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Design and Implementation of a Sound Activated Alarm System

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Abstract- Abstract – This paper presents the design and implementation of a Sound Activated Intruder Alarm System (SAIAS). It describes the automatic operation of an alarm by converting the energy generated by a "sound" into electrical pulses used to drive electronic circuitries which switch ON/OFF an alarm. The SAIAS can be described as a low frequency sound-/pulse-activated switch that is free from false triggering. The input transducer is a condenser microphone of high sensitivity that receives the sound and converts it to electric signal. This signal is amplified and used to drive integrated circuits components which changes output state to energize and de-energize a switch or relay causing the device to be able to switch the alarm circuit. The system was implemented and tested accordingly using sound sources like hand claps, door bang, drop of metallic object within 3 metres from the system location. In order to mitigate interference due to vibration effect of the device casing, the microphone surface was padded to prevent it from making direct contact with the casing so as to avoid mechanical vibration being transmitted to the microphone through the casing of the device.

Keywords: Decade-Counter, False-Triggering, Multi-vibrator, Relay, Sound.

1. Introduction

Generally, an intruder alarm system is an electronic system that notifies someone (probably a security officer) of the presence of an unauthorized person at a particular place. This can be either a visual alarm or an audio alarm system (Oshevire and Oladimeji, 2014). Sound being a form of energy, can be converted into another form employing different transducer, the energy of which can be utilized to operate, activate or drive another system – be it electronic, electrical or mechanical. In the SAIAS, sound energy is utilized to activate an alarm system within a set time period that is determined by a time constant component value in the circuit making up the system.

The SAIAS can be described as a low frequency sound pulse activated switch. The input component is a transducer that receives sound as input and converts it to electrical pulses (Barkat *etal*. 2015). The applications of sound activation technology are numerous, these include control of alarm, electronic tools and toys, high-end security system etc (Hashmoto, 1991). The dangers associated with intruders or unauthorized persons entering a house or a premises can be minimized or totally eliminated by the utilization of sound technology.

Sound technology has been in development for more than 25 years resulting in varieties of hardware and software tools for personal computers. In a typical application, a voice-activation circuit board and compatible software are inserted into a computer. These add-on programs which operate continuously in the background of the computer's operating system are designed to accept spoken commands or convert the words into text. The disadvantage in using this approach to control individual and electronics in a building are expensive, complicated and require custom installation (Matulich and Ligi, 2001)

In telecommunication engineering, a sound-activated switch is a switch that operates when a sound over a certain threshold is detected (Sinclair and Webser, 1995). Systems adapted for the protection of property including devices which may be activated at one location to provide a signal on unauthorized entry to a premises or displacement of an article within the premises at another location are known to the prior art.

These systems suffer from certain disadvantages such as the requirement of leads which communicate from a power source to the location of the device which shall signal the unauthorized entry or displacement, must carried out using connector leads whether or not the device is hidden from view, the connector leads most likely will be visible to intruders providing the opportunity to disable the system. The previous technology for sound activation alarm fails to provide a hand-free, economical, compact and easy to use device. Additionally, available designs do not offer solutions for inaccuracy due to false response, user frustration, and ambient noise interference (Barkat *etal*. 2015). These problems and deficiencies are clearly felt in the design and are solved by the present invention.

2. Methodology

The SAIAS comprises of a sound generator, a sound responsive switching circuit and an alarm. The sound generator is any element capable of snapping rapidly producing a sound of predetermined frequency. The switching circuit is a sound activated switch which is energized in response to a sound of a predetermined frequency. This creates an electrical signal that passes through the switching circuit to activate the alarm. Figure 1 shows a block diagram of the Sound Activated Intruder Alarm System.

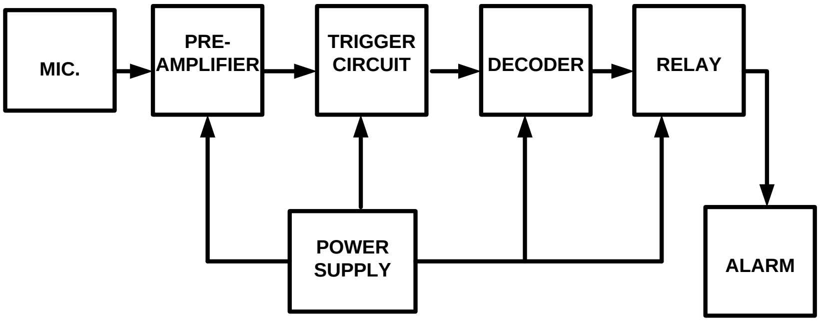


Figure 1: Block diagram of the SAIAS

The alarm is an audible one and the sound activated switch after a predetermined time may de-energize the audible alarm. This device was positioned at locations where the change in sound threshold frequency is to be sensed. The condition which is monitored may include entry into a building illegally, removal of an object from its normal position etc which results in the activation of the alarm. The system operates unattended and keeps the owner of the premises from a possible peril from an intruder and the sudden exposure of the presence of the intruder is intended to result in the intruder seeking escape from apprehension or in alerting the appropriate personnel.

