Design and Construction of a 'Snore-Guard'

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DEDICATION

I dedicate this project to all those that have in the past been, are presently being or will in the future be disturbed by the sound of a snore.

DECLARATION

I Ahmad Umar Mungadi 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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Many people have in one way or the other contributed to the successful completion of this work, however due to limited space, i am able to mention only a few. I am grateful to:

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My supervisor; Dr Elizabeth Onwuka, for her guidance and encouragement

They have all through Allah`s will contributed to my success

ABSTRACT

This project is aimed at constructing a device that will be able to detect that a sleeping person is snoring, and the device will then gently shake the sleeping person so that he stops snoring. This is based on the fact that most (if not all) snorers stop snoring as soon as they are shaken, and the person to do the shaking is usually the one that is in the same room or on the same bed with the snorer. This device will hence relieve the snorer's partner the disturbance of waking up many times during the night thus giving him a chance for a better night sleep.

The device, named 'Snore Guard' works by vibrating gently when it is triggered by a snore sound. Therefore it could be comfortably placed under the snorer's pillow so that its vibration affects only the snorer. It has been tested and found to perform very well. It has the remarkable attribute that it does not in anyway disturbs the snorer's partner and the snorer himself is subjected to no form of inconveniencies, unlike most of such devices currently available in the market.

The device is inexpensive and very easy to operate, hence any interested person can afford to have one.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER ONE

INTRODUCTION

It is estimated that as many as 40 percent of adults, most of them men, snore [1]. Snoring is a problem as old as sleep itself, and it has been immortalized as the butt of countless family jokes. However, for some snorers, it is no laughing matter.

At the roof of the mouth, separating the mouth from the nasal cavity is a tissue called palate, the palate consists of two portions: the hard palate in front and the soft palate behind. The hard palate is formed of periosteum, a bony plate covered by mucous membrane, and arches over to meet the gums in front and on either side. The soft palate is a movable fold of mucous membrane enclosing muscular fibers. Its sides blend with the pharynx (throat), but its lower border is free. It is suspended from the rear of the hard palate to form a wall or division between the mouth and the pharynx [3].

Snoring is a harsh or rattling noise that is usually produced during deep sleep. The sound of snoring is produced when air inhaled through the mouth vibrates the soft palate (the tissue in the roof of the mouth near the throat). As the soft tissue vibrates, the lips, cheeks, and nostrils can also vibrate, making the snoring even louder. Almost everyone snores occasionally, but men usually snore more often than women and children [3].

Snoring has several causes. A cold or other infection can make breathing difficult and cause the sound of snoring as the sleeping person struggles to draw air through blocked nasal passages and throat. Sometimes snoring is the result of a medical condition, such as swollen tonsils and adenoids (lymphoid tissues located at the back of the throat). A misshapen wall separating the nasal cavity, called a deviated nasal septum, or a growth in the cavity, called a nasal polyp, both of which cause nasal blockages [2].

can also cause snoring. Snoring can also occur when flabby throat muscles are drawn into the airway, particularly when alcohol, drugs, or deep sleep overly relaxes muscular control.

Doctors usually advise snorers to tighten flabby muscle tone through exercise. They also recommend that snorers lose weight, avoid alcohol within two hours before sleep, avoid tranquilizers, sleeping pills, and antihistamines before bed, and sleep on their sides rather than on their backs.

When snoring and rapid, heavy breathing are interspersed with seven- to ten-second periods of halting in breathing, the problem may be sleep apnea, a more serious disorder that can cause excessive sleepiness during the day, and has been associated with some heart disorders.

Most of the times people do not know that they snore while asleep, hence it is usually the person close to the snorer that is subject to frequent waking up in the night and that could be very annoying and disturbing, some times this can even lead to some medical complications.

Take for instance the case of Melvin Switzer, a 250-pound British dockworker who is known as the loudest snorer in the world. Melvin trumpeted his way into the Guinness Book of World Records with a snore registered at 88 decibels, about the same intensity as a motorcycle engine revved at full throttle [4].this caused his wife to go deaf in one of her ears and is forced to sleep with her good ear to the pillow.

1.1 Objectives

It is our aim in this project to construct a device that will detect a snore sound much more quickly than a human being in close proximity of the snorer will. Who is likely to be disturbed or even woken from sleep by the sound, and the said device will be able to gently shake the snorer thus interrupting the sound and saving the person (s) around the pain suffered due to the irritating noise.

1.2 Methodology

This project is carried out by first conceptualizing the idea, then constructing the device module by module; ensuring that each block has operated as conceived before proceeding to the next block. Most of the references of this project are from the Internet due to its nature though many books and articles are also consulted, but notably, some individuals that have specialized in electronics were contacted for advice and correction in some instances.

CHAPTER TWO

LITERATURE REVIEW / THEORETICAL BACKGROUND

2.1 Literature review

Snoring is estimated to be a problem as old as sleep itself [2] and by nature, human beings spend their entire lives trying to solve their various problems, snoring is no exception.

Over the times, different people ranging from the very crude in the olden days to the very sophisticated in our present time have devised different means of treating snore. For clarity, we will classify these means into two: surgical and non-surgical. We will further classify the non-surgical into two as well: non-electronic and electronic.

2.1.1. Surgical remedies of snoring

The oldest and most frequently performed type of snoring related surgery is called a UPPP (UvuloPalatatoPharyngoPlasty) [5, 16]. An ear, nose and throat specialist (Otolaryngologist) performs it. This procedure relieves snoring well if the major obstruction lies behind the soft palate.

Traditionally, a surgeon tightens and trims excess tissues of the throat. This procedure reduces the intensity of snoring most of the time, but it is a painful procedure and requires one to three days' hospitalization and about a two-week recovery.

The Orthognathic solution is a major surgical technique in which both the upper and lower jaws are advanced forward together drawing the tongue and soft palate with

[5]. The advancement of the mandible can be approximately 10 to 12 millimeters, which is almost certain to relieve the obstruction

Another type of surgery is the Radiofrequency tissue volume reduction (somnoplasty). In this type of surgery, doctors use a low-intensity radiofrequency signal to remove part of the soft palate to reduce snoring. It's an outpatient procedure performed using local anesthesia. The technique causes slight scarring of the soft palate, which may help to reduce snoring. The effectiveness of this newer procedure needs further study [5, 16].

Sometimes doctors employ the use of Laser surgery. In an outpatient surgery for snoring called laser-assisted uvulopalatoplasty (LAUP), a doctor uses a small hand-held laser beam to shorten the soft palate and remove the uvula. Removing excess tissue enlarges the airway and reduces vibration. Treatments are based on the severity of snoring. Two to five sessions May be needed, each lasting about 30 minutes. These treatments occur four to six weeks apart. Laser surgery is not advised for occasional or light snoring, but it is an option if snoring is loud and disruptive [5].

The newest form of OSA surgery is a major surgical procedure that advances the genial tubercle (a bump on the inside of the tip of the chinbone) along with its associated muscle attachments and the Hyoid bone (the Adams apple). The procedure is called a GAHM procedure (Genioglossal advancement with hyoid myotomy/suspension), and in combination with the UPPP has an overall 61% success rate [4]. The GAHM procedure may be done in conjunction with modifications to the back of the tongue (laser midline glossectomy and lingualplasty) to further open the airway.

It should however be noted that no drug or medical procedure can fully guarantee to eliminate snoring tendencies [5].

2.1.2. Non-surgical remedies

• The Snore Ball

Invented in the early 20th century [6], the snore ball has undergone a series of advancements, and modern versions are available today. Snore balls are devices that snorers puts on their back while sleeping (i.e. putting it in a pouch on the back of their pajamas). When these people move to sleep on their back – and thus generally open their mouths and emit loud snoring – the snore ball gives them discomfort. These balls are particularly useful for those who do not toss and turn a lot during sleep, and simply need a bit of a nudge to return back to a side-sleeping position.

