Design and Construction of Clap Activated Switch

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Abstract

A sound activated switch is a device that utilizes sound to control appliances. An example of a sound activated switch is the one that works by mere clapping of hand. This could be likened to the stopwatch system used in the international athletics competition which uses a gunshot to trigger it to start. Clap activated switch (CAS) is a simple type of control system that requires a clap to control e.g a lamp. This is able to be achieved because it has a microphone that picks up sound and a high gain amplifier that amplifies the sound to about 120times of its input level. The sound is now sent to one-shot monostable circuit that is configured to be triggered by a clap.The monostable circuit also acts as a Schmitt trigger as it converts the clap sound to a square pulse, sending it as a clock pulse to a D type flip-flop. The flip-flop causes a change in output latching it either ON or OFF. This latching is used to control light bulb, using a relay via a relay driver circuit.

Keywords:

Flip-flop, Monostable, Astable, Relay.

I. INTRODUCTION

In the past, appliances and gadgets were manually controlled. The radio and cassette players that are available then had buttons and variable knob for switching on and controlling the sound. This made it difficult for appliances to be controlled from afar.

Later in the 1990s the remote control was invented, but these made use of a transmitter and receiver, enabling control through electromagnetic waves. It, however, has its own disadvantages even if it can control appliances from afar. The transmitter can get lost and it also requires consulting manuals to understand their operations, and also considering that it is not very applicable that certain appliances are controlled by the remote control, e.g. light bulb [1].

In the 1980s, the sound activated control system was invented to overcome the shortcoming of the remote control. This made use of all type of sounds for controlling basic appliances and can be adjusted to different sensitivity level enabling it range to be variable.

This project is a prototype of a sound activated control system, but it was designed to make use of 'clap' as it sound source.

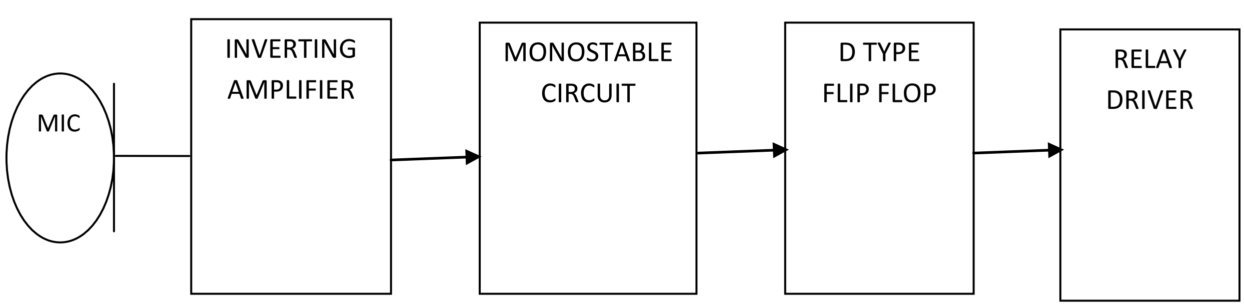

Figure 1: Block Diagram of Clap Activated Switch (CAS)

II. COMPONENTS OF CLAP ACTIVATED SWITCH

The Clap Activated Switch makes use of certain components to achieve its purpose. The components include:Microphone, Resistors, Capacitors, Transistors, ICs, Relay

A) Microphone

A microphone converts sound waves to electrical audio waves of the same frequency and relative amplitude. Microphonesare transducers. They transform one form of energy (air or mechanical) to electrical their electrical equivalent energy. There are several types of microphones. Examples include: Crystal microphone, Dynamic microphone, Electret microphone.

But this project makes use of the Electret microphone for its operation. An Electret microphone is the most recent addition to the range of commonly used microphone. It is also known as the CAPACITOR MICROPHONE or CONDENSER MIC and it is so called because it behaves like a capacitor and has polarity.

The microphone uses an electrets element, which is a special capacitor with one plate being a flexible diaphragm. If a voltage is applied to the electrets element, the capacitor is charged and there is no current flow apart from a negligible leakage current. However, sound waves hitting the diaphragm charge the capacitor (which depends on spacing between the plates). The amount of charges in the capacitor does not change as the capacitance varies. The voltage across the capacitor varies to maintain a constant charge.