2.1 *Microphone*

The microphone is a transducer that converts acoustic energy to electrical energy, basically electrical current. The generated current by the microphone is in form of electrical pulses (Hellyer, 1966). For the purpose of this design, an electric condenser microphone, having the following specifications was employed. Operating voltage: 1 -10V (V_{rated}) Rated current, I_{rated}: 2mA, Sensitivity: 44dB ± 3dB S/N ratio: 55dB The microphone biasing resistor R1,

$$R1 = \frac{V_S - V_{rated}}{I_{rated}} \tag{1}$$

Where V_S is the supply voltage for the device circuitry.

2.2 The pre-amplifier stage

A low-noise transistor was used for the audio signal amplifier in this design and this was wired in a common-emitter mode.

From the datasheet $V_{CE(sat)} = 0.3V$.

$I_{C(sat)} = V_{CE} – V_{CE(sat)}$ (2)

Where I_C =2mA

$$R_C + R_E = \frac{V_S - V_{CE(sat)}}{I_C} \quad (3)$$

For linear amplification and maximum power output, the operating point should lie around the mid-point of the load line. The quiescent point normally takes a value about half the supply voltage, hence the quiescent point is

$$V_{CE} = \frac{V_S}{2} \quad (4)$$

(Carpenter and Chama, 2000).

The voltage from emitter to ground V_E was arranged to be one-tenth of the supply voltage, V_S.

$$\therefore V_E = \frac{V_S}{10} \quad (5)$$

Emitter resistor, R_E

$$R_E = R_6 = \frac{V_E}{I_C} \quad (6)$$

The voltage across R_4 is

$$V_B = \frac{R_4}{R_3 + R_4} \times V_S . \quad (7)$$

$$V_B - I_B R_{TH} - V_{BE} - I_E R_E = 0 \quad (8)$$

But $I_E = (\beta + 1) I_B$ (9)

(Theraja and Theraja, 2002).

Equation (8) becomes

$$V_B - I_B R_{Th} - V_{BE} - (\beta + 1) I_B R_E = 0 \quad (10)$$

$$I_B = \frac{V_B - V_{BE}}{[R_{TH} + (\beta + 1) R_E]} \quad (11)$$

From equation (7)

$$V_B (R_3 + R_4) = R_4 V_S \quad (12)$$

$$\{V_B = V_E - V_{BE} = \frac{V_S}{10} - 0.7 = \frac{12}{10} - 0.7 = 0.5V\}$$

$$(V_E - V_{BE})(R_3 + R_4) = R_4 V_S \quad (13)$$

$$0.5(R_3 + R_4) = R_4 \times 9 \quad (14)$$

$$R_3 = 17 R_4 \quad (15)$$

For design purpose,

$$10 R_4 \le \beta R_E \quad (16)$$

$$R_4 \le \frac{\beta R_E}{10} \text{ or } R_4 \le \frac{\beta R_6}{10} \quad (17)$$