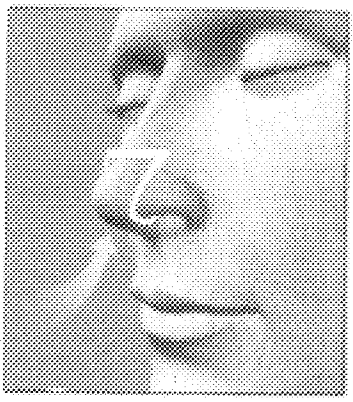
Some people actually construct their own snore balls out of tennis balls, golf balls, baseballs, or anything that can reasonably fit into a pajama pocket. Over time, many people who use snore balls find that they habitually sleep on their side, and hence, the snore ball becomes redundant.

• Nasal Strips

Nasal strips, which are used to widen the nasal valve and thus open up the airway to the throat and lungs, are extremely popular anti-snoring remedies [6]. These strips are made (usually) of plastic, adhere to the nose, and are worn throughout the night. Some people may notice that football players, hockey players, and basketball players wear nasal strips while performing their sport, in order to keep the airway open and promote maximum respiration efficiency.

• Nasal Dilators

Nasal dilators are most often made of plastic or stainless steel coil, and are inserted into the nostrils during sleep [6]. The impact of these dilators is that they help keep the airway open (similar to nasal strips), and thus cut down on vibration that leads to snoring.



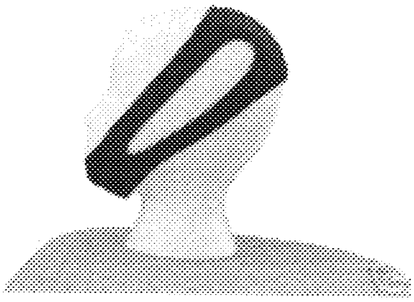
[6]

Fig. 2.1 a nasal strip

- Throat Sprays

Throat Sprays work somewhat like saline sprays, yet instead of salt water, they deliver natural lubricating oils to the back of the throat. This can dramatically reduce the amount of vibrations that occur in the trachea during sleep, and thus effectively diminish (if not outright end) snoring. Similar to nasal strips, throat sprays are low cost, mobile, and can be purchased in bulk. It should also be noted that throat sprays, if used too frequently, could actually cause throat irritation. This can ironically lead to more snoring! [6,15].

Another remedy is the use of a device named Sleep Wizard [8], which is a lightweight aid that supports jaw comfortably while sleeping. It keeps jaw closed while sleeping.



[8]

Fig 2.2 a sleep wizard

Dr. Parker's Snore Relief Cushion™ is the first product designed to help treat positional snoring [7]: the snoring associated with sleeping on the back, which accounts for 60 percent of snoring

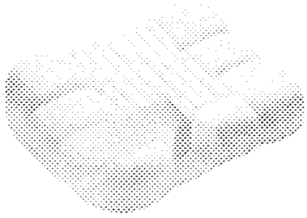


Figure 2.3 Dr. Parker's snore relief cushion [7]

Silent Partner™ ASD (Anti-Snoring Device) is a non-obtrusive appliance made of FDA approved vinyl that fits firmly into the mouth over the upper & lower teeth, positioning the lower jaw slightly forward and the mouth slightly open. This minimal repositioning of the mandible leaves the airway open, allowing more breathing through the nose. Research shows that this type of device is 80% effective in treating snoring

In the year 1981, Dr. Sullivan created a device, which he appropriately named a continuous positive airway pressure (CPAP) device [8]. A CPAP device has a mask, tubes and a fan. It uses air pressure to push tongue forward and open throat. This allows air to pass through the throat. It reduces snoring and prevents apnea disturbances. CPAP have three forms: a chinstrap, full-face mask and nasal pillow. The major disadvantages of these devices are that the mask feels uncomfortable and continual usage will make nose dry, stuffy and blocked up [5], [10], and [16].

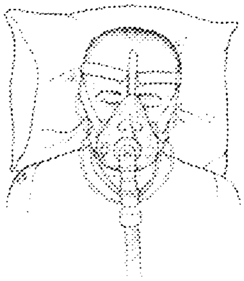


Fig.2.4 full face mask.

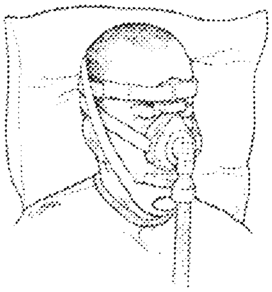


Fig. 2.5 a chinstrap

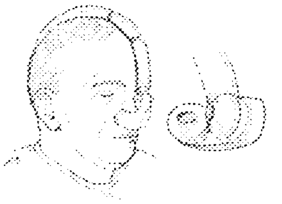


Fig. 2.6 a nasal pillow [5]

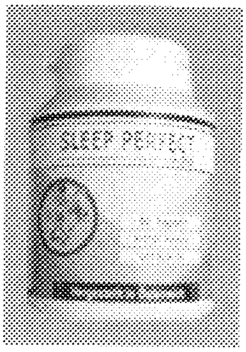
The NAPA Appliance

The NAPA appliance has been in use since 1983 and ranks as the oldest snore appliance in continuous use [15, 16]. Like Elastomeric appliance, it is built in a fixed jaw relationship, which cannot be changed. It is made out of hard acrylic and is held in place by eight clasps that firmly grasp the teeth. The extension in front is a breathing tube, which keeps the lips apart. Over the years, it was found that this arrangement was unnecessary since patients tend to breathe through their noses when asleep and block the breathing tube with their tongue. However, many patients like the security of an airway that is always open and unobstructed.

Early attempts to eliminate snoring used mechanical devices, which were designed to fit into the snorer's mouth or around his chin to physically prevent snoring. Examples of such devices can be found in British Pat. No. 1,248,474 and U.S. Patent Nos. 3,434,470; 3,312,217 and 3,132,647. These mechanical devices were not popularly accepted since they suffered from the disadvantage that they were uncomfortable to wear and interfered with the user's sleep [13].

Among all the remedies of snoring, ear plugs are the only non-electronic means that by a person other than the snorer himself wear, and their use have proved to be very helpful. The earplugs with a good design can block out the sound of snore completely [11, 15].

Some people prefer taking tablets and capsules like the Sleep Perfect Plus capsules. The capsules ease breathing during sleep through enzymes, which act as expectorants, and medicinal herbs with a decongesting effect. The oscillations of the velum become reduced through better respiration [17, 18].



[17]

Fig.2.7 snore relief capsules

2.1.2.2 Electronic devices

A later generation of anti-snoring devices worked on the principle of detecting a snore electronically and making the snorer conscious of the fact that he had snored [13]. U.S. Patent No. 2,999,232 discloses a device adapted to be worn by a sleeper and to provide an alarm automatically when the person's mouth opens, whereby the device causes the sleeper to become conscious of the fact that he has lost control of his mandible. The device of U.S. Patent No. 3,480,010 consists of a neckband worn by the sleeper, which comprises a circuit to detect a snore and to impart a high voltage shock to the sleeper to condition him against snoring. Similarly, German Patent No. DE 3,018,336 and U.K. Patent Application No. 2,103,807 disclose apparatus responsive to snoring sounds to impart a stimulus voltage to the snorer.

These devices suffer from the disadvantage that their use can result in nervous injury to the user by continually waking him up or giving him electric shocks. It is obvious that the snoring does not annoy the snorer, but his partner, thus, the snorer will be reluctant to use a device, which is uncomfortable or painful when he is not mal-affected by the snoring. Further, it is clearly inadvisable for a device to incorporate an alarm or other stimulus that is likely to disturb the snorer's partner. Both considerations are taken into account by the present project.

• Snore Stopper™

A rather effective non-surgical anti-snoring device that has many people buzzing is called the Snore Stopper [6]. There are a few variations of this device:

It can be worn around the arm, and provides a little jab of electricity (feels like a small pinch) when the sound of snoring is sensed.

It can be worn around the wrist instead of the arm (but the same pinch is there!)

It can be used to stimulate tongue muscles, which forces them to contract; and ultimately, to open up the airway (at least a little).

