On Designing a System to Supervise Patients' Vital Signs through Wireless Sensor Network

N.T. Dung[1], P.T. Nghia[1], D.Q. Long[1], N.H. Tuyen[2], N.V. Dung[2], and N.T. Ha[2]

[1] Thai Nguyen University of Information and Communication Technology, Thai Nguyen University, Vietnam
[2] School of Electronics and Telecommunication, Hanoi University of Science and Technology, Vietnam

Abstract— **The demand of health care of citizens has been increasing with the development of economy nowadays. In health care, the measurements of body temperature, heart rate… are the most interested. The medical specialists normally concern about these parameters when running a healthy check or evaluation of the effectiveness of a therapeutic method in general. Besides, surveillance of the parameters is important to detect bad signals of patients for timely treatment. Recently, the overcrowding in hospitals that have long become the concern of the health sectors in particular and whole society in general. With the application of wireless sensor networks (WSNs) to design and build a sensor which is capable of monitoring the heartbeat and body temperature parameters will be the solution to help take care of health for patients effectively, and will actively support for physicians in the treatment process. In this paper we introduce the design of a system that can monitor heart rate and body temperature of the patient in an effective and accurate manner through wireless sensor network.**

Keywords— **wireless sensor networks, body temperature, temperature sensing, heart rate, supervise patients.**

I. INTRODUCTION

In recent years, wireless sensor networks (WSNs) have become increasingly important in daily life. Beginning to the development of military applications, wireless sensor networks are now also used in many other fields such as environmental monitoring, smart homes, health cares ... With the convergence of the microelectronic technology, integrated circuit technology, sensor technology and signal processing ..., scientists have created very small and multi-functional sensors with low costs increasing the applicability of wireless sensor networks .

In Vietnam, the overcrowding in hospitals that have long become the concern of the health sectors in particular and whole society in general. The application of technology in particular and wireless sensor networks in general will be effective solutions to help take care of health for patients effectively, and will actively support for physicians in the patients treatment process.

There are no units in domestic researching and designing about running equipment above. Almost similar devices have to be imported from overseas with high prices, while the demand of the treatment from patients is very large. The successful design of this device will bring enormous benefits in both science and economics terms.

II. SYSTEM DESIGN

A. System Description

The system overview is given in figure 1. It composes of sensor nodes and a base node. There heartbeat sensor (based on SpO_2 sensor) and a body temperature sensor (using the Microchip DS18B20) and a radio transceiver module (using the Microchip XBee) are integrated on each sensor node. The sensor nodes are worn on patient's body. A PIC 16F877a microcontroller on each sensor node receives the heartbeat and body temperature then spread them over the wireless networks. At base node, a 16F877a microcontroller receives the data and sends them to PC to display and store.

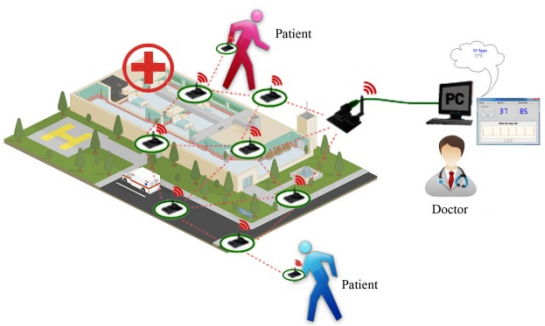

Fig. 1 The system overview.

The nodes are designed with an integrated sensors capable of monitoring heartbeat parameters and body temperature. The nodes are compact and conveniently designed so that they can be wearable and do not affect the movement of patients. To be energy saving, the sensor node on the patient's body is often different active and free statuses [1]. Normally, a node will be free more than active status. The base node is in charge of collecting data from the sensor nodes of each patient, and then displays the results on computer of doctors.

