Design and Construction of Electronic Various Pests Repeller Circuit

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Abstract

The electronic pests repeller circuit was designed to repel or eliminate pests. In this device, CA 3130 IC gives clock pulse and CD 4017 IC acts as counter. Astable Multivibrator NE555 was used to generate the required ultrasonic frequency. A D-type flip-flop CD 4013 IC was used to obtain a symmetrical output signal which was amplified in push-pull mode by NPN transistors (BD-139) and PNP transistors (BD-140). Five presets were used to control the different frequencies selection. The ultrasonic frequency ranges 32-80 kHz is known to be disturbing to pests and a device operating at that range was developed. Tweeters was employed to produce an efficient sound generated. The electronic pests repeller circuit generates ultrasound or a very high frequency for repelling away animals.

Keywords: NE555IC, CA 3130 IC, CD 4017 IC, CD 4013 IC and Tweeter

Introduction

Numerous electronic pest control devices are readily available throughout the world. Electronic pest control is the name given to the use of any of the several types of electrically powered devices designed to repel or eliminate pests, usually rodents or insects.

CA3130A and CA3130 are op amps that combine the advantages of both CMOS and bipolar transistors. Gate-protected P-Channel MOSFET (PMOS) transistors are used in the input circuit to provide very-high-input impedance, very-low-input current, and exceptional speed performance.

The CD4017 is a CMOS Decade counter IC. CD4017 is used for low range counting applications. It can count from 0 to 9 (the decade count). This IC is also used in electronic industries, automotive industries, manufacturing medical electronic devices, alarms and in electronic instrumentation devices.

The 555 timer IC is a versatile and widely used device because it can be configured in different modes as a monostable multivibrator or as an be astable multivibrator or as a bistable multivibrator. It is composed of the window comparator circuit, flip-flop circuit and transistor switch. It contains 8 pins. The 8-pin DIP (Dual-In-Line Package) 555 timer IC is used in this project.

The IC 4013 is another important member of the CMOS IC family. They normally are available in 14-pin hermetic DIL (Dual-In-Line) ceramic package- with suffixes carrying the letters D or F. The IC 4013 incorporates two sets of identical, discrete data-type or D-type flip flop modules. Each module is further equipped with a group of pin-outs, assigned as data, set, reset, clock inputs, and a couple of complementary outputs, Q and $\bar{Q}$. D-type flip flops refer to circuits which may have a couple of outputs that change or toggle states in response to triggers

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applied at the input terminals. The block diagram of the electronic pests repeller circuit is illustrated in Figure 1.

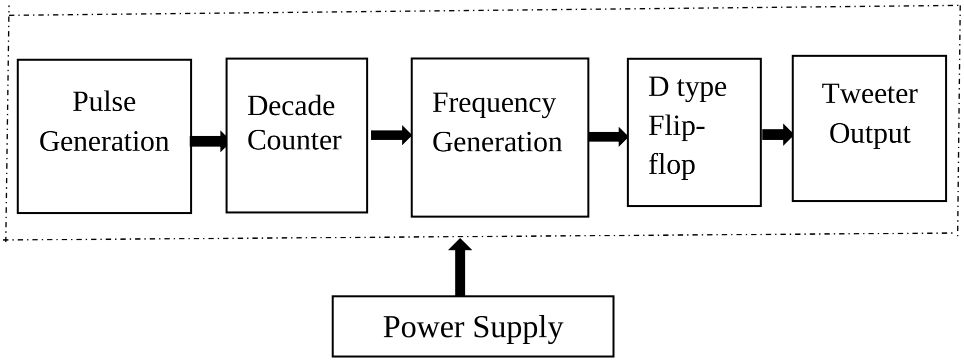

Figure 1. Block diagram of the electronic pests repeller circuit

Ultrasound

Sound generated above the human hearing range (typically 20 kHz) is called ultrasound. Although ultrasound behaves in a similar manner to audible sound, it has a much shorter wavelength. Ultrasound is an oscillating sound pressure wave with a frequency greater than the upper limit of the human hearing range. Ultrasound is thus not separated from 'normal' (audible) sound based on difference in physical properties, only the fact that humans cannot hear it. Although this limit varies from person to person, it is approximately 20 kHz (20000 Hz) in healthy, young adults. Ultrasound devices operate with frequencies from 20 kHz up to several gigahertzes. Ultrasonic vibrations travel in the form of a wave, similar to the way light travels. However, unlike light waves, which can travel in a vacuum (empty space), ultrasound requires an elastic medium such as a liquid or a solid.

