

A Review of Security System for Smart Home Applications

Mohammad Syuhaimi Ab-Rahman and Mohd Ariff Razaly
Department of Electrical, Electronics and System Engineering,
Faculty of Engineering and Built Environmental,
University Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

Abstract: Problem statement: This study was discussed the development of security system for smart home applications. A more robust security system built around the world. The security system had developed based on a microcontroller device as a receiver, processor and transmitter of information. **Approach:** The method of transmitting and receiving data was done wirelessly using a ZigBee device. ZigBee had the data transmission characteristics suitable for this system, as data was sent quickly and accurately. A microcontroller interface circuit had produced to promote the ZigBee wireless communication. A display system had produced as an indicator of conditions around the house that could be carried anywhere. **Results:** The transmission and reception were indicated by LED data display. The LEDs had represented sensors deployed around the house. **Conclusion:** From the results, it is shown that the security system performs effectively and properly. Improvements can be made, primarily on the input of the sensor to detect the presence of the object effectively.

Key words: Home application, security, ZigBee, LED display, prototype development

INTRODUCTION

Nowadays, the security level is very important, always emphasized and enhanced system. Different ways of security system have been enhanced such as use a large number of security officers, the use of sophisticated weapons, the use of alarms, monitoring system, through the production of electronic hardware and software and much more. All of this improvement depends on their usage. One of the most important safety system and required for all social group is home security. Houses need to be monitored at all times such as from theft, fire and short circuits. Recently, the rate of crimes involving robbery, murder and fires is increasing and worrying all of us. So, home surveillance system must be upgraded to be more effective to keep up with the increasing crime rate.

Various methods can be done to improve home security monitoring including the usage of security officers. However, this method is not suitable for all levels, wasteful and less reliability. All these improvements need to work more effectively, giving advantages to the user and can monitor without any errors that may hinder the security process. At present, a lot of study on smart home systems has been done and it covers all aspects. For example, smart home systems study in terms of multimedia, security monitoring, lighting, temperature control and others. In a smart

home system, manual methods are no longer used and replaced by an automated system that helped users to monitor the condition of the house, thus facilitating and speeding up daily works. Automatic system can prevent the effects of human error and saving electricity.

Problem statement: Security monitoring system requires data transmission system fast receiving data and accurate at a certain distance, so that users can place devices freely at important locations for the data display receiver. In other words, this system must be portable and user friendly. Display system is shown to be straightforward and easy to understand, so that users can take important immediate action. The system must not be hacked by anyone, no matter in various ways including on input source power, the content of data transmission, content of receiving data and location of security sensor device's main processor is stored. The system must also have characteristics such as water-resistant, high temperature resistant and robust, so that data transmission process and data receiving will not fail. Many of other security systems have some limitations on the usage of sensor devices. These problems will result in limitations of the security system. However, it is inevitable that a security system requires extensive use of sensors for the system to operate efficiently and be able to detect objects in every

Corresponding Author: Mohammad Syuhaimi Ab-Rahman, Department of Electrical, Electronics and System Engineering, Faculty of Engineering and Built Environmental, University Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia

area of the house. The use of sensor devices is also very important in security systems. Sensors must be sensitive to human motion. Sensors must be working on the most appropriate range, that is not too close and too distant to detect movement and should be according to the human nature.

Related work: Bridgwater (2005) justified the use of ZigBee in wireless systems in Hotels wireless system management. Bridgwater listed possible usage of functions that are possible to be implemented wirelessly. He has also showed how the wireless system can be implemented using ZigBee. Culter (2005) aimed to preserve existing industrial automated networks to save cost. He uses compatible address between Modbus and ZigBee to demonstrate that ZigBee can be integrated into the traditional system. Egan (2005) stated his opinion from the commercialization point of view. He stated the advantages of ZigBee and argued that ZigBee will become more and more popular in Building Automation and Industrial Control applications. Cox *et al.* (2005) worked on time synchronization for ZigBee Networks. They have implemented a protocol called Flooding Time Synchronization Protocol (FTSP). They have found that the slave node's error is always smaller than 61 μ s. Evans-Pughe, 2003 reviewed on ZigBee. He stated the advantages of ZigBee in terms of cost, power consumption, reliability. He predicted that ZigBee will experience tremendous growth in the near future. the WDM-POF and FTTH-PON which introduced many excellent features to home network today; such as high bandwidth, immunity, safety and survivability. The system is also able to be integrated with any home security system to enable the home status be monitored on-line through telephone or internet. This is a new era of home network systems.