Electret microphone is high quality microphones with excellent sound quality. Recent development in technology has reduced its size to a very small size that can be fitted into miniature tape recorders. It is cheap and easy to use. It is because of its ease and high sensitivity that it was chosen for the design and construction of the CAS[2].

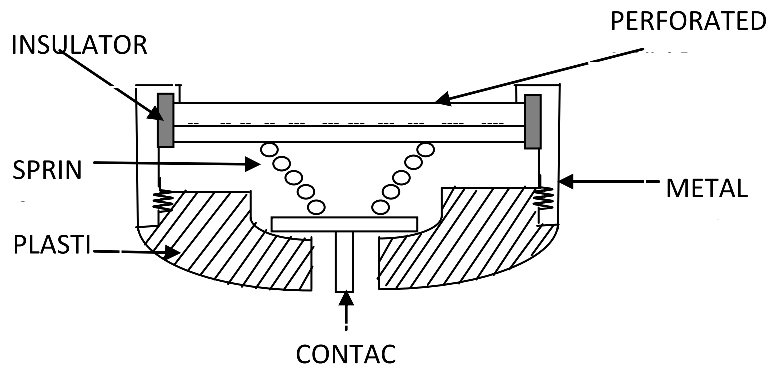

Figure 2Electret Microphone

III. THEORY OF TRANSISTOR OPERATION

The theory of NPN transistor operation is shown below in the Figure 2. The negative terminal of the battery is connected to the N-type emitter. The positive terminal of the same battery is connected to the P-type base; therefore the emitter-base circuit is forward biased.

In the collector circuit, the N collector is connected to the positive battery terminal. The P base is connected to the negative terminal. The collector base circuit is reverse biased. For the PNP transistor, the battery will be connected in the positive way of the NPN transistor. Electron enters the emitter from the negative battery source and flows towards the junction. The electron bias has reduced the potential hill of the first complete emitter-base circuit. However the base is a very thin section of about 0.001 inches. Most of the electrons flow on through the collector. This electron flow is added by the low potential hill in the second PN junction approximately 95 to 98 percent of the current through the emitter to the collector. About 2 to 5 percent of the current moves between the emitter and the base. A small changein the emitter bias voltage causes a somewhat large change in the emitter-collector current. It is this characteristic of a transistor that enables it to be a current amplifier and also as a relay driver as used in the Clap Activated Switch [3].

The 555 Timer IC can be operated in two modes:

i. Monostable mode
ii. Astable mode

IV. RELAY

A relay is device which operates when the electrical quantity to which it responds, changes in a prescribed manner, causing an abrupt change in its related circuit or causes operation of other interconnected devices.

The relay must have the power to be energized, once power is removed, it de-energizes, making or breaking a circuit. Relay control circuits because they are indispensable in controlling variables. They are mostly used as final element on its usage and its size. Some of the mostly used and easily constructed relays include: The Plunger Type Relay, The Armature Type Relay. But this project makes use of the latter because it is cheap, simple to use and readily available.

This relay makes use of an armature, with one end attached to a restraining spring. It has a normally open contact (NO) and normally closed contact (NC), with the armature acting as the common (COM). It also has a coil that can be energized or de-energized to attract or release the armature. This is how it operates when voltage is applied to the coil contacts, the coil is energized and a flux is set up in the relay coil and air gap. The surface adjacent to the air gap becomes magnetized. This pulls the armature plate to the No contact. When no voltage is applied, the restraining coil pulls the armature back to its original place, switching off the adjacent circuit[4].

