International Journal of Scientific Engineering and Science
Volume 2, Issue 5, pp. 25-31, 2018. ISSN (Online): 2456-7361

Design and Implementation of a Low-Cost Automatic Home Alarm System

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Abstract*—Security alarm systems come in various forms: manual or automatic; individual or organizational; cabled or wireless; etc. They also provide different levels of efficiency and at varying costs of implementation. Some systems are combined for improving their overall effectiveness. Home alarm systems focus on the monitoring of the premises' access points for alerting dwellers (owners) of the intruders. Literature shows that these are normally beyond the reach of the larger market segment. The aim of this study was to avail a low-cost home alarm system. Using an experimental approach, the researchers used components recovered from old and obsolete computers in implementing a circuit designed for that purpose. The produced prototype product was realized on a breadboard and passed all practical tests. It was recommended that the designed system be put into a commercial production for use on premises such as small businesses (shops), banks and storerooms, plus remote entrepreneurial sites (away from the electricity grid) such as green houses, fish ponds and gardens.*

***Keywords*—** *Security, low-cost, automatic, home alarm system.*

I. INTRODUCTION

1.0 Section Introduction

According to Mago (2016), security means safety and the measures taken to guard or protect it. Its purpose is to avoid the infringement of personal, group or entity rights by any other party. This also applies to any vulnerable premises, dwelling, community, asset, nation or organization. It is a measure that is taken as a precaution against theft, loss, harm and/or sabotage. An alarm system is an example of a security system designed to detect intrusion (unauthorized entry) into some premises. Security alarms are used in residential, commercial, industrial and military (Baily, 2010).

Many security systems come in different types, methods and kinds that have different advantages and disadvantages one against the other. Some of them are local (individual) while others are global. Fast *et al* (1996) say that a global security system is one for determining the position of an object to be protected using a local positioning system and issuing messages to a monitoring message center at predetermined times and/or at times when the object to be protected is under an alert condition, such as being outside an allowed position zone during a defined time period. In contrast, Muggah (2012) defines individual or personal security as a highly political issue touching on essential functions of the state, the nature of the social contract and the effectiveness of service delivery. In the home, personal security is also achieved in many different ways. Designing one such ways is an attempt to implement a desired security solution that may have to undergo some stringent functionality tests for approval purposes.

1.1 Background

The level of security attainable in a property such as a home is dependent on the type and method of security system used. Many have been proven to leave a lot to chance. Some are manual, but others are automatic.

Some manual security systems employ human security guards and door shakers that have been attributed to either sleeping on duty due to fatigue or simply turning into intruders themselves. In the Third World, the high costs of living continue to raise wages and salaries of these human centered systems, without any corresponding improvement in the services that they provide. The other method uses control panels and deadbolt locks which are said to be too mechanical and exposed, proving to be inadequate for the canning intruders of nowadays. Although automatic systems are considered to be more effective than their manual counterparts, a majority of them originate from the First World and are highly priced such that they are beyond the reach of many home owners, especially in the developing world.

1.2 Problem Statement

Literature demonstrates that the majority of the current security systems being used in homes depend on the awareness and responsiveness of human beings, whose inefficiency has been proved to be prevalent due to insufficient basic rewards (wages and salaries) and/or fatigue. The more efficient automated ones are generally beyond the reach of many, especially in the financially struggling Sub-Saharan Africa region. If the status quo in allowed to persist, the general public will continue to lose out from the marauding undesirable elements in society. This is the gap that this study will endeavor to address by producing a more affordable automatic system for these homes.

1.3 Study Objectives

The main objective of this study is to design and implement a cheap automatic home alarm system. It is purposefully segmented into the following specific objectives:

- To design a low power consuming alarm circuit.
- To source the necessary components from old obsolete machines.
- To manufacture and test the alarm system.
- To recommend commercialization of the successfully designed and tested prototype product.

1.4 Justification

In many areas, security should not only be available but affordable because it may provide the dividing line between life and death. This is because some intruders murder their victims for the sake of advancing their interests without any resistance, so an efficiently responsive security alarm system is a must in most homes.

