A Multilevel Home Security System (MHSS)

Jer-Vui Lee, Yea-Dat Chuah and Chin-Tin Chai

Department of Mechatronics and Biomedical Engineering, Faculty of Engineering and Science, Universiti Tunku Abdul Rahman, Kuala Lumpur, Malaysia
leejv@utar.edu.my

Abstract

In this project, a multilevel home security system (MHSS) has been designed, developed, tested and validated. MHSS is basically a multilevel security system which consists of different sensor nodes as the input elements while the output elements react to the signal received from the input elements. The sensor nodes consist of a thief alarm, presence detecting circuit and the break-in camera. A UART is applied as the communication tool between the hardware and the computer. A graphic user interface (GUI) is developed and configured which enables the function of capturing images and sending emails. The captured images are delivered to the house owners and the police forces. The task is performed in order to prevent the thieves' invasion.

Keywords: *Home Security System, Sensor Nodes, PIC and UART*

1. Introduction

Home security has been a concern of worldwide. As the technology is emerging every second, abundant home based security systems have been developed and implemented to keep their welfare safe. Home security system is an essential mean of protecting our home from illegal invasion. A conventional home security system consists of a Closed Circuit Television, CCTV and burglar alarm. CCTV captures video in 24 hour to identify what goes on around the house and in the house as well as get a hold of the evidence if there is a house breaking around the captured areas. Burglar alarm acts as the tool to alert the house owners and their neighbors. In additional, it may also chase away the burglar as the system may emit a high frequency sound wave. Nevertheless, the memory consumption is considerably large as the camera keeps recording non-stop. The power consumption is considered as a concern of installing a security system. In this project, a multilevel home security system that sends alert messages to the house owner and police station has also been designed, developed and validated. Section 2 introduces the background of the project. Section 3 introduces an overview of MHSS. Section 4 and 5 discusses the system implementation and hardware & circuit testing respectively. Section 6 makes the conclusions of the project as well as highlights the future work.

2. Background

2.1. GSM/GPRS Based Security System

Based on the IEEE802.11 standard, wireless home network is known as WiFi, which provides a medium for transferring media files [1]. However, it is high cost and high

power consumption. Y. Zhao [2] has developed a low cost GSM/GPRS based wireless home security system which includes wireless security sensor nodes and a GSM/GPRS gateway [2-3]. It has the following features: (a) low cost, (b) low power consumption, (c) simple installation, (d) fast response and (e) simple user interface. In general, GSM modem acts as the interface between the users and the sensors nodes. There are 3 types of sensor nodes applied in the system which include the door security nodes, infrared sensor nodes, and fire alarm nodes. This architecture includes components such as filters, amplifiers, analog to digital converters and communication interfaces. The system used a wireless transceiver module to transfer data between gateway and sensor nodes. Every sensor node comprises a microprocessor and a wireless transceiver module. The function of the microprocessor is to receive and analyze the signal from the sensors' node as well as the current status of the nodes. This system also consists of a sleep timer and switch mode pump circuit, which reduces of the power consumption.

C.K. Ng [4] has developed a wireless security system where an alarm system is programmed in a graphical user interface (GUI). The system is used to monitor the RFID reader, RFID tag and the GSM terminal. The information obtained from the tag is sent to the server in a RF link that is exhibited in a GUI. If the laptop is stolen from the covered region, the alarm system will start to draw attention. Meanwhile, the laptop owner will be notified by an alert message. In addition, the alarm system will not be stopped until the laptop is put back in the covered region, or the program is stopped/terminated.

RFID have been available for many years for reading bar codes RFID tag located several meters away [5-8]. It is increasingly being used in other applications ranging from inventory management to anti-counterfeiting protection. In a wireless security system (WSS) [8], a RFID tag is attached to the laptop and RFID reader is connected to server. If the laptop is stolen from the reader, the alarm system will be triggered to draw attention with loud noise. The laptop owner will be notified with short messaging service (SMS) from the server via GSM module system in a few seconds. Alternatively, it can be improved with Bluetooth technology which is embedded in most of mobile laptop today [9]. The GSM terminal is used as the SMS interface to send messages [10]. Generally the notebook acts as the base station to run the program. Usually GSM terminal comes with a RS232 connector to external terminal equipment, and the Subscriber Identity Module (SIM) cardholder and the external connector [4].

