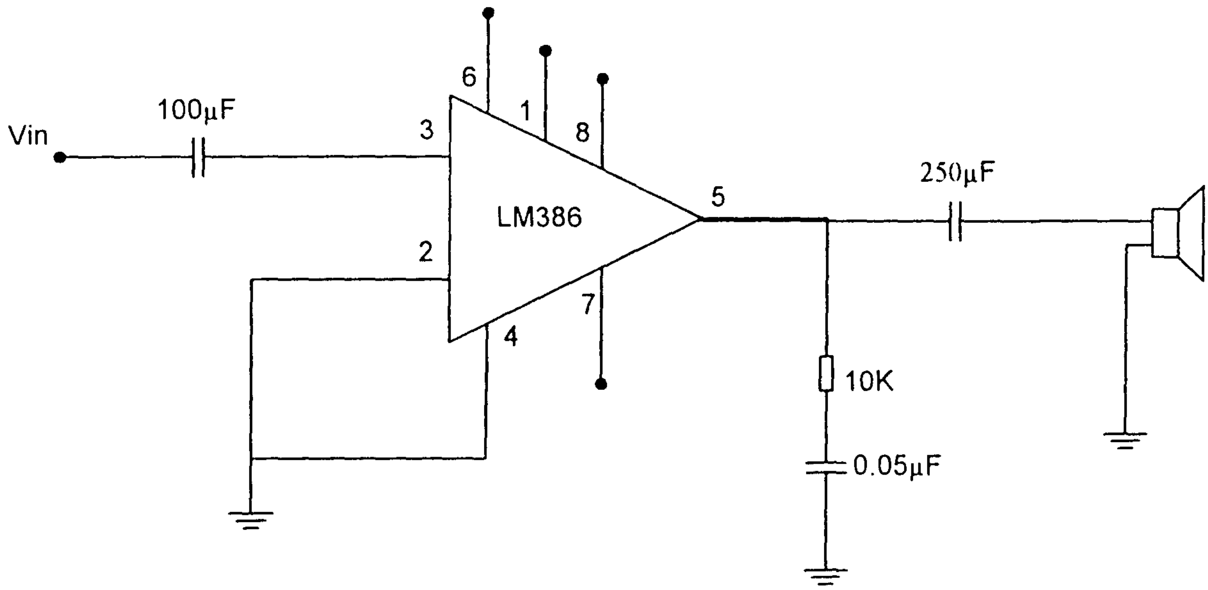

FIG 3.8 POWER AMPLIFIER CIRCUIT DIAGRAM

From the requirement given by the Absolute Maximum ratings of LM386 power amplifier.

The input voltage is given as ± 0.4V

The supply voltage to the amplifier = 9V

From the formula of voltage open loop gain;

V_o =Ao V_{in} .... (iv)

Therefore, Voltage gain Ao =V_o/V_{in}

Ao = 9V/ 0.4V

Ao = 22.5 [1]

3.6 THE LOUDSPEAKER

This is a transducer that converts electrical signal to sound energy, it is the final unit of any sound reproducer.

Loudspeaker uses a coil and diaphragm arrangement that is free to move in annular gap. a strong magnetic field produced by either a permanent or electromagnet is applied across the gap. The audio signal from the audio amplifier is the input of the coil (known as speech coil) that has n alternating current causing it to move in the magnetic field as a result of electromagnetic induction. The diaphragm is thus caused to vibrate at the same frequency as the alternating current and the sound waves produced by it.

For the purpose of this project, 8Ω capacity loudspeaker is used for effective sound output.

CHAPTER FOUR

CONSTRUCTION, TESTS & RESULT

4.1 CONSTRUCTION

The construction was made based on circuit diagram shown earlier on the Chapter Three of this project write-up.

The components were initially mounted on a breadboard to troubleshoot the circuit. This was achieved by carefully mounting each component while following the circuit diagram closely. After this, the construction was connected to power supply and the result proved satisfactory.

