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DESIGN AND IMPLEMENTATION OF A MUSEUM SECURITY SYSTEM USING AN IR PROXIMITY ANTENNA

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ABSTRACT

This paper highlights the drawbacks of the current security systems for museums and banks. Accordingly, it introduces a design of an efficient and simple security system. The system is based on the fact that any human being radiates an infrared radiation. The proposed security system consists of antenna, Programmable System on Chip (PSoC), a Silicon Controlled Rectifier (SCR), and an alarm. If any human being approached valuable protected item, the antenna collects the infrared radiation and gives an analogue output equivalent to this radiation to the PSoC where it converts the analogue to a digital and compare it with the preset threshold level. If the level of the collected signal is greater than the threshold level, PSoC feeds logic level high (five volts) to the SCR. The output of the SCR will activate a load which could be a buzzer or Light Emitting Diode (LED) to give either a sound or a light alarm, respectively. The paper describes the design and implementation of the proximity alarm system. The system is tested and found to be working successfully. Advantages of the proposed security system are: immediate response, no apparent components, no interference with daily business, and all-the-time activation.

Keywords: *IR antenna, Security System, PSoC, Antenna Temprature, Proximity Antenna*

1. INTRODUCTION

There are a lot of concerns in securing buildings that contain valuable things, such as museums and banks against vandalism and theft. Before discussing different types of security systems in banks and museums, let us read some real stories of stolen museums and robbed banks.

On Monday, August 21, 1911, the world's most famous work of art - Leonardo da Vinci's Mona Lisa, see fig.1, was stolen from the Louvre museum in Paris, see [1]. Luckily, the painting was recovered 27 months after it was stolen.

Vincent Van Gogh's "Poppy Flowers", see Fig. 2, also known as "Vase with Flowers" was stolen in October, 2010 from Khalil Museum, Cairo, Egypt that highlighted major security lapses in cultural institutions. Official investigations found that the museum had reduced the number of guards and that most of the surveillance cameras were not working.

Public prosecutor has said that each painting in the Mahmud Khalil museum, which also has works by Monet and Renoir, had an

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alarm but that none of them worked, see [2].



Fig. 1. Mona Lisa

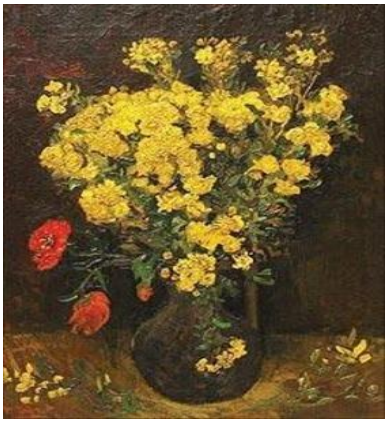

Fig.2. Poppy Flowers

Banks have many security practices and are usually considered the most secure of all commercial businesses. Banking security practices are highly standardized and electronic security is commonplace even among branches that are robbed. By 2000, 98 percent of robbed branches had both cameras and alarm systems, see [3] – [5]. Alarms are in widespread use by banks but do not appear to reduce robbery.

While alarms lead to the arrest of bank robbers in only about 6 percent of crimes, there is evidence that prompt activation increases apprehension rates. Some bank employees do not activate alarms until after the robber has left the premises, reflecting concerns about the safety of employees and customers, lest police trap the robber inside the bank and provoke violence. In other cases, the delay might be due to panic or to comply with instructions made by the robber.

We conclude from these stories that museums and banks have security systems that suffer the following drawbacks:

1. Can't be activated automatically
2. Can't respond immediately
3. It has significant features such as camera to be seen or light to be detected
4. It interfere the daily business or activities.

2. SYSTEM DESIGN

This paper is a significant extension of our previously presented and published work, see [6].

The basic concept of the proposed security system relies on the fact that the human body radiates energy in the infrared region. We designed a system to detect this energy, process it and give alarm accordingly.

