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Amewornu, E.M. (2015) Design of Wireless Home Security Alarm System. In: Mojekwu, J.N., Ogunsumi,L.O., Ojigi,L.M., Atepor, L., Thwala,D.W., Sackey,S. Awere E., and Bamfo-Agyei, E. (Eds) African Journal of Applied Research .(AJAR) Journal, Vol.1,No.1 ISSN 2408-7920 January 2015, Cape Coast, Ghana. 397-412

DESIGN OF WIRELESS HOME SECURITY ALARM SYSTEM

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ABSTRACT
Security is said to have started right from the existence of mankind. This therefore makes it an important aspect of human life. According to history the first known lock was made in Egypt. This invention has been built upon since centuries. Now sophisticated security systems have been made and due to the rate at which technology grows, wireless systems are now used in security systems. The proposed design for this research is a wireless based security system. The objectives are to design the security system; to use variations in received signal strength indicator value and to find intrusion activity at home. To make this work, literature of other researchers were reviewed and knowledge was acquired from this literature which helped in the design. The components chosen for the design work were selected based on certain conditions; its reliability and cost, effectiveness and accuracy and also its availability on the market. The sensor was selected based on the temperature range required for our design, and the distance with which we want it to cover. From the research conducted, the sensor used in the design circuit is an infrared detector which uses temperature range of 20^0C to 70^0C to detect intrusion in an environment; hence we conclude that the difference in received signal of 20^0C to 40^0C of human temperature and 10^0C to 50^0C of animal temperature is used to detect intrusion.
Keywords: Design; Wireless; Home Security; Alarm System

INTRODUCTION

The security industry of today has highly evolved versions of this basic human need to protect each other from harm. Security certainly hasn't always been the iris-scanning technology we see today. From forming groups to build 4,000-mile-long walls, let's take a look at how it all began. Our ancestors, from thousand years back they exhibited the first security-seeking behaviors such as forming groups and larger communities from those groups Shinghal et al., (2008). There's safety in numbers, and when prehistoric humans banded together, they could share food, organize tasks, and protect each other from predators. More ancient security milestones included the creation of tools, weapons, and fire.

Humans have always relied on nature for some part of their security as well. For example, prehistoric Native Americans of the present-day Southwest found security in natural caves high up in mountains and cliffs. They created ladders that could be pulled inside the cave, making their dwelling impenetrable by animals and unfriendly human counterparts.

The new technology of wireless sensor network has brought a new level of building monitoring systems by saving the cost and time of implementation and maintenance, providing more safety and robustness and making these systems more stable in "hazardous" circumstance is due to the nature of wireless sensor network (WSN). In WSN each node in the network is independent of the other nodes; they are battery powered, small in size with attached sensors.

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In this paper we develop a web-based application using WSN to provide the remote monitoring of home security. It can detect theft, and in case of any dangerous condition detected, it will give high pitch sound user and to those in the environment.

Statement of the problem

Security is an important aspect of all our lives. A secure environment tends to give individuals rest of mind. However with a global recession occurring, people have resorted to less honorable means to make ends meet. Theft rates on campuses and in the country as a whole has increased causing disharmony in the areas where such events occur. This sometimes leads to unpleasant occurrences such as fights and sometimes injuries.

These injuries are either sustained when the culprit is caught and a mob action is decided upon. To take control of the situation, high level security is needed. In as much as we look at security as an important factor, the affordability and the complexity of the security facilities must be taking into consideration.

For these reasons, the design of a security system using wireless sensor network was proposed to overcome the cost oriented and complex wired networks in our homes to make it available to the average human.

Aim of the Study

The aim of the paper is design of wireless Home Security Alarm System.

The objectives of the research work are state as follows:

1. to design the security system
2. to use variations in received signal strength indicator value
3. to find intrusion activity at home

DEVELOPMENT OF WIRELESS SENSOR NETWORK

A wireless sensor network for early fire detection of mines was proposed by Tahmina et al., (2009). Researchers introduced a system composed of data collecting, data-processing and monitoring subsystems. This study focused on appropriate network topology, scheduling mechanism and communication protocol.

