Wi-Fi and GSM Based Motion Sensor for Home Security System Application

Mohamad Huzaimy Jusoh¹ ², Muhammad Firdaus Bin Jamali ², Ahmad Faizal bin Zainal Abidin¹ ², Ahmad Asari Sulaiman¹ ² and Mohamad Fahmi Hussin¹ ²

¹Applied Electromagnetic Research Group, Advance Computing and Communication Communities of Research, ²Faculty of Electrical Engineering, Universiti Teknologi MARA Shah Alam, Selangor

E-mail: huzaimy@salam.uitm.edu.my

Abstract. The Wi-Fi and GSM based home security system is a system designed to reduce the high rates of crimes in most personal housing. The overall project consists of three major parts; the input part that consists of sensors, the software part that operates the entire hardware structure, and the output part, which consists of camera, alarm system, and micro secure digital (SD) data storage card. It is based on the principle of infrared radiation generated by a human body heat which trigger the passive infrared (PIR) sensor. The microcontroller processes the received signal, then trigger the buzzer alarm, camera and alerts the home owner through an SMS. Once triggered, the camera will capture the image of the intruder and the image will be saved in SD card. As alert to the user (away), the Global System for Mobile Communication (GSM) will send the Short Message Service (SMS) from the device to the user's mobile phone. The image will be sent to Dropbox data cloud storage via Wi-Fi for further clarification. The prototype was successfully developed, tested and has been installed at residential area in Taman Cahaya Alam, Section U12, Shah Alam, Malaysia.

1. Introduction

In this modern day of digital technology, home security system is becoming one of the fastest developing application based technologies in the world because human needs for their living and property crime protection. The concept of this project is to integrate wireless technologies on the system and powered with clean renewable energy. Wi-Fi is a technology that allows electronic device to exchange data wirelessly via radio waves. Network access point (or hotspot) has 20 m (65 ft) range indoors and a greater range outdoors. However, most of security systems available in current market, needed wiring, expensive, bond with a contract, complex system, bulky size, and fixed. Hence, a comprehensive portable and simple security system should be develops to fill these loophole gaps. The implementation of this project is to provide the user monitoring ability of their premises from anywhere in real time, alert the user through SMS and photo capture based on plug and play system. From the paper [1], the authors propose a system which is works when there is a breach attempt at the house area, the owner will be alerted through e-mail and message is sent to home owner instantly. However, there is a lack of function camera capturing application. In paper [2], the system used the camera to capture the image when the sensor is triggered without real time notification to the owner. From the paper [3], the proposed system contains three kinds of security sensors. When any of these three sensors triggered, the alarm will triggered. In paper [4], the system is developed by using
wireless sensor network based on the Zigbee technology. Besides, the system used the GPRS network for monitoring application. In paper [5], the security system consist of sensors, buzzers, relays and the owner will be alerted through SMS, alarm and e-mail. This developed Wi-Fi and GSM based motion sensor for home security application project aim is to comprehend the existing security system.

2. System Design
The initial system was designed by using block diagram as shown in Figure 1. The system consists of two parts which are transmitting and receiving part. For transmitting part, the motion sensor, camera, RF transmitter, SD card, solar panel and battery are connected to the microcontroller. RF link Transmitter and Receiver act as the medium of the data communication between the sensor and the microcontroller. At the receiving part, the system consists of RF receiver, alarm and GSM module.

![Figure 1. System Block Diagram](image.png)

2.1 Arduino Yun Prototype Board
The Arduino Yun is a prototype board consists of one microcontroller; Atmel Atmega32u4) and one Wi-Fi System-on-Chip (WISOC); Atheros AR9331. It features built-in Ethernet (IEEE 802.3 10/100Mbit/s) and Wi-Fi (IEEE 802.11b/g/n) support, 2.0 USB-A port, micro-SD card slot, 20 digital input/output pins, 16 MHz crystal oscillator, and micro USB connection. This board is used as a processor unit for transmitter system.

2.2 Atmel Atmega328P Microcontroller Development Board
Arduino Uno Board functioning as microcontroller processor unit for receiver system. The microcontroller board operates at 5V. It has 32 KB flash memory in which 0.5 KB of it used for boot loader, 2 KB of Static Random Access Memory (SRAM), 1 KB of Electrically Erasable Programmable Read-Only Memory (EEPROM) and 16 MHz clock speed [6]. This development board features six analog-to-digital converter (ADC) pins, six pulse width modulation (PWM) pins, 14 digital input/output (IO) pins, 5VDC voltage output pin and 3VDC voltage pin. The small physical dimensions; 68.6 mm × 53.4 mm and 25 g in weight enhance the device portability.

