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Design and construction of security alarm system for a computer laboratory

R.C. Okoro[1]

ABSTRACT

In the present day Information and Communication Technology (ICT) everybody tries to be ICT compliance and this has led to many people entering a laboratory at particular instance. Therefore there is need for the movement of people in and out of the laboratory to be checked because fraudulent individuals can capitalize on this to perpetrate evil. In this work a security alarm was designed and constructed to monitor the movement of people in and out of the laboratory. It was discovered that with proper calculation of components like the resistor values R_1 and R_2 which were found to be 3.9kΩ and 10kΩ respectively, capacitors C_1 and C_2 as 10µF and 100nF respectively, a good security alarm can be constructed choosing particular frequencies. In this research 6Hz for IC_1 and 600Hz for IC_2 respectively were chosen for audibility. This can be used in checking the movement of people in and out of the laboratory.

INTRODUCTION

When security alarms are mentioned, it is not unreasonable to think of high techniques developed in the silicon age. For thousands of years man used animals, more notably dogs, to guard and alert him of any intruder or robber In the middle ages gongs were used to warn a community of impending danger or large bonfires lit to warn of imminent invasion.

As important as these development were, in 1852 the first electromechanical alarm system was invented by Edwin Holmes, an American inventor from Boston Massachusetts – www.ezinearticles.com (2008). These early alarm systems continued to make use of simple electrical circuits and relays. For typical installation, these made use of wire wound along windowsills and around doorframes coupled with conductive lead foil and mechanical or magnetic switches laced with thin wires.

From mid 1960s to early 1970s, the security alarm system experienced a revolution caused by the advent of integrated circuits (IC). Transistors and other electronics components were combined and embedded into a single chip, thus the name integrated circuit. With such circuits, security alarm system became smaller, more sensitive and reliable. During this time, NE555 timer IC was invented by Hans R. Camenzind in 1970 and introduced for use in 1971 by Signatics and later acquired by Philips (Nkulo, 2006). The original name was NE555/SE555 and was called "The Time Machine".

NE555 timer found application in the construction of security alarm systems and inverters. is widely used because of its ease of use, low price and good stability. It has 23-transitors, 16-resistors and 2-diodes embedded in a silicon chip installed in an 8-pin mini dual-in-line package (DIP).

Significant and objective of Study

In any organization, it is imperative to properly protect items, offices and staff. This ensures greater security and profit, in the computer laboratory, since both staff and students make use of it, there is good need to have an alarm system to restrict the movement of people. This will help in keeping away unauthorized people from entering the laboratory. Security alarm system therefore makes work easier for security staff and helps in protection and productivity of the security agents. The objective of this work is to effectively control movement and be able to detect the loss of items by knowing who used the laboratory last. Secondly to show that little efforts can be put into use to protect staff and properties.

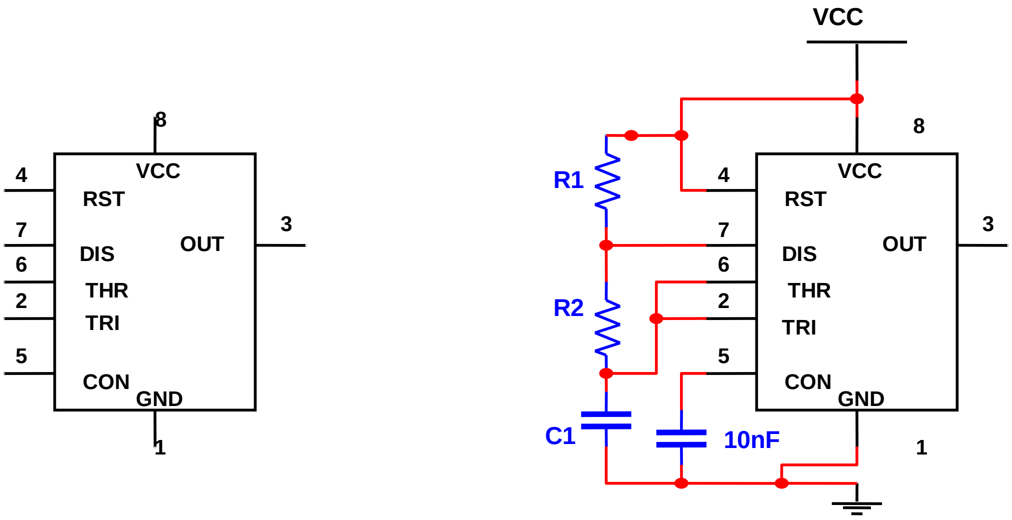
METHODOLOGY

Design and Calculations Involved

The values of the components used for this construction are calculated in this part of the work showing their tolerance values for effective use in the construction process.