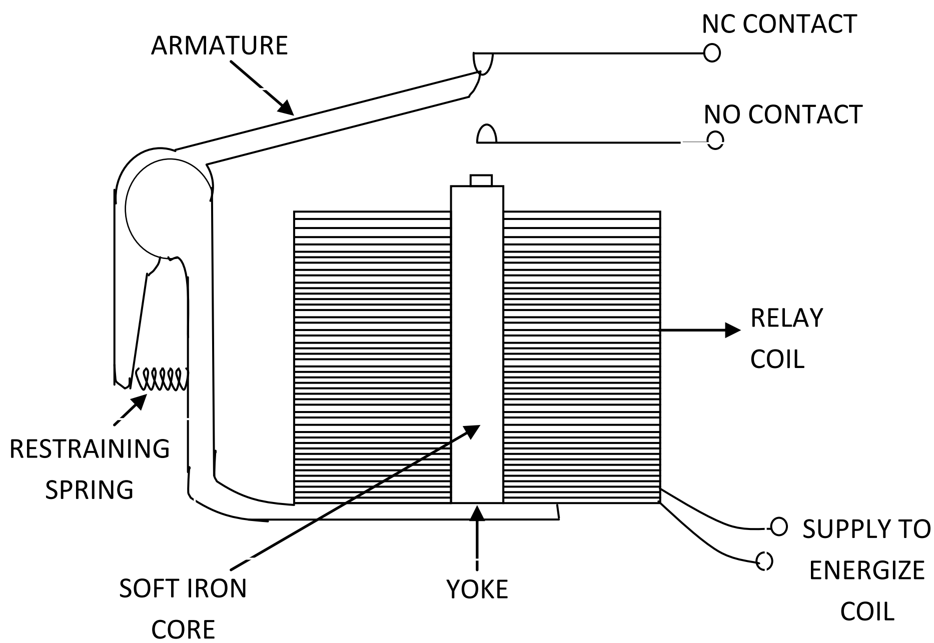

Figure 3 Armature Relay

V. METHODOLOGY

A) Design of Clap Activated Switch

The clap activated control circuit is divided into three main stages:

i. VERY SENSITIVE AMPLIFIER
ii. MONOSTABLE MULTIVIBRATOR
iii. DUAL D TYPE FLIP-FLOP

But the thrust of this project bothers on the stages (i) and (ii) which can be collectively called the CLAP DETECTOR. The whole project is powered by 12V regulated power supply circuit which falls within the supply voltage range for the LM324, 555Timer and 4013ICs.

During the process of designing the circuit, a way of creating a very sensitive amplifier circuit (using an Op-Amp), was considered. The first operational amplifier that came to mind was LM324 Op-Amp which is a general purpose Op-Amp. Also its frequency compensated and it has very good characteristics[5].

For the monostable circuit, a 555 timer was used. It is the single simplest way to create a monostablemultivibrator, utilizing very few components.

Also, although the Op-Amp LM324 is normally operated with positive and negative voltage, it is designed to work with positive and ground as well. This was used in this project and it was observed that the 324 Op-Amp operated fine.

A very sensitive amplifier design must have a high gain; at least a gain of 100and must be configured in such a way as to pick up very small sounds. Also, it must be capable of preparing the signal for the next stage. With this in mind, a high gain inverting amplifier was made use of and the circuit diagram is as shown below:

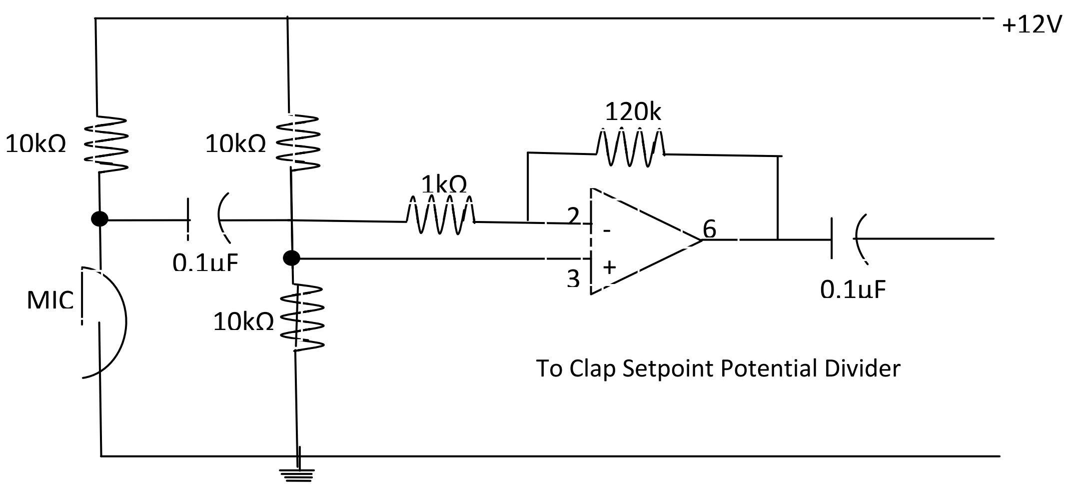

Figure4 High Gain Inverting Amplifier

The non-inverting input of the Op-Amp is held at $1/2V_{cc}$, while its inverting input is connected to Electret microphone whose resistance is about 2K, maintaining the voltage at its input below $1/2V_{cc}$ for the most sound making its output to be zero.