2.3 SIM900 Quad-band GSM GPRS Module
The SIM900 Quad-band GSM GPRS module delivers GSM/GPRS 850/900/1800/1900 MHz performance and it provides service for voice, SMS and data [7]. AT commands are used to interface, configure and control the GSM GPRS shield. The GPRS Shield consists of 12 GPIOs, embedded TCP/UDP stack, speaker jack, headphone jack, SIM Card holder, GSM Antenna and ADC [7]. This module powered by 9VDC.
2.4 Passive Infrared (PIR) Motion Sensor
Passive infrared (PIR) sensors detect motion by comparing the amount of infrared radiation that reaches on a pair of detectors. When the two detectors read different values, the sensor indicates it as movement of an object, such as a person. The sensitivity of the PIR motion sensor can be up to 7m. The angle of detection is about 120°.

2.5 RF Link Transmitter and Receiver
RF link transmitter and receiver are used as a medium of data communication between the sensor and the microcontroller. It consists of two ranges of frequency mode, which are 315 MHz and 433 MHz. The radio frequency operate by applying Amplitude Shift Keying (ASK) modulation technique. These modules have the capability to communicate up to 100m range for open air and 40m for indoor uses. The transmitter operates from 3-12V.

3. System Design
The microcontroller at transmitter system (shown in Figure 2 (a)) will connect to the network and then calibrate the PIR motion sensor to avoid false trigger. When PIR motion sensor detect any physical motion, the LED indicator will turn on and the signal will be transmitted from the RF transmitter to the RF receiver at the microcontroller. Next, camera will capture image of the intruder. The image will be saved on the SD card and will be uploaded to the database via Wi-Fi. The image quality depends on the internet access speed and Wi-Fi signal quality. The user enable to access the intruder image on the website database. The microcontroller at receiver system (shown in Figure 2 (b)) processes the received signal, turn on LED and triggers alarm for 15 seconds. The microcontroller will send a short messaging service (SMS) text to inform the user via mobile phone to notify invasion. The buzzer and LED will be turn off if there is any signal received by the microcontroller.
4. Methodology

4.1 Project Development

At the beginning of the project, the background of the related field has been studied to collect data and generate the ideas. Based on the survey on the current home security in market today, there are still have some loophole and could be filled. The idea in here to design and implement a wireless sensor home security system using clean renewable energy. The next step is designing the overall system including the system functionality and specification. The components of hardware that will be used for this project is studied and chose according to the specification, flexibility, cost and user friendly, which comply with engineering economic management.

After one month performing system evaluation, the system finally works properly and meet the project objectives. Then, the system undergoes laboratory analysis and measurement to obtain the result for technical paper writing. After the laboratory evaluation done, the system was installed at Taman Cahaya Alam Section U12 residential area. After the site testing done, the feedback from the owner of the tested house was collected for system upgrading and improving. From here, we could know the ideal home security system.

4.2 Testing and Troubleshooting

First problem was the GSM did not send the SMS to the user when the sensor was triggered. The solution of the problem is by using the GSM_GPRS_GPS_Shield_GMSHIELD Library since the GSM shield don’t have its own firmware c-language library. The second problem is the camera did not capture the image when sensor was triggered. This issue was happened because there was a loose wire connection between camera and microcontroller. The third problem happened when the buzzer was not working properly. The issue was overcame by changing the buzzer.

4.3 Installation
Figure 3 shows that the sensor device had been installed at the residential area. The sensor was installed at the height of 4.2m to avoid intruder easily terminate the sensor. The sensor will be triggered if someone located at the range of the angle $\alpha$ which is $85^\circ$.

![Figure 3. Horizontal detection angle and distance](image)

In Figure 4, the blind spot is at the angle $\beta$ and the minimum distance of detection is 1.5m.

Hence, the sensor disable to detect movement at 1.5 m distance and 35$^\circ$ angle. The sensor should be installed at the angle $\gamma$ of 55$^\circ$. The angle $\beta$ can be reduced by facing the sensor toward the ground to increase the angle of detection. However, this procedure will decrease the distance of detection, the maximum distance of detection is 5.5m from the sensor. Any motion in this distance will be detected by the sensor.