After the troubleshooting of the construction on breadboard, the whole components were transferred to veroboard for permanent construction. Veroboard generally has hole on it through which the "legs" of all the components (resistors, capacitors, 555 timer ICs e.t.c) are soldered. The distance between each hole is approximately 3.8mm. The various components were soldered using the right polarity (i.e aligning the positive side of the components to the positive side of the veroboard and doing the same for the negative side), the excess wiring from the component was then cut off underneath the veroboard.

Components are mounted at least 1cm above the veroboard, this is to prevent the components from getting damaged when being soldered to the board.

4.1.1 SOLDERING

Components used had to be soldered since instead of Printed Circuit (P C), veroboard was used. Although, PC board is reliable and durable (thus it is used for commercial use), the veroboard was chosen because of its ease to utilize.

To ensure good quality soldering, the following precautions were adhered to;

1. Prior to the soldering, the board was cleaned thoroughly to ensure it was free from oil, dust and other material, if there are any.
2. All circuitry and contacts that were not to be soldered were covered with heat resistant materials.

3. Care was taken while soldering (especially the 555 timer and amplifier) to avoid damage to components and circuit board by using IC socket and by not applying heat in a localized region.
4. After cooling, excess jumpers or wires used were cut off by using wire cutter and soldered joints were cleaned and made to have a smooth uniform shinny surface with the use of suction tube. [5]

4.1.2 CONSTRUCTION TOOLS USED

The following construction tools were put into use during the modeling and construction of variable-tone siren.

1. Soldering Iron and Lead : These were used to solder the components to the veroboard. The usual procedure is to insert the components, turn the board over and bend the leads aside to hold the components in place. With the soldering iron plugged to the main, the components were soldered permanently to the board.
2. Digital Multimeter: The digital multimeter was used to test for continuity in conducting paths of the components and to measure voltages, currents and resistances of various components.
3. Suction Tube: Used to remove the unwanted de-soldered lead from soldered points on the board.
4. Wire Cutter and Plier: These were used in cutting wires to desired length for construction and removing excess wiring from the soldered joint.

4.2 CASING

With the prior knowledge of the intended output which is sound, I decided to opt for a wooden casing. Because of this desired output, I felt that wooden casing will be a better choice. This is because vibration of sound will be lesser with wooden casing than in metallic one. The resonance effect that the wood will produce with the sound coming from the loudspeaker is very low compared to that produced by other materials.

The casing was constructed with dimension of length 20cm , height 13cm , and width 16cm. The speaker was fixed at the side with holes drilled into the wood to provide vent for it. Also the power supply was located at a corner where holes were also drilled at the end to provide cooling for the transformer. The switch and the variable resistor were well arranged and fitted to the casing properly. The casing was finally covered using small nails for tight fixing. Other finishing touches like polishing and smoothening were put on the wooden casing to make it look attractive and presentable.