Hui-Nien et al., (2004) proposed a forest fire detection solution using wireless sensor networks. The system is made of sensor nodes, gateway(s), and task manager(s). Each sensor node is equipped with temperature and humidity sensors. After obtaining sensory information at sensor nodes, data are fused at gateways and data-analysis and decision making are done by task manager nodes.

Hui-Nien et al., (2004) proposed an innovative framework for residential fire detection. This study introduced metric of interval-message-ration (IMR) and evaluated the framework using the IMR metric. It was later concluded that the framework is not only applicable for fire-

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detection but can also be applied for other disaster recoveries.

To help with firefighting operations, an alarm application based on Telos B motes was proposed by Bagheri (2007). The authors used a combination of temperature, light and humidity sensors in difficult access environments. They considered a scattered wireless sensor network (WSN) consisting of several isolated WSN's. The situation, in which sensor nodes are destroyed by fire, was also taken into account. They concluded that mote longevity (avoiding synchronization costs during idle period) can be applied in the fire situations where a timely response to destructive events is needed.

Bagheri (2007) utilized FWI index and the novel k-coverage algorithm to detect forest fires, K-coverage algorithm monitors each point by using k (where k is the number of nodes) or more sensor nodes to increase fault tolerance. Therefore, some sensors can be put in standby mode to extend network lifetime. Although there are many algorithms to find the minimum number of sensors to be used, the frequently used ones are usually NP complete problems. The proposed k-coverage solution proved to prolong the network life time. Forest fire detection was not the focus of Bagheri's work and was considered as an application for the novel k-coverage problem.

A sensor network was used for real-life forest fire detection in Vescoukis and Olma (2007). Each sensor node was equipped with a GPS and a thermometer. They proposed that each sensor node should be mounted on a tree with a height of at least 3.5m. To keep sensor nodes protected against direct sunshine, sensor nodes should be covered. Since the sensor nodes might be destroyed by fire, a dynamic routing protocol was proposed.

Zervas *et al.* (2007) proposed a sensor network approach for early fire detection of open spaces such as jungles and urban areas. A temperature sensor was incorporated and maximum likelihood algorithm to fuse sensory information. The system architecture in figure 1 was proposed which is composed of:

- Sensing subsystem,
- Computing subsystem, and
- Localized alerting subsystem.

The author concluded the applicability of their approach for early fire detection.

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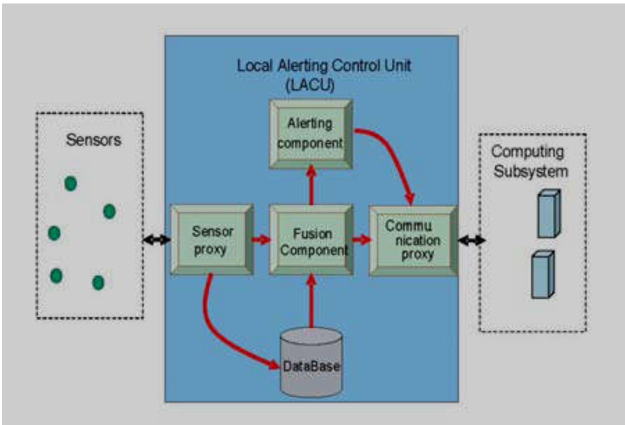

Figure 1: System Architecture Proposed in (Zervas et al., 2007)

A skyline approach for early forest fire detection is proposed by Zervas et al.(2007).Skyline is built using greater values, i.e., those sensor readings with large temperature and high wind speed. Figure 2 shows the proposed skyline. Only data on skyline are sent to a sink to be used for fire detection. Sink processes the data according to the suggested algorithm and results in a fast and energy efficient forest fire detection.

Timers for alarm systems

There is the frequent need for astable and monostable number of integrated circuit timers has been designed. Easily the most commonly employed is the 555 circuit which is second-sourced by several manufacturers. The 555 is a dipolar device and CMOS equivalent is the 7555. 556 is the dual version and the quad version is 558/9 while the ICM 7555 and TLS 555 and low power CMOS version.

Other timers, such as the 2240(7240 CMOS version) incorporate a programmable counter which gives the device extra flexibility. The timed period is determined by the time constant CR or external timing components and maximum period is limited to a few seconds. Some other timers are able to give much longer timing periods.