2.1 ANTENNA TEMPERATURE

Every object with a physical temperature above absolute zero *(*0 K = –273˚C*)* radiates energy. The amount of energy radiated is usually represented by an equivalent temperature. The brightness temperature emitted by different sources is intercepted by antennas, and it appears at their terminals as an antenna temperature.

A graphical representation of all the parameters is shown in Fig. 3. The effective system noise temperature *Ts* includes the effective temperature of the object, the physical temperatures of the antenna, the transmission line, and the receiver, see [7]. In most of the communication applications, we consider the power appeared at the receiver due to an object close to the antenna as a noise power and it is good to avoid or minimize this noise. However, the concept of

the proposed security system is mainly based on this noise power.

The noise power transferred to the receiver due to temperature of an object is given by:

$$P_s = k(T_a + T_r)\Delta f = kT_s\Delta f$$

Where:

P_s = system noise power (at receiver terminals) (W)

T_a = antenna noise temperature (at receiver terminals) (K)

T_r = receiver noise temperature (due to thermal noise in the receiver components) (K)

$T_s = T_a + T_r$ = effective system noise temperature (at receiver terminals) (K)

K = Boltzmann's constant (1.38×10^{-23} J/K)

Δf = Bandwidth of the receiver (Hz)

The infrared region of the spectrum shown in Fig. 4 is usually subdivided conditionally into the near (λ ranges from 0.74 to 2.5 μ), middle, or intermediate (2.5–50μ), and far (50—2,000 μ) infrared regions, see [8].

2.2 The Concept of the Proposed Security System

The proposed security system consists of antenna designed at IR frequency band connected to a PSoC to convert the analogue signal collected by the antenna to a digital signal as shown in Fig. 5. Then, inside the PSoC there will be a C file to check the level of the digital signal compared to preset threshold value. Based on this comparison, the PSoC will generate an output as seen in Fig. 6. This output may be logic low (0 volt) or logic high (5 volts). Selecting the threshold value will determine the sensitivity of the system. As seen in Fig. 7, if small threshold value is adjusted, the system will be more sensitive and weak IR radiation collected from small creatures like rates or lizards can activate the system. On the other side, if large threshold value is adjusted, the system will be less sensitive and needs strong IR radiation to activate it. Hence, a real threat may be missed. Threshold optimization is very essential based on environment and expected threats.

The output of the PSoC is used as a triggering signal for an SCR. The output of the SCR will activate a load which could be a buzzer or LED to give either sound or light alarm. If any human being approached the system, the alarm will be activated.

2.3 Types of Antennas Used

Different antennas are designed and tried in this work. The types of the antennas we tried are microstrip, half-wavelength dipole, quarter-wavelength monopole, and circular loop. We even introduced new antenna not mentioned in the literature. It is hybrid microstrip and circular loop, see [9], and [10].

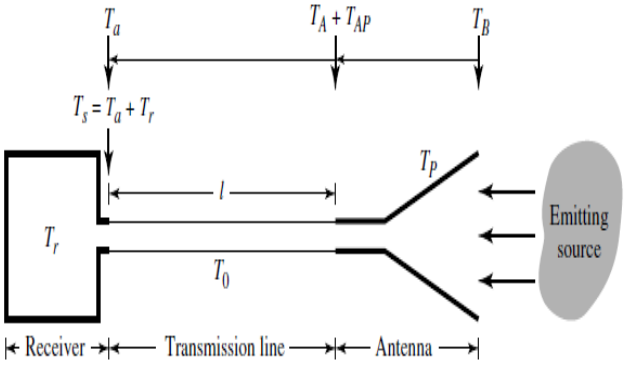

Fig. 3. Antenna is collecting radiation from emitting source and transferring it through a transmission line to a receiver.

