Wireless Patient Monitoring System

N. M. Z. Hashim[1], M. S. Sizali[2]

[1, 2] Faculty of Electronics and Computer Engineering, Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia

Abstract: ***The development of wireless patient monitoring system has been quite intensive in the past decade. Hence, in the present study, a new approach of wireless patient monitoring system was proposed as a prototype to minimize the power consumption and the costing issue. Visual Basic Net. 2010 as the software and Peripheral Interface Controller (PIC) 16F877 microcontroller as the hardware circuit were used to implement the system. The communication between the hardware and software systems is in the full duplex communication via the XBee modules happened. The results show that XBee module is successfully communicated with the whole system and the monitoring software is in the best condition to be implemented. Since the prototype using variable voltage, good comparison with the experimental and previous studies shows that the present study can be improved by using the real ECG machine so that the system can be ready to the real user.***

Keywords: Full Duplex, Microcontroller, Wireless Monitoring System, Zigbee

1. Introduction

The Zigbee is a short ranged communication protocol with a reliable, cost effective, low power, and wirelessly connected product in monitoring and control applications which are based on an open global standard. The Zigbee protocol is based on the IEEE 802.11.4 standard for wireless home area networks. The IEEE 802.11.4 standard specifies the bottom two layers of the Zigbee protocol. Due to fast communication, easy to operate and low cost the Zigbee is became the choice for implementing the present wireless study. The wireless patient monitoring system monitors the patients 24 hours daily by using computers so that the immediate action can be taken to help the patient. In the normal practice, Electrocardiography (ECG) machine will be used to record and send the patients' heart beat rate data to the computer. In this study, a dedicated machine will be considered as a normal ECG in order to get the heart beat rate data. A variable voltage will be designed by using PIC 16F877A microcontroller as a reading of the patients' heart beat rate according to the amount of given voltage.

Lack number of doctor is the major problem in most of the hospitals. Furthermore a significant difference between the doctor and patient ratio specifically in Malaysia is quite high [1]. The recent experimental knowledge by B. Priya et al. reported details experimental results on the Remote Wireless Health Monitoring Systems [2] used Short Message System (SMS) via Global System for Mobile (GSM) for transmitting the patients' information to predefined mobile number. The output data from the sensors are converted to digital form and the data is read by a Basic Stamp microcontroller which does some processing and was sent through the serial port to the Visual Basic data processing software. Critical values of the measured data can be set and Visual Basic will initiate the communication unit to send SMS to the predefined mobile number.

Other experimental work is Ashwin K. Whitchurch et al. reported in the Wireless Remote Point of Care Patient Monitoring System [3]. The study designed and developed wireless data acquisition from eight patient-worn sensors. This system used Bluetooth technology for communication with a home based monitor which in turn relays this data to the remote healthcare facility using the internet. A few sensors are connected to demonstrate the concept of remote patient monitoring. The system is a Bluetooth enable device based on a Single Board Computer (SBC) running embedded Linux and built around an ARM processor. The data from the patient will be monitored in PC. Xiaoxin Xu Mingguang Wu et al. reported in the Outdoor Wireless Healthcare Monitoring System for Hospital Patients based on Zigbee [4] that the Zigbee-compliant WSN platforms outdoor wireless healthcare monitoring system for hospital patients provides a unique opportunities for sensing physical environment of our daily lives.Lew C. K. and M. Moghavvemi reported through the study of A Simple And Low-Cost Remote Heart Rate Monitoring System, To a Patient [5], which used a portable transmitter, carried by the moving patient send the ECG data to the receiver. It is formed by the front-end module and the FM transmitter. The front-end module is used for ECG wave form detection from a patient's body and signal conditioning. The transmitted signal is received by an FM radio. Two PIC 16F877 microcontroller are programmed for heart rate counting and ECG waveform display. Therefore, two software in Visual Basic language are also developed in order to display the heart rate and the ECG waveform on the computer screening.

