Design And Construction Of High-Frequency Multitone Police Security Siren For Students of Technology And Electrical Engineering Practical Experience

De. K. R. E. Okoye * P.E.Elemuwa †

Abstract

This research project is based on signal processing using common laboratory electronic chips. The generated signals were caused to pass through appropriate electronic circuit compartments to obtain the desired signal waves that produced siren effects. Two unique design methods were tried with success. The first employed the use of transistors and resistors with appropriate capacitor values for their timing constants and presented in astable multivibrator circuit. The second involved the configuration of astable multivibrator into 555IC timer circuit which produced the same effects with improved frequency. The designs deviate from the customary in the sense that they could be used in both survey and practical course. Hence, the project satisfies the increasing students' curiosity in electronics which creates such awareness that the primary forces impelling social and cultural changes are largely the result of technological innovation.

Keywords

System clocking, Duty cycle, Synchronization, Sampling method, Audio digital mixing.

1 Introduction

The growing rate of crime, disorderliness and emergencies in our society today demands that extra care should be taken to check the excesses. One of the ways to check these excesses is to introduce a special control-order that informs and alerts the public utilizing an identifiable but unique security engineering feat that should be associated with the police. Success in this feat involves electronics circuit configuration in form of high frequency multitone security siren designed to assist the police perform their duties creditably.

Multitone security siren provides an emergency but eclectic alarm; which differentiates police multi-alarm from other security services tones in the society. It is one of the designs borne to boost in no small measure the numerous activities of human endeavor in electronics engineering. It is believed that the society is growing wide and complex. Therefore, if sanity should be maintained, greater consciousness directed towards human-kind welfare and security should be emphasized.

On the other note, the growing emphasis on engineering and technology has come to lime light judging from students' enrolment population in the fields and the consumers' usage of engineering and technological products. Hence, to satisfy such curiosity, it becomes pertinent that a project in this capacity which may tend to inform the learner on the basic practices guiding some of the electrical/electronic circuit operations should be thought of.

Moreover, the man's ability to secure himself from danger or problem is as old as history. Human-kind has dug trenches around their living homes to ensure security. String has also been tied around a protected item through a bell such that if the string is mistakenly touched, the bell would ring thereby provoking the owner's attention. But in most cases, these systems of providing security did not ensure adequate security since such designs could be averted by an intruder. Hence, this security system design is, therefore, needed.

The electronic sirens do not have motional parts. This is why it is more advantageous than other forms of security siren, since it is less prone to tears and wears when compared with the electromechanical and mechanical kinds of siren. The electronic siren system utilizes less amount of current from the power source. It also has an added advantage that different or multi-tone could be produced using a single circuit.

In this design, it is built in semblance of the kind used by the police security force that has tones of different pitches capable of being triggered or switched into operation by AC or DC source.

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2 Design Specifications

2.1 Operational And Computational Specifics

This design adopted a stable multi-vibrator principles of operation. There are three kinds of multi-vibrator including the bi stable and mono stable. The bi and mono stables could only get into action when triggered. In the case of a stable type, it is capable of getting into operation repetitively without input signal. It is also called free running and can produce output without input. Thus, it assumes the nature of an oscillator. The circuit diagram of an a stable multi-vibrator as designed for this work is shown in 1.

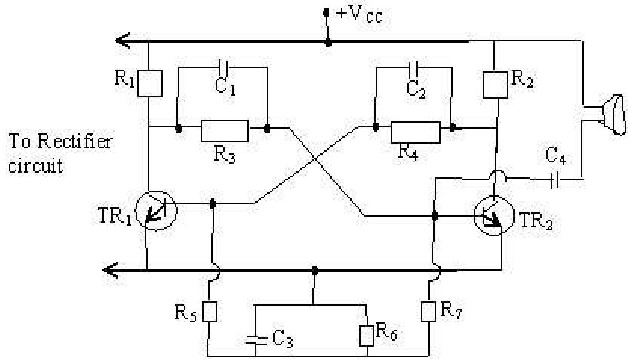

Figure 1: Astable multi-vibrator producing multitone siren effect.