U.S. Patent No. 4,788,533 issued to Jean C. Mequignona on Nov. 29, 1988 discloses a Device for Interrupting the Snoring of a Sleeping Person [13]. The device is an electronic apparatus that operates by detecting sounds above a predetermined threshold. The device then emits a sound to awaken the snoring sleeper. The device is deficient in that (1) it may trigger an alarm due to another sound source than the snorer, and (2) the audible alarm is about as likely to awaken another nearby sleeper as the snorer, particularly if the nearby person is a light sleeper.

U.S. Patent No. 4,848,360 issued to Gote Palsgard et al. on Jul. 18, 1989 discloses a Device for Preventing of Snoring comprising an electronic device to detect the sound of a person snoring [13]. The device is somewhat more complex than the Mequignona apparatus discussed immediately above, including means to differentiate the sound of snoring from other sounds. The only means disclosed to awaken the snoring person are the provision of an audible signal as in the case of Mequignona above so the use of this device too can affect the snorer`s room partner.

U.S. Patent No. 5,081,447 issued to Wilford R. Echols on Jan. 14, 1992 discloses a "Keep off Your Back" Alarm comprising plural gravity actuated switches on a belt or headband [13]. The switches are disposed toward the uppermost part of the belt or band when the sleeper is resting upon his or her back, and are adapted to trigger an alarm when the sleeper is in that position. The alarm may take the form of a single vibrating device, similar to one of the means of the present project. The switches of the Echols device are located in positions that would be uncomfortable to the sleeper when lying upon his/her side or stomach, which the gravity switches encourage the sleeper to do. Audio alarm means are also disclosed, unlike the present project. Finally, the Echols belt must provide for electronic interconnection between the plural switches and the separate single alarm device; the present project requires no such electronic circuitry.

U.S. Patent No. 5,113,176 issued to Frank W. Harris on May 12, 1992 discloses a Lumber Roll with Audible Alerting Capability [13]. The device includes a pressure activated switch, but also includes time delay means to activate an audible alarm if the pressure activated switch is later closed for a predetermined amount of time. Further, the device includes an automatic shutoff if no movement is detected for a given time period. With the timer delays and automatic shutoff features, the device would not provide timely stimulation to a snorer, and might shut off if the snorer remained stationary for some time.

U. S. Patent No. 4,644,330 is a compact self-contained electronic anti-snoring device adapted to be worn in the outer ear or attached thereto. It comprises a miniature microphone for detecting snoring sounds and means responsive to the detection of snoring sounds for generating an aversive audio signal. The aversive audio stimulus is emitted via a speaker in the user's ear. Preferably, a combined microphone/speaker is used and the snoring sounds are detected via the auditory canal. Means are also provided to vary the amplitude and duration of the audio stimulus with successive snores to obviate habituation. A counter is also provided to record the number of snores during a sleeping period and provide an indication of the effectiveness of the device.

In addition to the above-discussed patents, the following patents are generally related to the remedy of snoring: U.S. Pat. No. 648,028 issued to Josephus Hooper on Apr. 24, 1900 for a Device for Preventing Mouth Breathing; U.S. Pat. No. 746,869 issued to Stillman A. Moulton on Dec. 15, 1903 for a Device for Preventing Snoring; U.S. Pat. No. 1,354,652 issued to Richard H. Jeffries on Oct. 5, 1920 for a Device to Prevent Mouth Breathing; U.S. Pat. No. 2,178,128 issued to Donald H. Waite on Oct. 31, 1939 for an Anti snoring Device; U.S. Pat. No. 2,627,268 issued to Elsa L. Leppich on Feb. 3, 1953 for an Anti snoring Device; and U.S. Pat. No. 4,817,636 issued to Thomas H. Woods on Apr. 4, 1989 for an Anti-Snoring Device [13]. The six patents listed in the immediate paragraph are all related to masks or appliances installable in or over the mouth to reduce or prevent the opening of the mouth, particularly during sleep. As such they are not seen to relate to the structure of the present project.

A list of some more US patents related to snoring is shown below.

Table 2.1 List of some patents related to Snoring

US Patent References:	3480010	Nov., 1969	Crossley	128/136.
	3802417	Apr., 1974	Lang	128/724.
	3834379	Sep., 1974	Grant	128/132.
	3998209	Dec., 1976	Macvaugh	128/419.
	4295133	Oct., 1981	Vance	340/575.
	4344441	Aug., 1982	Radke	128/733.
	4381788	May., 1983	Douglas	128/782.
	4403215	Sep., 1983	Hofmann et al.	340/573.
	4420001	Dec., 1983	Hearne	128/419.
	4440160	Apr., 1984	Fischell et al.	128/132.
	4492233	Jan., 1985	Petrofsky et al.	128/774.
	4593686	Jun., 1986	Lloyd et al.	128/136.

None of the above noted patents, taken either singly or in combination, is seen to disclose the specific arrangement of concepts disclosed by the present project.

2.2 Theoretical Backgrounds

The aim of this snore guard is just to rouse the snorer, not the entire household. To wake the sleeper, vibration is used, not an audible alert. The vibration is provided by a small motor, which can be placed under the sleeper's mattress or pillow. This circuit has a level control and peak display indicator, a variable trigger threshold and trigger indication.

This snore guard is designed to trigger after a preset period, adjustable by a variable resistor (VR2). It is designed not to be activated by background noises, like a soft music from a distant place, or a sudden and non-continuous sound like slamming of doors; car horns etc, but instead wait for a set delay before triggering. Since snore is continuous for several seconds, the delay before triggering could be set by a threshold control mechanism.

The loudness of the snore is controlled by setting another variable resistor (VR1), so for loud snorers VR1 will be set at a low value of resistance and at high value for quiet snorers. Once snore is detected, vibration mechanism is used to gently shake the snorer. We implement this by using a small dc motor. A block diagram of the modules that make up the device is shown in the figure below:

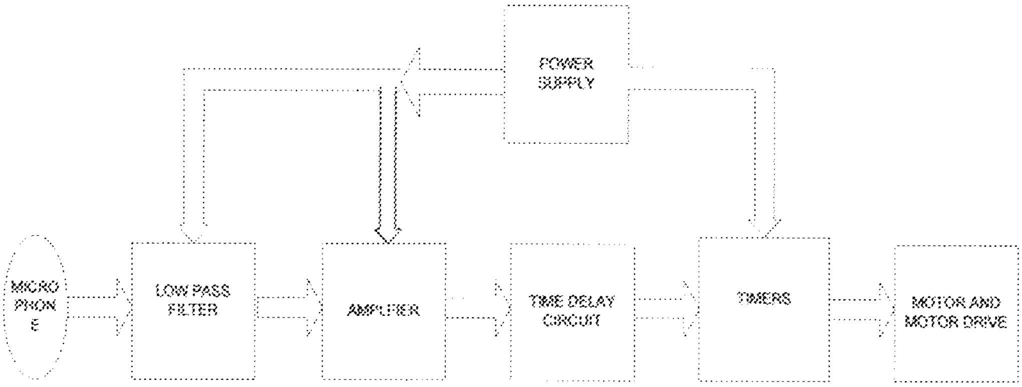


Fig. 2.8 block diagram of snore guard

From the diagram we have seven blocks (or modules); we will hence explain each separately.

2.2.1 Power supply

The power needed by the entire device is about six (6) volts DC; this can be sourced in many ways but due to certain considerations (explained in chapter three), we used a nine (9) volts battery and a 6 volts rectifier.

2.2.2 Microphone

Since our input (snore) is a sound, the input transducer to be used must be a microphone, and the best for this purpose is the electret (ECM) microphone. It converts the input sound signal into electrical signals in a linear fashion (i.e. the louder the snore, the higher the output voltage and vice-versa). The output of the microphone is fed (i.e. connected to the input of) a low pass filter.

2.2.3 Low-pass filter

The function of the low pass filter is to amplify and pass the output of the microphone which is below a certain frequency only. This is to prevent the device from being activated by high frequency signals like radio signals. We implemented this by the use of an active filter which has a gain of about 46 times if the input signal is of low frequency, and the gain decreases as soon as the input signal's frequency exceeds a pre-defined value adjustable by a variable resistor (VR1).