![Figure 4. Vertical detection angle and distance](image)

The solar panel is installed on the house roof. The distance limit of transmitter and receiver must not be exceed 40 m.
5. Result and Discussion

5.1. Testing and Measurement

Figure 5 shows the graph of the voltage versus time of the PIR motion sensor and RF transmitter. The X-axis represent time and Y-axis represent voltage of the PIR sensor and RF transmitter within duration of 45s. The graph show the voltage value increase from 0V to 3.27V when the sensor is triggered. The data will be sent from RF receiver for 2 seconds duration. The voltage will be drop to 0V after 40s. This indicates that the sensor is now at the off state or no movement is detected.

![Figure 5. PIR motion sensor and RF transmitter response graph](image)

Figure 6 show the graph of voltage versus time of the RF receiver and alarm. The X-axis represent time and Y-axis represent voltage of the RF receiver and alarm within duration of 45s.. During 5s to 6s, the graph indicates that there will be a sending data from the RF transmitter. When the motion sensor detects the motion, the signal will be transmit to the microcontroller. The graph shows 4.8V indicates that the alarm will be turned on by the microcontroller. After 15s, the voltage will be dropped to 0V. This indicates that the system is on the standby mode.

![Figure 6. RF receiver and alarm response graph](image)

The PIR motion sensor is chose as the main proximity sensor due to low cost, low power consumption, and small form [8]. The angle of blind spot of the sensor can be reduced by facing the sensor towards the ground to increase the angle of detection. However, this procedure will decrease the distance of detection. Wi-Fi is used to upload the captured image into database compared to GPRS due to size of the picture which is about 80KB to 100KB, depending on the quality, contrast and brightness of the image.
Increasing the sensitivity of the sensor will result the increase of the distance of detection but it will lead the sensor to consume more power. The level of security system will be increased by installing more sensors and camera will result in increasing in power consumption, cost, size and weight of the device. Besides, it wills faster the time on the SD card to reaches full capacity.

6. Conclusion
As the conclusion, the Wi-Fi and GSM Based Motion Sensor for Home Security System has been designed and tested with real time monitoring capability based on renewable energy. With limited budget, it is possible to develop and implement the system. This system will help to increase the safety of the private premises because the user can monitor premises from anywhere in real time. The user can get alert anywhere through GSM technology as long as the mobile communication network coverage is present. Besides, the user is also possible to identify the captured image through database system in real time. With implementation of this system, the security system can be improved to a higher level and educate the community to implement renewable energy concept in daily life. The security could be improved more by considering more detection features. However, this is only a crime prevention and detection mechanism. In order to fully eliminate crime issues, the development on positives human capital and attitudes is the best way of crime prevention solution. this project.

7. References
[1] Assaf M.H., Mootoo R, Das S.R., Petriu E.M., Groza V., Biswas S., Sensor based home automation and security system” Instrumentation and Measurement Technology Conference (I2MTC), 2012 IEEE International, DOI: 10.1109/I2MTC.2012.6229153, Publication Year:2012, Page(s): 722-727
[2] M.Meyer, M. Hotter and T. Ohmacht, A new system for Video-based Detection of moving objects and its integration into digital networks, Security Technology 1996, 30th Annual 1996 International Carnahan Conference (1996), pp.105-110
[3] Y. Zhao and Z.Ye, Low cost GSM/GPRS based wireless home security system, IEE Trans. Consumer Electron, vol.56, no.4, (2007) January, pp. 546-567
[4] Ming Xu, Longhua Ma, Feng Xia, Tengkai Yuan, Jixin Qian, Meng Shao, Design and Implementation of a Wireless Sensor Network for Smart Homes, Beijing 2001 International Conference.
[5] Jayashri Bangali and Arvind Shaligram, Design and Implementation of Security Systems for Smart Home based on GSM technology, International Journal of Smart Home, Vol.7, No.6 (2013), pp. 201-208
[6] M. Banzi, M. Shiloh, Getting Started with Arduino 3rd edition, Maker Media Inc, Sebastopol, California, USA 2014
[7] GSM/GPRS Shield Datasheet, Tynosine (Tinyos) Electronics, Anhui, China, 2014
[8] P. Zappi, E. Farella, L. Benini, Tracking Motion Direction and Distance With Pyroelectric InfraRed Sensors, in IEEE Sensors Journal, Volume 10, no.9, pp.1486-1494, September. 2010.

8. Acknowledgement
The authors would like to thank Mr Shamry and his colleague from Lui(M) Sdn. Bhd. for participating in series of technology discussions and technical support. The authors also appreciate the cooperative from resident of Taman Cahaya Alam, Section U12 Shah Alam for allowing the premises to be used as test site. Lastly, the authors would like to acknowledge Research Grant 600-RMI/DANA 513/REI and Faculty of Electrical Engineering, UiTM Shah Alam for financial and facilities support in developing this project.