The system block diagram is given in figure 2. [2]

© Springer International Publishing Switzerland 2015

V. Van Toi and T.H. Lien Phuong (eds.), *5th International Conference on Biomedical Engineering in Vietnam,*
IFMBE Proceedings 46, DOI: 10.1007/978-3-319-11776-8_28

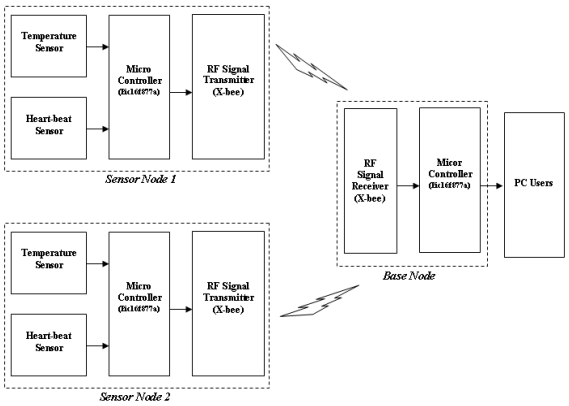

Fig. 2 The system block diagram.

B. Materials and Methods

- Microcontroller

The centre controller uses a microcontroller named PIC16F877A [3]. Currently, the microcontroller - PIC16F877A is the most popular line (be strong enough in terms of features, 40 feet, enough memory for most normal applications). The general structure of the microcontroller consists of 8KByte Flash ROM, 368 Byte RAM, 5 ports (A, B, C, D, E) in the independent signal controlling; two timers with 8 bit (Timer 0 and Timer 2), a timer with 16 bit (Timer 1) operating in the power saving mode (Sleep mode) with the external clock source; two sets of CCP (Capture / Compare / PWM); an AD transducer with 10 bit, 8 inputs, 2 analog comparators [4].

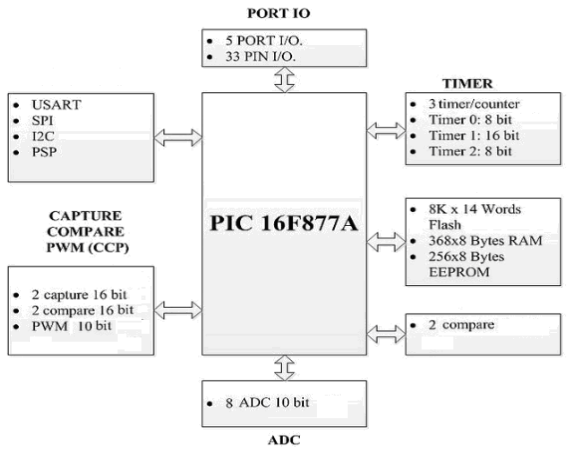

Fig. 3 Block diagram of PIC16F877A

- Temperature sensor

DS18B20 [5] is a temperature sensor, including 3 feet (operating from -55 to +125). With the temperature range from -10 to +85, the accuracy is 0.5. The function of DS18M20 is to warn about the excess of temperature. The voltage used for the equipment from 3 to 5V, you can configure for the encryption of temperature from 9 to 12 bit because the larger the number of bits is, the higher the accuracy is. The conversion time of the temperature maximum is 750ms for 12 bit encryption.

The digital temperature sensor- DS18B20 shows data to indicate the measured temperature under the form of the binary code – 12 bit. The received information is transmitted via one wireless interface (1 - wire), therefore you need only two paths including a signal line and a ground line (GND) to connect from the microcontroller to the measured point (figure 4). The source supplying for the reading/ writing/ conversion manipulating can be obtained from the signal line, no need to add any separate lines to purvey the source voltage. Each the temperature measurement microchip of DS18B20 has a unique identification code, which is engraved by the laser in the IC fabrication process so a lot of DS18B20 microchips can be connected together in a bus having one wire without confusion. This feature makes the installation of multiple temperature sensors in many different locations become easier and with low cost. The number of sensors connected to the bus without restriction.

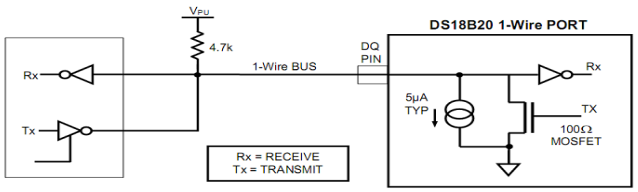

Fig. 4 Connection diagram with DS18B20

- Heartbeat counting circuit based on SpO_2 method

In the block diagram of the circuit (figure 5), IR LED is used to illuminate the user's fingers by the infrared light [6] [7]. Each heart rate, the blood will push out capillaries in the fingers making the change of infrared reflectance intensity, causing the output voltage on photo transistor.