Hassinen Marko and Marttila-Kontio Maija reported in the Wireless System for Patient Home Monitoring [6] that the system is managed by wireless data acquisition equipment, a web camera and a suitable data collector device using a PC. The measurement devices are connected to the collector device via Bluetooth. In this system, the data was sent to a server at hospital via General Packet Radio Service (GPRS) connection or Asymmetric Digital Subscriber Line (ADSL). LabVIEW is used in data acquisition and analyzing, control and measurement systems for implementing the monitoring software in this system.

According to all these papers, a convenient wireless patient monitoring system is prepared to allow the system to be used in a wide range of area. The efficiency of data transferring led the Zigbee to be used in this study as to compare to the other wireless technology. Furthermore, the personalized Graphical User Interface (GUI) is important for a system to have for a minimal affect on both the patient and the measurement result. The continuous effort to develop this

system will be very useful in creating a more promising system for the patients and also the versatility of this system could benefit many people. Without a convenient wireless patient monitoring system, the doctor cannot give full attention to the patients at all the times. This system enables the doctors to remotely monitor multiple patients' condition simultaneously, whereas the data obtained from the patient are transferred wirelessly via XBee.

The system development can be divided into three parts. The first part is developing a program for microcontroller, the second part is transmitting the data from microcontroller to the PC using XBee module and the last part is designing the GUI as the interface for the doctors. The scope of developing the system included identifying the suitable method that will be used for designing a pulse which represents the heartbeat. The system design needs to be controlled wirelessly using computer based on wireless protocol and suitable GUI for the user to monitor and save all the data from the patients.

The three objectives for the developing the system are to study and analyze the microcontroller and visual basic software in order to embed all these tools in the system. Secondly is to design a wireless monitoring system using XBee module that can be easier to monitor the patient at hospital. The third objective is to design a friendly user GUI to display the received data as a result of the study.

2. Materials and Methods

2.1. Overall Methodology

The backbone of this study is to develop the hardware and software with the wireless connection that is Zigbee. The whole system is shown as Figure 1 below. The system design begins with a construction of circuit concept including data acquisition from ECG. In this study, a voltage regulator circuit is assumed as the patient's data originally collected from ECG machine. PIC 16F877 microcontroller [7], [8] and XBee module are used as the tools for transmitting the data from transmitter to the receiver. To configure the XBee modules, X-CTU software is required to be installed.

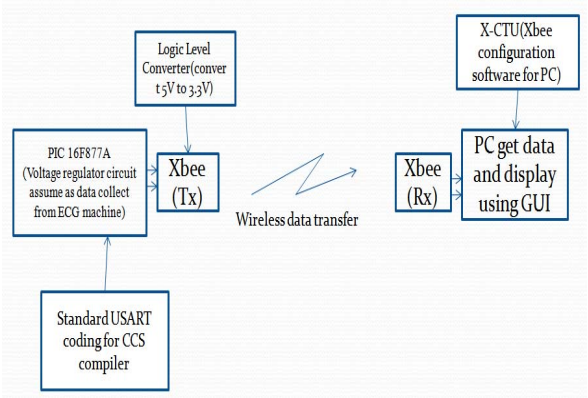

Figure 1: Block Diagram of the system

The both transmitter and receiver XBee Pro series use the same installer to be communicated each other successfully. Data communications between two XBee modules are tested individually to ensure the functionality by entering a simple word to be send to the receiver. Data communications of all the parts involved in this study are tested individually to ensure the functionality. The focus in hardware part is the data communication between the PIC 16F877 microcontroller [9] and the XBee module. The next element to be focused on is the designing the program by using the Visual Basic Net. 2010. A GUI is designed by using Visual Basic Net. 2010 for data viewing toll [10]. The overall flow chart of the study is shown by Figure 2.