Nakrop Jinaporn [11] has developed a security system against asset theft by using radio frequency identification technology. The system consists of five main parts: (a) RFID reader and tag, (b) GUI, (c) database system, (d) CCTV and (e) wireless transmitter and receiver. The RFID reader is installed at the entrance of the campus and the tags are attached on/in student ID cards and their properties. The program of the developed system has the capabilities of investigating the identification process, database management and controlling function of the hardware.

GUI is used in a vehicle security system where the information is controlled via the GUI [11-12]. The system is activated when the tag is read while the motorcycle is being located within the effective range. The system will automatically record this incident and exhibit the information on the monitor. Any theft occurrence will turn the monitor on automatically with the alarm signal which alerts other systems. When the burglar occurs, the CCTV will also be started for recording is immediately. The motorcycle engine is shut off automatically when the asset theft occurs however this requires a further investigation.

3. An Overview of the Multilevel Home Security System (MHSS)

As shown in Figure 1, MHSS comprises of three major components which are the inputs, main control unit and outputs. Each component contains of its sub-components. The input elements are such as thieves' alarm, presence detecting, and break-in camera that will be triggered if a thief has broken into the covered area. Meanwhile MHSS is divided into three levels where the input elements work simultaneously with the output elements. The inputs elements are formed by the sensor nodes that will react when the system is triggered. Table 1 summarizes the relationship of the inputs and output elements.

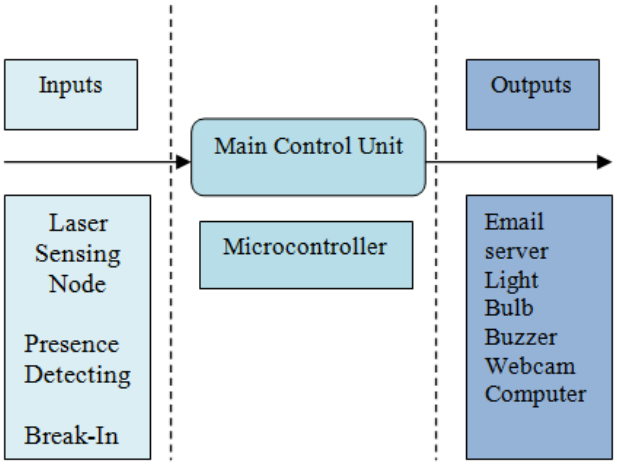


Figure 1. The Block Diagram of the Home Security Systems

Table 1. The Outcomes of the Triggering from Inputs

Inputs	Outputs	Explanations
Laser sensing node	Light Bulbs	When the circuit is triggered, a signal is sent to the main control unit, and then first set of light bulbs is turned on.
Presence detecting	Light Bulbs	When the circuit is triggered, a signal is sent to the main control unit, and then 2nd set of light bulbs is turned on.
Break-in node	Webcam, light bulbs and computer	When the circuit is triggered, a signal is sent to the main control unit, and then the 3rd set of light bulbs is turned on. The camera will start capturing images when the third level is violated. The captured images will be delivered to a specified email through the server.

4. System Implementation

4.1. Electronic Circuit Design

MHSS is divided into three levels as shown in Figure 2. Each level has different sensor nodes which identifies of stimulants. Each electronic component serves its role

based on the arrangement of the respective location. Each component is placed according to system level.