NE555 is a timer IC that produces time delays or pulses. It is sometimes called an astable multivibrator, because it periodically switches between two stable states (Rizzoni, 2000). Typical NE555 timer is shown in figure 1(a).

[1] Electronics and Computer Technology Unit Department of Physics, University of Calabar, Nigeria.



(a)

(b)

Fig. 1. NE555 timer IC

Fig. 1(b) shows how the IC is connected externally in order to obtain the required waveform with a particular frequency. It is important to note that the frequency produced by the IC is mostly dependent on the two external resistors (R1 and R2) and one external capacitor C1. A stable multivibrator generates a square wave signal of fixed period and amplitude as shown in Fig. 2.

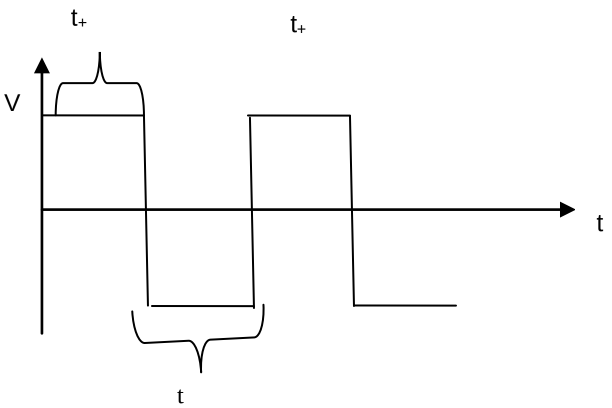


Fig. 2. Multivibrator output waveform

The positive pulse width can be calculated using the formula :

$$t_+ = 0.69\ (R_1 + R_2)\ C \qquad (1)$$

While the negative width can be calculated from the equation.