The circuit schematic diagram is given in figure 6.

Voltages changing on the photo transistor (at point A) will be put through a high-pass filter circuit to filter the DC components on the circuit with high cut-off frequency

$$f_{C_H} = \frac{1}{2\pi R_1 C_1} \approx 0.6\ Hz \quad (1)$$

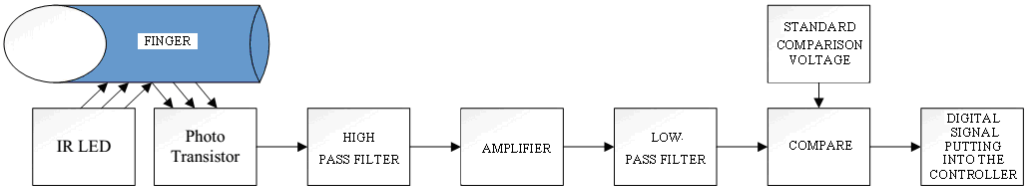

Fig. 5 Block diagram of the heartbeat counting circuit

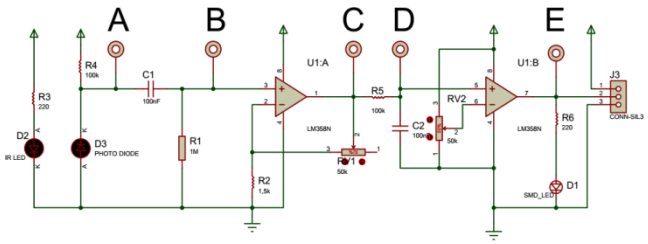

Fig. 6 Schematic diagram of the heartbeat counting circuit

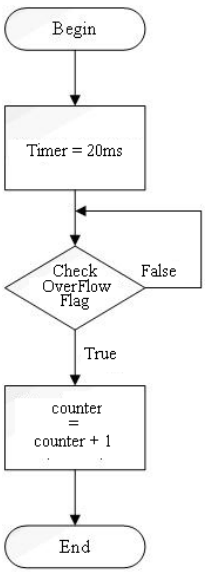

Fig. 7 The program flowchart

After high-pass filtering, the signal at point B (according to the heart rate) is amplified by $K = 1 + Rv_1 / R_2 \approx 34$ times. The amplified signal at point C is then low-pass filtered to remove high frequency noises (due to light, vibration ...). The low cut-off frequency is

$$f_{C_L} = \frac{1}{2\pi\sqrt{R_5 C_2}} \approx 15\ Hz \qquad (2)$$

The signal at point D is compared with a standard voltage through a comparison circuit to convert from analog form to digital form that can be processed. The output signal of the circuit (at point E) has only two possible levels: "0" or "1". Whenever having a heartbeat, the output level is in "1" level.

Flowchart of counting heartbeat algorithm is illustrated in figure 7.

- Xbee communication module

The XBee RF Modules were engineered to meet IEEE 802.15.4 standards and support the unique needs of low-cost, low-power wireless sensor networks [8][9]. The XBee RF Modules interface to a host device through a logic level asynchronous serial port. Through its serial port, the module can communicate with any logic and voltage compatible UART; or through a level translator to any serial device. The Xbee module communicates with the microcontroller by DI pins transmitting data, DO receiving data, the notification flags of transmitting and receiving CTS and RTS (figure 8) [10]. Devices that have a UART interface can connect directly to the pins of the RF module as shown in the figure below.