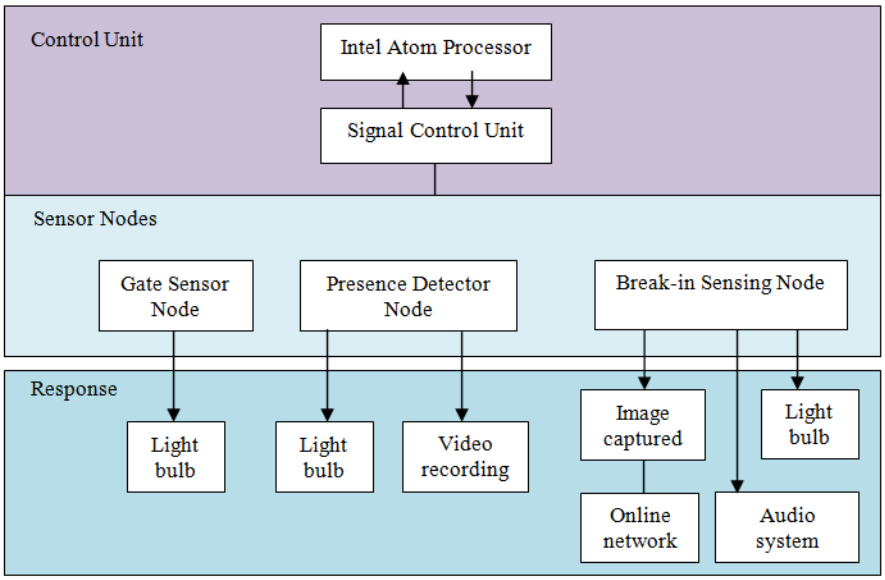


Figure 2. Overall Block Diagram of the Multi Level Security System

4.1.1. System sensor nodes: As shown in Figure 3, 6v power source is supplied to power up the system. The output of each level of MHSS is passed to a PIC that will trigger the following tasks such as turn on the light bulbs and switch on the camera and sending emails. The output signal of each sensor is directed to PIC, and then the "high" or "low" signal will be delivered to the Intel Processor and eventually interpreted in a developed graphical user interface (GUI). A responsive signal will return to the output components such as light bulbs, buzzer and webcam to perform the appropriate programmed functions.

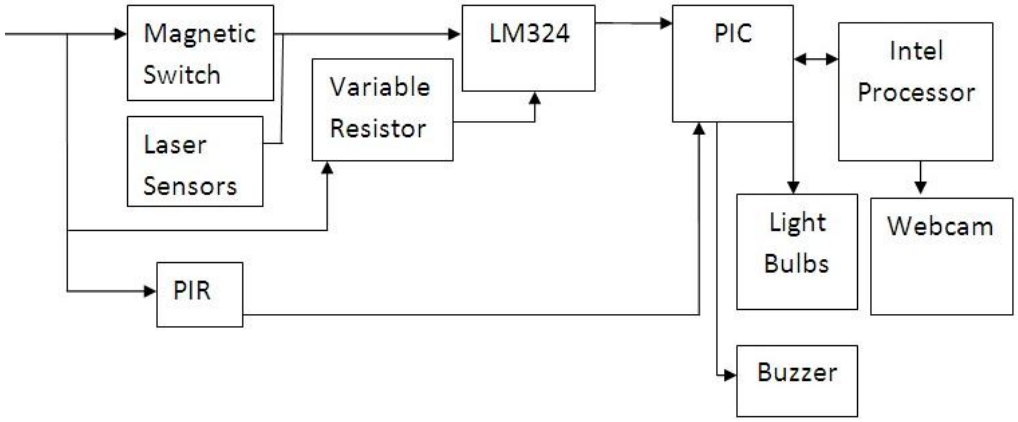


Figure 3. Block Diagram of the Electronic Components Arrangement

4.1.2. Gate Sensor Nodes: The circuit is positioned as the first level of MHSS which acts as the indicator. Light Dependent Resistance (LDR) is put at a location where it can detect thieves. Laser diode is used as the light source and the laser beam is adjusted with a reflector to make the beam fall on the LDR. An input source of 5 V is supplied to the laser sensor and LDR. They are arranged in a manner that when the laser beam is blocked by a thief, an output approximately from 3.5 to 4 V is supplied to the LM324, then it will be compared with the reference voltage of 2.5V. Generally, 5V will be supplied by LM324 to the microcontroller as a high signal. The laser sensors can be placed on the wall of the house yard. The output of the sensor, 5V will be directed to the PIC and the responding signal will turn on the light bulbs that placed at the sides of the entrance.

4.1.3. Presence Detecting Node: A passive infrared sensor (PIR) is placed at side of the house yard and the central position of the wall. It acts as the second level of MHSS. The sensor output voltage is 0.3v when there is no motion detected. When the sensor senses the motion of a thief, its output range of 3.3 to 5v and it will be sent to the signal control unit. Then, it will be processed in the CPU and eventually it will make the webcam start recording.

4.1.3. Break-in Sensing Node: The principle of this stage is similar to the first stage. The magnetic switch is supplied with 0 signal and the output will be compared with a reference voltage of 2.5V. When the magnetic switch is opened, an output range of 3.5 to 4v is supplied to LM324 for comparison. Then LM324 will send an output, 5V to the microcontroller. The output is treated as a high signal, the microcontroller eventually send an output of 5V to the LEDs and the buzzer as the responding action to the input signal.