2.4 SCR Conduction Mode

There are two conditions to conduct the SCR. First, is to apply a positive trigger voltage to the SCR gate. This voltage should be greater than certain threshold voltage. The second condition for SCR conduction is to apply a reasonable positive DC voltage to the SCR anode. This DC voltage should be high enough to generate anode current greater than the latching current, see Fig. 8. The threshold

voltage and the latching current vary from device to another and can be configured from the data sheet. We found that the buzzer internal resistance is 4.5 MΩ. So, we connected 450 Ω - resistance in parallel with the buzzer which leads to a resistance of 450 Ω in total. The total anode current with a dc battery 12 V is around 27 mA. The SCR that we used (BT151 500R) has a latching current around 10 mA, see [11] - [13].

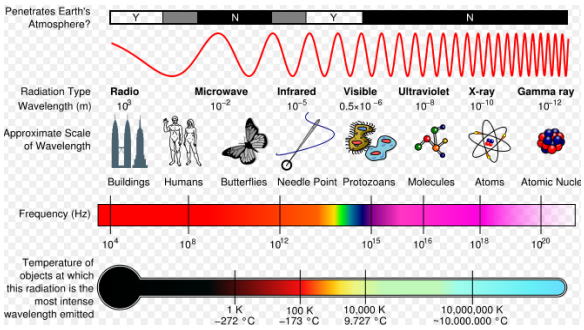

Fig. 4. Electromagnetic Spectrum

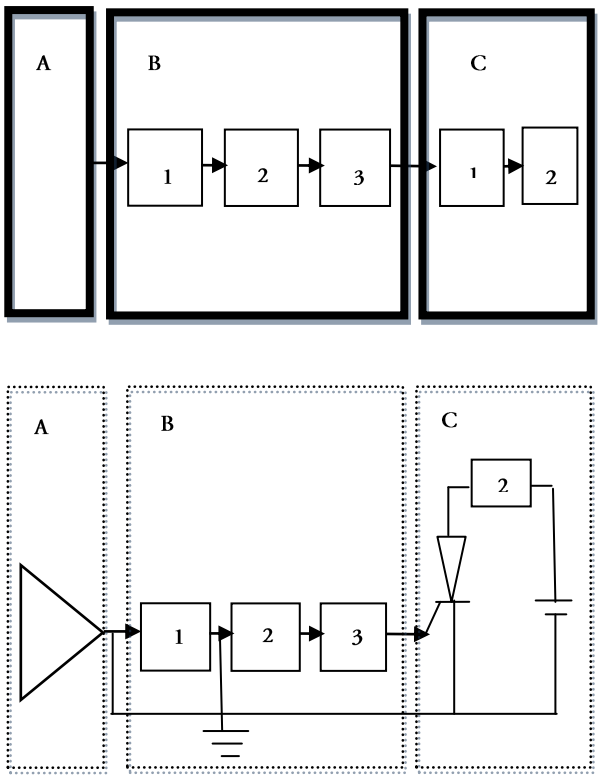

Fig. 5. The Block and Circuit Diagram of the Proposed System; A: Antenna, B: PSoC, B-1: PGA, B-2: ADC, B-3: Threshold level, C: Alarm, C-1: SCR, and C-2: Buzzer.

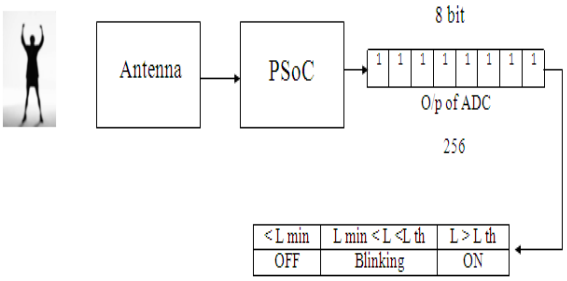

Fig. 6. Flow of the Signal in the System, the output after antenna is analog while the output after PSoC is digital.