It is a two stage RC with the output of one stage connected to the input of next stage. The feedback factor is unity (β=1) and positive because of 180^0 phase shift in each stage. As a result the circuit oscillates.

When the device is in action, the two transistors are driven into either action or cutoff value alternately. That is, when TR_2 conducts, TR_1 is driven into cut-off value and vice versa. This is as a result of the 180^0phase shift between the two stages. The C_1 charges through R_1 up to 2/3 of the supply voltage positive $+V_{cc}$ when TR_1 is in cut-off value. Also C_2 is charged through R_2 up to 2/3 of the collector potential $+V_{cc}$. The time taken for signal transition depends on the resistor-capacitor time constant.

Mathematically;

Since C_1 and C_2 charge up to 2/3 of the collector potential $+V_{cc}$,

Utilizing this result, analysis of the 555 a stable multi-vibrator as used in this design is presented. See figure 2.

From figure 2,

$$T\omega = 0.693\ (R_a + R_b)\ C\ for\ charging\ capacitor. \quad (1)$$

When the power supply is switched on, the timing capacitor C charges to $2/3V_{cc}$ through R_a and R_b. Intermittently,

$VC_1 = VC_2 = +V_{cc}$

But $V_{cc} = V_{cc}\left[1-(1+\beta)e^{\frac{-t}{RC}}\right]$

$VC_1 = VC_2 = V = V_{cc}\left[1-(1+\beta)e^{\frac{-t}{RC}}\right]$

Hence, 2/3 $V_{cc} = V_{cc}\left[1-(1+\beta)e^{\frac{-t}{RC}}\right]$

$2/3 = \left[1-(2/3)e^{\frac{-t}{RC}}\right]$

$2/3 = 1-2/3e^{\frac{-t}{RC}}$	$1-2/3 = 2/3e^{\frac{-t}{RC}}$
$\frac{1}{3} = 2/3e^{\frac{-t}{RC}}$	$\frac{1}{3} \times 3/2 = e^{\frac{-t}{RC}}$
$e^{\frac{-t}{RC}} = \frac{1}{2}$	$\text{In } e^{\frac{-t}{RC}} = \text{In } 0.5$
$\frac{-t}{RC} = -0.693$	$-t = -0.693RC$
$t = 0.693RC$	

where t = the pulse width or interval (tω)

$R = R_1 = R_2$

$C = C_1 = C_2$

$t\omega = 0.693RC$

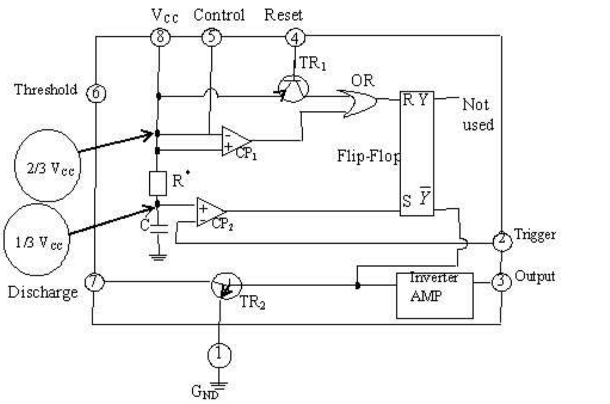

Figure 2: 555 Timer Configured into astable multi-vibrator.

Key	
4- Reset	*Connect to V_{cc} when not used. This action will turn TR_1 off so that it does not conduct.*
5-Control	Ground when not used through 0.1 μF (Capacitor rating) R^* = *series combination of*

R_a and R_b.

the capacitor charges and discharges between $2/3V_{cc}$ and $1/3V_{cc}$ respectively.