4.2 Microcontroller and UART

The microcontroller used in MHSS is PIC184520 from MicroChip Inc. as shown in Figure 4. This microcontroller is interfaced to a PC via the Universal Asynchronous Receiver/Transmitter (UART). UART takes bytes of data and transmits the individual bits in a sequential fashion. Since the microcontroller makes use of Transistor-transistor Logic (TTL) level of UART while the PC serial port uses RS-232. Since both standards uses similar software protocol, both of them are able to communicate via UART.

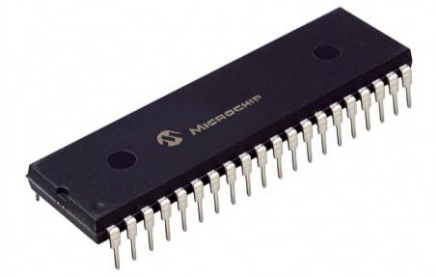


Figure 4. PIC184520 from MicroChip

UART enables the communication between the sensor nodes and the GUI to be established. UART is configured so that the functions developed on the GUI can be corresponded to the stimulated signal triggered from sensor nodes. The analogue signal is sent to UART. Then the "high" or "low" signal is delivered to the CPU and the GUI will translate it into an ASCII code as programmed. Then the functionality is based on the ASCII code will be returned by the GUI.

4.2.1 PIC Programming: The process is initiated by a power source switch as shown in Figure 5. The triggering of each sensor node results in different sequential actions that are aimed to chase the thieves away. The triggered signal will be sent to a microcontroller to be interpreted. Then a responding signal is directed to output components like light bulbs and buzzer. In the first level of MHSS, the laser sensing sensor is in the standby mode where the sensor is actually waiting for the triggering of external stimulant which refers to the thief's breaking-in e.g. the gate is opened or the wall is climbed over without switching off the main power source of the system. Once the first level is triggered, the light bulbs will be turned on by the responding signal which directed from the microcontroller unit after receiving the triggered signal. This level is basically to alert the house owners that thief has entered the covered area without any authorized mean.

The next flow of the process is followed by the second level of the MHSS where the unauthorized presence of the thief will trigger the second level system which consists of presence detecting sensor node. In the triggering stage of this level, the second set of light bulbs and the camera are turned on. Then, the third level of MHSS makes the light bulbs of the first and the second level to be turned on since the camera needs a higher brightness level to capture the break-in evidence before it is automatically delivered to the house's owner and the law enforcement body. The buzzer will also make noise in this stage.

The triggered signal is given approximately two minutes before the whole system is reset. It simply means that the light bulbs will turn off automatically even without any manual action. Then the whole system is restarted. The whole logic is mainly controlled by the main control unit of MHSS which consists of an 18F4520 microchip. If one level has not been stimulated, then the prompting will loop from the specific stage until the specified period has past. Figure 5 summarizes the process flow of the security monitoring of MHSS.