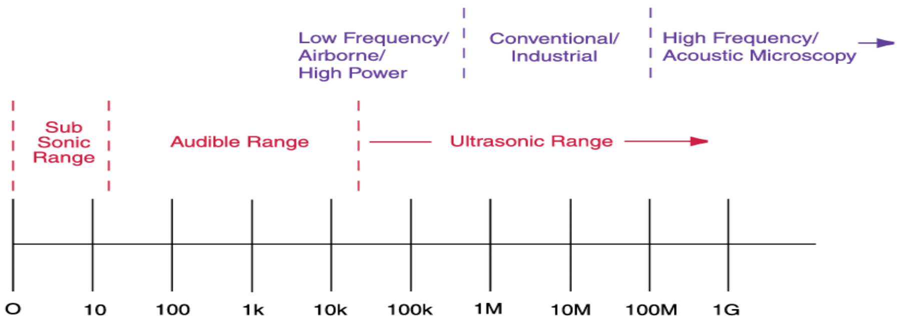

Figure 2. The acoustic spectrum breaks down sound into 3 ranges of frequencies

Decade Counter CD 4017 IC

The IC CD 4017 is used for counting applications, it has the capability to turn on 10 outputs sequentially in a pre-defined time and reset the count or hold it when required. It also has the capability to indicate the status of counting using Carry pin. This is commonly used for LED chaser and other logical output projects. It is a sequential decoded counting IC that can count up to 10. The timing diagram of the CD 4017 shows the counting sequence of the outputs, shifting from one pin to its next. Before applying the clock signal, the RESET is set to High, so the reset pin input sets all the output to their initial state. Then the output of the first output pin 3 will be high. Next this output is shifted to its next output pin and this sequence continues till the next clock cycle. The pin connections of the 4017 IC are shown in Figure 3.

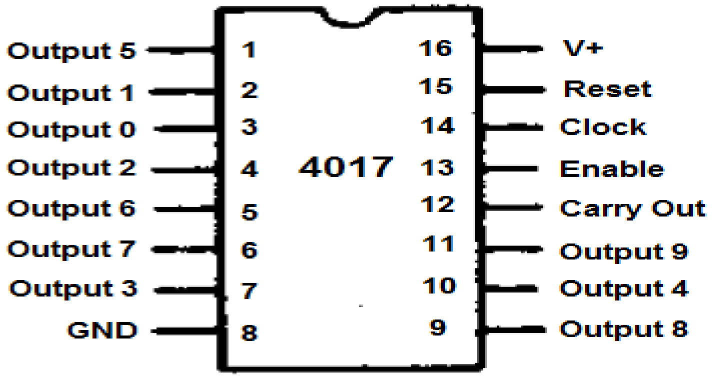

Figure 3. Pin connections for the 4017 IC

Astable Multivibrator

External connection of 555timer in the astable mode is shown in Figure 4. It will trigger itself and free run as a multivibrator. The external capacitor charges through R_1 and R_2, discharges through R_2 only. Thus the duty cycle may be set precisely by the ratio of these two resistors.

In this mode of operation, the capacitor charges and discharges between 1/3 V_{cc} and 2/3 V_{cc}. As the triggered mode, the charge and discharge times and hence the frequency is independent of the supply voltage.