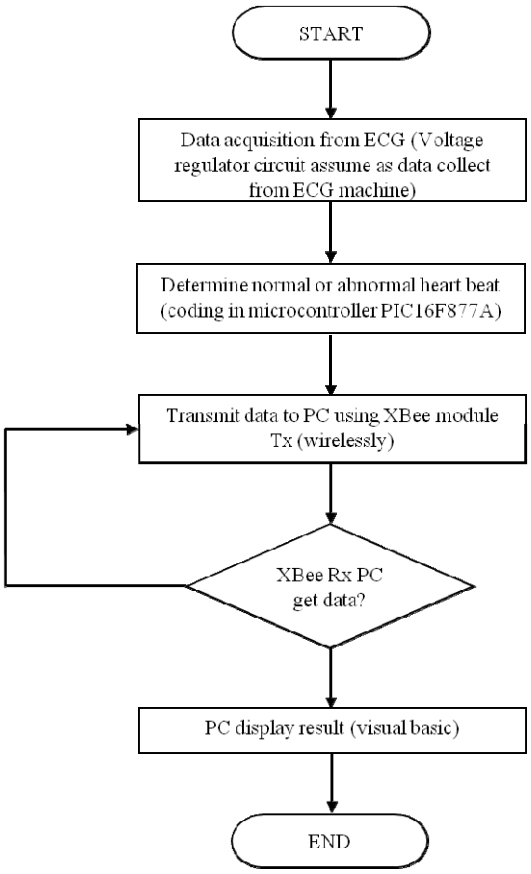

Figure 2: Flow Chart of Project Design

2.2. Designing the circuit

In this study, 4 outputs are used which include the Direct Current (DC) mode. For a DC model, LED will be represented by the indicator for displaying the patient condition whether normal or abnormal depends on heart rate reading from the PIC circuit. In this design, green LED shows that patient is in normal condition and for yellow LED shows that the patient is in abnormal low heart rate. Meanwhile for the red LED, the heart rate is abnormal high. This system contains a buzzer which will notify the doctor or nurse when the patient is in abnormal condition. LCD display will display the heart rate and at the same time it also shows the patient condition whether normal or abnormal. The last output as the GUI is to display the heart beat reading by using Visual Basic Net. 2010.

A few transistors were used to gain the current from microcontroller in order to support the weak current and provide a sufficient current to activate the circuit. Further, diodes also were used to protect the circuit from the high spike voltage and prevent the alternating current (AC) when polarity is mounted in the reverse order on the circuit. The circuit was constructed as in Figure 3 in schematic diagram using ISIS 7. The circuit will be transferred to ARES 7 before etching process.