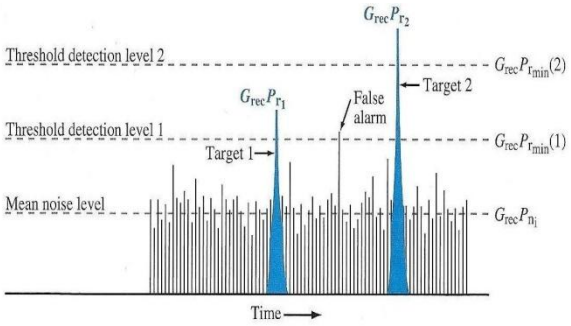

Fig. 7. Optimization of the Threshold Level

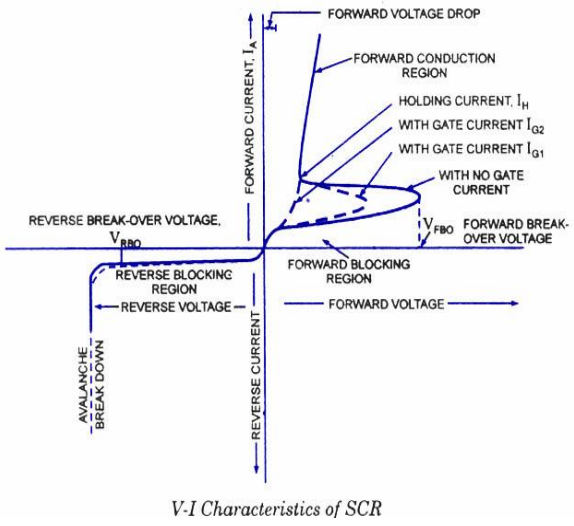

Fig. 8. V-I Characteristics of SCR

2.5 Introduction to PSoC

There are many applications where we need a system to control some variables under certain conditions and constraints.

The Programmable System on Chip (PSOC), see Fig. 9, is one of the most recent SW and

HW introduced by an American Company named Cypress, see [14]. It has many advantages over other control systems currently available on the market. The current control systems include but not limited to PLC, Microcontroller, FPGA, and ASIC, see [15]. Fortunately, the PSoC system overcomes most of the previous systems drawbacks. PSoC is a family of integrated circuits made by Cypress Semiconductor. These chips include a CPU and mixed-signal arrays of configurable integrated analog and digital peripherals.

When developing more complex projects, there is often a need for additional peripheral units, such as operational and instrumentation amplifiers, filters, timers, digital logic circuits, AD and DA convertors, etc... As a general rule, implementation of the extra peripherals brings in additional difficulties: new components take space, require additional attention during production of a printed circuit board, and increase power consumption. All of these factors can significantly affect the price and development cycle of the project.

2.5.1 Analog inputs and outputs

Some of input-output pins, beside their standard use can perform analog input or output operation. Any pin of port P0 as well as lower four pins of port P2 can be used as analog input. Inputs of port P0 are connected to analog blocks over analog multiplexers, while in case of port P2 they are connected directly to programmable SC blocks. Pins P2[4] and P2[6] can serve as external referent voltage inputs. Outputs from analog blocks can be connected to 4 output buffers, which are connected to P0[2],P0[3],P0[4] and P0[5] pins, as shown in Fig. 10 and Fig. 11.

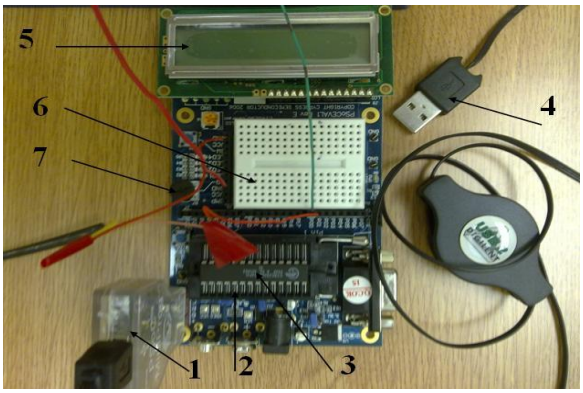

Fig. 9. The interface of PSoC Evaluation kit: (1) USB Adaptor, (2) IC Base, (3) IC: CY8C29466, (4) USB, (5) LCD, (6) Small Board for testing, and (7) Potentiometer

