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Design, Construction and Characterization of a Solar-Powered Multi-tone Ultrasonic Rodent Repeller

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Abstract: ***A solar powered multi-tone ultrasonic rodent repeller was designed, constructed and characterized to complement the use of conventional methods of trap and chemical (poison) which have been found totally inefficient in repelling rodents. An Integrated Circuit (IC) timer oscillator was connected in astable multivibrator mode to generate the multiple frequencies and the signal was converted to sound using a piezo which radiates this ultrasound at frequencies of 35 KHz, 38 KHz, 40 KHz and 50 KHz. A shift register was incorporated in the design to automatically shift the voltage V_{cc} to the required astable multivibrator circuit at time interval which is determined by the clock for the particular frequency generated. The solar energy as power supply was successfully actualized and this enable the use of the device in areas where electricity is not accessible and in farm yards and gardens. The change in the ultrasonic frequencies at interval as a result of multiple frequencies generated by the repeller does not create room for the rodents to get to particular sound and this makes the repeller unique.***

Keywords: 555 timer, Ultrasound, Multivibrator, Repeller, Rodents, Piezoelectric and Solar energy.

1. Introduction

In 1850, John Le Conte, an America Scientist initiated the study of ultrasonic wave. This study was developed for observing gas flame [1, 2]. In 1889, Pierre Curie and Jacques, French Physicists discovered the piezoelectric effect which forms the primary means of producing generating ultrasonic wave [1, 2, 3].

Moreover, the application of this ultrasonic wave was not possible until 20th centaury which electronic oscillators and amplifier wave used to drive piezoelectric element. [1, 2].

In the past ultrasound was used in the detection of submarines. This device was produced by Paul Langevin in 1917 at frequency of 50 kHz of a vibration quartz crystal propagating ultrasound in wafer [1, 2, 3]. Also ultrasound was first used therapeutically in the mid 1930s and for flaw detection between 1939 and 1945 [1, 2, 3].

However, after Second World War, a reasonable progress was made in the development of new piezoelectric crystal. This includes the use of the device in industry, machine, consumer products and signal processing and testing [4,5,6].

2. Literature Review

The applications of ultrasound in domestic, industry, commercial and medical areas have been reported by many researchers. The applications are briefly discussed.

Domestic Sources and their Ultrasonic Applications:

A lot of consumer-oriented ultrasonic devices are being manufactured for one or more purposes. These include garage door opener, television channel selector, remote control, burglar alarms, dog whistles and repellers. The ultrasounds that are used in these operations are of low intensities and of 20-100 kHz. Hence ultrasound is a sound above 20 kHz that is above human hearing [4-10, 11].

Industrial and Commercial Sources and their ultrasonic Applications:

Depending on the intensity levels required, the application of ultrasound in the industries can be categorized into high and low power application.

The high power applications of ultrasound are usually based on compound vibration induced phenomena occurring in the object or the material which include cavitations and micro-steaming in liquids, heating and droplet formation at liquid/liquid or liquid/gas interfaces and welding and soldering. The frequency range in this application is between 20 KHz – 60 KHz. [4-7].

The low power applications of ultrasound are found in the following areas: the determination of viscosity, transport properties, position, phase composition, anisotropy, texture, grain size, stress and strain, elastic properties, the detection of bubbles, particles and leaks non-destructive testing, acoustic emission, imaging and holography [4-7].

Material and Method of construction:

The block diagram for the design and construction of the multi-tone ultrasonic repeller is shown in fig 1

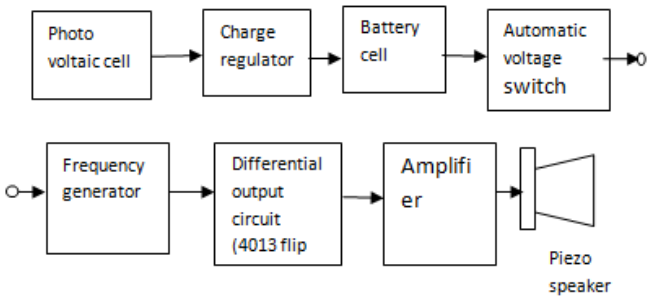

Figure 1: Block diagram of Designed and Constructed Solar Powered Multi- tone Ultrasonic Rodent Repeller

Power Supply:

The solar cell power supply of 12V, 50 watts was connected to power the circuit. Photovoltaic or solar cell is a device that converts solar energy to electrical energy [12, 13].

Battery Cell (Accumulator):

The battery cell of 12V was used as a backup power source in case there is no sun.

Charge Regulator:

Charge regulator is very essential to keep the life the accumulator. The charge of the accumulator by the solar cell needs to be regulated to avoid overcharging or over discharging the battery which may lead to shortening the life span of the battery. In this design a dual op-amp comparator circuit was used for the regulation [12,14, 16].

Automatic Voltage Switch:

Here a shift register (i.e. 4017) automatically shifts the voltage V_{cc} to the required 555 timer circuit at the time interval which is determined by the clock of an astable multivibrtor.