The IC timer and its description

The 556 IC contains two separate astable/monostable of 200mmultivibrator with common supply voltage pins of a maximum output current. A multivibrator has two output states. “HIGH” when the output voltage equals that of a battery or supply voltage, e.g. 9v and “LOW” When the output voltage is zero. Free-running multivibrator is stable in neither state (hence “astable” which means “no stable”) but switches to and fro from one state to the other to give a square wave output. It is a square-wave oscillator. It is also called a “clock” because it’s used to keep the various parts of a computer in steps.

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A monostable or 'one-shot' multivibrator is state in one state. When suitably 'triggered' by an incoming signal, its output voltage goes from the stable "LOW" state to the unstable "HIGH" state, e.g. from zero to 9v and after ascertain time, it returns to the 'LOW' state where it remains until triggered again. It produces one square-wave output pulse. The device can be used for various timing purposes producing accurate timing period from few microseconds (µs) to hundreds of seconds. It can also be connected to operate either as monostable or as an astable connection of the 8 and 14 pin packages.

$$Frequency = 4\ waves\ per\ second = 4Hertz\ (Hz).$$

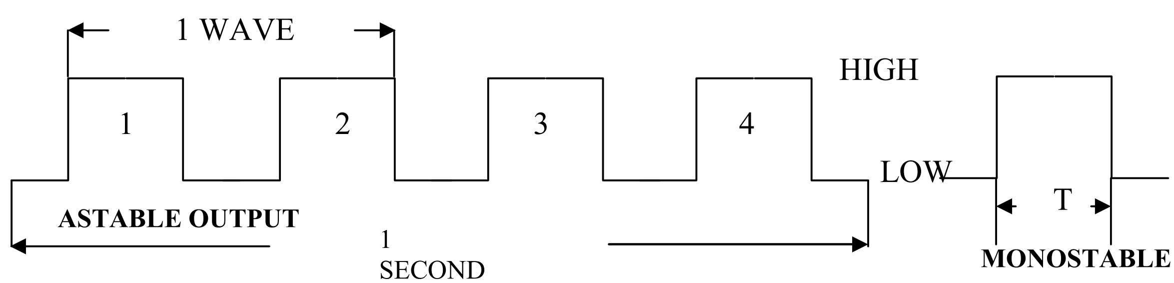

Fig 2. shows a square-wave output.

The basic concept of the 556 timer circuit

The 556 IC consist of two 555 timers in the one package and 558 is a quad 555 time. Also available are number of other timers but perhaps the most important are the CMOS version of 555 and the 556 which are as 7555/6.

The CMOS device has identical pin connections to the bipolar transistor versions and offers the advantages:

- Smaller power dissipation
- Higher input resistance
- It is much less prone to interference from transients in the power supply line.

Timing to events in digital system is related to a common clock. In other situations, however, the independent time delay provided, say by a monstable is required.

The may be at an interface where pulses of equal amplitude and duration.

Wireless security systems using wireless sensor network

Wireless security system (i.e. using wireless sensor network) in development today, has a main predecessor and several related wireless network models: specifically Packet Radio technology, cellular networks, and Bluetooth.

These days, companies and individuals have started to use wireless devices for important communications such as personalized email, mobile commerce activities, corporate data transmission etc. Apart from voice communication, data communication is also being done through mobile devices. This is possible due to very high advancement happened in wireless technology industry.

Maxim Integrated (1997) used wireless sensor network specifically Packet Radio technology, cellular networks, and Bluetooth to solve the high cost problem of home security services such as ADT by some poor communities. Amulti-hop topology was used as no other design has used this model.An all together different model was implemented: the RadiotronixWi.232 DTS module, which implements a wireless serial engine (WiSE™) that combines an RF transceiver with a microcontroller designed to be a complete solution to the wireless security system issue.

Thomas and Bruce (2011) has invented an intelligent environmental sensor for irrigation systems for which he got an US Patent: 796224, in 2011. The invention provides a regulator system for regulating the operation of an irrigation system which is responsive to user programmed information. It has a control element for issuing watering control signals to an irrigation system.

Khandare and Mahajan (2010) designed a SMS based technology and uses a wireless based system like Wi-Fi to revolutionize the standards. The system is ideal & cost-effective. Khandare and Mahajan (2010) provide an objective of developing a home automation and security system which can be controlled and monitored remotely using any telephone line. The system can also be implemented for security purposes in banks or at home.