1.5 Feasibility

1.5.1 Economic feasibility

The components that are going to be used in this design are going to be recovered from old and obsolete computers that are lying idle in many organizations. This will enable the produced devices to be low-cost and highly economic through exempting the affected organizations from further stocking costs of unused machines. In all economically struggling countries, every dollar counts so such a project will easily make a positive impact to the national fiscal. Safe home occupants sleep well and are known to be better performers in the workplace for producing better economic results that can easily provide positive impacts on national gross domestic products (GDP).

1.5.2 Social feasibility

Since this system will be automatic, functioning without the assistance of human beings, it will be able to provide the service beyond the capabilities and efficiencies of persons. Furthermore, it can easily be compounded by other existing and future methods of security for the gratification of those owners that can afford. According to Muggah (2012), there is ample evidence that personal insecurity has negative implications for development because it naturally affect the social status and wellness of individuals.

1.5.3 Environmental feasibility

The use of components from old and obsolete machines will help to clean up the environment by providing a way of disposing the old unused and unwanted machines, in a way that satisfies the departments responsible for enforcing environmental management in most countries.

1.6 Conclusion

This section adequately introduced the subject of study, its background, problem statement, objectives and feasibility. The next section that follows covers literature review, an identification of previous works undertaken on the topic that underpin the current one.

II. LITERATURE REVIEW

2.0 Introduction

Automatic security alarms are realized in many different ways. The objective however, remains to achieve a system that is self-responsive to intrusion, without much input from the ineffective human beings. This section looks at the different ways of achieving this goal, in order to develop a sharper and more insightful exposure about the topic. The researchers will analyze the following themes: alarm circuits designs, their components, noting how the concept of security has changed in the modern home. It ends with a summary on the key literature areas, a critique of prior literature and mapping its future direction.

2.1 Designs of Alarm Circuits

Greichen (1992) argues that the reason why home automation has not succeeded is still mostly cost. In agreement, Brush (2011) illustrates four barriers that need to be addressed before home automation becomes amenable to broader adoption: high cost of ownership, inflexibility, poor manageability and difficulty achieving security.

Monnet *et al.* (2006) identify the problem in yesteryear synchronous alarm circuits that they consist of doubling every node of the circuit, which is very costly in terms of area and speed. Such circuit technology has now been improved with the use of asynchronous logic which make them inherently resistant against a large class of faults and give them an interesting alternative to design robust systems. Similarly, in embedded systems for hazardous gas detecting and alerting, Ramya and Palaniappan (2012) note that current systems available are not so portable and are costly and difficult to implement and modifies by designing microcontroller based toxic gas detecting and alerting systems.

Abidi *et al.* (2000) realize the great importance of power consciousness and the relationship between current consumption and the components used in its manufactures, which leads to the value of the device. The cost threshold of many alarm designs has not been reached for the most important market segment, which is the upper-middle income people (Greichen, 1992). Building on the discoveries and recommendations of such studies, the researchers see the opportunity of establishing a cheaper and equally efficient design.

2.2 Alarm circuits components

In the design of an ultrasound bladder volume measurement and alarm system, Niu *et al* (2011) notice that the system is complex and costly because too many transducers are used. Pedersen *et al* (2005) also notices that readings using sophisticated sensor technology can minimize the occurrence of costly false alarms.

The selection of the components (type and source) for realizing the alarm circuit is therefore correlated with the value of the complete circuit and device. The availability of high frequency components in current computer systems that are being discarded for reasons such as low processing speeds and inadequate memory levels (which are not required in alarm circuits) provide a ready source of the required components. According to Wu et al. (2003), the current state-of-the-art of circuit design and implementation platforms based on the new concept of high-frequency integrated circuits called substrate integrated circuits (SICs) is providing a reasonable contribution. Wang *et al.* (2004) demonstrated this

by presenting a new low cost 10-kW converter system to overcome the obstacle of high cost to the system.

2.3 How the Concept of Security has Changed in the Modern Home

The tasks of a modern security system include identifying an intruder trying to gain access to the home, alerting the owner(s) about the intrusion or attempt so he/she can block the intruder, while taking measures to prevent recurrence of such incidents.