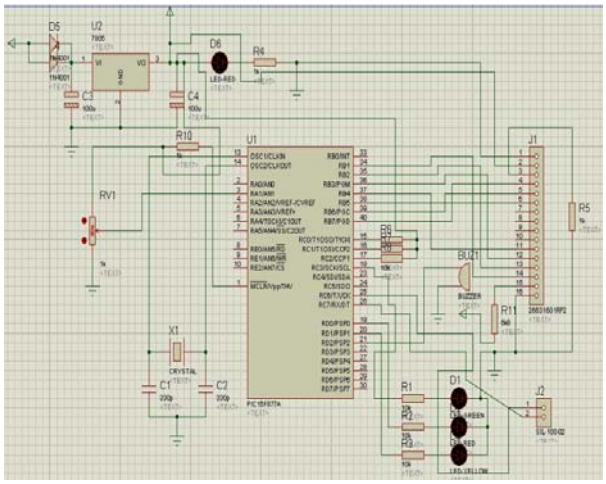

Figure 3: End Device Schematic Diagram

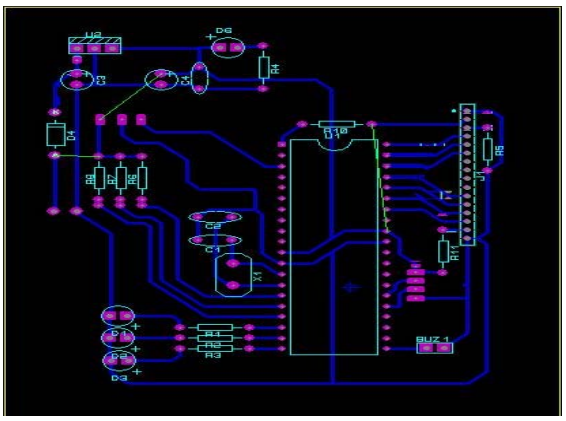

Figure 4: PCB Layout

At the wireless part, there are four pins in XBee module that need to be connected to the microcontroller. These pins are TX, RX, VDD, and GND pins. All these pins will be the medium for transmitting and receiving the decoded and encoded data. VDD is to supply the voltage to power up the XBee Pro module. To avoid any the XBee Pro module damage the voltage regulator is used to drop down the voltage to 3.3V. In this study, PIC 16F877A, a 40-pins PIC was used to operate the end device system since it has many ports and most importantly it supports UART features. Further, this PIC also acts as the heart for end device unit which execute the command from Visual Basic Net. 2010 through serial port communication. The CPU is clocked at 20MHz for full speed operation.

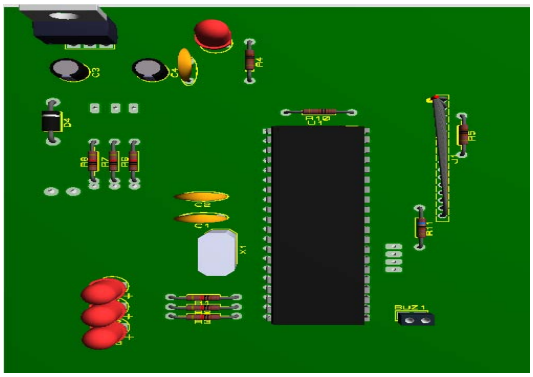

Figure 5: PCB Layout (top view)

2.3. Logic Level Shifting

In designing the end device circuit, PIC16F877A microcontroller requires a voltage from 2V to 5.5V to be operated. Hence, a voltage conversion needs to implement as to meet this requirement and it can be done by using 7085 voltage regulator IC. This type of regulator converts an input up to 35V maximum into steady 5V output as shown in Figure 6. The operation of this voltage regulator was constructed using Proteus 7.

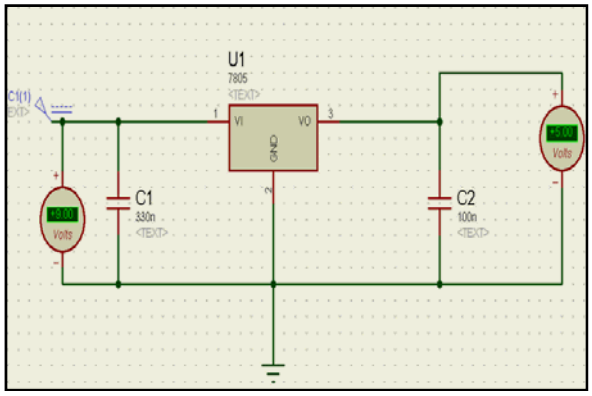

Figure 6: Logic Level Shifting Connection

The same method goes to the XBee Pro module since it operates at 3.3V, but the voltage regulator is change to LM117T voltage regulator IC.

2.4. Wireless Communication Part

The XBee module need to be set before it can be used as serial communication between hardware and software connection. This setting requires an installation of X-CTU software created to configure the XBee module by Digi Corp. Both XBee and XBee Pro series are using the same installer. In this software, it has four tabs that have its own function:

i. PC Settings
   Allow user to select the desired COM port and configure ports to fit the radio settings.
ii. Range Test
   Allow user to perform a range test between two radios.
iii. Terminal
   Allow access to the computers COM port with a terminal emulation program.
iv. Modem Configuration
   Allow the ability to program the firmware settings via a graphical user interface.

For the configuration of XBee Pro module, it can be done by using X-CTU software. The software will automatically detect an available COM port to the user. By clicking the "Test/ Query" button the software began to interact with the module to test the selected COM port. Figure 7 shows the message box appears if the COM ports are OK.