Total period (T) for charging and discharging could then be found as follows;

$T = tw_1 + tw_2 = 0.693\ (R_a + R_b)\ C + 0.693\ R_bC = 0.693\ (R_a + 2R_b)C$

$$f = \frac{1}{0.693(R_a + 2R_b)C} \quad (2)$$

Time for charging period is expressed as;

$$tw_1 = (R_a + R_b)C \ In \left[\frac{V_{cc}-2/3V_{cc}}{V_{cc}-1/3V_{cc}} \right]$$
$$= (R_a + R_b)C \ In \left[\frac{1-2/3}{1-2/3} \right] \frac{V_{cc}}{V_{cc}}$$
$$= (R_a + R_b)C \ In \left(\frac{1/3}{2/3} \right)$$
$$= (R_a + R_b)C \ In \ 1/2$$
$$= (R_a + R_b)C \ In \ 0.5$$
$$tw_1 = 0.693(R_a + R_b)C$$

Discharging,the capacitor discharges through R_b.

$$tw_2 = R_bC \ In \left[\frac{1-2/3}{1-1/3} \right] \frac{V_{cc}}{V_{cc}}$$
$$= R_bC \ In \left(\frac{1-2/3}{1-1/3} \right)$$
$$= R_bC \ In \left(\frac{1/3}{2/3} \right)$$
$$= R_bC \ In \ 1/2$$
$$= 0.693 \ R_bC$$

Where f = *Load or output frequency of the siren*

$$Dutycycle(D) = \frac{Time\ for\ charging\ Capacitor}{Total\ time\ for\ charging\ and\ Discharging} \quad (3)$$

$$= \frac{tw_1}{T} = \frac{0.693(R_a+R_b)C}{0.693(R_a+2R_b)C}$$

$$= \frac{R_a+R_b}{R_a+2R_b}$$

Utilizing unequal values of R_a and R_b resistors or by changing the coupling capacitor C values, a symmetrical square waveform is generated. This action will give rise to siren effect resulting in multitone siren. It is based on this principle that this multitone siren is designed. This was possible because by charging and discharging of the various capacitor values through the resistor components many frequency levels are produced.

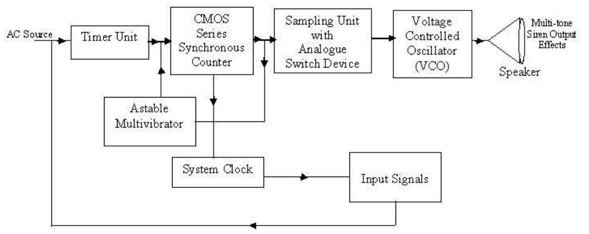

Figure 3: Simplified Block Diagram for Multi-tone Electronic Security Siren

3 Signal Generation Unit

3.1 System Clocking

In this design, the system clocking was used to generate the fundamental frequency (the square wave). It is typical of the dual 555 timer configured into a stable multi-vibrator circuit shown in figure 2.

Clocks are usually utilized to control the time lapses at which changes occur in digital circuits. Among the electronic devices that can be used as clocks are the multivibrators, timers, oscillators and frequency dividers. The best way to achieve effective system clocking is to arrange it in series-carry synchronous counter. In this design therefore, the clocking is sourced from single phase (series-carry) dual timer. From the voltage controlled oscillator (VCO), several signals were selected at the output. To effectively join these signals avoiding any noticeable lapse between one signal and the other, the issue of synchronization was treated. In this design the problem of synchronization was solved using the series-carry synchronous counter which provided frequency division as shown in figure 4. The seemingly block diagram of this design pattern of system clocking is shown in figure 5.