Problem solving: The use of ZigBee Pro device known as Xbee Pro is a device for sending and receiving wireless data. Xbee Pro is able to send and receive data in range of about 1.7 km without barriers, work quickly and at low power. So the display and acceptance of data can be done at a location that is not limited in the house. The data receiver can be taken anywhere and does not affect the operation of sending and receiving data. The data receiver can be considered as portable and user friendly. Display process is made on a relatively large size in order to provide a clear picture of invaded sites. LED is used as a main device to display data for users. The characteristic of LED which produces a clear and bright light is suitable for long

distances to the user's observer. The use of the beeper alarm also can be added as a tool to inform the consumers. Among the ways that can help to prevent someone from hacking the security system is the programming process should be specific and not known by anyone, so no interruptions of the same data signal received by the microcontroller. If either one has power failure no matter on transmission or receiving data, then the system will fail to function. So the use of two power supplies that works automatically if one is cut off has been designed, so that the intruder cannot defeat the system in power supply source. Data transmission system should be placed in a safe place and cannot be detected by anyone. Places and special containers should be built so that tools are not allergic to water or high temperature. Microcontroller is used as a main processor with a lot number of Input and Output (I/O). The number of these input and output can be connected to the sensor device that used. Thus, the use of many sensors can be applied in order to improve the home security. The best sensor device to detect human movement is a Passive Infrared (PIR). This device will detect the arrival or obstacles that have body heat. The human body has heat content, thus it can be detected by PIR sensor when there is a movement of a human.

Objectives: The main objective is to build a security system that can detect human presence around the house and displayed to the user in a form that is easy to be understood. To achieve the main objective, several sub-objectives have been identified:

- Build an interface circuit between microcontroller and Xbee Pro
- To construct transmission and receiver of wireless data
- To build a data display to the user

Tests on the whole circuit connection is done by looking at display effect from instructions that given by using the input from PIR sensor. Each PIR which detects human presence can be seen at their location. The addition of several devices is also needed in order to increase the effectiveness of display such as the addition of an alarm, which will attract the attention of users when PIR has detected human presence.

Analysis on microcontroller input: After completion of the program into the microcontroller memory space, this microcontroller system will be connected to a PC using an RS232 connection. The purpose of this connection is to ensure that the program in the microcontroller can communicate in series with a

computer. Software has used Access Port. Each input will be shown on the display software of port access. If the test was successful, it indicates that the program has functioned well and the microcontroller can communicate in series with a computer. So, Xbee Pro can be connected directly to the microcontroller with additional MAX232 and MAX3232 devices by using the RS 232 connection.

Analysis of microcontroller output: Program receiver will be downloaded into the microcontroller memory space. This microcontroller will be tested on the software effectiveness by using a direct connection from the data transmission microcontroller. When the receiver on microcontroller has received the order, it will serve to light only certain LEDs. This section depends on the input signal.

Result on overall system: To ensure the effectiveness of this system, several tests were done. PIR sensors are connected to the transmitter. Display system and the receiver are placed within 10 m from the transmitter system with wireless communications. A thief will pass through the sensor and the sensor will detect human presence. It continues to light the LED display and shows the location of detected objects. At the same time, an alarm was sounded to give an indication of corruption. The second test is done when there are two thieves who have passed through the sensor; then the display system will directly light the two sides of LED that has been skipped by thieves. This shows that the system can detect the presence of thieves in different locations and presented information to user wirelessly.

Suggestions for improvement: After several tests were done, there are some modifications to increase the sensitivity of the user to display. An alarm has been installed on display circuit and programming has rearranged in order to ensure that these new devices operate properly. The alarm will be activated when one of the sensors detects movement. Therefore, the operator will be alerted and observe the data display more attentively during anomalous events.

Comparison of existing products: Table 1 shows the products named PIR Motion. It has been compared with the product that was released today, PIR Motion and HA Motion.

Flowchart: From Table 1, it shows the difference between products that are reviewed and produced nowadays. The first comparison is on type of display.

Table 1: Comparison of products

Type characteristic	PIR motion	PIR motion	HA motion
Display	LED and sound	Sound	Sound
Type of communication	Wireless	Wired	Wireless
Distance of communication	600 m	-	92 m
Power source	2	1	1
Number of sensor	12	1	1

Many security products use only the alarm for notification to the user and it cannot show the specific location where the object is detected to be around the house. PIR Motion microcontroller serves to inform the user where the object is detected by use of LED and alarm. While PIR Motion microcontroller using wireless communication with the display system and there are also other products that using this communication. But with the use of Xbee Pro, communication distance between the display and sensor is 600 m and it is different from other products that have shorter distance. In case of power source, the PIR Motion microcontroller has two power sources compared to others and it is functional to operate even when there is no electricity. The number of sensors used for product X is enough in order to monitor around the house compared to other products. As a result, a lot of features and characteristics have been improved (Fig. 1).

Motion sensor: Movement can be detected by calculating changes in speed or vector of the object. This can be done using electronic devices that can measure changes in a particular environment. There are basically three types of sensors used in the motion detector spectrum.