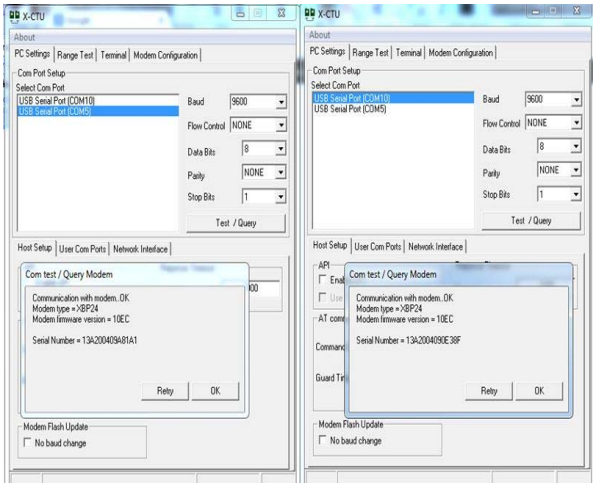

Figure 7: Message Box for COM Port Testing

At Modem Configuration, the specified information about the module can be modified according to user desired. To make a two ways connection between these modules, a few changes need to be done by modified the selected properties as shown in Figure 8.

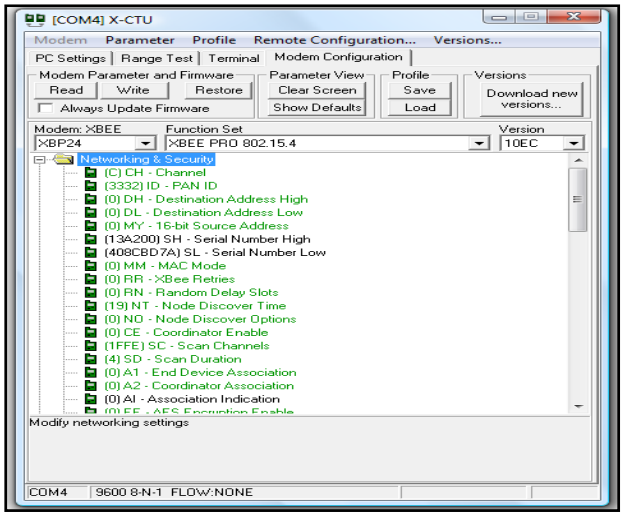

Figure 8: Modem Configuration using X-CTU

As in Figure 8, four properties need to be modified in order to communicate all these modules with each other. The Destination Address High and Destination Address Low are set according to the user, as for this project it is set as 0. This address will be the receiving and transmitting address for the module. In other way, the both modules need to use the same address. Basic configuration of a XBee involves setting XBee module self- address and destination address (the address of another XBee be transmitted to). Table 1 shows the basic configuration of two XBee modules (named XBee #1 and XBee #2) for wireless communication between the both transmitter and receiver.

Table 1: The Concept Of Setting Basic Configuration Of Two Xbee Modules For Wireless Communication

XBee #1	XBee #2
• Setting self-address as “1111”	• Setting self-address as “2222”
• Setting destination address as “2222”	• Setting destination address as “1111”

As seen from Table 1, it is clear that the destination address of XBee #1 is set to match self-address of XBee #2 , which is “2222″ and also the destination address of XBee #2 is set to match self address of XBee#1, which is “1111″. The address matching are very important so that XBee #1 and XBee #2 are able to associate with each other successfully to establish wireless link between them for communication when the system is powered up. Figure 9 shows the Transmitter and Receiver Configuration.

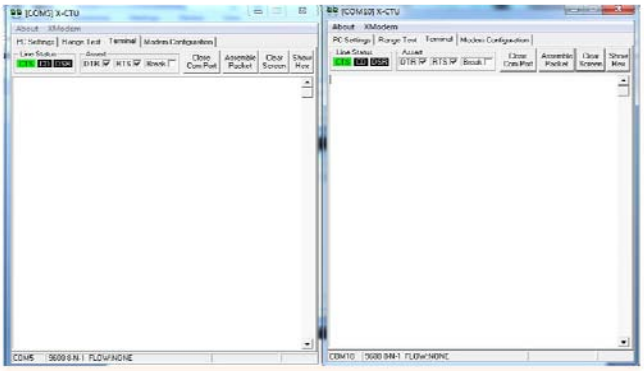

Figure 9: Transmitter and Receiver Configuration

The configurations for communication for both XBee are successfully done as the Figure 10 below.