2.2.4 Amplifier

The output signal from the low pass filter is then passed to an amplifier with a good gain (about 46 times also) to boost signal levels, this is to produce signals large enough to charge a capacitor to a desired level. Two resistors (R4 and R6) and a capacitor

(C4) bias the non-inverting inputs of op-amps IC1 and IC2 to half the supply voltage. Peak signal levels pass through a capacitor (C5) and a resistor (R8) a light emitting diode (LED 1) which provides visual indication of peak levels. LED1 will not illuminate continuously but will give intermittent display in response to peak sound. VR1 is adjusted so that LED1 flickers with each snore.

Since a snore sound is continuous for a period, the circuit must only trigger after someone begins to snore. If there were no delay, then the circuit would be set off by any background noise. Even though some degree of high frequency roll-off is employed in this snore guard, it should be noted that all sounds consist of a fundamental frequency, plus a number of harmonics. Thus a car horn or a door opening in the middle of the night could trigger the alarm, hence the need for an input delay.

2.2.5 Time Delay circuit

Another capacitor (C7) and a resistor (R11) provide the input delay. The amplified signal from the amplifier is now filtered again and used to slowly charge C7: a 470uF electrolytic capacitor. C7 will only charge when an input signal is present, i.e. by a loud noise such as a snore. With no input signal, C7 discharges through R12 and R11. The signal is further rectified by D2, R9 and R10 providing a slight forward bias to bring D2, a 1N4148 diode into conduction. This also pre-charges C8 with no signal to a few tenths of a volt. To provide the delay, op-amp IC3 is used as a variable level detector. VR2 now acts as a threshold control, so that the charge on C8 must equal the voltage at pin 3 of the op-amp, set by VR2. When this happens, the circuit will trigger as indicated by LED2. Note that the output of IC3 is normally high, changing to low output on trigger.

If a fixed DC current charges a capacitor, its charge time can be calculated, however as the charging current to this circuit is not fixed, and provided by an intermittent noise source (a snore) then calculation becomes difficult. The easy option was experimentation, and with the values shown on the schematic, my prototype made on a breadboard provided between 2 and 10 seconds worth of delay.

2.2.6 Timers

This stage comprises of two 555 timers. The output of the transistor of the time delay circuit trigger the first timer configured as a monostable to provide a single pulse. The pulse is then used to trigger the second timer, which is configured as an astable to provide a stream of pulses, it is this pulses that will activate the motor at the output. This is necessary to make the motor run and stop at least four times within the time duration of the pulse of the first timer (which is about 22seconds).

2.2.7 Motor and motor drive

At this stage, the pulses from the timers are differentiated to produce voltage spikes; these are rectified by a diode. The rectified pulses drive a transistor into conduction and this provide a complete voltage path for the motor hence the motor vibrates with each pulse. The motor used here is a DC Motor rated at about six volts: the vibration produced should be enough to shake the sleeping person. It must be kept in mind that our aim is not to continually wake the snorer with heavy vibrations.

CHAPTER THREE

DESIGN AND IMPLEMENTATION

3.1. Power supply

The source of power to this device is a 9V battery used purposely for its stability and availability, though the device typically requires 6V for its operation. We therefore incorporated a voltage regulator to provide steady 6V supply.

3.1.1. Regulator

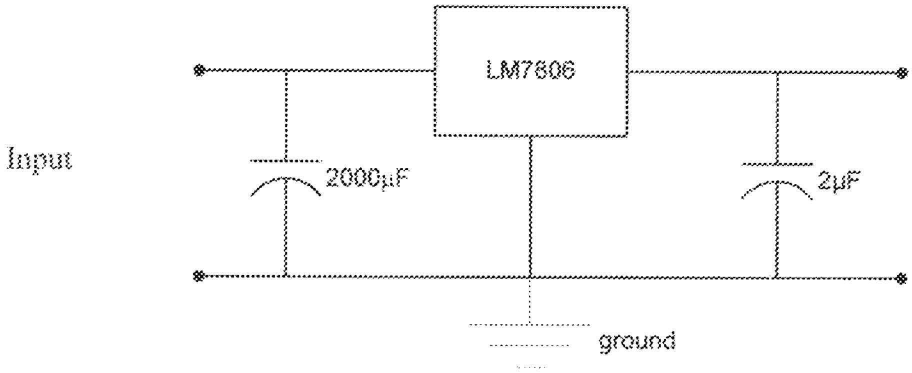


fig. 3.1 voltage regulator schematic

A voltage regulator is an electrical regulator desi gned to automatically maintain a constant voltage level [19], [20]. As a general rule the input voltage to the regulator should be limited to 2 to 3 volts above the output voltage [19] [20] [21], hence if 6V is required at the output, the most appropriate input is 9V. The LM78XX series can handle up to 30 volts input, but the power difference between the input voltage/current ratio and output voltage/current ratio appears as heat. If the input voltage is unnecessarily high the regulator will get very hot. Unless sufficient heat-sinking is provided the regulator will shut down. It should also be noted that reverse polarity destroys the regulator almost instantly. Our choice of LM7806 is therefore justified.

The 2000µF capacitor is used to maintain a constant input to the regulator and as a general rule should be rated at a minimum of 1000uF for each amp of current drawn and at least twice the input voltage [19]. The 2uF capacitor eliminates any high frequency pulses that could otherwise interfere with the operation of the regulator.

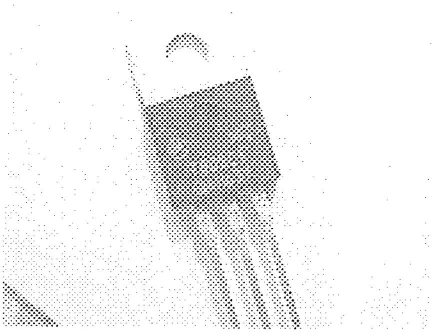


Fig. 3.2 a voltage regulator

3.2 Microphone

All microphones capture sound waves with a thin, flexible diaphragm (or ribbon in the case of ribbon microphones). The vibrations of this element are then converted by various methods into an electrical signal that is an analog of the original sound. Most microphones in use today use electromagnetic generation (dynamic microphones), capacitance change (condenser microphones) or piezoelectric generation to produce the signal from mechanical vibration.

An electret microphone is a relatively new type of condenser microphone invented at Bell laboratories in 1962 by Gerhard Sessler and Jim West [2], and often simply called an electret microphone. An electret is a dielectric material that has been permanently electrically charged or polarised. The name comes from *electro*static and magn*et*; a static charge is embedded in an electret by alignment of the static charges in the material, much the way a magnet is made by aligning the magnetic domains in a piece of iron. Unlike other condenser microphones, they require no polarising voltage, but normally contain an integrated preamplifier which does require power (often incorrectly called polarizing power or bias).

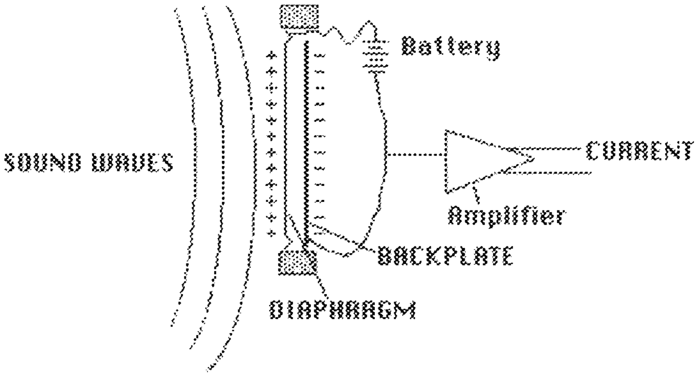


Fig. 3.3 Electret microphone schematic

3.3, Low pass filter

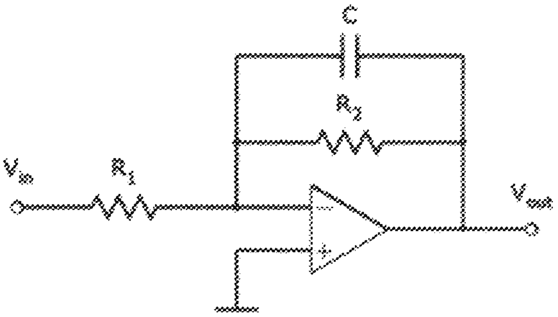


Fig. 3.4simple lowpass filter

A simple gain or attenuation amplifier (operational amplifier) is turned into a lowpass filter by adding the capacitor C. This decreases the frequency response at high frequencies and helps to avoid oscillation in the amplifier [19]. Electric filters are used in circuits, which require the separation of signals according to their frequencies [21] such as the device we are constructing. Any sound signal has a fundamental frequency as well as some harmonics. the frequency of snoring sound is generally between zero and four hundred Hertz (0-400 Hz) [23,24], but to accommodate variations, we use a filter that can pass up to one thousand Hertz(1KHz).