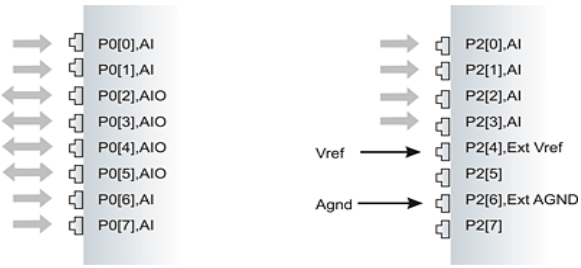

Fig. 10. Input output pins for PSoC IC.

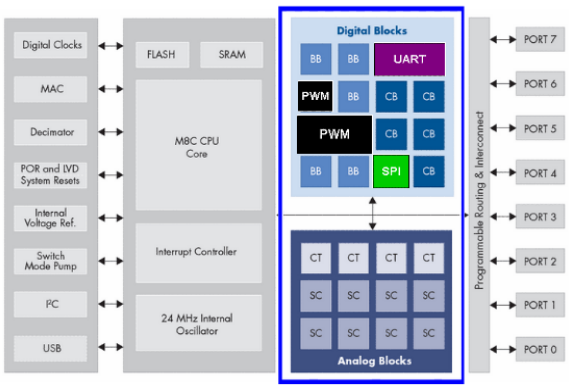

Fig. 11. Input output pins for PSoC IC.

2.5.2 Design Process of PSoC IC Type CY8C29466

PSoC Designer™ is two tools in one. It combines a full featured integrated development environment (IDE) with a powerful visual programming interface. The two tools require and support two different design processes. The two tools are the System Level and the Chip-Level.

The design procedures for the tool that we have used (Chip-Level) are found in [14]. A snapshot of some PSoC blocks is seen in Fig. 12.

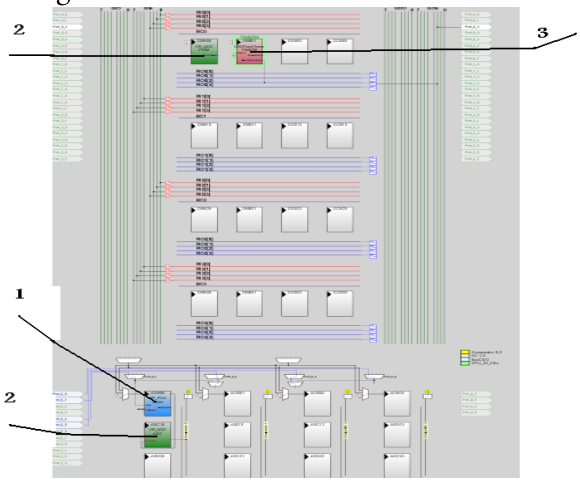

Fig. 12. PSoC software programming where: 1- PGA, 2- ADC, and 3- Flash timer

2.6 ANTENNA DESIGN

We used several antenna types and we compared among their performances. We designed microstrip antennas with rectangular and circular patches. We also designed dipole and monopole antennas. In addition, a circular loop antenna is attempted. We introduced a hybrid antenna consists of circular loop over microstrip with either zero height or with height, see [7], [9], and [10]. In our design for monopole or dipole antenna, we consider to levitate the element over a ground plane which will lead to a pattern that has more than major lobe. In our design, we used the software package, IE3D [16], to optimize the antennas.

3. HARDWARE IMPLEMENTATION AND TESTING

Pictures in Fig. 13 – Fig. 16 illustrate the process of antenna fabrication, integration of the antenna with other elements, and testing of the whole system.

In our fabrication of different types of antennas, due to lack of etching facility, we used simple materials such as foam which has dielectric constant near to free space and sheets of copper for the patch and ground plane, see [17].