$$t_- = 0.69\ R_2C \qquad (2)$$

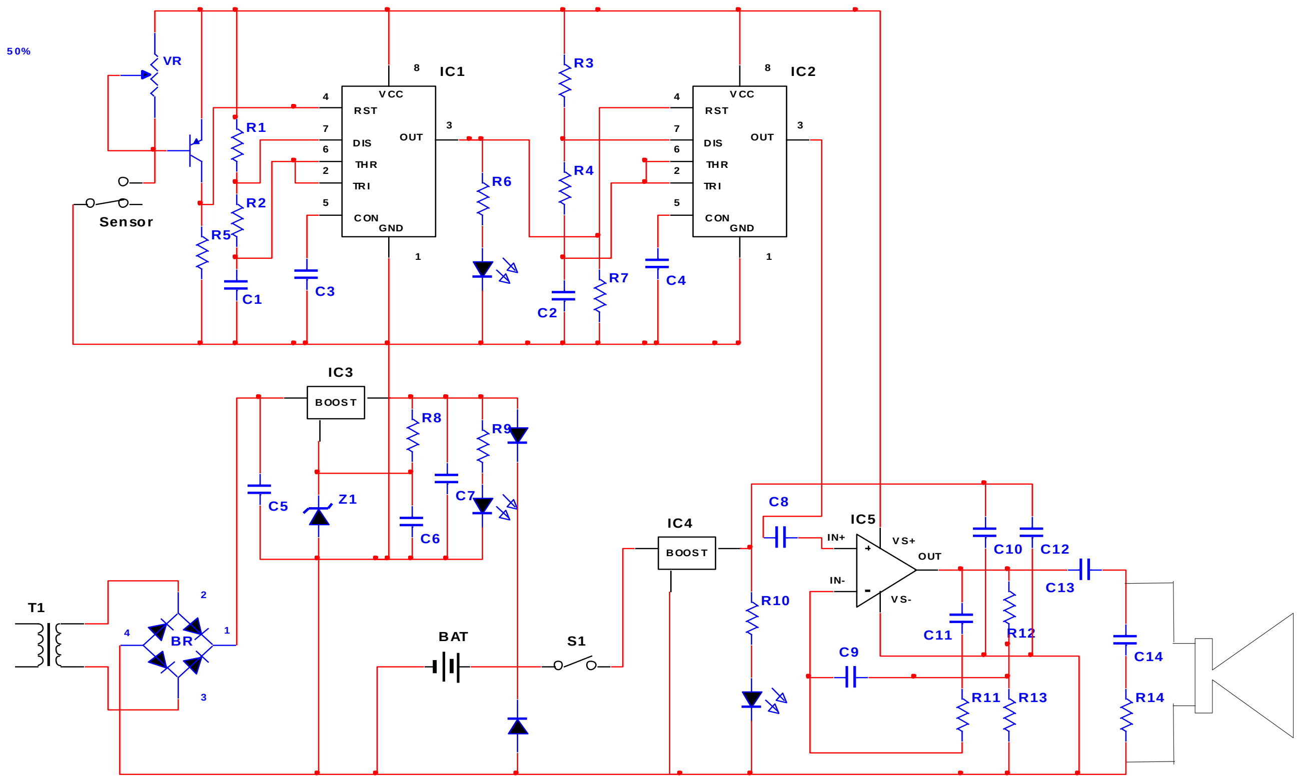


Fig. 3. Schematic circuit of simple security alarm system (Source: Introduction to Microelectronic Circuits, Gopalan, 1996)

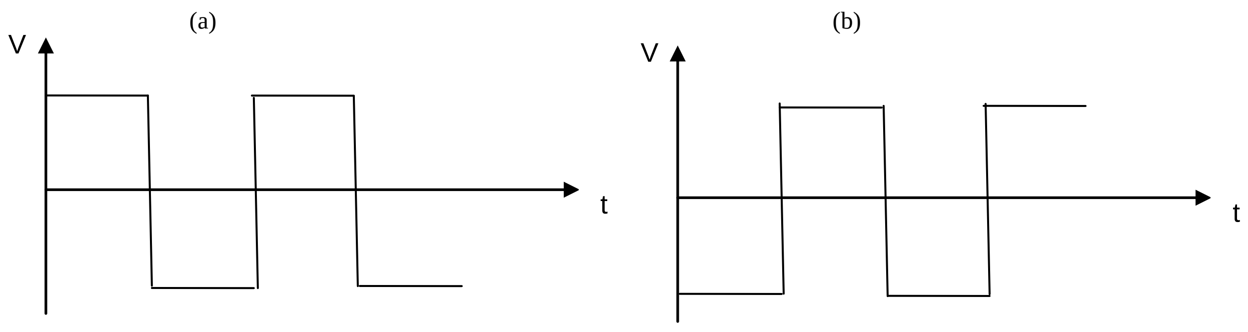


Fig. 4. Two versions of multivibrator output waveform

Period (T) = $t_- + t_+$ (3)

Putting equations 1 and 2 into equation 3, we have:

$T = 0.69\ R_2\ C_1 + 0.69\ (R_1 + R_2)\ C$

$T = 0.69\ (R_1 + 2R_2)\ C$ (4)

Choice of Frequencies

In designing an alarm system with an oscillator like NE555 timer IC, there is need to know the purpose of the oscillator and therefore choose a frequency that suits that purpose. In this research, the system described by Gopalan (1996) was adopted, in which there are two NE555ICs (Fig. 3). This entails that two signals (waveforms) will be generated from the output (Fig. 4).

The purpose of the first NE555 timer IC is to generate a signal that is below audio frequency <20Hz, while the purpose of the second one is to generate a signal that is within the audio frequency range, 20Hz to 20 kHz

Once the value of the frequency has been chosen, the values for resistors and capacitors can then be calculated using the right formula and principle. Frequencies of 6Hz and 600Hz were chosen in this research for IC_1 and IC_2 respectively. These values are chosen so that the alarm system can produce a cut and join tone. There is no calculation involve in the value of frequency it is just a matter of choice of an individual. The choice must be based on the purpose or aim of the oscillator (but one must be below the audio frequency and the other one within the audio frequency) .