Frequency Generator Circuit:

In this design and construction, an integrated circuit of 555 timer astable multivibrator was used to generate an electrical signal of the needed frequencies as shown in fig 2. This signal was converted to ultrasonic frequencies using a transducer, otherwise known as piezo speaker. The different frequencies generated were made possible with the help of a shift register, which automatically switches voltage (V_{cc}) to the particular timer circuit that oscillates at the needed time interval which is determined by the clock of a decade counter, which is designed to produce a chain of pulse train for the shift register. The output of this signal is made symmetrically by producing a sample of high frequency pulse train inputs and its compliment which were needed to produce an output signal which is in anti-phase with each other (-ve and +ve). This was further amplified accordingly through a power amplifier to a level required to drive the piezo speaker [12-16].

The frequency of the 555 timer is calculated thus: [12-16].

$$f = \frac{1.44}{(R_1+2R_2)C}$$

Where R_1=15 k and R_2=60 k are resistors, C=330pF is capacitor

$$f = \frac{1.44}{330\times10^{-12}\times(4.7\times10=10^3+120\times10^3}$$

$\therefore f = 35$ kHz

Hence, following the same procedures, the other frequencies were obtained as 38 kHz, 40 KHz and 50 kHz.

Also the time interval during the output high and low of the timer is expressed as [12-16].

$T_{high} = 0.7(R_{1+}R_2)\ C$
$T_{Low} = 0.7RC$
Hence
$T = T_h + T_L$
$T = 0.7(R_1$ and $R_2)\ C$

3. Results and Discussion

After the design and construction of the solar powered ultrasonic rodent repeller, four frequencies are generated and are thus: 35 kHz, 38 kHz, 40 kHz and 50 kHz. These frequencies were confirmed using a frequency detector. The designed and constructed solar powered multi-tone ultrasonic rodent repeller repelled the rodents when introduced on it to confirm the efficiency of the device as shown in fig 3, 4 and 5.

Multi-tone ultrasonic repeller is an effective and best method of eliminating or eradicating rodents in a particular environment and hence the multiple tones do not create room for rodents to be accustomed to a particular sound. The ultrasonic frequency repeller was discovered as an alternative measure for repelling rodents rather than the use of trap and chemicals (otherwise called poison).

4. Conclusion

The ultrasonic repeller is an application of Science and Technology used in controlling rodents. The repeller has no side effect unlike chemical and trap which is dangerous to man especially in a place where there are children and their pet. It does cause any harm to the environment or interfere with the freshness of air. The operation of the device is easy and straight forward. The device is durable when handled carefully and the maintenance is cheap as compared to the ones designed to use alternating current or battery as power supply since it uses solar energy. However, it is only the cost of construction that is required; using the device does not attract any additional money since it is solar powered. Hence it can be used in homes, villages, farm yards, gardens and stores where electricity is not installed.

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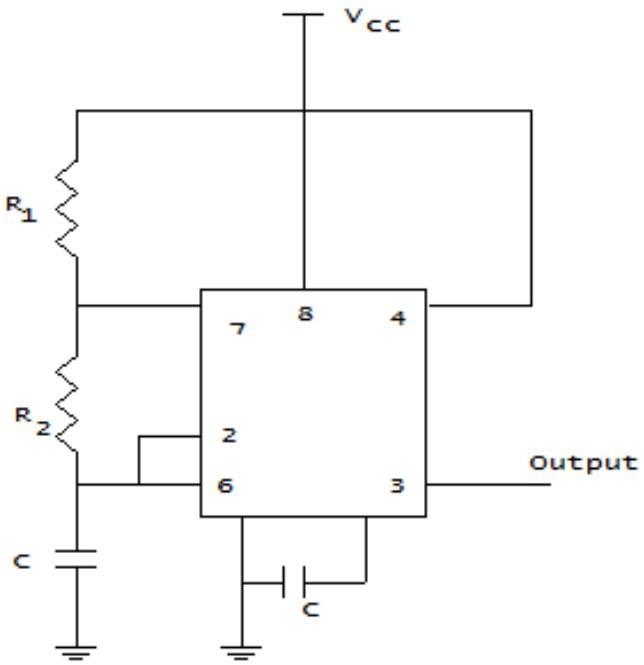

Figure 2: 555 timer that is connected in astable multivibrtaor that produced ultrasonic sound used to eliminate rodents.

Figure 3: The rat is seen running away from the room as a result of the ultrasonic frequency.

Figure 4: The rat is seen irritated and demobilized as a result of the ultrasonic repeller.

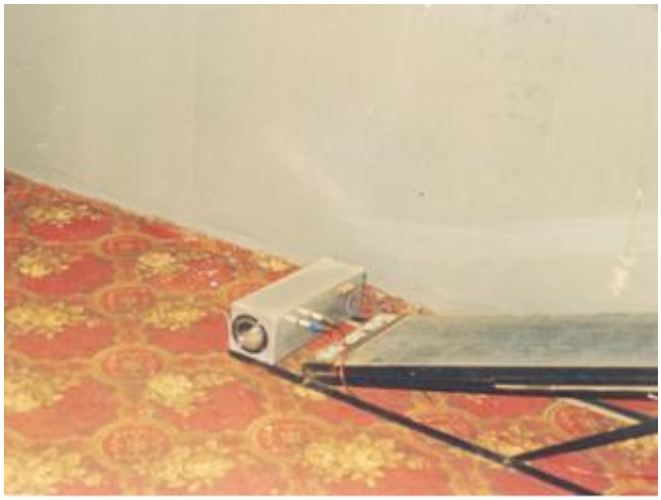

Figure 5: The mice is seen disturbed and irritated and is trying to run away from the room because of the ultrasound from the repeller