$$R_C + R_E = \frac{V_S - V_{CE}}{I_C} \tag{18}$$

$$R_C = R_5 = \frac{V_S - V_{CE}}{I_C} - R_E \tag{19}$$

$$R_2 = \frac{V_S}{I_{rated}}$$

The designed pre-amplifier unit is as shown in figure 2

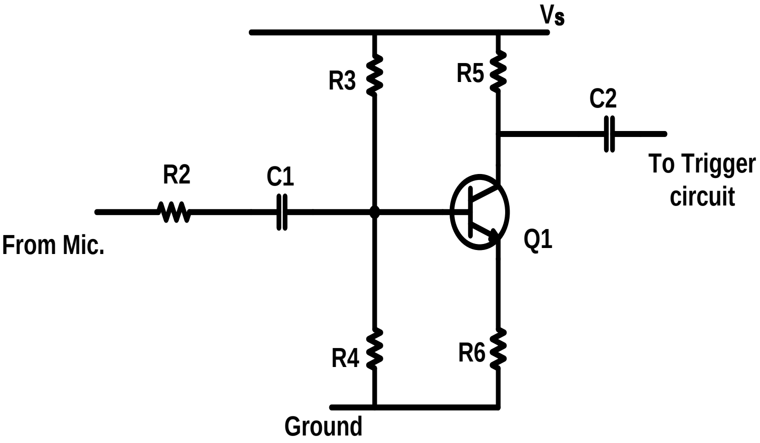


Figure 2: The pre-amplifier circuit diagram

2.3 The regulated power supply

The electronic integrated circuits employed in the design of the SAIAS require a constant and regulated power supply for reliable operations. The required voltage supply for these circuits' ranges from 5V to 15V and current supply from 50mA to 200mA (max), hence the design of a 12V 200mA dc regulated power supply. The power supply was designed carefully employing voltage transformation (step-down transformer), voltage rectification (bridge rectifier), voltage smoothing (capacitive filtering) and voltage regulation (IC voltage regulator).
Step-down transformer: 220V – 12V, 300mA

$$V_{peak} = V_{rms} \times \sqrt{2} \tag{20}$$

A fullwave bridge rectifier **3N258** was used to implement the voltage rectification stage. The average dc voltage after fullwave rectification, $V_{av(dc)}$

$$V_{av(dc)} = \frac{2V_{rms}}{\pi} \tag{21}$$

The ac component of the rectifier output voltage, V_{ac}

$$V_{ac} = \sqrt{\left(V_{rms}^2 - V_{av(dc)}^2\right)} \tag{22}$$

Obtaining the smoothing capacitor value,
Max load of the system,

$$R_L = \frac{V_{rms}}{I_L} \tag{23}$$

$$V_{dc} = \left(\frac{2fCR_L}{1 + 4fCR_L} \right) \tag{24}$$

$$C = \left(\frac{V_{dc}}{2fR_L - 4V_{dc}fR_L} \right) \tag{25}$$

Where;
f (ripple frequency) = 2 x frequency of ac supply (Hz)
C = capacitance of the smoothing capacitor (µF)
I_L = Total load current (Amp)
R_L = total load resistance of the system
V_{dc} = the resulting voltage from the smoothing capacitor
The voltage regulation stage employed voltage regulator IC LM7812 for regulated voltage output of +12V. Figure 3 shows the circuit diagram of the regulated power supply.

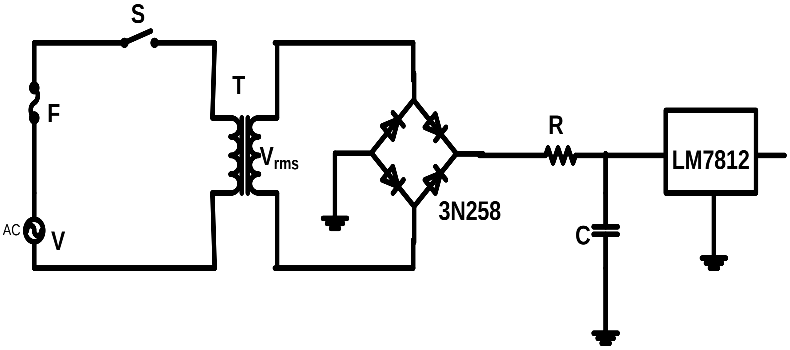


Figure 3: The regulated power supply circuit diagram

2.4 Triggering ccircuit

This stage was implemented with two NE555 timer ICs. The ON time (T) is the duration of the pulse and it is determined by the values of R8 & C3 and R10 & C5.
For IC1 NE555

$$T = 1.1 \times R_8 \times C_3 \tag{26}$$

For IC 2 NE555

$$T = 1.1 \times R_{10} \times C_5 \tag{27}$$

In order to prevent false triggering of the alarm, it was ensured that the monostable circuit of IC 2 is reset automatically when power is supplied to it. This was achieved by a “Power ON” reset circuit.
Resistor R11 and capacitor C7 determine the duration for the brief delay before IC 2 receives the triggering signal.

$$T = 1.1 \times R_{11} \times C_7 \tag{28}$$

Figure 4 shows the triggering circuit of the alarm system.