Choice of Resistors in the Alarm Unit

From equations 1 and 2, it is obvious that t_+ and t_- cannot equal each other unless $R_1 = 0$. If $R_2 \gg R_1$, the mark to space ratio becomes nearly one to one (i.e., $t_+ \approx t_-$) however, R1 and R2 can have values between 1kΩ and 1MΩ (Johnson, 1987). The value of R_2 should be at least twice the value of R_1. Hence for this research, let $R_2 = 2.5\ R_1$

When $R_1 = 3900\Omega = 3.9k\Omega$

$R_2 = 2.5 * 3900 = 9750\ \Omega \approx 10k\Omega$

Since the frequency of the oscillator is dependent on resistance and capacitance, the values of R_1 and R_2 are connected to IC_2 while changing the capacitance of C_2 to suit the frequency generated from IC_2. Therefore;

$R_1 = R_3 = 3.9k\Omega$

$R_2 = R_4 = 10k\Omega$

Note that the value of R_3 and R_4 could be changed, provided $R_4 \gg R_3$ and ensuring that their values fall within the range of 1KΩ to 1MΩ.

Choice of Capacitors in the Alarm Unit

Recall that, frequency of 6Hz was chosen for IC_1 ($f_1 = 6Hz$).

If $f_1 = 6Hz$

$T_1 = 1/f_1$

$T_1 = 1/6 = 0.167$ Sec = 167 mSec

Putting the values of T_1, R_1 and R_2 into equation 4 and solving for C_1, we have;

$0.167 = 0.69\ (3900 + 2*\ 10000)\ C_1$

$0.167 = 0.69\ (3900 + 20000)\ C_1$

$0.167 = 0.69\ (23900)\ C_1$; $0.167 = 16491\ C_1$

$C_1 = 0.167/16491$; $C_1 = 10*10^{-6}F = 10\mu F$

Similarly, IC_2 is designed to generate an audio frequency of about 600Hz.

If $f_2 = 600Hz$

$T_2 = 1/f_2$; $T_2 = 1/600$

$T_2 = 1.67*10^{-3}$ Sec = 1.67mSec

Putting the values of T_2, R_3 and R_4 into equation 4 and solve for C_2,

$1.67*10^{-3} = 0.69\ (3900+2*10000)\ C_2$

$1.67*10^{-3} = 0.69\ (3900+20000)\ C_2$; $1.67*10^{-3} = 0.69\ (23900)\ C_2$

$1.67*10^{-3} = 16491\ C_2$; $C_2 = 1.67*10^{-3}/16491$

$C_2 = 101*10^{-9}F \approx 100nF$

When a fixed-frequency astable is required, it is usual to connect the control input (pin-5 of NE555 timer IC) to ground through a 10nF capacitor (Johnson, 1987). Because of this reason, C_3 and C_4 are equal to 10nF. In summary,

$R_1 = R_3 = 3K9$, $R_2 = R_4 = 10k\Omega$

$C_1 = 10\mu F$, $C_2 = 100nF$, $C_3 = C_4 = 10nF$

Q_1 is a general purpose pnp transistor. It is used here as a current controlled switch and ensures that negative voltage is fed or driven to the reset pin (pin-4) of NE555 timer IC_1.

IC_5 is an audio power amplifier. It is used to amplify the audio signal that comes out from the output (pin-3) of the NE555 timer IC_2.In order to minimize noise and distortion at the output, a negative feedback is employed. The negative feedback equally provides the specified voltage gain and frequency response of the amplifier (Crecraft, et al 1993).

Construction

After carrying out the necessary calculations and applying the appropriate principles to ensure that the circuit has been perfectly designed, the next step is the construction process. This process involves connections on an electronic board (shown in figure 5) of the components which have been calculated above. After mounting the components, care was taken in soldering the components onto the board because if not properly done could cause loss of signal.