The advancement of technology has contributed to the changing concept of security in modern homes. The implementation of Internet-of-Things (IoT) involves cameras, microphones, contact sensors, proximity sensors, silent alarms, etc. By connecting homes to the Internet, users can access and control accessibility to their homes remotely. Inhabitants can keep an eye on their homes using live video and audio feeds from different parts of the home. The employment of these solutions has however been retarded by the high costs involved. Furthermore, the commonly used technologies and networks for home security automation have many other vulnerabilities, as discussed by Karloff and Wagner (2003): sinkholes, selective forwarding, sybil and cloned ID attacks. Similarly, Hu *et al.* (2006) detected an important attack on wireless networks called Wormhole attack in which the attacker records data packets in the network at one location without being detected. Oluwafemi *et al.* (2013) also demonstrate that non-networked devices such as light bulbs might be connected to networked devices and hence can be attacked by remote adversaries.

Such instances are a demonstration that home security currently goes beyond the traditional sense – thieves attempting a break-in. It now expands to involve sophisticated thieves who are good with technology or criminals who work hand in glove with hackers. To account for device vulnerabilities, it has become essential to evolve the concept of intruder beyond the traditional sense and limitations. This shows that not all security resources have to be invested in the intrusion traditional detection systems, since more will be required for complementing them. It leads therefore towards the need to reduce the costs of the basic home alarm systems, so as to leave resources towards additional solutions.

2.4 Conclusion

Automatic home alarm systems are a security measure for alerting home owners of possible intrusions into the premises by any unauthorized elements. As presented by different authors, it can be realized in different ways. The intended benefit however remains securing the home and its inhabitants by warning them of the intentions of intruders. Its laxity exposes the premises and its owners to the vagrancy of the undesired elements.

Literature suggests that there are various reasons that may lead to the failure in performance of these systems such as high costs (Greichen, 1992; Brush, 2011; Ramya and Palaniappan, 2012) which may cause the securing of unsatisfactory devices and/or under complimented systems. It becomes paramount that less costly systems be availed and this is the gap that this study will try to address. The main purpose here is to try to design and implement a low cost automatic home alarm system.

III. METHODOLOGY

3.0 Introduction

The purpose of this study was to design and implement a low-cost automatic home alarm system through the use of components recovered from old obsolete computers. This section examines the technique that was applied in solving the puzzle and the testing process done to verify the accuracy of the proto-type device.

3.1 Study Design and Strategy

A research design is the logical sequence that connects the empirical data to the study's initial research questions and ultimately to its conclusions, Yin (2009). "Colloquially, it is a logical plan for getting from 'here to there', where 'here' may be defined as the initial set of questions to be answered, and 'there' is some set of conclusions (answers) about these questions" (Yin, 2009, p.26).

Issues of design are meant to technically explain the intricacies in the operation of the goings-on in the variables under study. It was for this reason of explaining how the variables are related which led the researchers into adopting an explanatory design. Saariluoma (2005) says that explanatory design means the practice by which design solutions are evidence-based and has been the norm in engineering design, relying as it does on the laws of science. Alternatives are the exploratory design which seeks to unravel new heights that are useful in clarifying an understanding of the problem and the descriptive design whose main purpose is to describe a system, culture or arrangement. These other designs would not have been able to address the overall explanatory objective of this study.

The strategy used in the process of tackling the chosen study design took the following sequence:

- A design of the intended circuit was accomplished on paper.
- The circuit was analyzed for satisfying electronic properties of a circuit.
- A proto-type of the circuit and/or device was produced on a breadboard to enable easy changing/altering any components as found befitting at that stage.
- The proto-type went under test at some selected home access facilities such as doors and windows.
- After the researchers were fully satisfied with the performance of the proto-type product, commercial production was then recommended.

3.2 Population and Sample

According to Salant *et al.* (1994), a population is a set of units (usually people, objects, transactions, or events) that we are interested in studying. Here the study population consisted of a pool of electronic elements recovered from abandoned computers donated to the university department by different cooperates in the country. A convenient sample of 5 tested components of each of the required elements were used. The

components that were used in the design of this device circuit were: computer DC power supply units, resistors, light emitting diodes (LED), NPN bipolar junction transistors, contact switches, buzzers, breadboard and jumper cables.