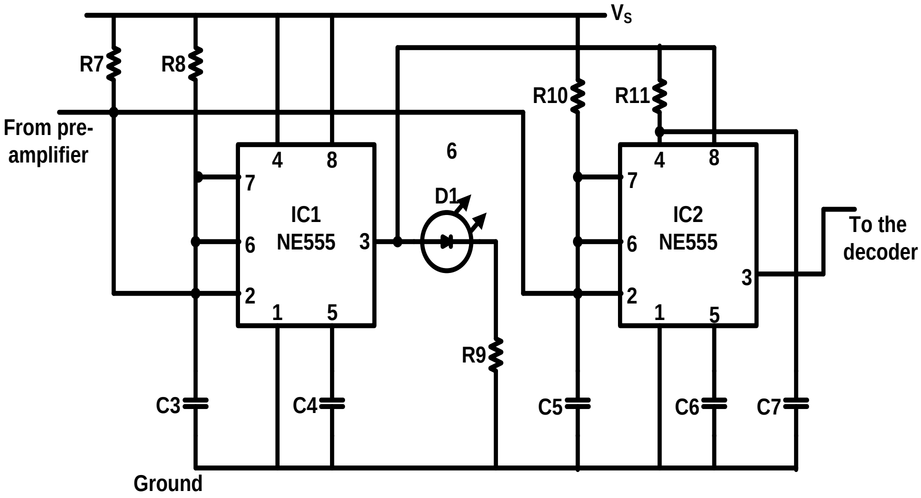
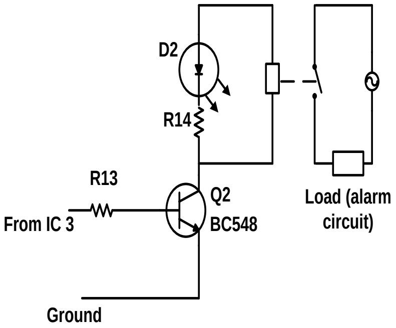


Figure 4: The triggering circuit diagram

2.5 The decoder

In this design, the outputs of a decade counter, **CD4017BC** was used for a transistor switch which enables the switching of the relay. The CD4017BC is a five stage divide-by-10 counter with 10 decoded outputs and a carry-out bit. The IC CD4017BC as used in this design was connected as a bi-stable multivibrator by connecting its decoded output 2 (pin 4) to its Reset (pin 15). Figure 5 shows the connection of the CD4017BC to achieve this.



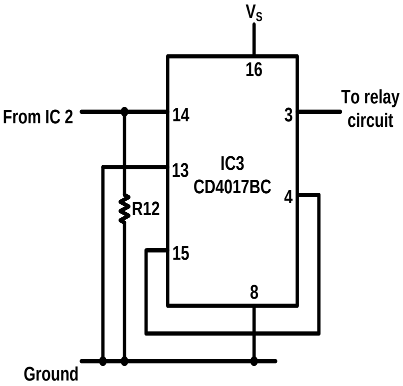


Figure 5: The decoder circuit diagram

Figure 6: The relay driver circuit diagram

2.6 The relay driver

This stage functions to operate the appropriate alarm (audible or visual) whenever it is activated by the preceding circuit. Its contacts are closed on larger amount of current and voltage when operated necessitating a low power transistor to switch the current for the relay coil. Using a general purpose transistor, **BC548**, the load drawn by the transistor from the relay R_L

$$Lood\ current, I_L = \frac{Supply\ voltage, V_S}{Load\ resistance, R_L} \tag{29}$$

$I_{C(max)}$ (for BC548) must be greater than I_L i.e. $I_C > I_L$ ($I_{C(max)}$ = 100mA (manufacturer specification.)

$$R13 = \frac{V_S \times h_{FE}}{5I_C} \tag{30}$$

$$R_{LED} = \frac{V_S - V_F}{I_F} = R9 = R14\,. \tag{31}$$

V_F = required voltage across LED D2
I_F = required current through LED D2
Figure 6 shows the relay driver circuit