The charge time (output high) is given by:

$$t_H = 0.693\,(R_1 + R_2)\,C_1$$

The discharge time (output low) is given by:

$$t_L = 0.693\,(R_2)\,C_1$$

Thus the total period T is given by:

$$T = t_H + t_L = 0.693\,(R_1 + 2R_2)\,C_1$$

and the frequency of the oscillation is then:

$$f = \frac{1}{T} = \frac{1.44}{(R_1 + 2R_2)C_1}$$

The duty cycle is given by : $D = \frac{(R_2)}{(R_1 + 2R_2)}$

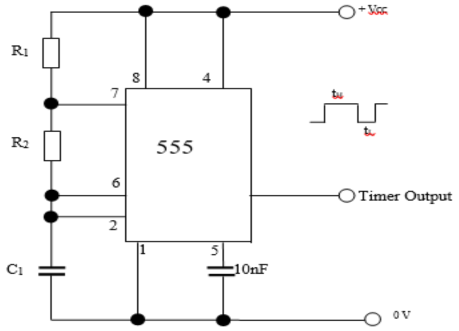

Figure 4. External connection of the 555 timer in the astable mode

Dual D-Type Flip-Flop CD 4013B CMOS IC

The CD4013B device consists of two identical, independent data-type flip-flops. Each flip-flop has independent data, set, reset, and clock inputs and Q and $\overline{Q}$ outputs. These devices can be used for shift register applications, and, by connecting $\overline{Q}$ output to the data input, for counter and toggle applications. The logic level present at the D input is transferred to the Q output during the positive-going transition of the clock pulse. Setting or resetting is independent of the clock and is accomplished by a high level on the set or reset line, respectively.

The CD 4013 can be used as a frequency divider in which the output is half the input frequency. It can also be used in TOGGLE MODE (this is exactly the same as a frequency divider) where the output toggles ON then OFF after each clock (input pulse). Figure 5 shows the pin connections of CD 4013 IC.

Piezoelectric tweeters

A tweeter or treble speaker is a special type of loudspeaker (usually dome or horn-type) that is designed to produce high audio frequencies, typically from around 2,000 Hz to 20,000 Hz (generally considered to be the upper limit of human hearing). A tweeter is a type of electromechanical loudspeaker that produces sound and music in the upper (higher frequency) music range. They compliment woofers and other speakers that can’t produce higher-pitched sounds.

Tweeters are typically small in size as they produce smaller-wavelength audio and have a small cone. Generally speaking, they’re best used when pointed toward the listener. The typical tweeter design (although various other types exist) consists of a small magnet with a circular gap inside of it. A wound copper wire voice coil, called a voice coil, is attached to a speaker dome made one of many different materials.

A piezo (or piezo-electric) tweeter contains a piezoelectric crystal coupled to a mechanical diaphragm. An audio signal is applied to the crystal, which responds by flexing in proportion to the voltage applied across the crystal's surfaces, thus converting electrical energy into mechanical. Figure 6 shows piezoelectric tweeters.

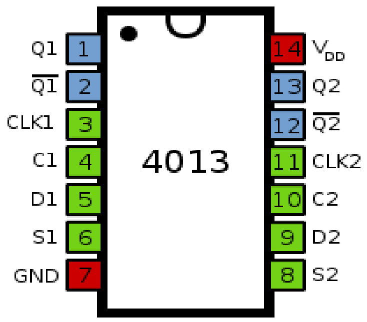

Figure 5. Pin connections for the 4013

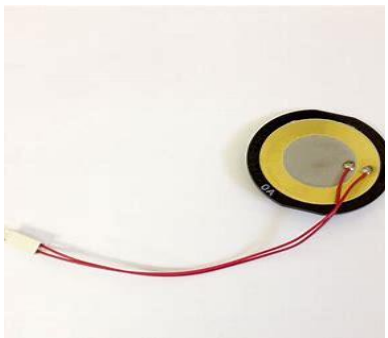

Figure 6. piezoelectric tweeters

Operational Amplifier CA 3130 IC Circuit

CA3130A and CA3130 are op amps that combine the advantage of both CMOS and bipolar transistors. Gate-protected P-Channel MOSFET (PMOS) transistors are used in the input circuit to provide very-high-input impedance, very-low-input current, and exceptional speed performance. The use of PMOS transistors in the input stage results in common-mode input-voltage capability down to 0.5V below the negative-supply terminal, an important attribute in single-supply applications.