3.3 Study Instrument

An instrument is a tool or device that is used to do a particular task, especially a scientific task (https://www.collinsdictionary.com/us/dictionary/english/instrument, Assessed 17/02/2017). There are a number of such instruments used in various studies. They include questionnaires, questionnaire guides, personal interviews, observations and experiments. This study used an experiment because it was found to be most appropriate to the subject under study, its method and strategy.

3.4 Conclusion

This section gave a synopsis of the reasons that led to the selection of the research method and strategy used, identified the target population and the study instrument applied. The following section gives the details of the components used, the design made and the implementation process that followed.

IV. Design and Implementation

4.0 Introduction

While the previous part provided the rationale behind the applied methodology, this one presents the design that was made and explains the various components that were used. According to Miller (2005), design is the synthesis of all three of these aspects of thought (insight, intuition, and reason) that forms the complete and verifiable conceptualization of possibility. They are applied in architectural blueprints, engineering drawings, business processes, circuit diagrams, and sewing patterns. Implementation is defined as a specific set of activities designed to put into practice an activity or program of known dimensions (http://nirn.fpg.unc.edu/learn-implementation/implementation-defined, Assessed 17/02/2018). It was the process that put the design into practice for testing its functionality and resilience.

4.1 Components and their use

4.1.1 Battery

A battery is a device that consists of one or more electrochemical cells with external connections provided to power electrical gadgets such as lights, phones, vehicles and other electronic circuits. When a battery is supplying electric power, its positive terminal is the cathode and its negative terminal – anode. The anode is the source of electrons that will flow and deliver energy to power up a circuit in a connected external gadget. Large batteries, which use a liquid medium provide more energy and are much more expensive than their smaller counterparts which are dry and meant to provide less energy. The amount of power they provide is determined by the potential difference between the two terminals – the anode and cathode, measured in volts (V). Below is a diagram on Figure 4.1 that shows a 9V low-cost alkaline Duracell battery type.

Fig. 4.1. Duracell dry battery (Adopted from https://www.amazon.com/Duracell-041333213019-Batteries-Size/dp/B00000JHQD)

This study design used an old computer DC power supply. Its advantage was the provision of clean (properly regulated) voltages for selection of the most effective levels. The following Figure 4.2 shows a PC power supply unit.

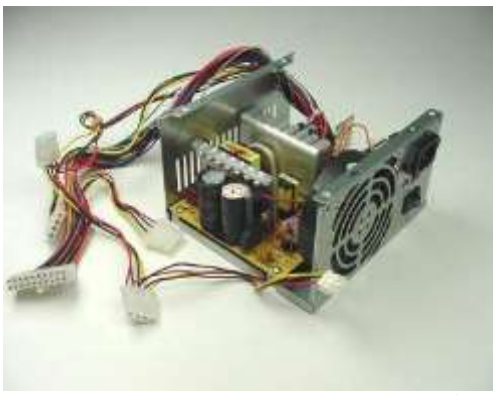

Fig. 4.2. Computer DC power supply unit (Adopted from https://computer.howstuffworks.com/power-supply.htm)

4.1.2 Resistors

These are the elements that are used for resisting (regulating) the flow of current in electronic circuits. Their sizes, measured in units called ohms (Ω) determine their resistance values. These values can also be established by using the small colored stripes (4, 5 or 6-band codes). Figure 4.2 below shows the color coded ceramic resistor types that were used.

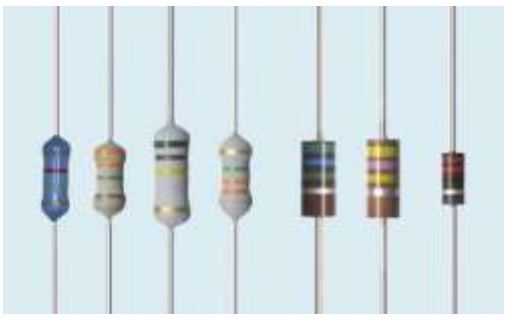

Fig. 4.3. Color coded ceramic resistors (Adopted from http://www.circuitstoday.com/working-of-resistors)

4.1.3 LED

A light-emitting diode (LED) is a two-lead semiconductor diode that emits light when its p-n junction is 'forward biased' connected, but does not when reverse biased. The color of the light corresponds to the energy of the photon and is

determined by the energy band gap of the semiconductor. LEDs are generally low energy consumers; have long lifespan, improved physical robustness, small sizes and fast switching. Figure 4.3 below shows the type of LEDs that were used in this design.