The cutoff frequency (i.e. the maximum frequency that the filter will pass in hertz) is defined as:

$$f_c = \frac{1}{2\pi R_2 C} \qquad [20]$$

or equivalently (in radians per second):

$$\omega_c = \frac{1}{R_2 C}$$

Thus we use a resistance value of 80KΩ and a capacitance value of 2*10^-9 Farad (2nF). This will give us a cutoff frequency of 1/ (2π*80,000*2*10^-9) =994.72Hz ≈1KHz.

Intensity of the snoring sound is the next thing to be considered. Since the output from an electret microphone is small in magnitude, it need to be amplified; thus the choice of an active filter. We chose that particular resistance value of 80KΩ and calculated the required value of capacitance to be 2nF because the gain in the passband (i.e. the maximum frequency to be passed) is $\frac{-R_2}{R_1}$. With R_2 being equal to 80KΩ and R_1 equal to 220Ω we got the gain to be equal to 80,000/220 =363.64.

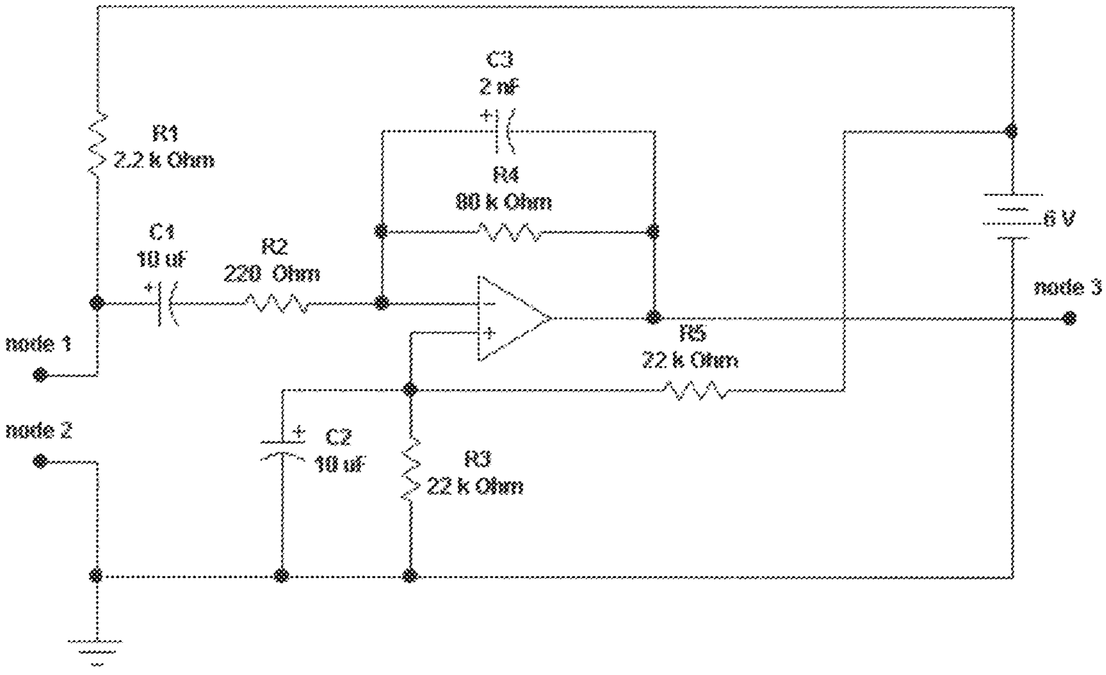


Fig. 3.5 Lowpass filter

The microphone is connected to the low pass filter shown above at node1 and node2 on the left. When sound is received, it goes directly to the operational amplifier. The resistor R2 is necessary to provide bias to the microphone. The value of the resistance is not critical but should generally be in the range of 1 kilo Ohm to 10 kilo Ohm (1KΩ10KΩ) [19].

The Opamp IC itself provides amplification that is necessary since the output of the microphone is so low that it cannot drive the other components of the device. Resistor R3 and capacitor C1 perform the filtering action (R3 and C1 are the same as R2 and C in figure 3.3 above.), while the same resistor R3 and the resistor R5 provide the gain. Capacitor C2 is a decoupling capacitor, while the capacitor C3 and resistors R4 and R1 bias the non-inverting inputs of op-amps IC1 and IC2 to half the supply voltage.

3.4 Amplifier

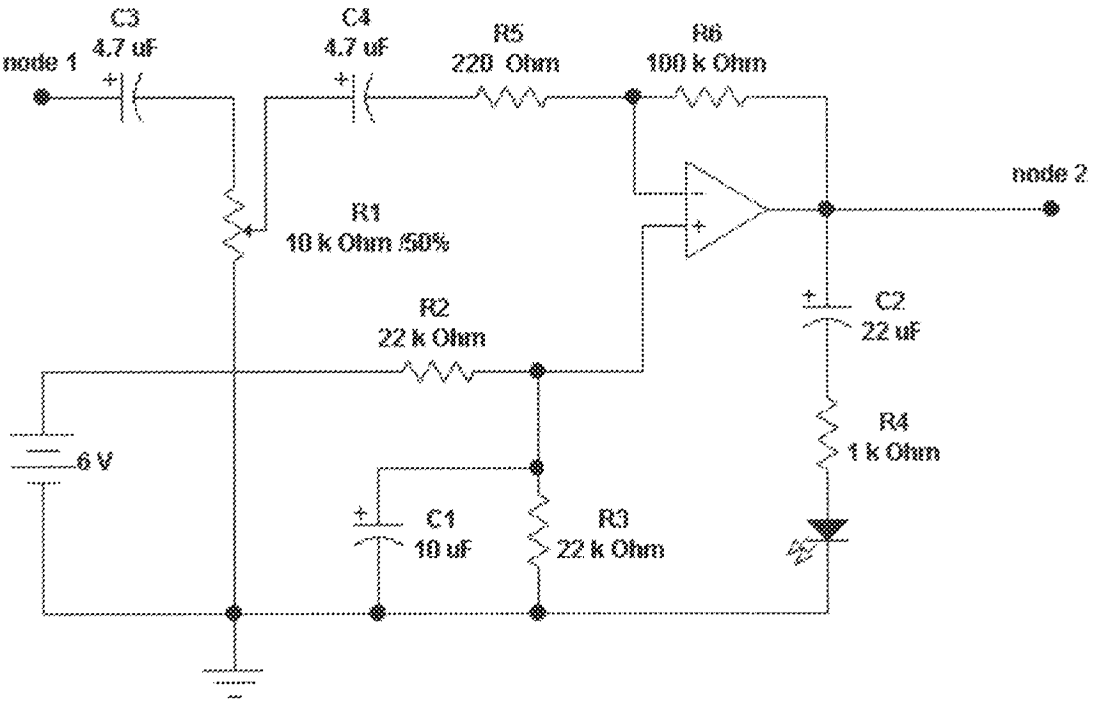


Fig. 3.6 Amplifier

The signal emerging from the lowpass filter is still low in magnitude and needs amplification; hence an Opamp is used again with a gain of R6/R5 as shown in figure 3.5 above. The gain is 100,000/220=454.6. This makes the total gain of the two amplifiers to be 363.64*454.6=165,310.744 (i.e. any signal from the microphone is magnified about one hundred and sixty thousand times). Capacitor C3 is a DC block while capacitor C1 and resistors R1and R2 are used to bias the non-inverting input of the amplifier to half the supply voltage. Capacitor C4 decouples the operational amplifier from the lowpass filter and the variable resistor R1 serves as a level shift; the value of the resistance is varied to provide different voltage levels at the input of the amplifier through the capacitor C4. This is to enable the device respond to various magnitudes of snore. Peak signal levels pass through C2 and R4 to a Light Emitting Diode (LED), which provides visual indication of peak levels. The LED will not illuminate continuously but illuminate briefly in response to peak sound. The Variable Resistor R1 is adjusted so that the LED flickers with each snore.