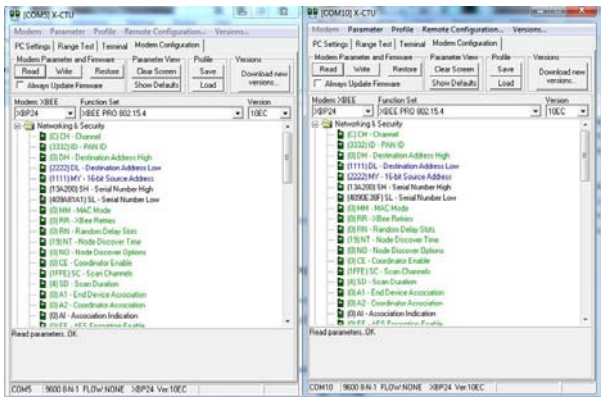

Figure 10: Transmitter and Receiver Configuration

After all the setting has been made, a testing need to be done in order to find out if the communication works. Figure 11 shows the transmitting and receiving data works properly. The blue color represents the transmitting data while the red color represents the receiving data. Thus, between software and hardware communication will works properly through wireless serial communication.

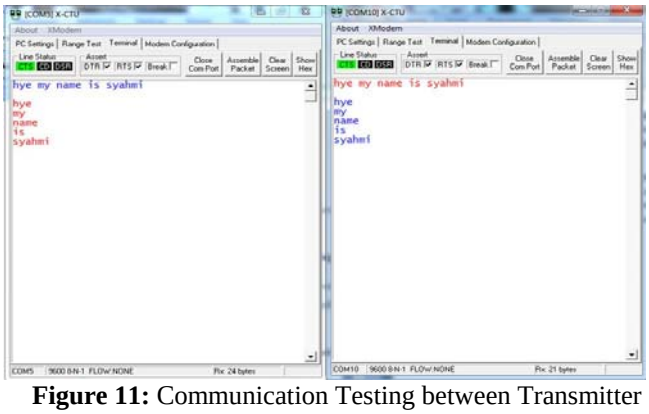

Figure 11: Communication Testing between Transmitter and Receiver

3. Results, Finding & Discussion

In this project, Visual Basic Net. 2010 software is used for monitoring, recording and saving all patient data in the PC. For software design, the GUI display heart rate reading comes from PIC circuit.

Figure 12: GUI display

Figure 12 shows the GUI for heart beat reading which taken from PIC circuit wirelessly, e.g. the number of heart beat is "71" and the patient status is normal. In this system, the value of heart beat reading is set for three parts, abnormal low for heart beat from "0" until "60", normal "61" until "100" and lastly abnormal high is more than "100". The GUI will display the same reading at the LCD from hardware. Every changing of heart beat reading will update the GUI. As the result, this system is very effective to monitor all patients every minute. This system also designs to save all patient data in the PC. Figure 13 shows the patient data which save in a PC. This data will be saved in Notepad format with date, time, patient condition and the reading of heart beat.