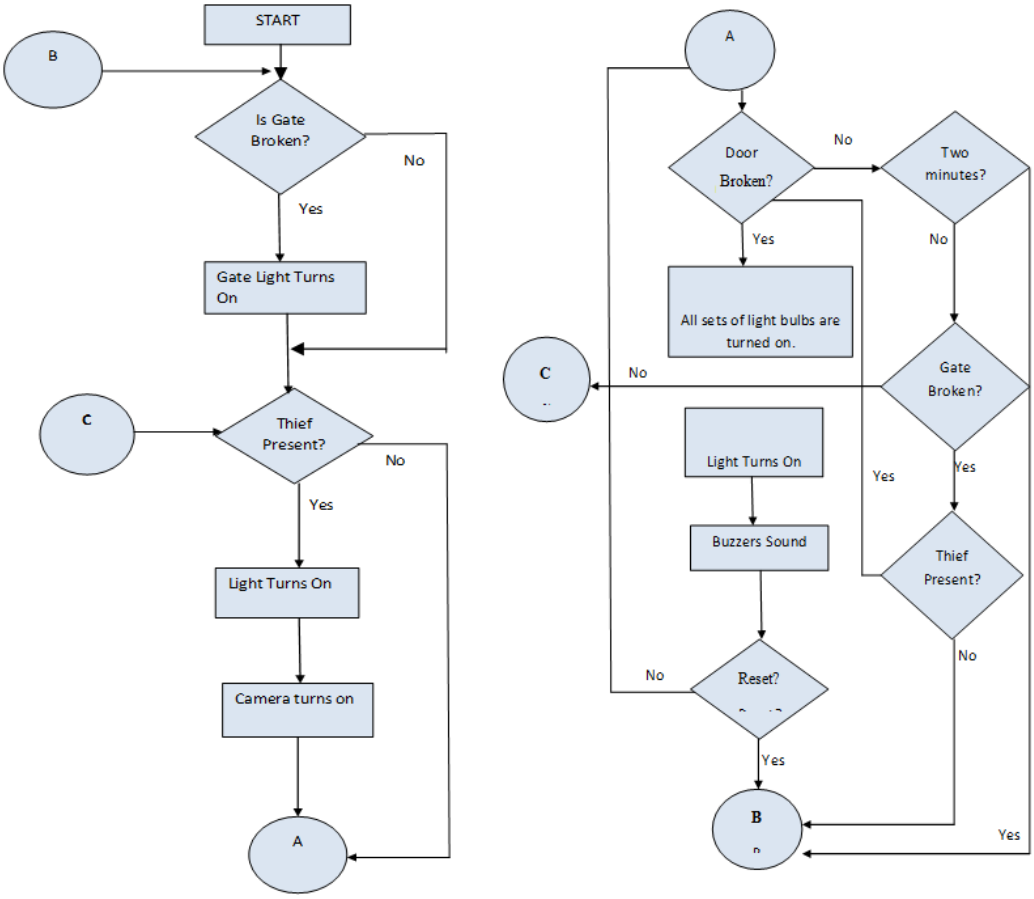


Figure 5. Overall Process Flow of Security Monitoring

4.3 Security System Control GUI

The GUI is developed by using Visual Basic 2010 Express Edition. It is used to display and perform the function that is triggered when the signals are received from the hardware. The signal is sent to the GUI through the signal reflected by the UART which enables the communication between the hardware and the software as discussed in the previous section. This calls the video recording function and image capturing function. It also sends instant messages to the house owners and the police station. As shown in Figure 6, the description of the features is divided into two parts which are section A and section B. The GUI enables the communication between the UART and the computer as well as reading data received from the serial ports.