3.5 Trigger

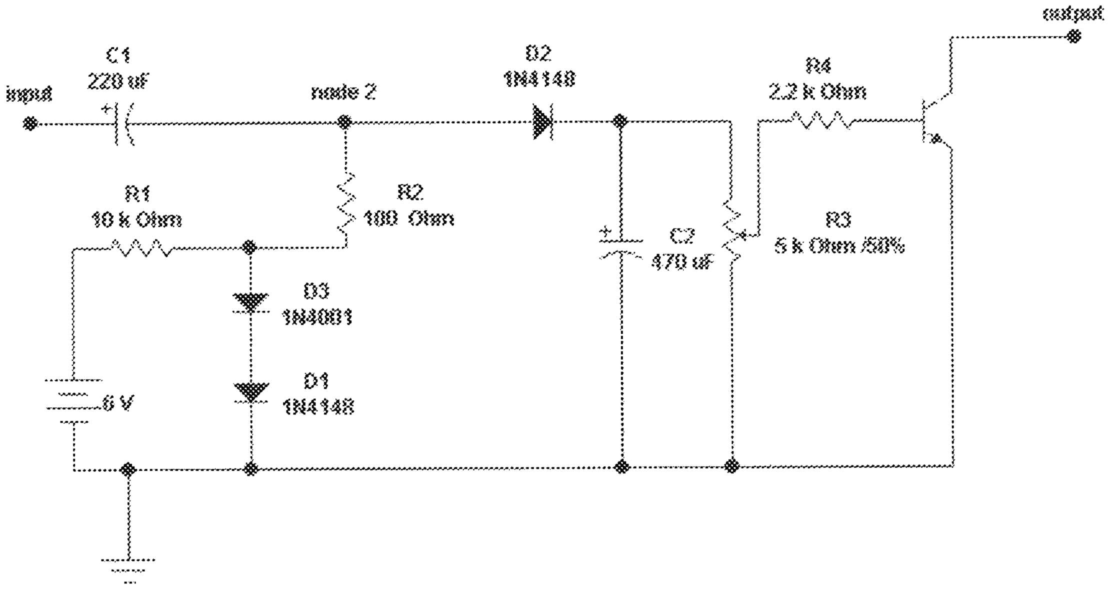


Fig. 3.7 trigger circuit

We now use the amplified signal to trigger the timers that drive our output (i.e. the motor). The triggering action is effected by passing the signal through a diode D2 (which acts as a rectifier passing only positive voltages) to charge a capacitor C2. the capacitor C1 serve as a DC block, while resistors R1 and R2 together with diodes D1 and D3 clamp the voltage level at the input of diode D2 at a constant value of 0.5volts, this is necessary to ensure that the diode D2 is biased positively to ease conduction when snoring sound is detected. The output of the diode D2 is zero unless a sound is detected;

then it will vary with the magnitude of snoring. This output signal will now charge C2 and as soon as it charges completely, it will discharge through the variable resistor R3 (adjusted to suit the intensity of snoring), the variable resistor connects to base of the transistor through R4.

The transistor behaves as an open circuit with no current at its base, but as soon as C2 discharges, the emitter and collector of the transistor become connected as shown below, hence the collector is effectively connected to ground.

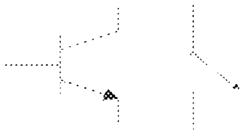


Fig. 3.8 Transistor as an open circuit (without base current)

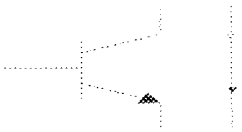


Fig. 3.9 Transistor as a short circuit (with base current)

The sub circuit of variable resistor R3, resistor R4 and transistor now reduces to the one shown below.

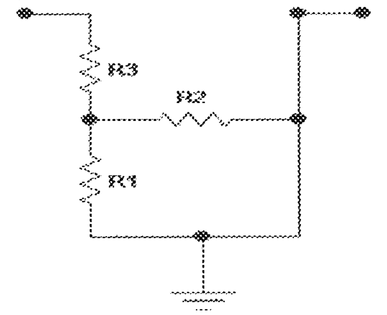


Fig. 3.10 voltage divider

3.6 Timers

The output from the trigger circuit is normally high, changing shortly to low on detection of a prolonged snore; this is of the correct polarity to trigger a 555 timer configured as a monostable.

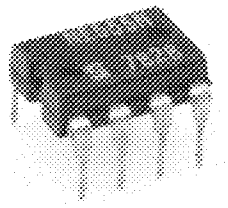


Fig. 3.11 555 timer IC picture

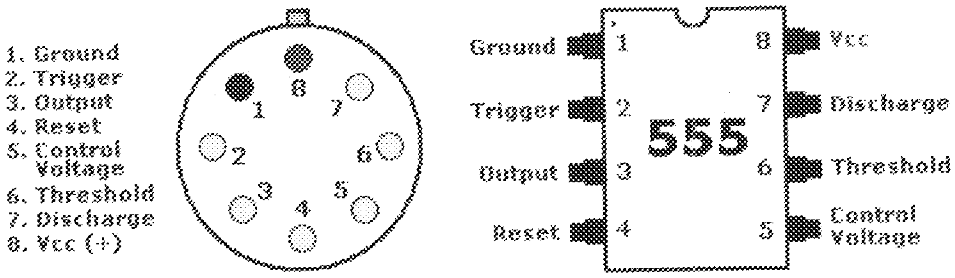


fig. 1. 8-pin T package

fig. 2. 8-pin V package

Fig. 3.12 Pin configuration of 555 timers

3.6.1 Monostable

A monostable circuit produces a single output pulse when triggered. It is called a monostable because it is stable in just one state: 'output low'. The output high state is temporary. The duration of the pulse is called the period (T) and an external capacitor and resistor [22] determine this.

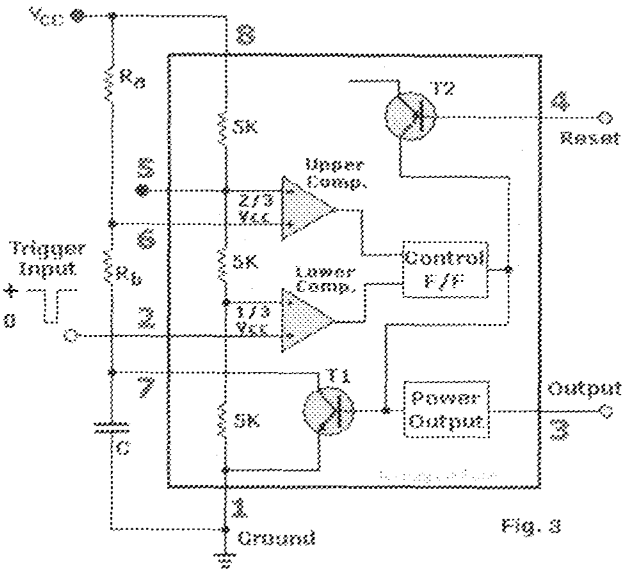


Fig. 3.13 555 timer schematic diagram

Fig. 3.9 above shows the basic circuit of the 555 connected as a monostable multivibrator. An external RC network is connected between the supply voltage and ground. The junction of the resistor and capacitor is connected to the threshold input, which is the input to the upper comparator. The internal discharge transistor is also connected to the junction of the resistor and the capacitor. An input trigger pulse is applied to the trigger input, which is the input to the lower comparator. With that circuit configuration, the control flip-flop is initially reset. Therefore, the output voltage is near zero volts. The signal from the control flip-flop causes T1 to conduct and act as a short circuit across the external capacitor. For that reason, the capacitor cannot charge. During that time, the input to the upper comparator is near zero volts causing the comparator output to keep the control flip-flop reset.