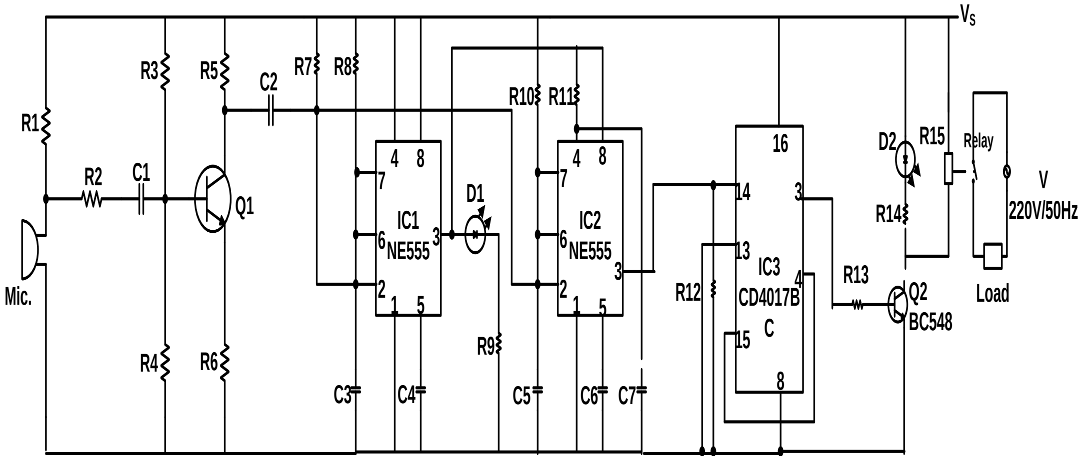


Figure 7: The entire circuit diagram of the Sound Activated Intruder Alarm System

3. Results and Discussion

In order to affirm the functionality of each stage of the device, each stage was thoroughly tested to satisfy the operational purpose and desired performance especially those of the timing circuits. When the monostable circuit of IC 2 of the complete circuit diagram was bypassed, it was observed that at a sound input, the relay made several clicking noise. It was inferred that the vibrating effect of the relay is as a result of the bounce of the switch fired by several pulses generated from the decade counter. This was corrected by de-bouncing the switch using the combination of “Power-On Trigger” and “Power-On Reset” circuit.

Using a single 555 timer (IC2) and by –passing IC 1 in the original circuit, it was observed that the Led, D1 indicating the time period only flashed once at a sound signal and the relay was energized and no bounce noticed. The circuit was placed on a hard table surface, and the surface was struck twice within the design set “Time Period”. It was observed that LED D1 came on for the struck surface several times and the same result was observed with the relay. The vibration test was repeated but with the microphone allowed to make contact with the table surface. It was observed that the circuit responded and the relay was energized.

To prevent interference due to vibration effect, the microphone surface was padded to prevent it from making direct contact with the casing. Several alarm modules were used to test for the load limit with which the SAIAS can be used comfortably.

Table 1: Test result table

Test Description	**Observation**
Sound signals from 3 metres away from device	Alarm switched appropriately
Sound signals at close range to the device	Device switched appropriately
Sound signal from a clap	Device switched appropriately
Sound from a banged door	Device switched appropriately
Vibration effect on the device	Device switched but bounced severally.

Having designed, implemented and tested the SAIAS thoroughly, it can be concluded that it functioned properly by responding to sound signals of different pitch and loudness within about two to three metres away and finger tap sound at close range. The resulting device is realizable, has good reliability, inexpensive and can be deployed to function in residential premises

References

[1] Barkat U. M., Humayun K. T., Roy Ashraf M. K. Golam M., Ramjan A., Abdul M. C.; “Design and Development of Low Cost Security Alarm Using Optoelectronic Device”; Journal of Electronics and Communication Engineering (IOSR-JECE), 2015, 10(4), P 9-23

[2] Carpenter G.L. and T. Choma Jr. “Large Signal Analysis: DC Operating Point”. The Electrical Engineering Handbook. CRC Press LLC. 2000.

[3] Hellyer H.W. “Questions and Answers on Radio and Television”. George Newness Ltd. Butterworth Group, Great Britain. 1966.

[4] Horowitz P. and Hill W., (1996); “ The Art of Electronics” Cambridge University Press London.

[5] Matulich R. and Ligi A. (2001); ‘Voice Activated Switch with User Prompt’. United State Patent. Published by Google.

[6] Oshevire P. and Oladimeji T. (2014); “Design and implementation of a Micro- controller based burglar alarm displaying; Journal of Advancement in Engineering and Technology: 1(1) pg1-4

[7] Sinclair G.S. and Webster M.A. (1995); ‘Voice Operated Switch’. Harris Corporation, Melbourne Fla.

[8] Roy A. C., Donald A. N. and Charles F. H. (1984); “ Electronic Circuit Analysis Basic Princioles”; John Wiley & Sons, New-York.

[9] Theraja A. K. and Theraja B. L. (2002); “Load Lines and DC Bias Circuits. A Textbook of Electrical Technology. S. Chand, New Delhi.

[10] Theraja A.K. and Theraja B.L. (2002); “DC Power Supplies: Shunt Capacitor Filter”. S. Chand, New Delh.