Shinghal *et al.* (2010) report on the application of wireless sensor network technology to improve potato crop production. By monitoring and understanding individual crop and its requirements, farmers can potentially identify the various fertilizers, irrigation and other requirements. In the study was also the presentation of an irrigation management model is given to estimate agricultural parameters using mathematical calculations with specific example of potato crop.

RESEARCH METHODOLOGY

To achieve the objectives, the researchers investigated into the components that can help in the reliability and effectiveness of a wireless sensor network. The components chosen for the design work were selected based on certain conditions; its reliability and cost, effectiveness and accuracy and also its availability on the market.

Methods of Selecting and Testing the Components

In the selection of components for the design work, we took in to consideration the range in which the device should work and the sensing parameter required.

We used the thermal parameter i.e. using the heat from the body of an intruder to operate the wireless security sensor network. This was chosen because of the thermal changes humans or

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animals bring to the environment in which they find themselves. The converter (i.e. from thermal or heat to electrical) was chosen due to its advantages over the others.
The sensor was selected based on the temperature range required for our design, and the distance with which we want it to cover (i.e. its operational range).
The IC used was selected due to its ability to give two tones at a time as compared to the others and also its low power consumption. The resistors and the capacitors used were selected based on the current requirements of the IC and the output speaker. The relay was selected base on the minimum current that will flow through the convertor.

Block Diagram of the security system using wireless sensor for door alarm system
The diagram in figure 3 indicates the general representation of diverse stages of the security system using wireless sensor network. The diagram consists of power supply unit D.C supply.

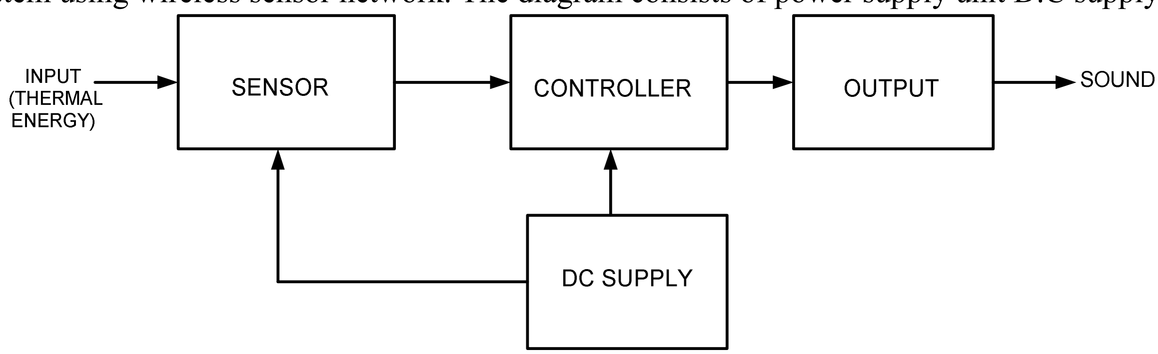

Fig. 3 Block diagram of security system using wireless sensor network

Selection of components
The target temperature range for the humans is $20°C$ *to* $40°C$ and for animals $10°C$ *to* $50°C$, for this reasons the PIR sensor was selected and used as the basis for the selection of all the components.

Selecting the Passive Infrared Sensor (PIR)

According to Maxim Integrated (1997) (refer to literature review) when the active elements of the PIR sensor are exposed to a change in the surrounding temperature field, electrical charges are separated within the sensor elements. The voltage across the sensors controls a J-FET source follower impedance converter and thus modulates the output current of the PIR detector.
The RE 200B is a passive infrared sensor designed to pick up heat radiation with high wavelength, typical value 10 micron. It has two active elements configured as balanced

differential series opposed type. This results in good compensation of environmental temperature and excellent sensitivity for small changes of a spatial temperature pattern. It has sensitive trigger ability, i.e. thermal signals far below one microwatt. The temperature range of operation of the PIR is from $-20°C\ to\ 70°C$. For further information about the sensor refer to datasheet on appendix.