A sound made, e.g., a clap, one create a waveform that causes the “normally below” inverting input voltage to jump a little above the non-inverting voltage ($1/2V_{cc}$). This is amplified to large negative voltage at its output (because it is an inverting amplifier). The negative voltage appears at the clap set -point potential divider junction of the monostable circuit [6].

For the resistor value,a standard value of 10K was made use of.

$$A_V = \frac{V_O}{V_i} = -\frac{R_f}{R_i} \quad \text{……………………(1)}$$

$$A_V = \frac{V_O}{V_i} = -\frac{120\ K}{1K} = -120 \quad \text{………………..(2)}$$

Therefore, the gain of the amplifier is 120times the input voltage. It bears a negative sign because of its phase reversal.

Below is the circuit diagram of the Clap Activated Switch:

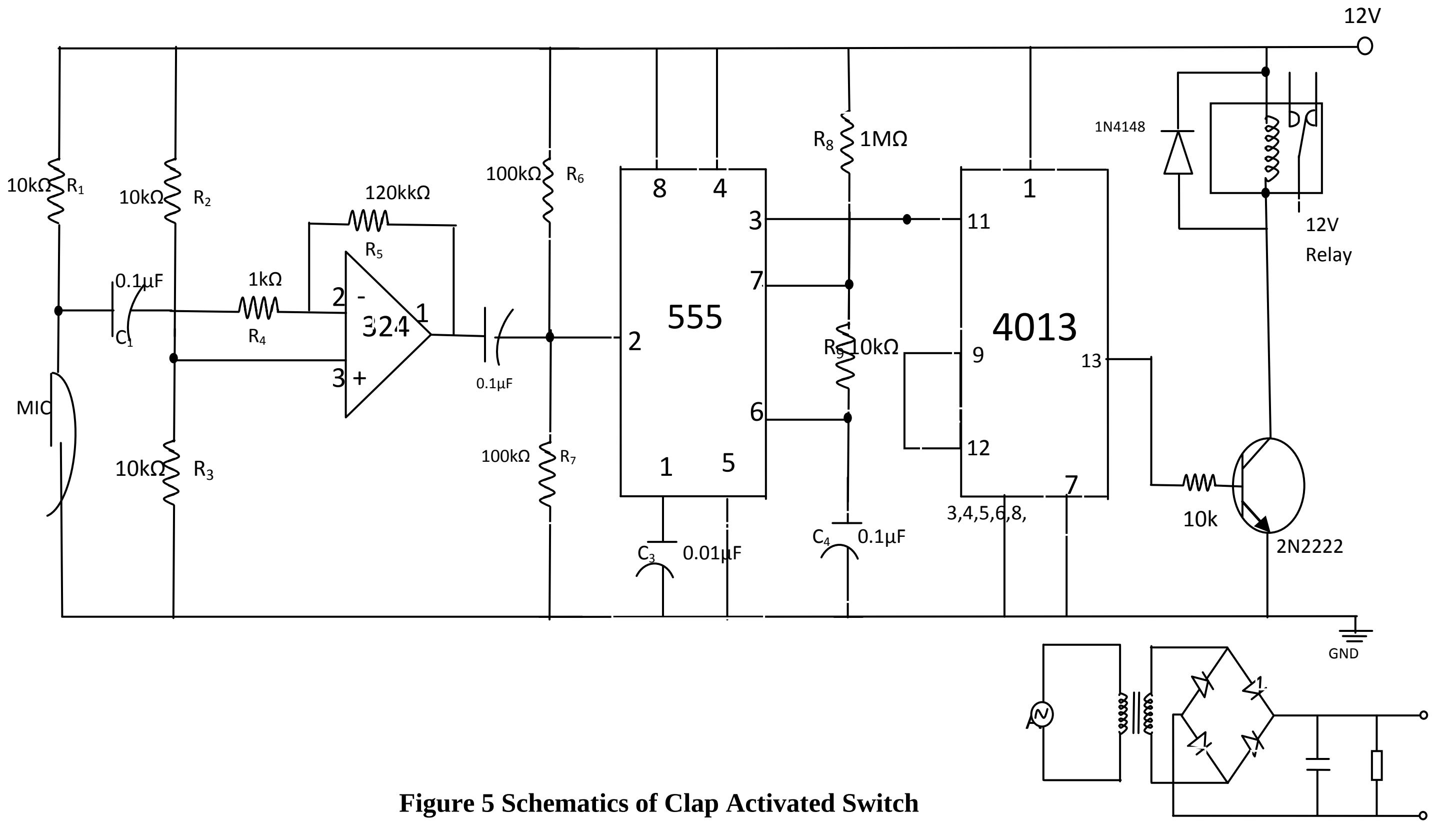

Figure 5 Schematics of Clap Activated Switch

VI. DESIGN OF THE CLAP SETPOINT POTENTIAL DIVIDER

The clap setpoint potential divider is the most important part of this project. This is because it is the part that sets the monostable trigger pin in such a way as to enable just clap frequencies triggers it. It was design previously with a potentiometer.

The value of the potentiometer was gotten thus:

The minimum current value that is able to be triggered for pin 2 is about 1µAmp. For safety reason the value of the current chosen is 48µAmp.

To get the resistance value of R_6 and R_7 ohms law is put into application.

$$V = IR \text{ ....} \quad (3)$$

$$V = 12\ V$$

$$I = 0.048\ mA$$

$$R = \frac{12}{0.048} = 250,000\ \Omega$$

So the preferred value was 250K

Using a 250K potentiometer, the set up was connected as shown below:

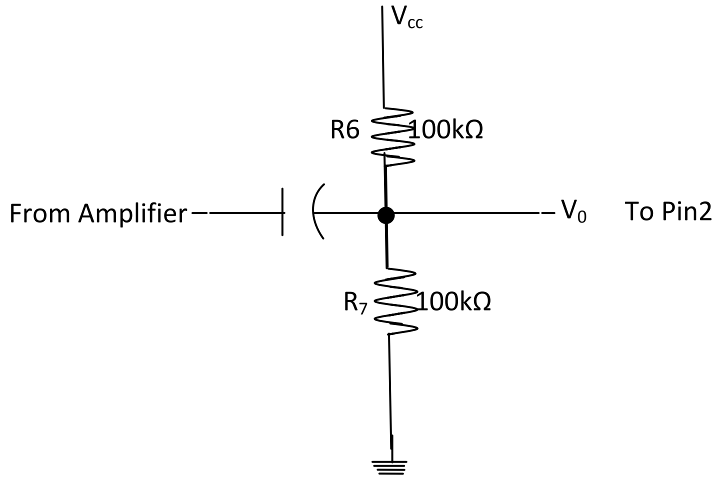

Figure 6: Clap Set point Potential Divider

After connection, the voltage for the 1/3V_{cc} was calculated:

$$\frac{1}{3}V_{CC} = \frac{1}{3} X\, 12 = 4V \text{ ....}(4)$$