- Passive infrared sensors: effects of body heat, no energy are transmitted from the sensor
- Ultrasonic: sending a pulse and calculate the reflection from moving objects
- microwaves: sensor sends a microwave pulse and measuring the reflection from a moving object

Passive Infrared Sensor (PIR): Passive Infrared Sensor (PIR) is an electronic device that can measure the transmitted infrared light. The term passive in this regard should be translated that the device does not emit infrared rays PIR but only passively receive incoming infrared radiation. "Infra" Wilkins below our ability to detect visually and "Red" because this color represents the lowest energy level that we see before it becomes invisible (Fig. 2). The PIR can be used to detect movements, normally used to detect human movement when passing in or out of range sensor. PIR is a small, cheap, low power, easy to use and durable. PIR is basically made of pyroelectric sensor that can detect infrared radiation levels.

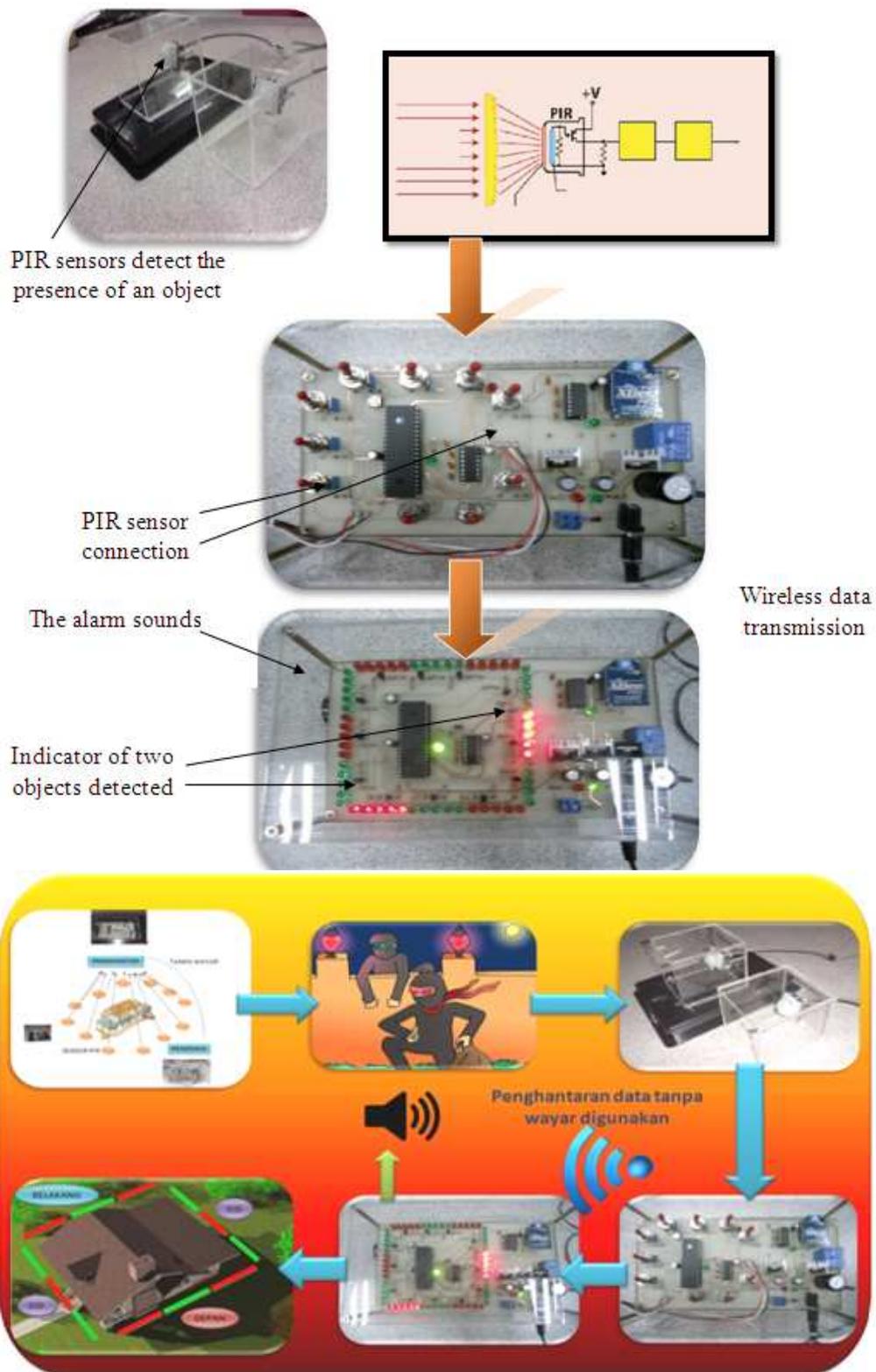


Fig. 1: System flowcharts that applied at home

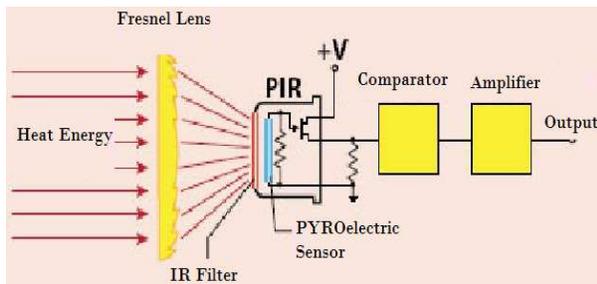


Fig. 2: PIR structure

Table 2: Product comparison

Type	PIR motion	HA motion
Feature display	Sound	Sound
Communication type	Wire	Wireless
Communication distance	-	92 m
Source	1	1
Number of sensor	1	1

How PIR works: Body temperature is usually around 37 degrees Celsius higher than the background temperature. When people walk past the sensor, high temperature will result in higher charges in pyroelectric material. Small signal generated by the amplifier circuit will be expanded by adding infrared energy and connected to the comparison of the difference (differential COMPARATOR). The comparison is used to distinguish the signal from the reading before giving output.

However, this simple arrangement can operate and monitor from any other sources of a sudden temperature change, such as flash or bright lights or reflections of objects in hot weather. Several techniques are used to reduce the error due to external interference. First, the human body radiates infrared energy waves of 9-10 um. Thus, an infrared filter that can pass between the wavelength of 8-14 um placed in front of the sensor to increase the sensitivity of infrared energy from humans. Second, the infrared energy that is placed in front of the sensor has two purposes. It will focus the infrared energy emitted over a wider area into the sensor and is divided into zones of cold and heat sensitivity. When a person walks past the zone, the sensor will see changes in the infrared and will result in variations of the output signal from the sensor movement. Comparison will see and will act to change this signal. Hot things that do not move, such as light, will not be producing a variety of products. Comparison ignores the infrared source is not changed.

Compared with existing products: There are two product safety system is used for comparison of important functions in the development of a security system. The first product is the PIR Motion and a second product is HA Motion is a product in the market

today. Table 2 below is a comparison of the functions and features available in a security system.