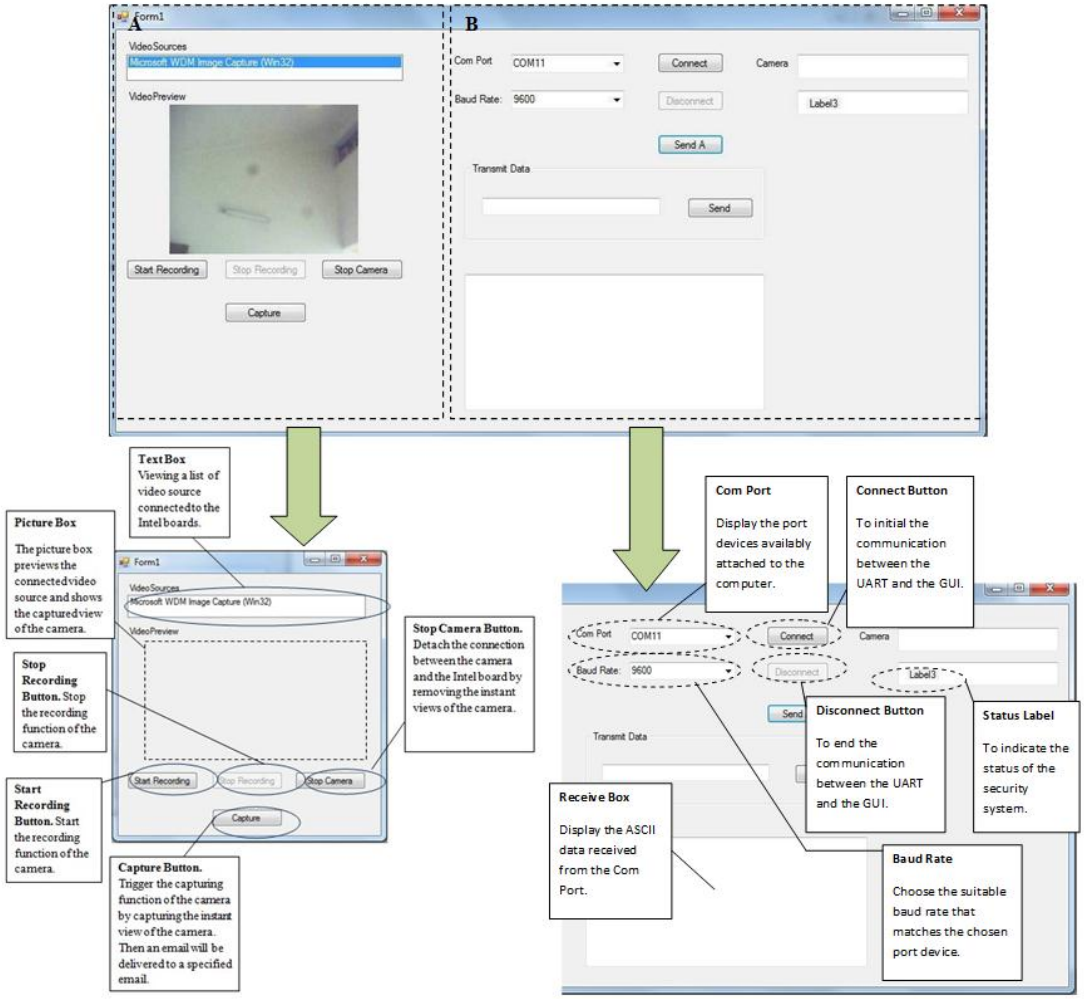


Figure 6. Security Cam GUI

5. Hardware and Circuit Testing

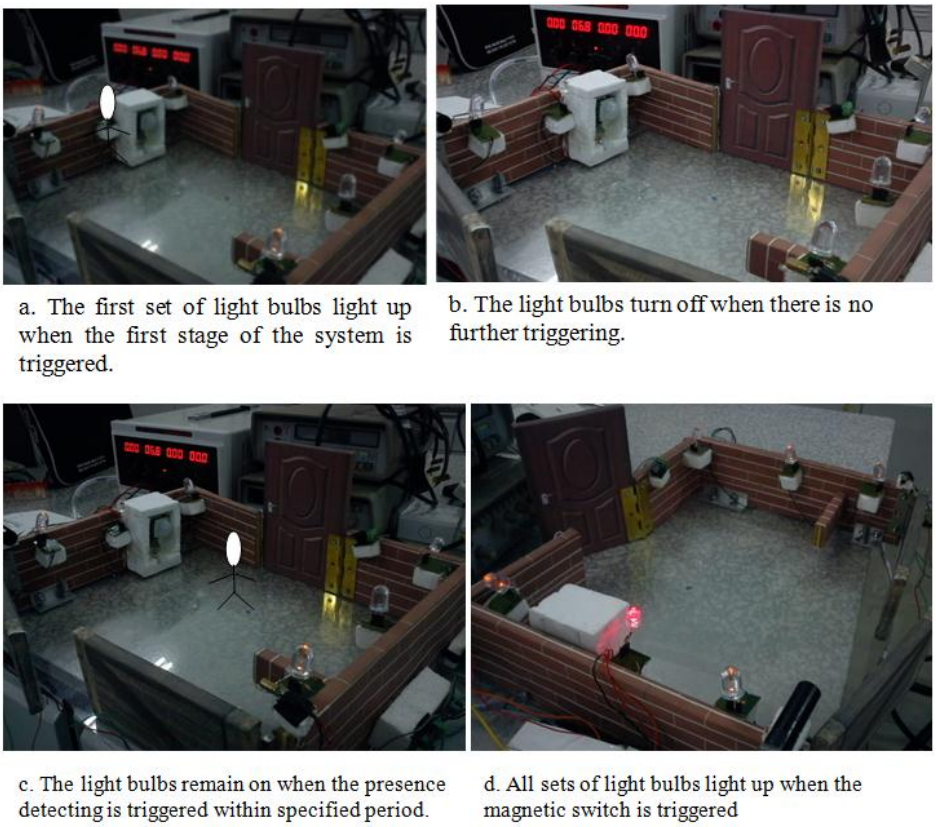
MHSS has been tested at a model of the house yard. The circuitry is integrated with the model to simulate the real multilevel security system. The hardware is divided into three modules which are the input modules, interfacing module and output module as discussed in section 4. The input module consists of laser sensing node, presence detecting node, and break-in sensing node. The interfacing module comprises a UART and a PC. The output modules contain a series of responding components which correspond to the input obtained from the input modules such as webcam, light bulbs and a buzzer.