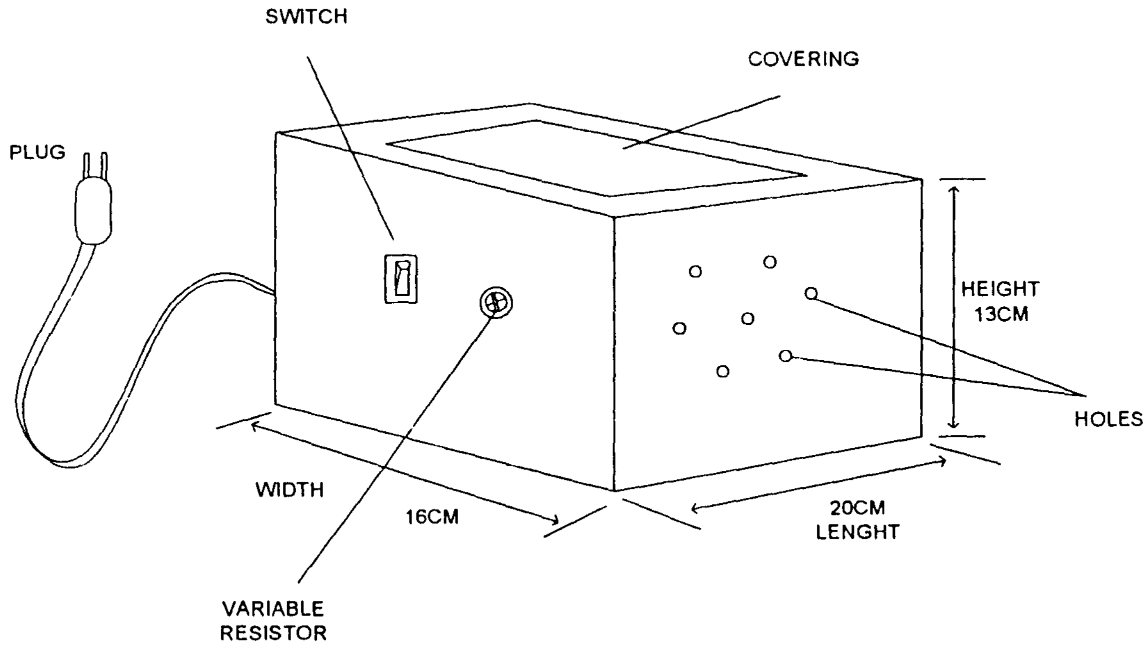

FIG 4.1 CASING

4.3 TESTING

The siren system was tested both at the prototype stage and the final construction stage. With the use of digital multimeter, the following tests were carried out.

1. Continuity of the copper wires used in the construction was tested from time to time.
2. The polarities of the components like the diodes and the electrolytic capacitors were ascertained through testing with the multimeter.
3. The output voltage from the public power supply was observed and was found to be within acceptable range.
4. The regulated output voltage and the negative voltage (ground) of the voltage regulator were measured and found to be within acceptable range, approximately 9V.

5. The switch was tested to ascertain its conductivity in the ON state, and its non-conductivity in the OFF state.
6. The overall operation of variable-tone siren system was tested.

4.4 RESULT

With the power supply switched on, by connecting the input of the step-down transformer to the A.C mains, a variable tone will be heard. And the frequency of these sounds can be varied by tuning the variable resistor connected to the system

CHAPTER FIVE

CONCLUSIONS

5.1 PROBLEMS ENCOUTERED & SOLUTION

Before the final construction was put in proper reliable state in conformity with the desired function of the system, some problems were encountered during testing. One of such problems was that there was short circuit between the source and the ground. As a result of this fault, current was not flowing through the circuit, hence causing overheating of the power supply unit. This fault was corrected by point to point continuity test of the circuit.

Another problem encountered during the construction was that at the initial testing, there was no output voltage delivered to the 8Ω speaker. By confirming the whole output stage of the circuit, it was discovered that the 100μF capacitor was open-circuited. This was removed and replaced with another functioning capacitor of the same value with proper connection. After this, the speaker started working.

The final problem encountered was poor power supply from the Power Holding Company of Nigeria (PHCN) which slowed-down the duration of the construction of the project because it needs to be tested from time to time.

5.2 CONCLUSION

The project which is the design and construction of variable-tone siren system, like any other electronic system requires proper and careful planning and implementation. It was designed considering some factors such as economic application, design economy, availability of components and research materials, efficiency, compatibility, portability and durability. The performance of the project met design specification i.e by giving multiple tones when switched on and by tuning the variable resistor creating a variable-tone output.

However, the general operation of the project and perfomance is dependent on the user who is prone to human error such as dropping of the device on hard surface, and spillage of fluid like water on the gadget.

Also the operation is dependent on how well the soldering is done and the positioning of the components on the veroboard. If poor soldering lead is used, the circuit might form dry joint early and in that case the project might fail. Other factors that might affect performance included transportation, packaging, ventilation, quality of components, handling and usage. The construction was done in such a way that it makes maintenance and repairs easy to carry out. By the successful construction of this project, it is to suggest that this country has great potential young men and women, and that expenditure on local product is going to be a worthwhile investment.

5.3 RECOMMENDATION

Considering that this project work is still subject to future improvement, I hereby make the following recommendation

1. That further research to be conducted for improvement on this project.
2. That the government should encourage local production of this project and other useful electronic systems by creating a favorable environment for the productions, as this will improve our economy and curb importation of such devices which is usually at exorbitant price.
3. That the school authority within their capacity to ensure that students participate in project design and construction, for this is a worthwhile experience and will give them the opportunity to showcase what they have learnt.

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