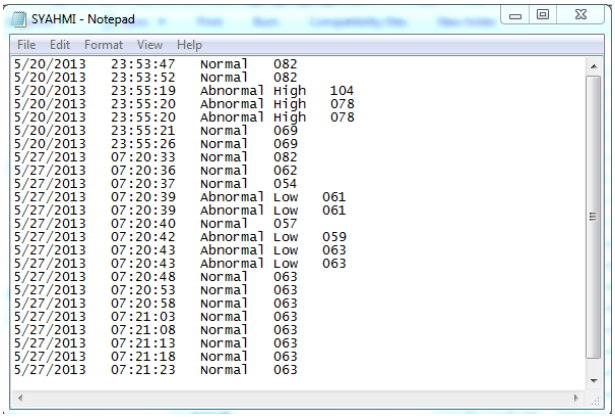

Figure 13: Patient Data Result

4. Conclusions

In this study, the Wireless Patient Monitoring System has monitored the patient condition especially the heart beat easily and also increases the efficiency of patient data monitoring. The data successfully transmitted wirelessly to the receiver and display the data at the PC. All the hardware design, data communication between hardware and software, wireless communication and GUI for the whole system is successfully function and can be used as a wireless patient monitoring system using Zigbee as to replace the usage of Bluetooth and SMS through GSM as the communication tool. For the future, this project will be improved by using the real ECG machine as the input reading with the real sensor e.g. pulse oximeter.

5. Acknowledgement

We are grateful to Universiti Teknikal Malaysia Melaka (UTeM) for their kind help for supplying the electronic components and giving their laboratory facility to complete this study.

References

[1] http://www.bharian.com.my/bharian/articles/Satudoktoruntuk400pesakitpada2020/Article/
[2] B. Priya, S.Rajendran, R. Bala and Gobbi, "Remote Wireless Health Monitoring Systems", in Conference on Innovative Technologies In Intelligent Systems and Industrial Application, 2009.
[3] Ashwin K. Whitchurch, Jose K. Abraham, and Vijay K. Varadan, Member, IEEE."Design and Development of a wireless remote point-of-care patient monitoring system", in High Density Electronic Center, University of Arkansas, Fayetteville.
[4] Xiaoxin Xu Mingguang Wu, Cheng Ding and Bin Sun Jiangwei Zhang , "Outdoor Wireless Healthcare Monitoring System for Hospital Patients based on Zigbee" publish from Department of Control Science & Engineering, Zhejiang University Hangzhou, CHINA.
[5] Lew C. K. and M. Moghavvemi, "Remote Heart Rate Monitoring System Based on Electrocardiography" 2002 Student Conference on Research and Development Proceedings, Shah Alam, Malaysia, 2002
[6] Hassinen Marko, Marttila-Kontio Maija "Wireless System for Patient Home Monitoring", Department of Computer Science University of Kuipio, Kuipio, Finland.
[7] http://www.microcontrollerboard.com/pic_memory_organization.html, "PIC 16F87XA Memory Organization Tutorial"
[8] ww1.microchip.com/downloads/en/DeviceDoc/39582b.pdf, "MICROCHIP PIC16F87XA Data Sheet, 28/40/44-Pin Enhanced Flash Microcontrollers", 2008
[9] N. M. Z. Hashim, A. S. Jaafar, N. A. Ali, L. Salahuddin, N. R. Mohamad, "Traffic Light Control System for Emergency Vehicles Using Radio Frequency", IOSR Journal of Engineering (IOSRJEN) Vol. 3, Issue 7, pp 43-52, 2013.
[10] N. M. Z. Hashim, N. A. Ali, A. S. Jaafar , N. R. Mohamad, L. Salahuddin, N. A. Ishak, "Smart Ordering System via Bluetooth", International Journal of Computer Trends and Technology (IJCTT) – volume 4 Issue 7, pp. 2253-2256, 2013.

Author Profile

N.M.Z Hashim received the B.Eng. and M.Eng. degree in Electrical and Electronics Engineering from University of Fukui, Japan in 2006 and 2008, respectively. From 2008, he worked as Lecturer in Faculty of Electronics and Computer Engineering, Universiti Teknikal Malaysia Melaka (UTeM), Malaysia. He is acting the Head of Department of Computer Engineering Department. His works are in Signal and Image Processing,

Wavelet Transformation, Communication and Electronic Engineering. He joined Institute of Electrical and Electronic Engineers (IEEE), Board of Engineering Malaysia (BEM), Institute of Engineering Malaysia (IEM), Society of Photo-Optical Instrumentation Engineers (SPIE), International Association of Computer Science and Information Technology (IACSIT) and International Association of Engineers (IAENG) as member.

M. S. Sizali received the B. Eng degree in Electronic Engineering (Wireless Communication) from Universiti Teknikal Malaysia Melaka, Malaysia in 2013.