The trigger input is initially high (about 1/3 of +V). When a negative-going trigger pulse is applied to the trigger input, the threshold on the lower comparator is exceeded. The lower comparator, therefore, sets the flip-flop. That causes T1 to cut off.

acting as an open circuit. The setting of the flip-flop also causes a positive-going output level, which is the beginning of the output timing pulse. The capacitor now begins to charge through the external resistor. As soon as the charge on the capacitor equal 2/3 of the supply voltage, the upper comparator triggers and resets the control flip-flop. That terminates the output pulse, which switches back to zero. At this time, T1 again conducts thereby discharging the capacitor. If a negative-going pulse is applied to the reset input while the output pulse is high, it will be terminated immediately as that pulse will reset the flip-flop. Whenever a trigger pulse is applied to the input, the 555 will generate its single-duration output pulse. Depending upon the values of external resistance and capacitance used, the output timing pulse may be adjusted from approximately one millisecond to as high as on hundred seconds. IC timers are normally used where long output pulses are required. In this application, the duration of the output pulse in seconds is approximately equal to:

$$T = 1.1 \times R \times C \text{ (in seconds)}$$

The connection of the timers is shown below. The trigger input is shown on the right and output of the timers on the left. The monostable on the right has an output pulse duration of R3*C1 = 1.1*1*10^6*22*10^-6 = 24.2 seconds.

This pulse duration is chosen such that the motor will be able to produce vibration for a time long enough for the snorer to feel the impact and stop snoring and within that time, it is expected that the person close c to the snorer would not have been disturbed as to wake up from his sleep.

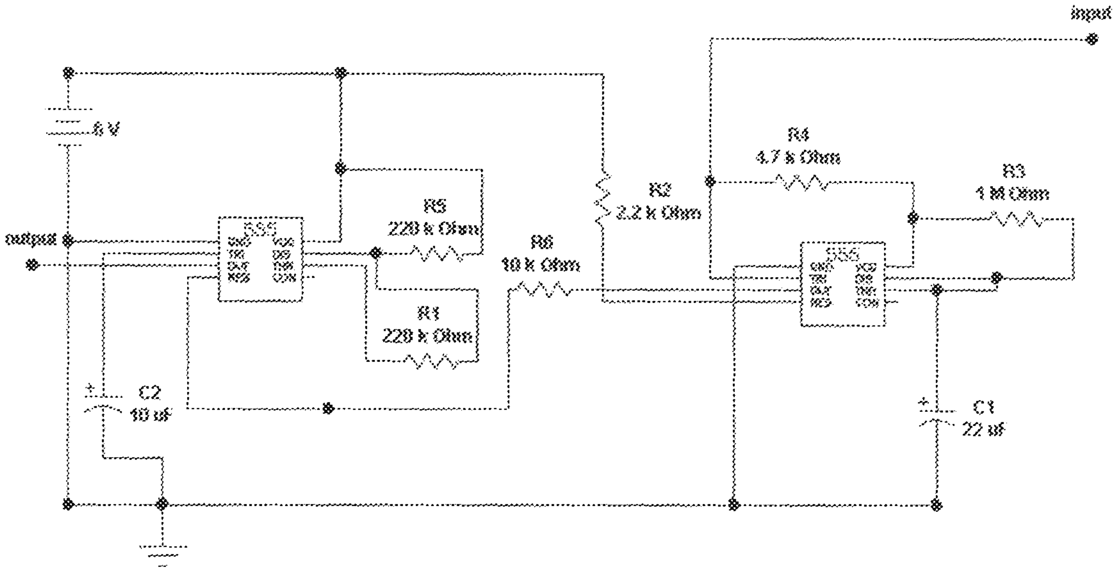


Fig. 3.14 Timers

3.6.2 Astable

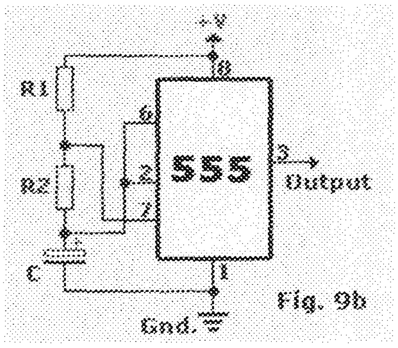


Fig. 3.15 Astable multivibrator

Figure 9b shows the 555 connected as an astable multivibrator. Both the trigger and threshold inputs (pins 2 and 6) to the two comparators are connected together and to the external capacitor. The capacitor charges toward the supply voltage through the two resistors, R1 and R2. The discharge pin (7) connected to the internal transistor is connected to the junction of those two resistors. When power is first applied to the circuit, the capacitor will be uncharged; therefore, both the trigger and threshold inputs will be near zero volts. The lower comparator sets the control flip-flop causing the output to switch high. That also turns off transistor T1. That allows the capacitor to begin charging through R1 and R2. As soon as the charge on the capacitor reaches 2/3 of the supply voltage, the upper comparator will trigger causing the flip-flop to reset. That causes the output to switch low. Transistor T1 also conducts. The effect of T1 conducting causes resistor R2 to be connected across the external capacitor. Resistor R2 is effectively connected to ground through internal transistor T1. The result of that is that the capacitor now begins to discharge through R2.

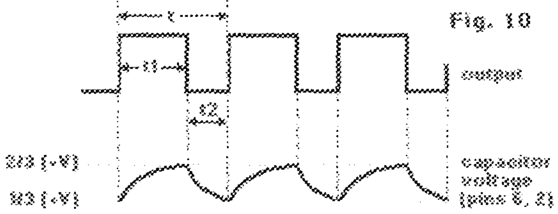


Fig. 3.16 Output waveform of an astable timer

As soon as the voltage across the capacitor reaches 1/3 of the supply voltage, the lower comparator is triggered. That again causes the control flip-flop to set and the output to go high. Transistor T1 cuts off and again the capacitor begins to charge. That cycle continues to repeat with the capacitor alternately charging and discharging, as the comparators cause the flip-flop to be repeatedly set and reset. The resulting output is a continuous stream of rectangular pulses.

The frequency of operation of the astable circuit is dependent upon the values of R1, R2, and C. The frequency can be calculated with the formula:

$f = 1/\ (.693 \times C \times (R1 + 2 \times R2))$.

With the values of C as 10µF and value of R1 and R2 as 220KΩ each, we get the frequency to be equal to $1/ (0.693*10\mu*(220K\Omega +2*220K\Omega)) = 1/45738 = 0.2186Hz$

From the above, it means that in any the 24.2 seconds of the operation of the timer, $0.2186*24.2 =5.29 \approx 5$ output pulses are produced.

The Frequency f is in Hz, R1 and R2 are in ohms, and C is in farads (note R1 and R2 in figure 3.11 are the same as R1 and R5 in figure 3.10). The time duration between pulses is known as the 'period' and usually designated with a't'. The pulse is on for t1 seconds, then off for t2 seconds. The total period (t) is t1 + t2 (see fig. 3.12). That time interval is related to the frequency by the familiar relationship:

$f = 1/t$ or $t = 1/f$.

The time intervals for the on and off portions of the output depend upon the values of R1 and R2. The ratio of the time duration when the output pulse is high to the total period is known as the duty-cycle. The duty-cycle can be calculated with the formula: $D = t1/t = (R1 + R2) / (R1 + 2R2)$

From fig. 3.10, the duty cycle of the astable is $(220K +220K)/ (220K + 440K) = 440K/660K = 0.66666 \approx 67\%$

We can calculate t1 and t2 times with the formulas below:

$t1 = .693(R1+R2)\ C =0.693(440K)*10\mu = 3.0492$ seconds

$t2 = .693 \times R2 \times C. = 0.693*220K*10\mu = 1.5246$ seconds

A duty-cycle of 67% means that the output pulse is on or high for 67% of the total period. The duty-cycle can be adjusted by varying the values of R1and R2.