Because the CA3130 is very useful in single-supply applications, it is pertinent to review some considerations relating to power-supply current consumption under both single- and dual-supply service. The operational amplifier CA 3130 IC circuit is shown in Figure 7.

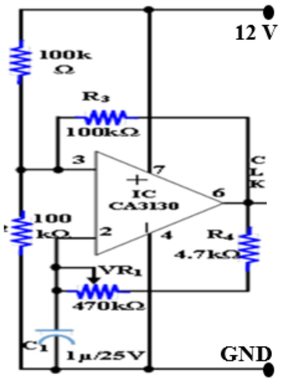

Figure 7. Operational amplifier CA 3130 IC circuit

Circuit Operation

When the circuit was powered by a 12 V power supply, an electric signal was generated from 3130 IC. This signal was used as a clock input of a decade counter. For each clock pulse output from 3130 IC, logic 1 output of the decade counter shifts from Q_0 to Q_4. Five preset variable resistors VR2 – VR6 (each connected at Q_0 to Q_4 output pins) are set at different values. The VR1 was used to change the clock pulse rate.

The frequency generator consists of a 555 timer and a dual D flip flop. The voltages from the five outputs of the decade counter are connected through D1-D5 and VR2-VR6 respectively to generate five frequencies. The frequency outputs of this 555 timer is not symmetrical but is fed to a dual D flip flop which delivers symmetrical signals at its outputs.

Push-Pull type amplifier was used to magnify the output signal from the dual flip flop. Complementary transistors (NPN and PNP) were used to obtain a full cycle output across a load using half cycles of operation from each transistor. A single input was applied to the base of both transistors.

The transistor, being of opposite types, conduct on opposite half cycles of the input. The NPN transistor was biased into conduction by the positive half cycle of the signal, with the resulting positive half cycle across the load. During the negative half cycle of the signal the PNP transistor was equally biased into conduction giving also a negative output. During a complete cycle of the input, a complete cycle of the output signal was developed across the load. The symmetrical outputs from the dual D flip flop are amplified in push-pull mode by transistors T1- T4 to drive the high frequency piezo tweeters. Thus the required frequency was produced by the piezo tweeter. Complete circuit diagram of the electronic pests repeller circuit is shown in Figure 8.

Table 1. Hearing frequency ranges for various pests

Pests Name	Minimum Frequency (Hz)	Maximum Frequency (kHz)
Grasshopper	95	50
Fly	20	55
Mouse	100	91
Rat	20	76