From the Table 2, both products showed different characteristics such as type of display used only alarms that sound when the sensor detects movement. From this comparison, a study should be done to produce a more effective security system compare to the products in the market today.

Problem and solution: During this study, several problems were encountered:

- Lack of references to Xbee Pro. Xbee Pro is a radio frequency device that is new and it still being studied because of its rapid development nowadays. However, this problem can be solved with a lot of testing and trial that have been done
- Difficulty in making printed circuit boards. Printed circuit boards for combined receiving and data display system is difficult to be done. To solve this problem, the use of two layers printed circuit boards is applied
- The difficulty of using appropriate sensors and is only able to detect human presence. Then the usage of PIR sensor has been applied in order to solve the problem because the sensor is not active against objects such as rocks or cars

CONCLUSION

Overall, this study has been completed properly. All sub-objective of this study has been completed, thus resolved the main objectives and research problems. This system managed to help users to detect human presence around the house precisely. The use of wireless connectivity based on microcontroller facilitates the installation process at home and can prevent anyone hacking into security systems. This system is a system that meets recently smart home applications in order to function in automation situation. During the study, a lot of knowledge and experience have been learned. Besides the exposure on microcontroller, this study also has much exposure to radio frequency technology which is Xbee Pro, where it helps in the transfer process for the wireless signal. This device has helped the development of security systems with its high-tech features.

Recommendation on scope of study: This program should be reviewed in order to improve the information display in terms of accuracy in the future. This study also can be continued in future to make improvements into the existing studies. Some suggestions for improving this study area:

- Increase the number of sensors to enhance the security features
- Implement a different variety of sensors in order to detect certain objects
- Use camera to capture images when PIR detects an object and use LCD monitor for image display
- Use GSM module so that data can be sent to the consumer by using a telephone line in long distance

Culter, T., 2005. Successfully deploying Zigbee in industrial automation networks. *J. Technical Papers ISA*, 459: 934-942.

Egan, D., 2005. The emergence of ZigBee in Building Automation and Industrial Control. *Comput. Control Eng.*, 16: 14-19. DOI: 10.1049/cce:20050203

REFERENCES

Bridgwater, J., 2005. Wireless systems management in hotels with Zigbee technology. *J. Elect.*, 22: 42-43.

Cox, D., E. Jovanov and A. Milenkovic, 2005. Time Synchronization for ZigBee Networks. *Proceedings of the 37th Southeastern Symposium on System Theory*, Mar. 20-22, IEEE Xplore Press, USA, pp: 135-138. DOI: 10.1109/SSST.2005.1460892