Selection of relay

The relay was selected based on output of the passive infrared sensor chosen. The sensor gives an output of 0.2mA for the minimum change in temperature in the environment and this is enough to put the relay chosen into operation. It is a Current Sensing relay, with contact from Single Pole Double Throw (SPDT) required for the contact. Input Voltage 1V to 24V,Trip Point (milliamps) 0.1 to 1,Trip Delay (Sec.) 0.1-10, Status Indicator Red LED/Output, Green LED/Input.

Selection of Electronic Switch

The relay manufacturer specified that the relay should be connected to single pole double throw (SPDT) switch. The SA630 SPDT switch was selected for this purpose. Its small size and light weight are combined with ample electrical capacity, precision operation, and extended life. It is best suited for lower cost-of-failure applications (Thomas, and Bruce 2011).

Features of the Electronic Switch

- Wideband (DC - 1GHz)
- Low through loss (1dB typical at 200MHz)
- Unused input is terminated internally in 50W
- Excellent overload capability (1dB gain compression point +18dBmat 300MHz)
- Low DC power (170mA from 5V supply)
- Fast switching (20ns typical)
- Good isolation (off channel isolation 60dB at 100MHz)

The specification of the DC Electrical Characteristics of single pole double throw (SPDT) switch is shown in the appendix.

Selection of IC

The 556 IC was selected to serve the purpose as it is mainly used for alarm systems. The selections of components were made based on the manufacturers specifications on the data sheet of the IC. On the IC data sheet manufacturer specified the resistor and capacitor values to be used. These specifications were justified by the manufacturer to enhance the efficient working of the IC, hence was followed. The data sheet supporting this is shown on appendix two (i.e. data sheet of IC.).

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For the charging of the capacitor C1, for the system to be efficient and reliable, the response time must be low hence a time of $4.7msec$ is selected for fast operation. Hence

$$\tau = R_2C$$

$$R_2 = \frac{\tau}{C}$$

$$R_2 = \frac{4.7 \times 10^{-3}}{0.1 \times 10^{-6}}$$

$$R_2 = 47k\Omega$$

For the R_3 resistor (i.e. at the reset pin), the reset voltage is $0.7V$ and the reset current is $0.1mA$ hence

$$R_3 = \frac{V_{RESET}}{I_{RESET}}$$

$$= \frac{0.7}{0.1 \times 10^{-3}}$$

$$= 7000\Omega = 7k\Omega$$

Selection of speaker

The speaker was selected based on the output voltage of the IC i.e. 12V and the speaker input voltage is 12V nominal and in a range of 9-17V.

Features of the speaker

- It has loud and clear sound typical value 90 dB gain output.
- It is easy to install and available on the market.
- It meets and matches the output of the IC used.

Calculation for the selection of the crossover capacitors for better sound (i.e. C_3 and C_4)

$$capacitor\ value = \frac{1}{2 \times \pi \times desired\ crossover\ frequency \times speaker\ impedance}$$

$$= \frac{1}{2 \times 3.142 \times 750 \times 21}$$

$$= 10.105 \times 10^{-6}F$$

$$= 10\mu F$$

Summary of Component Selected

This section gives the individual component and their specified values for the design of the circuit.

Component Needed

1. Dual astable multivibrator IC (556).
2. Resistor- 1kΩ (Brown, Black, and Red)
3. Resistor – 7kΩ (Red, Red, Orange)

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4. Resistor – 47kΩ (Yellow, Violet, Orange)
5. Resistor- 100kΩ (Brown, Black and Yellow)
6. Electrolytic capacitors $10\mu F$
7. Disc ceramic capacitors $0.1\mu F$
8. Loud speaker $2\frac{1}{2}$ in
9. 25 to 80Ω miniature slide switch (SPDT)
10. 9v battery (PP3)

Calculation of the Current in the Circuit

Considering the astable 556 timer circuit diagram with respect to $R_1 = 100K\Omega$and $R_2 = 47K\Omega$.