Fig. 4.4. Light-emitting diodes (Adopted from startingelectronics.org/beginners/components/LED)

4.1.4 Transistors

A transistor is a three legged (base, emitter and collector) electronic component that controls the movement of electrons and therefore electricity in a circuit. They operate as switches (enabling the flow and cut-off of electricity) and amplifiers (increasing the amount of current) in electronic circuits. Their invention revolutionized human civilization, enabling the production of massive low cost applications. They are found en-mass in all obsolete PCs and other computing gadgets. Figure 4.5 below shows different types of transistors found on the market.

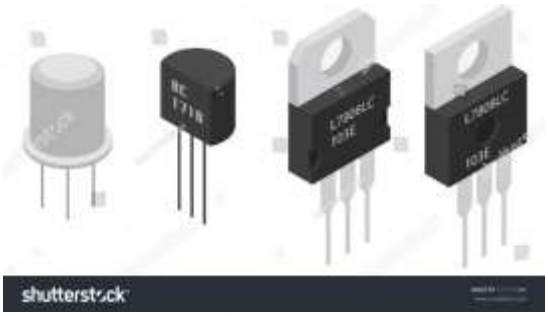

Fig. 4.5. Transistors (Adopted from https://www.shutterstock.com/image-vector/different-transistors-isometric-view-electronic-components-515172346?src=gnAyw3qNEGer76LRZOi6fw-1-1).

This study used the NPN bipolar junction transistors (BJT). They are prevalent in all old computers. Its other major advantages that enticed the researchers are: better voltage gain, operation in both low or high power applications and low forward voltage drop. These characteristics enable them to function for long periods without a specific requirement for a cooling system.

4.1.5 Switch

Switching devices come in different types, sizes and kinds, depending on the intended purpose. They are devices whose sole purpose in to provide on/off positions. In this case, they are meant to facilitate the flow (contact/ON) or cutoff (disconnection/OFF) of current onto the system circuit, with response to the closing (ON) and opening (OFF) of either the door or window of a home. The following figure 4.6 below shows the contact switch that was applied.

Fig. 4.6. Contact switch (Adopted from https://www.amazon.com/Normal-Recessed-Magnetic-Contacts-Switch/dp/B0056K5ZC2)

4.1.6 Buzzer

A buzzer is a speaker used in electronic alarm circuits for generating a sound that alerts the home dwellers of the presents of intruders, in response to the electronic signal that is generated in the system circuit when any of the monitored entry points has been disturbed. Buzzers vary in sizes and loudness of the sounds that they produce; and are also found abundantly in old computing machines such as computer desktop speakers. The following figure 4.7 shows the electronic Piezo buzzer that was used in this design.

Fig. 4.7. Electronic Piezo buzzer (Adopted from https://www.shutterstock.com/search/buzzer)

4.1.7 Breadboard

A breadboard, also called a plug-board, is a solder less board used in prototyping construction of electronic circuits. Its solder-less nature makes it more suitable for temporary designs and re-useable, especially for research and/or learning situations. Breadboards come in different sizes (full, half and mini), although they can be joined to produce bigger ones for larger projects. Figure 4.8 below shows the different sizes of breadboards found on the market.

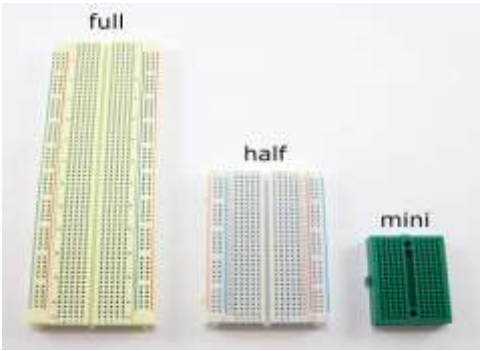

Fig. 4.8. Breadboard sizes (Adopted from https://www.sciencebuddies.org/science-fair-projects/references/how-to-use-a-breadboard)