5.1 System Demonstration

As shown in Figure 7a, the microcontroller sends a high signal output to the light bulbs when the laser sensing node is breached. Then the light bulbs are turned on instantly. The microcontroller is programmed to perform in such a manner that the light bulbs will be turned off if the triggering does not go to the next stage after 3 minutes as

shown in Figure 7b. The output of the microcontroller becomes low after this period. This serves as the purpose of power saving which reduces the cost of the monthly electric bill. The lighting of the light bulbs is to warn the thieves that their presences are known and notified.

The triggering of the second stage of the system retains on-state of the first set of the light bulbs. A presence detector sensor is placed at the central of the house yard. Basically, it detects the motion of the thieves when they pass through the central area of the house yard. The output components such as camera will be turned off when there is no triggering in the consequent stage. The light bulbs are turned on until the power supply is cut off. The light bulbs are turned on and off by the signal transmitted from the signal control unit. This is due to the signal control unit monitors the system's behaviour throughout the whole process of MHSS. When the magnetic sensor is breached, it will send a high signal output to the PIC and the signal will be processed in the GUI and the webcam will capture images then a text message with the attached captured images which will be sent to the users and the law enforcement body. All the three sets of light bulbs will be turned on and the buzzer will start making noises.



a. The first set of light bulbs light up when the first stage of the system is triggered.

b. The light bulbs turn off when there is no further triggering.

c. The light bulbs remain on when the presence detecting is triggered within specified period.

d. All sets of light bulbs light up when the magnetic switch is triggered

Figure 7. The Simulation of MHSS

5.2 Software Simulation

The operational process of MHSS has been validated by software simulation on Proteus 7 Professional as shown in Figure 8. The system is simulated using a push button while the LEDs denote the output components of the system. The simulation is carried out as the preparation before real time process is executed. Each button is

connected to different input pins which give different outputs when one of them is clicked. Pressing of each button simulate the triggering of the sensors nodes. The LEDs are turned on accordingly to the triggering button.

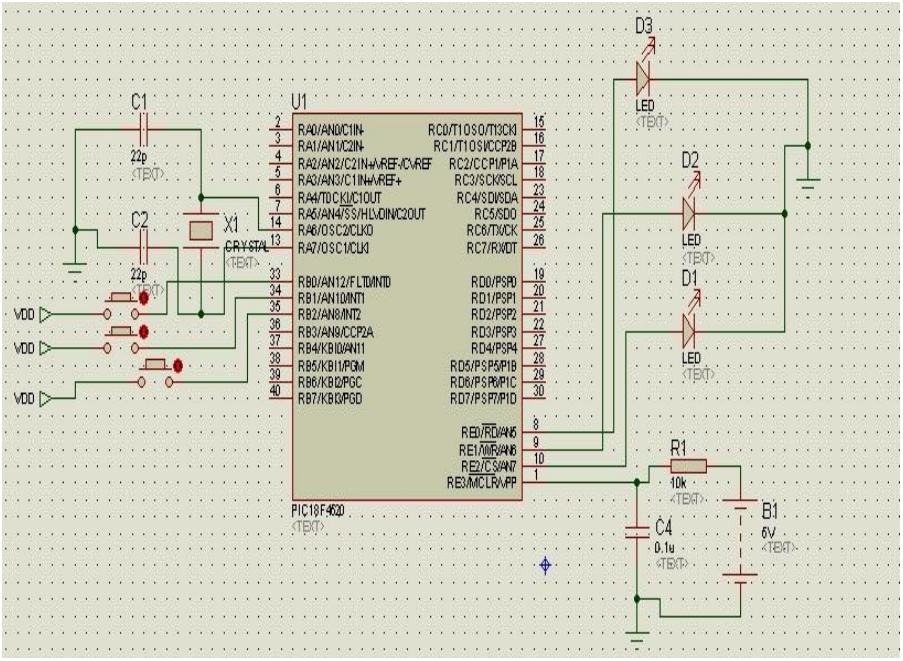


Figure 8. Simulation is Carried out on Proteus 7 Professional

6. Conclusion and Future Work

Multilevel home security system (MHSS) has been designed and developed. The sensor nodes have been introduced and implemented in MHSS. The UART communication between the hardware and the computer has been successfully established and configured which enables the integration of sensor nodes with the computer. The on-state of the camera is controlled by the PIC module through UART. Camera captures images when the third stage is triggered. WIFI is used to send an instant notification email to the home owner and police station. The email is attached with instantly captured images after the third stage of MHSS is triggered. In addition, MHSS has energy saving feature for example the light bulbs are turn off automatically after exceeding a specified period.