By ohms law current $I = \frac{Supply\ Voltage}{Total\ Resistance}$

Hence current $I = \frac{V_S}{R_T}$

$$V_S = 9V$$
$$R_T = 100K\Omega + 47K\Omega$$
$$R_T = 147K\Omega$$
$$I = \frac{9V}{147K\Omega}$$
$$= 0.05mA$$

But the current across the IC $= I_2 = 10mA$

Then total current $I_T = I + I_2$

$$I_T = 0.05mA + 10mA$$
$$= 10.05mA$$

Power Rating Calculation of the Circuit

$$Power(P) = Current\ (I) \times Voltage\ (V)$$
$$= 10.05 \times 10^{-3} \times 9$$
$$= 90.45mW$$

Circuit diagram of the security system using wireless sensor

The diagram below shows the overall circuit design for the security system.

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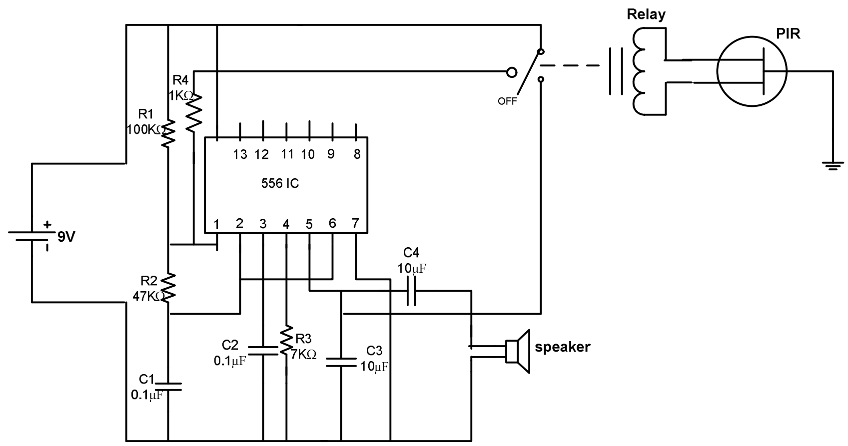

Fig. 4 circuit diagram of security system using wireless sensor

Mode of Operation of the Circuit Diagram

When switches 'ON', fast square wave pulses from the astable produce a note in the loudspeaker. The sound depends on the values of R1, R2 and C1. At the same time C3 charges up. When switch 'off', the astable continues to produce output pulses (at pin5) but faster than before because R4 (1kΩ) is now parallel with R1 (100k Ω) and effectively reduce the value of R1 (to less than1kΩ), A sound is therefore produced. It stops when C3 has discharge sufficiently (through R3) for the voltage across it to be less than 0.7v. The voltage at 'reset' (pin 4) is then too low for the astable to operate.

Waveform

The lower half of the 556 is fused as a 'fast' astable producing squares pulses at the rate of about 700 per second, decided by the values of R1, R2, C1 i.e. The frequency of the pulse is 750 Hz. The upper half of the 556 operates as a 'slow' astable, generating square pulses. The alarm system use is made of the fact that frequency of the output pulses can be varied independently of the R-C by varying the voltage applied to the control voltage connection square pulses.

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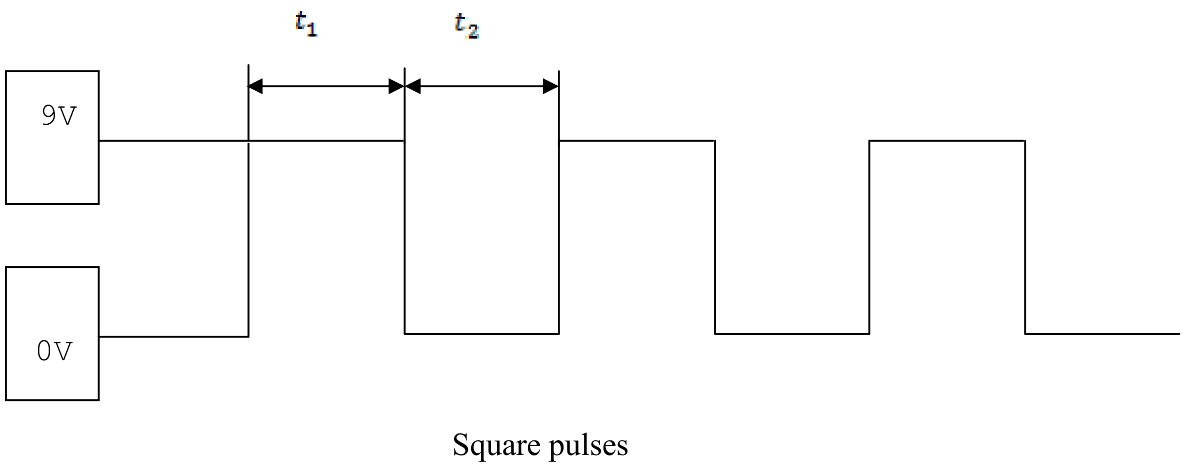