Fig. 13. Circular patch antenna during fabrication

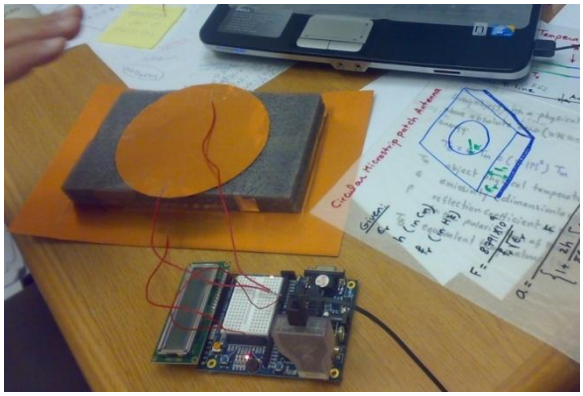

Fig. 14. Testing of circular microstrip patch antenna

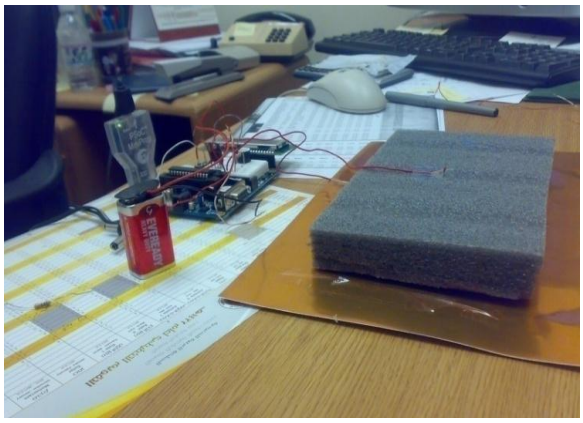

Fig. 15. Testing monopole antenna over ground plane

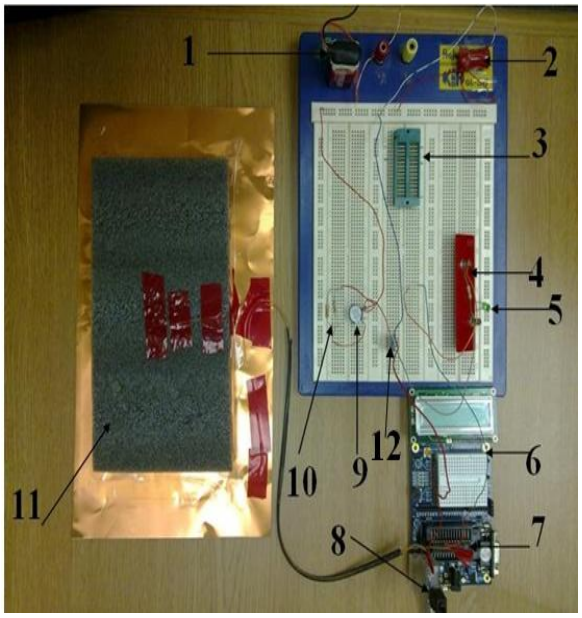

Fig. 16. The final layout of the security system with description of each element 1- 9 V battery, 2- 12 V battery, 3- IC base, 4- 1 kΩ resistance, 5- LED, 6- Board for testing, 7- IC type: CYC829466, 8- Adaptor for interfacing with PC, 9- Buzzer, 10- Two parallel resistors with the Buzzer, 11- Monopole antenna over a ground plane, and 12- Thyristor type: BT151 500 R.