3.7 Motor and Motor Drive

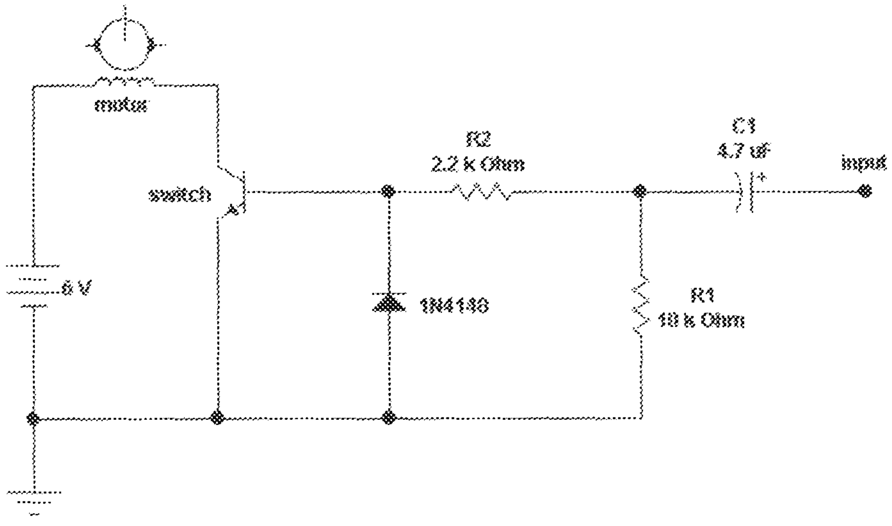


Fig. 3.17 Motor and Motor Drive

Capacitor C1 resistors R1 and R2 with the diode D1 differentiate pulses from the Timer circuit. The capacitor converts the pulses into voltage spikes, and the diode output only the positive going part of the pulses, thus the transistor receives intermittent positive sinusoidal pulses. Whenever a pulse is applied to the transistor, it acts like a switch because the emitter will be drawn to almost zero volts thus providing a complete path for the motor to run since the positive terminal of the motor is connected to the positive supply and the negative terminal to the collector of the transistor.

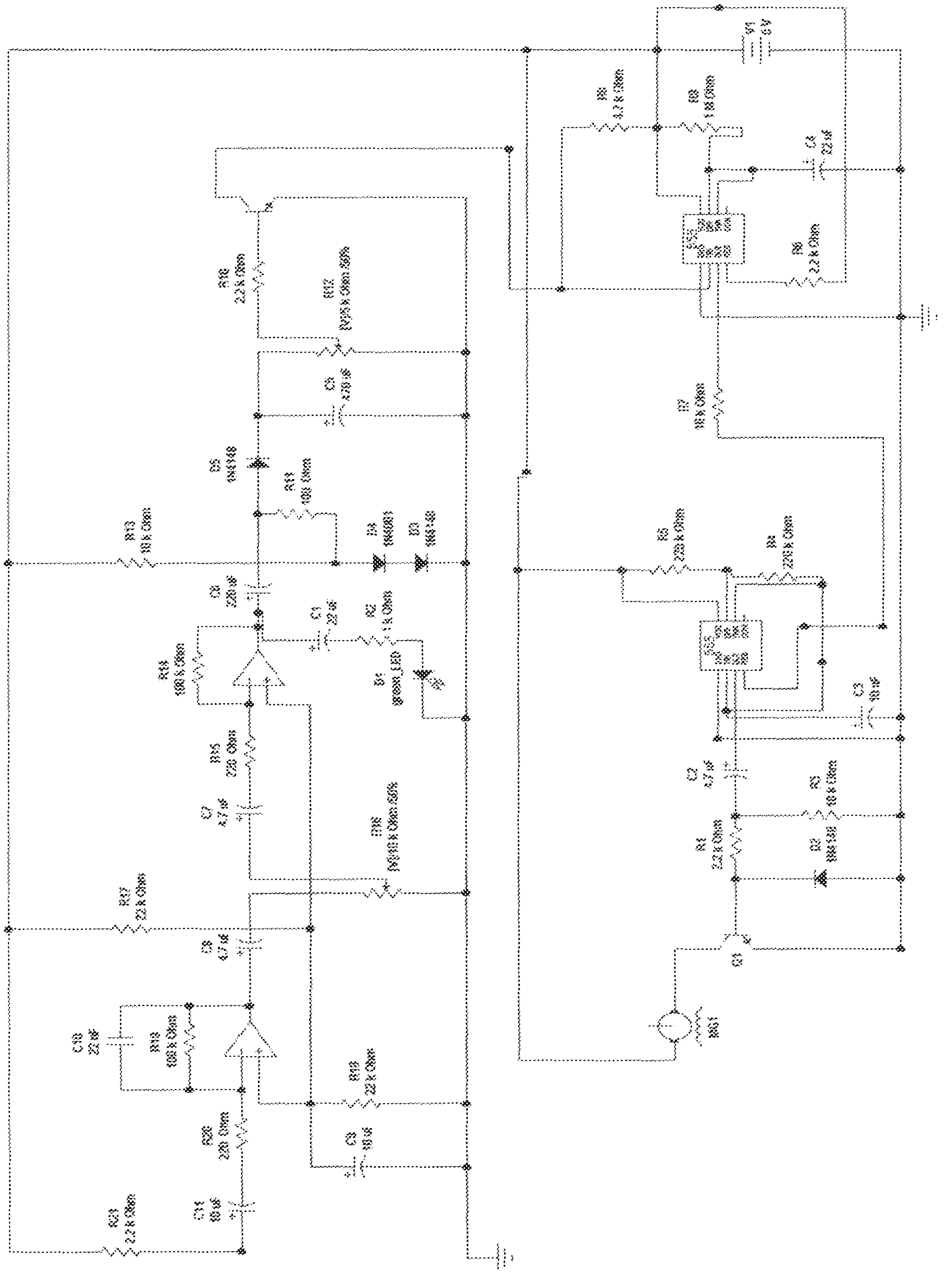


Fig. 3.18 complete circuit diagram of the snore guard

CHAPTER FOUR

TESTS, RESULTS AND DISCUSSION

We made Series of tests during the assembly of this device to ensure that it operates optimally. These include testing all the components before making use of them, measuring the outputs of the various blocks and adjusting the variable resistors to match the intensity of the snoring sound. To ensure that false signals do not activate the Snore Guard, we carried out our tests at the early hours of the morning.

The timers we used were two (2) 555 timers. This is to enable us convert a DC motor into a vibrator motor. The first timer is configured as a monostable. The monostable produces a single pulse of fixed duration; this pulse duration is measured to be about twenty two seconds (22 seconds). This time (22 seconds) is used because shaking a snorer continuously for such a period will be sufficient to make him stop the snoring. The single pulse from the monostable is then converted to stream of short pulses by the second timer which is configured as an astable. The astable produces five pulses each of period 3.0492 seconds within the period of the monostable, these five pulses when converted to vibrations will be the same as tapping a sleeping person five times within the period of twenty two seconds, and this obviously will be enough to stop a person from snoring.

We used a DC motor to produce the vibrations, but when a DC motor is running smoothly, it produces no vibrations. Hence we attached some plastic load on its rotating head and trigger it severally within a short duration (22 seconds) such that it produces jerky movements and effectively serves as a vibrator motor.

We could have used a standard vibrator motor but all the ones we could find in the market are too large for our purpose and produce excessive vibrations that if they are used will not only shake the snorer but keep him permanently awake.

CHAPTER FIVE

CONCLUSIONS

We have succeeded in achieving the aim of this project since the constructed device can detect snoring sounds and produce vibrations that can shake a sleeping person; this however is not without some limitations.

One: the device is operational exclusively in areas where the only disturbance is snoring sound, i.e. as far as there are other sound sources around, the device will not operate as required.

Two: size of the complete package is supposed to be very small so that it does not interfere with the snorer's comfort, but due to components sizes, our prototype became a little bulky. Use of miniature components will overcome this problem.

However, the Snore Guard is a simple device to operate and lead to no medical complications, thus it is safe to use. Moreover, since its power source is a DC battery, it is very reliable, requiring only periodic replacement of the battery.

Another advantage of this device is that it accommodates variations in snoring intensities by simply adjusting its potentiometers.

Conclusively, even though this device does not attempt to prevent a person from snoring, it tries to relieve the snorer's room partner the agony of interrupted sleep.

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