Fig 5 Waveform of the IC output

Reliability of the Alarm System

Systems using ICs fail less often per components hour of use. Then systems make use of discrete components. This is mainly because all interconnections are sealed within the IC case preventing corrosion on the intrusion of dust. The reduced failure rate translates into less downtime. However, the reliability of the alarm system is the ability of an item to perform a required function without failure under stated condition for a period of time.

The reliability of an electronic component is quoted between 96 to 99% and could be affected by the factors during the various stages of the component.

- Design and development
- Production
- Storage and transport
- Operation

Increasing or Lowering Reliability

Series and Parallel Redundancy: a method of improving reliability, i.e. component parts are so connected that if one fails another takes over the function. This is shown in the appendix.

Reliability Calculation

Mean time before failure (MTBF) $= 1/\gamma$

Where is the failure rate $= 7.41 \text{ x } 10^{-6}/_h$

$= 134952.7556$ hrs

Reliability (R) $= e^{-t/m}$

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Where t is the operation under well-defined operating condition which is assume to be 100hrs. M is the mean time before failure

$$\text{Hence reliability } R = e^{-t/m}$$
$$= e^{-100}/134952.7556$$
$$= 2.718^{-100/134952.7556}$$
$$= 2.718^{-0.00751}$$
$$= 0.99$$
$$= 99\%$$

Cost Analysis

In design it is very important to consider the cost of each component and the overall cost of the assembled unit. To achieve the target aim of producing a reliable unit with optimum cost, a research was carried out to find out the cost of different component in the market which can perform the same function taking into consideration their availability, reliability and prices. However, it was based on this that the component needed for this project was selected for this designing.

Table 1 the cost of component

Component	Type	Rating	Quantity	Unit Price GH₵	Total Price GH₵
Capacitors	Electrolytic	1µF	1	1.00	1.00
		1000 µF	1	1.50	1.50
		10µF	1	1.00	1.00
	Disc ceramic	0.01µF	2	1.00	2.00
Resistors		1kΩ/1W	1	0.50	0.50
		22kΩ/1W	1	0.50	0.50
		47kΩ/1E	1	0.50	0.50
		100kΩ/1 W1	1	0.50	0.50
Loudspeaker		21Ω	1	10.00	10.00

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Battery	Duracell (Alkalinepp3)	9V	1	9.00	9.00
Dual multivibrator	556 IC	5V	1	5.00	5.00
Switch	SPDT	5-9V	1	4.00	4.00
Grand Total					35.5

Labour cost = 40% of total cost
40/100* GH¢35.5

= GH₵ 14.2
Total cost = component cost + labour cost
= GH₵ 35.5 + GH₵ 14.2
= GH₵ 49.7

CONCLUSION AND RECOMMENDATION

From the research conducted, the sensor used in the design circuit is an infrared detector which uses temperature range of $-20°C$ *to* $70°C$ to detect intrusion in an environment; hence we conclude that the difference in received signal of $20°C$ *to* $40°C$ of human temperature and $10°C$ *to* $50°C$ of animal temperature is used to detect intrusion.

After the designed work, we compared the cost of the design to the already made ones on the market and the cost of using wired network and the difference was struck. It happened that the cost of purchasing an already made or a wired network on the market is about four times difference. Hence the cost of constructing the wireless network as compared to the cost of wired or already made once is low.

It also proved that the reliability of the designed work as calculated showed a reliable system of 99%. Hence we conclude that the designed system is reliable and effective.
The above conclusions were the conclusions made from the design of the home security system using wireless sensor networks.

Recommendation

Basically, all electronic alarm systems have similar objectives but the constructional cost as shown in table 1 is much affordable as compared to those at the market i.e. (GH₵ 80.00

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against GH₵ 49.70).This project can be adopted, improve upon and produced in large quantities for commercial and domestic uses when fully assemble.

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