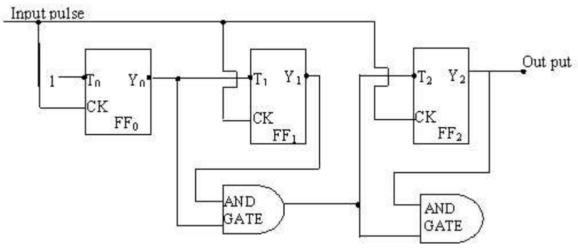

Figure 4: Series-carry synchronous counter for 3 bit ripple counter.

3.2 Audio Digital Mixing

The audio digital mixer is the section of a given circuit where the signals are mixed while filtering off the low frequency signals obtained from the system clocking. During the processes of mixing and modulation, the low pass signals are usually translated to a new center frequency. This is achieved by multiplying the band pass signal by a periodic signal. This process by which the low pass signals are translated to center frequencies after modulation is referred to as audio digital mixing.

The technique adopted in this design is similar to *sampling method.* The sampling method was achieved with analogue switch 4066. This arrangement permitted that the output from the frequency division unit was used to sample the phase clocking device 4049 as shown in figure 5. For effective filtering off of the low frequency signals, the method utilized in this design is the alternate sampling technique of

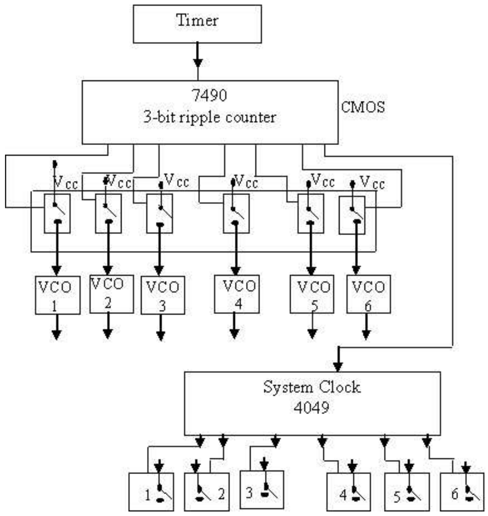

Figure 5: System clocking of the multitione siren

the several siren signals at the output of the counter. To alternate the sampling periods, that is why the system clocking is used. The filters employed are the high pass filters. The coupling capacitor C_4 (figure 1) that couples the signals to the load terminals (speaker) was valued at 100 μF whereas the load resistor R_7 was valued at 30 Ω. Hence to realize the cut-off frequency, the upper point frequency f_H was determined using the expression.

$$F_H = \frac{1}{2\pi f_0 C_4 R_L} \quad (4)$$

Where f_0 *= the fundamental frequency*

Substituting the values in the expression; f_H = 53 Hz Thus the filter rejects all signals from 0 to 53 HZ. This value agrees with the project objective which is expected to produce high frequency multitone siren.

3.3 Audio Amplification

The output voltage of siren effects is most often in mill volt. To boost the signal strength to a reasonable audio level, an audio amplifier was used. The audio levels at the output are usually measured in decibel and hence the LM 380 IC circuit audio amplifier was employed for this design.

4 Summary

The field of electronics is as challenging as it is interesting. With due regards to economic value, the authors tried to construct the project using the commonly available and simple electronic components. Though the project has been accomplished efficiently, there are certain features that could be incorporated to make for more versatile system.

5 Conclusion and Recommendations

5.1 Conclusion

This project was meant to be an improvement on already existing siren system by employing transistorized circuit regulated from resistors and capacitors using multivibrator circuit format. The paper combines both digital and analogue electronics but mainly focused on design aspect. It is satisfying to note that it has also been tested and found to be successful. Hence, staff and students of educational Technology and electrical engineering department could acquire good knowledge from this paper.

5.2 Recommendations

In this design, multiplexing and display units are not incorporated. The use of multiplexing and display units will make a number of units in the system to be monitored. Therefore, a unit could be packaged in the system, so that, when siren signals are produced, the display will indicate which area the siren comes from.

A further improvement could also be made on the design system whereby the zonal police office is alerted to needed emergency assistance using coded police number in case the siren is installed for residential use.

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