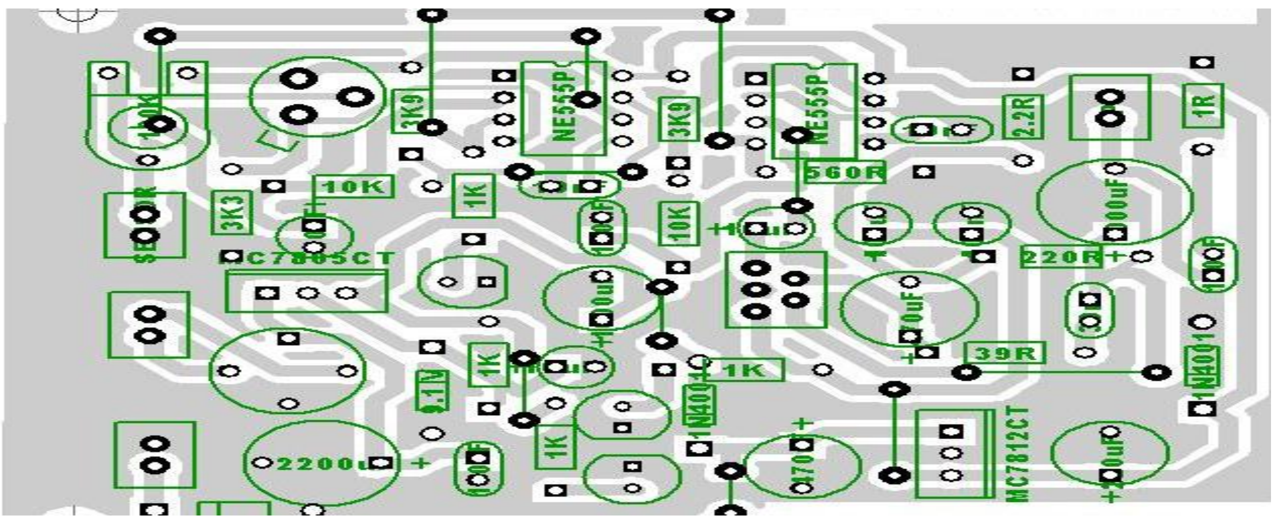


Fig. 5. Electronic board layout of the alarm system

To power this system, a 12-volts power is designed to take care of the power needs of the system. This power circuit is based on 3-terminal power regulators (IC1 and IC2) which provide the required 5-Volts and 12-Volts rails respectively. Power is derived initially from a standard 15-Volts transformer T1 rated 2-Amps. This is fed to a bridge rectifier BR1, the output of which is then filtered using 2200µF capacitor C1 and fed to IC1 (MC7805CT power regulator). Due to the combined effect of the zener diode Z1 and IC1, the voltage comes out to be 14.1-Volts which drop to 13.5-Volts when passed through diode D1. The 13.5-Volts is then use to charge the 12-Volts battery BAT1 at a current of about 20mA. The 12-Volts rail from IC2 (MC7812CT) is used to power the alarm system.

Table 1 lists the specifications of the components of the alarm system as determined by the study.

Operation

After construction, a few tests were carried out to ascertain the functionality of the component parts of the alarm before mounting it for use. The alarm is now fixed at the door post of the laboratory with good ventilation which makes it possible for the security personnel to monitor the in and out of people into the laboratory. The speaker is placed in a central region (externally) where security staff can hear the sound once the alarm system is activated. At the end of this the power cord is connected to the mains and the button turned on for activation.

RESULTS AND DISCUSSION

Values of the resistors and capacitors were calculated in the design process to be 3.9kΩ while the capacitor value is 10nF which conforms to the required frequency of operation of the alarm which operated at 1.67mSec. From the fore-going, the security alarm is designed and constructed for use in a computer laboratory. In doing this, it was discovered that precise calculations can be made to getting a correct component value for proper output from the alarm. This was done and tested to be good for movement restriction in not only the laboratory anywhere restriction is needed.

CONCLUSION

The security of life and properties is a very important issue and there is need to take proper care of this hence the need for this work. It has been shown how the components can be calculated for the designing of security alarm system. In the computer laboratory where movement of both staff and students are very common there is need to monitor the entry into this room. This will help in making sure that only authorized persons are allowed into the laboratory at a given time. This is achieved by using NE555timer IC in the construction of the circuit.

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Table.1. Specifications of the components used in the design and construction of the security alarm;

Components	**Values/Data**
Power unit	
T1	15V,2A
BR1	100V,2A
C5	2200µF
C6	10µF

C7	100µF
IC3	5V,1A
IC4	12V,1A
R8	1kΩ
R9, R10	2.2kΩ
Z1	9V1
LED2	Green colour
LED3	Red colour
DI, D2	100V,2A
BAT1	12V
SW1	Single pole-single throw
Amplifier unit	
C8	470µF
C9	100µF
C10	100nF
C11	1nF
12	39nF
C13	100nF
R11	220Ω
R12	39Ω
R13	2.2Ω
R14	1Ω
IC5	10W,8Ω
SPK1	3W,4Ω
Alarm unit	
R1, R3	3.9kΩ
R2, R4	10kΩ
R5	3.3kΩ
R6	1kΩ
VR1	100kΩ
IC1, IC2	NE555
Q1	PNP
C1	10Mf
C2	100nF
C3, C4	10nF
LED1	Yellow colour
Sensor	Single pole-double throw