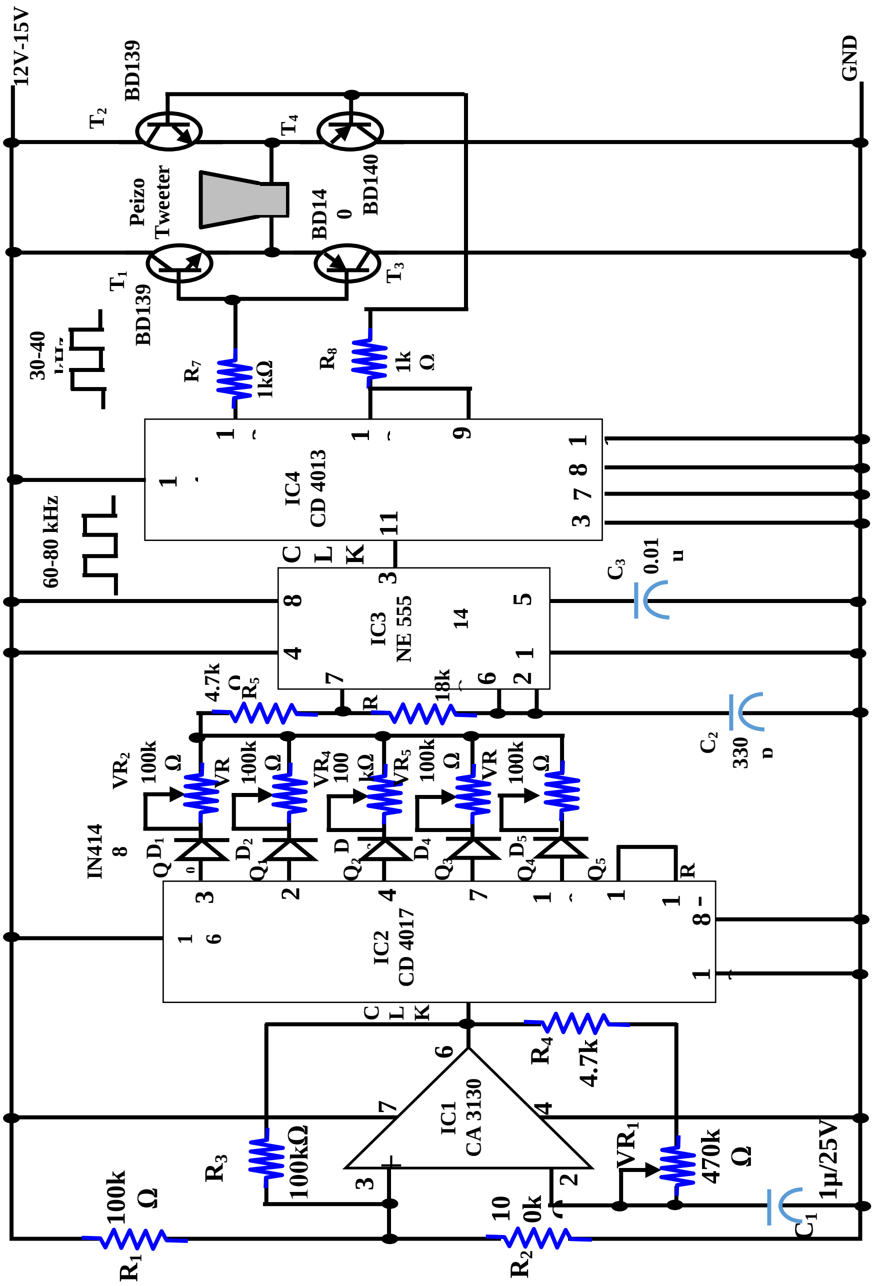

Figure 8. Complete circuit diagram of the electronic pests repeller circuit

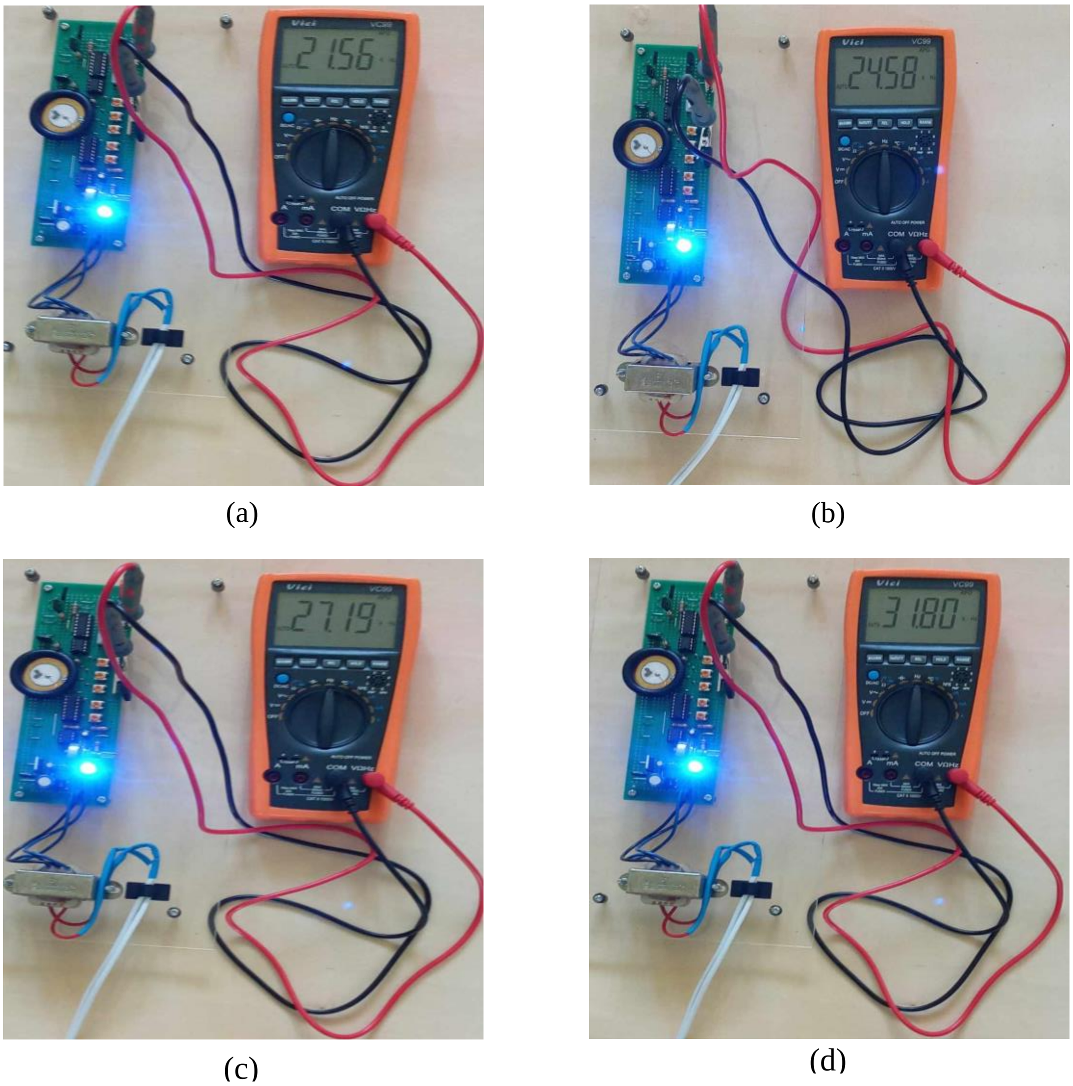

Figure 9. Photograph of the electronic pests repeller circuit for frequency (a) 21.56 kHz, (b) 24.58 kHz, (c) 27.19 kHz, (d) 31.80 kHz

Discussion and Conclusion

Ultrasound is inaudible to people and non-rodent pests. It is ideal for environments were the use of poisons is inadvisable or prohibited. So, the electronics pests repeller circuit was constructed. When the circuit was powered, an electric signal was generated and this signal generated was converted to ultrasound by the piezo tweeter. The performance of the device could be greatly improved with little modifications, for instance, using microcontrollers and ultrasonic sensors to transmit the sound in a special band of frequency. The device can be utilized by both small and large scale farmers for the purpose of repelling pests.

The electronic pest repeller circuit is constructed to repel pests. The actual (measured) minimum and maximum frequencies are respectively 32 kHz and 80 kHz against the designed frequencies 31 kHz and 105 kHz. The output frequency test revealed that there is variation between the designed frequency and the actual frequencies. This is due to the variation between the actual values of components used and the theoretical values. The theoretical values of components were used for the designed calculation. Comparing efficiency based on minimum frequency with that based on maximum frequency as computed above, it can be deduced that the device is more efficient in generating lower frequencies in the selected frequency range than the higher frequencies. This implies therefore, that the device is more effective in repelling pest that respond to sounds of the lower frequencies range. Mice can hear ultrasonic sound frequencies between 1 kHz and 70 kHz. Grasshopper can hear between 95 Hz to 50 kHz etc. Therefore, this electronic pest repeller circuit is available for pests to repel.

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