4.2 Circuit Design, Its Functionality and Cost Issues

4.2.1 Circuit diagram design

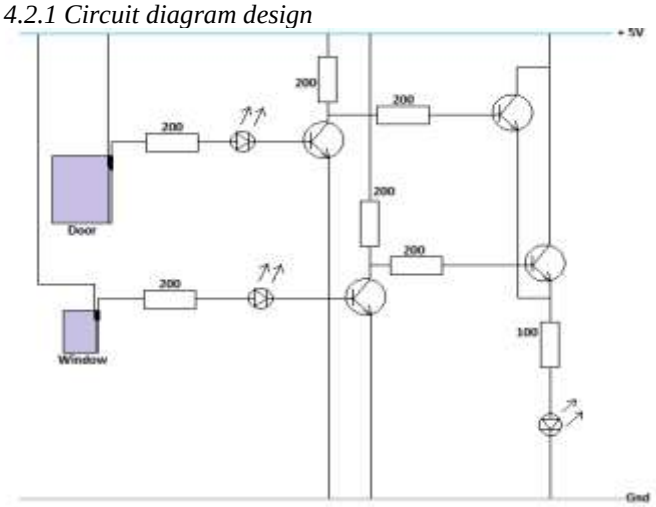

Fig. 4.7. Circuit diagram

4.2.2 Design Functionality

The design of this circuit was realized and tested (demonstrated) on one door and one window of a home. It uses one switch, two transistors, one LED and three resistors for each of the mentioned home assess points. Only a single buzzer (or represented by a resistor and LED), being the load of the circuit is used for alerting the home owners of any intruders. One 5 to 9V power supply unit energizes the entire circuit.

Below is a Table 4.1 that summarizes the operations of the circuit, in response to the situation (status) of the home access points that are being monitored.

TABLE 4.1. Circuit operations summary

Case	Status	Inputs	Medium	Result
1	Door closed, window closed	11	00	OFF
2	Door closed, window open	10	01	ON
3	Door open, window closed	01	10	ON
4	Door open, window open	00	11	ON

The power supply unit provides power to the circuit and the switches on the home access points control the flow of current in it, in response to the signals generated by the wired access points. The first lot of transistors determine the kind of instruction to pass over to the buzzer, through the second lot which in essence provide an OR logic operation. When the access points are both closed, the first LEDs light up to show that the circuit is well connected and in operation, but the circuit cuts off the buzzer. The buzzer rings or not as an indication that at list one of the access points has been opened, while its loudness increases when both points have been opened due to the increased amount of current that is passed to it.

4.2.3 Circuit cost issues

The majority of the electronic components used in this design were recovered from old and obsolete computers. These are largely abundant in many organizations, most of whom have no clue on how best to discard them. They continue to occupy the valuable and much needed storage capacity. Only a few items (switches) were sourced from the local electronic shop at a total cost of about US5. The breadboard was temporarily borrowed for the prototype product, but a hard wired printed circuit board (PCB) and housing can be mass produced for the commercial products at approximately US8. This will bring the total production cost of the home alarm system to less than USD20, including labor.

4.3 Conclusion

This section presented the design of the system and explained its functionality. The proto-type product proved the proper practical functionality of the circuit. Following are the established study recommendations and conclusions.

V. Recommendations and Conclusion

5.0 Recommendations

This system can also be used in other premises that house small businesses such as shops, banks, storerooms, since it is low-cost and financially affordable (compared to other systems currently available in the market). It is also suitable for remote areas, including those that are far away from the electricity grid since it is powered from low power (battery) DC supplies. It is recommended for production in the financially struggling but largely populated Sub-Saharan Africa (SSA) and the semi-developed Middle-East for the protection of many valuable entrepreneurial premises, including outside facilities such as green houses, fish ponds and gardens.

5.1 Areas for Further Study

This system is best suited for alerting owners or other security personnel in close proximity. The researcher proposes further studies that may be suitable for alerting reaction from people in a larger radius. A different design that is based on low consumption digital (logic gate) ICs which are also prevalent in old electronic machines may also produce interesting results.

5.2 Conclusions

The main purpose of this study was to design and implement a low-cost automatic home alarm system. The production of the device largely from discarded machines, thereby cleaning the environment, and the satisfactory testing of the manufactured prototype is an indication that the researchers satisfactorily accomplished the intended objectives.

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