At the current stage, MHSS lacks of the certain degree of freedom for the users. For example, the target email addresses where the instant notification email is sent to cannot be changed manually by users. It is proposed to improve the user's preference setting that enables the users to set the target email addresses. In the future, MHSS will include an image processing tool at the entrance of the house. The user's face will be used as the passkey to opens locked door and unlock other security system like alarm systems. Since the application of smart phone has become common which is affordable worldwide, thus it will be used as the tool to control and monitor MHSS by the user remotely.

References

[1] L. Ophir, "802.11 Over Coax – A Hybrid Coax – Wireless Home Network Using 802.11 Technology", Consumer Communications and Networking Conference, **(2004)** January, pp. 13-18.
[2] Y. Zhao and Z. Ye, "A Low Cost GSM/GPRS Based Wireless Home Security System", IEEE Transactions on Consumer Electronics, vol. 54, no. 2, **(2008)**.
[3] A. Alheraish, "Design and implementation of home automation system", IEEE Trans. Consumer Electron., vol. 50, no. 4, **(2004)**, pp. 1087-1092.
[4] C. K. Ng, K. S. Wee, N. K. Noordin, M. I. Saripan and R. Syamsul and A. R. Abdullah, "Theft Prevention using Wireless Security System (WSS)", IEEE International RF and Microwave Conference, **(2008)**, pp. 257-261.
[5] C. C. Tan, B. Sheng and Q. Li, "Secure and Serverless RFID Authentication and Search Protocols", IEEE Transactions on Wireless Communications, vol. 7, no. 4, (2008), pp. 1400 - 1407.
[6] R. Weinstein, "RFID: A Technical Overview and Its Application to the Enterprise", IT Professional, vol. 7, no. 3, **(2005)** May – June, pp. 27 - 33.
[7] K. Domdouzis, B. Kumar and C. Anumba, "Radio-Frequency Identification (RFID) applications: A brief introduction", Advanced Engineering Informatics, vol. 21, no. 4, **(2007)**, pp. 350-355.
[8] T. Phillips, T. Karygiannis and R. Kuhn, "Security Standards for the RFID Market", IEEE Security & Privacy, vol. 3, no. 6, **(2005)** November - December, pp. 85 - 89.
[9] Y. Tajika, T. Saito K. Termoto, N. Oosaka and M. Isshiki, "Networked home appliance system using bluetooth technology integrating appliance control/monitoring with internet service", IEEE Trans.Consumer Electron., vol. 49, no. 4, **(2003)**, pp. 1043-1048.
[10] Z. Yu, Z. Hou, G. Zhao and X. Zuo, "Family guard against theft and alarm system Based on GSM Modem", Proceedings of the 4th World Congress on Intelligent Control and Automation, **(2002)**, pp. 649 – 651.
[11] N. Jinaporn, S. Wisadsud, P. Nakonrat and A. Suriya, "Security System against Asset Theft by using Radio Frequency Identification Technology", Proceedings of ECTI-CON, **(2008)**, pp. 761-764.
[12] M. Lu, W. Chen, X. Shen, H.C. Lam and J. Liu, "Positioning and tracking construction vehicles in highly dense urban areas and building construction sites", Automation in Construction, vol. 16, no. 5, **(2007)**, pp. 647-656.

Authors

Dr. Lee Jer-Vui is an Assistant Professor in the Department of Mechatronics and BioMedical Engineering, Faculty of Engineering & Science, Universiti Tunku Abdul Rahman, Malaysia. His research interests are in the field of automation and robotics.

Chuah Yea-Dat is the Department Head of Mechatronics and BioMedical Engineering, Faculty of Engineering & Science, Universiti Tunku Abdul Rahman, Malaysia. He is a Chartered Engineer and member of The Institution of Engineering and Technology (IET) UK. His research interests are in the field of mechatronics and biomedical engineering system design.

Chai Chin-Tin is an engineer and graduated student of Department of Mechatronics and BioMedical Engineering, Faculty of Engineering & Science, Universiti Tunku Abdul Rahman, Malaysia. His research interest is in the field of smart home system design and application.