4. CONCLUSION

The security system is implemented and tested. The system has been tested for ten times and never fails for single try. Hence, the system is genuine, simple and efficient. To the best of our knowledge, this system never been mentioned in the literature yet. So, we keep our right to register it as a patent. Our system is based on the fact that any human being radiates an infrared radiation. The proposed security system consists of antenna operates at IR frequency band connected to a PSoC to convert the analogue signal collected by antenna to a digital signal. Then, inside the PSoC there will be a C file to check the level of the digital signal compared to preset threshold value. Based on this comparison, the PSoC will generate a binary output. The output of the PSoC (it is either low, 0 Volt, or high, 5 Volts) is used as a triggering signal for the SCR. The output of the SCR will activate a load which could be a buzzer to give sound alarm or LED to give a light alarm. If any human being approached the system, the antenna will collect the Infrared radiation and gives an analog output equivalent to this radiation.

One of the major tasks during the final testing of the work is to select the proper threshold voltage level below which the system will not be activated and above it the system will give alarm. It is recommended to select this threshold level on the actual place where the system will be activated.

The system is tested and found working fine. The system is just a prototype, it is not a final product, and however, it represents proof of concept. For interested readers, can download a 30 seconds clip for testing the system from the following link:

http://www.4shared.com/video/ZnH2Xp7V/3_project_testing.html

In this clip, we have tested the system three times successfully. In the first two times, the system is turned off by reducing the anode current by disconnecting the battery connected to the SCR. In the third time, when the gate of the SCR is disconnected the buzzer still working since the gate has no influence on the SCR once it is triggered.

The system is distinguished with the following advantages over the current security systems.

5. can be activated automatically or all the time,
6. can respond immediately,
7. it does not have any significance such as camera to be seen or light to be detected
8. it does not interfere with the daily business or activities

The proposed security system is very suitable for museums and banks which are suffering

from inefficient security systems that can be recognized by intruders.

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تصميم وتنفيذ نظام أمن للمتاحف باستخدام هوائي اقترابي في نطاق الاشعة تحت الحمراء

طريف محمد فوزي الشافعي

قسم هندسة الالكترونيات والالات الدقيقة
كلية ينبع الصناعية

الملخص:

تقدم هذه الورقة البحثية أهم عيوب انظمة الامن الحالية الخاصة بتأمين المتاحف والبنوك. وعلى ضوء ذلك يقترح البحث تصميم لنظام أمن كفئ وبسيط ويتغلب على كثير من العيوب الحالية.

يعتمد نظام الامن المقترح على حقيقة علمية أن اي كائن حي بما فيها الانسان يشع طاقة في النطاق الترددي للاشعة تحت الحمراء. وبالتالي يتكون النظام المقترح من هوائي ودائرة متكاملة يمكن برمجتها و موحد السيلكون القابل للتحكم بالاضافة الى وحدة انذار صوتي.

في حالة اقتراب اي شخص من نظام الانذار المقترح في الورقة البحثية يقوم الهوائي بتجميع والتقاط الاشعة تحت الحمراء التي يشعها هذا الشخص المقترب ويكون خرج هذا الهوائي لاشارة خطية مكافئة للاشعة تحت الحمراء التي تم التقاطها. يتم ادخال خرج الهوائي الى الدائرة المتكاملة التي يمكن برمجتها حيث تقوم هذه الدائرة من تحويل الاشارة الخطية الى اشارة رقمية وتقوم ايضا الدائرة المتكاملة بمقارنة هذه الاشارة الرقمية برقم ثابت تم ظبطه مسبقا. فاذا كانت نتيجة المقارنة ان الاشارة الرقمية اكبر من الرقم الثابت تقوم الدائرة المتكاملة باعطاء جهد عالي (5 فولت) الى موحد السيلكون القابل للتحكم والذي يقوم بدوره باثارة وحدة الانذار الصوتي. يمكن استبدال وحدة الانذار الصوتي بوحدة انذار ضوئي طبقا لطبيعة المكان وطبيعة التهديدات.

تقدم الورقة البحثية وصف تفصيلي لنظام الانذار المقترح وكيفية تنفيذه ونتائج الاختبارات الناجحة التي تم فيها تجربة النظام بكفاءة عالية. كما تقدم الورقة مميزات نظام الانذار المقترح مقارنة بالنظم الموجودة حاليا..