Which is the trigger pin voltage necessary to produce a shot.

Hence, if the voltage of the variable arm of the potentiometer can be gotten to below 4V, it will cause triggering. A clap was made, taking time to adjust the variable arm until it rested at a value whereby it was only triggered by Claps.

The resistance between the variable arm and each terminal of the potentiometer was measured and it was given as:

$$R_6 = 95\,K\ ,\ R_7 = 105\,K \text{ ……………………………..}(5)$$

So the preferred value for the resistors R_6 and R_7 was chosen to 100K.

VII. DESIGN OF THE MONOSTABLE CIRCUIT

A monostablemultivibrator is a one-shot circuit which produces pulses when triggered. In this project, the monostable circuit has its trigger pin held at 1/2V_{cc} $\frac{1}{2}V_{CC}$ and it is required that its voltage reduce below 1/3V_{cc} before a shot can be produced so when a clap is made, it creates a large negative voltage that has a reducing effect on the voltage at the trigger pin reducing it below 1/3V_{cc}. this sets the output of the monostable circuit and switches OFF the discharge transistor causing C4 to start charging. The capacitor charges through R8 and R9 till it reaches 2/3V_{cc}. Immediately it gets to this voltage, the upper comparator pin (pin6) resets the output and switches ON the discharge transistor, discharging the capacitor through R8. This creates a shot whose width is given by the formula:

$$T = 1.1RC \text{ ………………………………….}(6)$$

Were R is in Megaohms and C is in Microfarads, for t to be in seconds. But t has to be in microseconds as there should be no time lag between a clap and its response. For easy calculation, one-tenth of a second was chosen.

$$T = \frac{1}{10} S \quad \text{.....................................(7)}$$

R9 is a discharge resistor. It was inserted to improve the pulse response of the monostable circuit, practically.