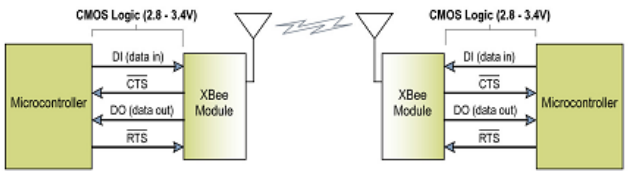

Fig. 8 System Data Flow Diagram in a UART-interfaced environment

Some parameters of the XBee ZB24 are

- ✓ Inside transmission range up to 30m
- ✓ Outside transmission range up to 90m
- ✓ Transmission Capacity: 1mW(dBm)
- ✓ Data Transmission Speed -RF: 250.000 bps
- ✓ Transmission Line: 45mA – 3.3V
- ✓ Using frequency range: 2.4 GHz
- ✓ Support Networks: Point to Point, Point to MultiPoint, peer to peer.

III. RESULTS AND DISCUSSIONS

We design a wireless sensor network for monitor heartbeat and body temperature. The network consists of two sensor nodes and a base node. An example of the data received by the base node and displayed in the PC is given in figure 9. It proves that our system allows doctors to monitor the health status of many patients at the same time and is capable of accurate warning and quick discovering bad signals on the patient's body for doctors to give handling measures timely.

Fig. 9 The base node is in charge of collecting data from the sensor nodes of each patient

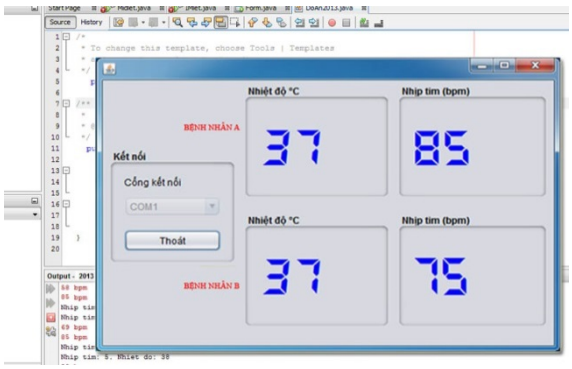

Fig. 10 Received data is displayed on PC screen

- Some features of the system:

The system is capable of monitoring temperature data, the patient's heart rate through wireless sensor networks and sending the results to the computers of the treating physicians.

- ✓ The system is capable of accurate warnings and quickly discovers bad signals on the patient's body for doctors to give timely remedial measures
- ✓ Allowing physicians can monitor the health status of many patients in the same time, thereby to facilitate the evaluation of the patient's treatment process.
- ✓ The implementation of the system is simple and efficient. Patients can wear the device on their body without affecting their activities.

IV. CONCLUSIONS

In this paper, a wireless sensor network for monitor heartbeat and body temperature is presented. It allows doctors to monitor the health status of patients. The system aims are to reduce the investment cost of hospitals, reduce the trade deficit contributed to implement the National Policy on medical equipment from the government. At the same time, the task will also contribute to improve the training of high qualifications human resources for the medical device sectors.

REFERENCES

1. Holger Karl and Andreas Willig, Protocols and Architectures for Wireless Sensor Networks, John Wiley & Sons, Ltd, 2005.
2. Sensor Information Networking Architecture and Applications, Chien-Chung Shen, Chavalit Srisathapornphat, and Chaiporn Jaikaeo, University of Delaware
3. Datasheet PIC16F87XA, Microchip Technology Inc, 2003.
4. Programming PIC Microcontrollers in BASIC, mikroElektronika © 1998 – 2004.
5. Datasheet DS18B20 - DS18B20 Programmable Resolution 1-Wire Digital Thermometer.
6. Design of an Infrared based Blood Oxygen Saturation and Heart Rate, Yousuf Jawahar, Electrical and Biomedical Engineering Project Report, McMaster University, 10/2009
7. Pulse Oximetry - Yun-Thai Li Department of Electronic Engineering, University of Surrey, Guildford (www.surrey.ac.uk)
8. Microchip ZigBee-2006 Residential Stack Protocol, Derrick P. Lattibeaudiere, Microchip Technology Inc.
9. Jason Lester Hill, System Architecture for Wireless Sensor Networks, page 166-177, 2003.
10. XBee®/XBee PRO® RF Modules - 802.15.4 [2009.09.23].