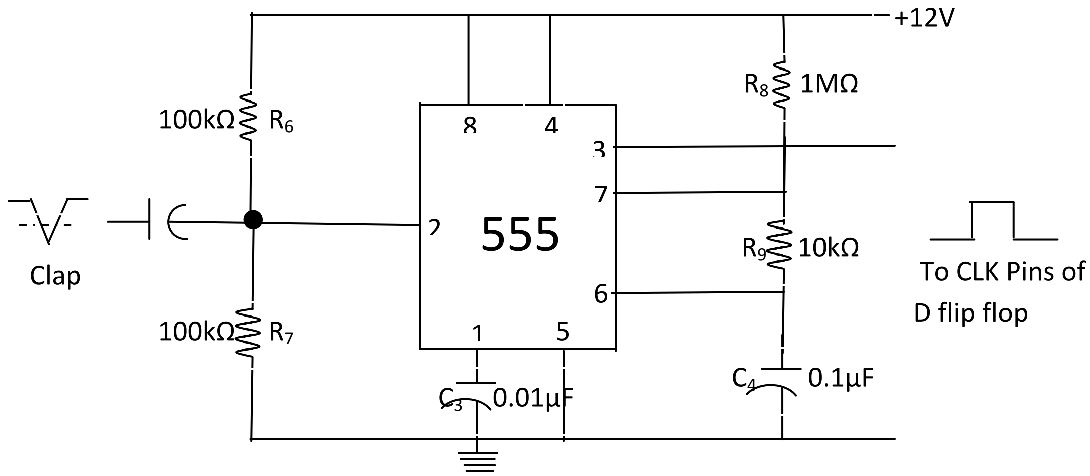

Figure 7: CAS Monostable Circuit

VIII. RESULTS

If a clap is made, the Electrets Microphone picks up the sound wave. It is converted to its electrical equivalent. This is amplified by thenon-inverting amplifier (1/4LM324). This amplifies the signal to 120times the input received from the MIC. This produces a negative voltage pulse that triggers pin 2 (Trigger) of the 555 timer. The timer produces one-shot pulse (square pulse) which now feeds the data input of the CD4013 flip flop integrated circuit.

The D flip flop is connected in a way that Complementary output (Q') is connected to the Data input (D). Basically, the Complementary output (Q') is the opposite of the Normal output (Q); that is, when Qis LOW, Q' is HIGH. Hence, D is HIGH.

At initial state, the output Q (pin 13) is 0 and Q' (pin 12) is 1, the Data input D (pin 9) is 1. When the first clap is made, the positive edge of the one-shot pulse from the 555Timer clocks the clock input (pin 11) of the 4013 flip flop hence transferring the 1 from D to Q output (1). Q' eventually becomes 0 and so is D (0).

When a second clap is made the (0) from D is transferred to Q (0).

Another clap reverses the set up and so on.

Note: The Normal Output (Q) determines the final output.

Table 1: Operation Flip Flop

INPUT		OUTPUT		
Claps	D	Q	Q'	Commentary
-	1	0	1	OFF
1st clap	0	1	0	ON
2nd clap	1	0	1	OFF

To produce a final output that powers a device, the output(s) received from the flip flop (Q) then switches a relay through a transistor interface.

IX. CONCLUSION

Before and after connecting the circuit in the casing, the set up was tested. The cord was connected to power supply and a clap was made: the light came on. A second clap was made: the light went off, hence confirming that the Clap Activated Switch is working properly. The Clap Activated Switch can be used to control any variable and not just light and other system also makes use of other sounds order than clap e.g. voice. Also the CAS, although a high quality control device, it is sometimes triggered by loud sounds like slamming doors, shouting, whistling etc. this can be prevented by the use of a high quality filter between the amplifier and the monostable circuit. This will enable the frequency sounds to be cut off. Employing this technology, several inconveniences faced at homes and other places can be considerably minimized.

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